Fanavaran Nano-Meghyas

Lab-Scale Electrospinning Unit (Electroris®) user manual

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Chapter 1 Information

1.1 General Information

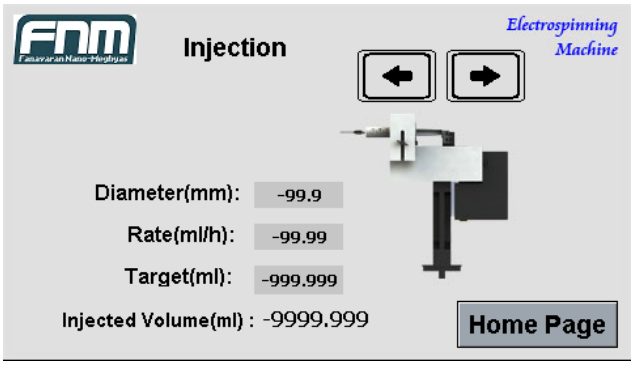
1.1.1 Serial Number

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

Electroris® serial number label

1.1.2 Calibration

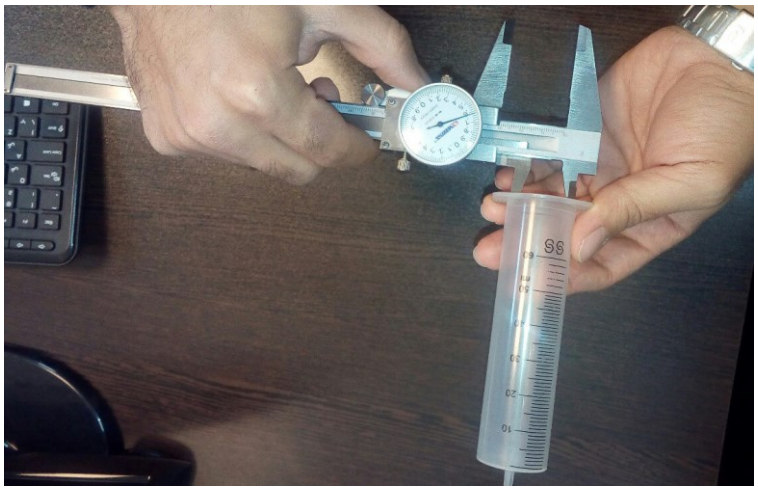
Note: High voltage power supply must be turned off during the calibration process.



Injection menu

All electrospinning units are designed and manufactured to meet their performance specifications at all voltages. It is sometimes necessary to check the calibration. The calibration process should be performed according to the following steps (it is not needed to mount syringe for doing calibration):

Step 1) Adjust the inner diameter of the syringe you want to use (the syringe diameter should be measured by a caliper),



Measuring the inner diameter of syringe using a caliper

Step 2) Adjust the flow rate of electrospinning solution,

Step 3) Adjust the target volume (the amount of solution that should be injected),

Step 4) Specify the start point of the pusher block of syringe pump (pusher block is the part that pushes the syringe to inject polymer solution),

Step 5) Press "Run" button on HMI "Home Page" to start the injection from the start point,

Step 6) After reaching the target volume, the machine will be stopped and now the end point should be specified and then the movement length of the pusher block (the distance between start and end point) should be measured,

Note: It is noteworthy that the injected volume of solution follows a simple mathematical formula:

$$V = \pi \times d^2/4$$

In which V is the injected volume of solution in ml, π is about 3.14, and d is the syringe diameter in mm.

For better understanding of the calibration procedure, the below example is presented:

Step 1) HMI panel → Home Page → Injection→ Diameter (mm): 10

Step 2) HMI panel → Home Page → Injection→ Rate (ml/h): 60

Step 3) HMI panel → Home Page → Injection→ Target (ml): 1

Step 4) Start point: ?

Step 5) HMI panel → Home Page → Run

Step 6) End point: ?, Calculate the distance between the start and end point. The obtained distance should be 12.73 ± 0.10 mm. If the calculated distance is higher or lower than 12.73 mm, the "Inject. calib. coefficient" in "Setting" menu should be changed.

Note: Entering the "Setting" menu needs password (Pass: 666666). In this case you can contact with us (info@fnm.ir).

Note: Please repeat the above procedure for injection rates of 6 ml/h and 1 ml/h (Step 2).

1.1.3 Warranty

Fnm Electroris is warranted for a period of one year from date of purchasing. Fnm Co. will repair or replace the unit if it is found to be defective as to workmanship or material.

The warranty does not extend to:

- Damage resulting from transportation, wrong connections with other systems, connection with defective equipment, voltage fluctuations, fire or intensive heat, water or corrosive chemicals, dust, lightning, natural disasters, collision, misusing the instrument or neglecting the manual description.
- The machines that have been repaired by other companies.
- The machines that have been manipulated.
- Damaging the machine labels or holograms
- Damage resulting from installation or updating the files, software, program and firmware by irresponsible people.
- Damage resulting from not connecting the machine to the earth.
- Damage resulting from connecting the high voltage wire to the body of the machine, drum, syringe pump and etc.

According to the warranty, our company will repair or replace the defective machine free of charge. You can send us the defective part(s) of machine (such as HV power supply or/and syringe pump) by post. We will accept any charge made for posting.

1.1.4 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.

1.1.5 CAUTION

Electroris use High-voltage power supply for generating nanofibers. The term high voltage usually means electrical energy at voltages high enough to inflict harm or death upon living things. High voltage can bridge long distances and break through the isolation. On the

surrounding objects it can form a dangerous charge. If not properly connected to proper discharge resistor, capacitors can remain charged even long after shutdown.

1.1.6 Sparks in air

The dielectric breakdown strength of dry air, at Standard Temperature and Pressure (STP), between spherical electrodes is approximately 33 kV/cm. This is only as a rough guide, since the actual breakdown voltage is highly depended upon the electrode shape and size. Strong electric fields (from high voltages applied to small or pointed conductors) often produce violet-colored corona discharges in air, as well as visible sparks.

1.1.7 Connecting the Machine to the Earth

Due to high voltages required to form polymeric nanofibers, it is necessary to connect the machine through an earth conductor of the power cord. Lack of a proper earth connection can cause electrical shock risks to the operator.
Given the importance of a proper earth connection, the laboratory wiring system should be equipped with an earth wire. There is a yellow socket at the back of the machine that must be connected to the earth.

1.2 Maintenance and General Safety Summary

1.2.1 GENERAL SAFETY SUMMARY

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

1.2.2 To Prevent Hazard or Injury

Use a Proper Line Cord

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

Use a Proper Power Supply

The unit is supplied with an approved power supply and line cord. To maintain the safety integrity of the machine, use only one of the following power supplies:

- *100 – 240 V AC, 50-60 Hz*

Connecting Electroris® to earth

This product is connected to the earth through the earth conductor of the power cord. To avoid electric shock, the earth conductor must be connected to earth by a yellow wire which is in the package. Before making any connections to the input or output terminals of the product, ensure that the product is properly connected to earth.

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 machine, do not operate it. Contact with qualified service personnel.

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

High viscosity solutions
Do not 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 instrument
Clean the panel and body of the machine with a medium detergent.

Lubricating
Lubricate the syringe pump screws and their connections in certain time.

Observe all Warning Labels on Product
Read all labels on product to ensure proper usage.

Please inform FNM Co. if there is any problem.

1.2 The machine limits

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

1.3 Warning

The sound alarm inside the machine can be set up to alert the user when completing each command.

Chapter 2 Introduction

2.1 Theory of Operation

2.1.1 Electrospinning Process

When a sufficiently high voltage is applied to a liquid droplet, the body of the liquid becomes charged, and electrostatic repulsion counteracts the surface tension and the droplet is stretched; at a critical point a stream of liquid erupts from the surface. This point of eruption is known as the Taylor cone. If the molecular cohesion of the liquid is sufficiently high, stream breakup does not occur (if it does, droplets are electrosprayed) and a charged liquid jet is formed.

As the jet dries in flight, the mode of current flow changes from ohmic to convective as the charge migrates to the surface of the fiber. The jet is then elongated by a whipping process caused by electrostatic repulsion initiated at small bends in the fiber, until it is finally deposited on the collector that is connected to the earth. The elongation and thinning of the fiber resulting from this bending instability leads to the formation of uniform fibers with nanometer-scale diameters.

2.1.2 Lab scale Electrospinning unit (Electroris)

Electroris is a setup to prepare polymeric/ceramic nanofibers with diameter range of 50 nm to a few microns. Electroris® electrospinning setup mainly consists of main body including syringe pump, spinneret, collector system and high voltage power supply. Two different types of Electroris are available: Standard model and dual pump Electrospinning system (Side by Side Electroris).

This machine employs an HMI control panel for controlling electrospinning parameters including injection rate of polymer solution, working distance, rotating speed of collector drum, working temperature (room temperature to 45°C) and working time. Electroris® supplies sufficient safety scheme for users with respect to the handling of a high voltage power supply and chemical solvents.

2.1.3 Characteristics and Capabilities

General

Chassis: Metallic body with 3 doors for easy access

Input power: 100-240 V AC/50-60 Hz

Ventilation: A programmable fan adjustable by HMI panel

Heating system: Adjustable from room temperature up to 45°C via HMI panel

Heater: 1000W, 4A

Safety: Voltage cut-off in case of door opening, grounding problem, or process disruption

Dimensions (L×W×H): 131 × 80 × 96 cm

Weight: 140 kg

Main Features

- Advanced safety features
- Reliable performance
- Modular design
- 4.3" HMI touch screen control panel for controlling process parameters
- Emergency button to stop machine in any unexpected situation
- Easy use and maintenance
- Dual syringe pump model is available
- Operation Software (Optional)

Flexibility

- Various polymers and composites have the potential to be electrospun.
- Different product specifications such as porosity, morphology, diameter, and ability to load beads can be obtained.
- Different polymers can be electrospun simultaneously, due to the existence of two syringe pumps
- The process is easy and economical.
- Many different polymer types such as synthetic, biodegradable and natural polymers and/or polymer/composite may be processed.
- Aligned nanofibers can be produced by high speed rotating collector or using wire type collector

Spinneret

Number of syringes: Up to 2 syringes
Configuration: Horizontal
Scanning rate: 0-30 mm/s
Scanning range: 0-30 cm
Syringe pump injection rate: 1 µl/h to 500 ml/h
Usable syringe size: 1-25 mm (Inner Diameter)
Operation mode: Constant flow rate and maximum volume of injection
Accessories (Optional): Co-axial nozzle with tubing
1 syringe pump (Up to 2 syringes can be used)
1 scan system

1 distance system

Collector
Type: Rotating drum (wire, cylinder, mandrel and disk collectors are optional)
Material: Stainless steel
Rotation speed: 350-3000 rpm
Spinning distance: 5-20 cm

Size:

- Drum:8(ø) cm × 30(L) cm
- Plate: 25(L) cm × 20(W) cm
- Wire: 8(ø) cm × 25(L) cm
- Disk: Diameter: 19.8 cm
- Mandrel:
  Length: 25 cm
  Diameter: 2, 4 , 6 , 8 and 10 mm

Attachable to negative high voltage power supply up to -20 kV (Optional)

High voltage power supply

Model: HV35P OV
Max. output voltage: 35 kV
Power: 35 Watt
Voltage monitoring: Digital, Accuracy: 0.1 kV
Body: Durable metal casing
Two high voltage power supplies are installed for dual pump series

Control

Type: PLC
HMI: 4.3" touch screen

- Start and end position of the nozzles
- Injection rate of syringe pumps
- Electrospinning distance
- Electrospinning time
- ON/OFF timer for exhaust fan
- ON/OFF timer for heater
- High voltage ON/OFF switch and ON/OFF button in HMI, Adjusting high voltage by a 10-turn potentiometer mounted on high voltage power supply
- Drum ON/OFF switch (RPM controller) in standard series, and control from HMI screen in dual pump series

- Temperature control (Dual pump series)
- Alarm after desirable volume of injection and after finishing the solution in syringe (after the operation of syringe pump switch)

2.1.4 An overview of Standard (Lab-scale) Electrospinning Machine

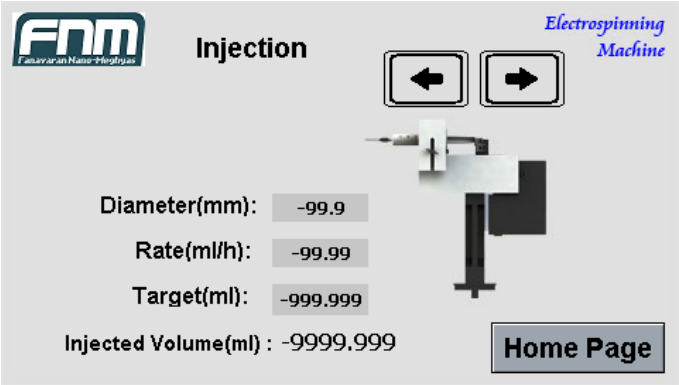
The main components of a lab-scale Electrospinning unit include the following:

1: HVPS, 2: Drum collector, 3: System controller & panel, 4: Syringe pump, 5: Scan system, 6: Distance system

2.2 Features

2.2.1 Syringe pump

The syringe pump of this machine has been designed in order to use a variety of syringes. The system is able to inject the certain volume of solution with different rates. All models employ a PLC 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. By pressing “Injection” button on “Home Page”, the data related to the injection of solution during the electrospinning process will be shown. The diameter of the syringes, rate, and target are entered by touching the rectangular box in front of each variable and the internal microprocessor drives a precision stepper motor to produce accurate fluid flow. The pump can hold syringes of nonconductive materials (plastic or glass) from about 10 µl to 50 ml (inner diameter: 1-25 mm). Nonvolatile memory stores the last syringe diameter and flow rate along with other configuration data.



Injection menu

2.2.2 Easy-To-Use Interface

The essential information is shown on a touch screen LCD. Different parameters such as flow rate, syringe diameter, maximum of injection, start & end scan position, scan speed and distance are adjustable.
There is a box in front of all adjustable variables in each menu. A virtual keyboard is shown by pressing the mentioned boxes and the variables can be changed. It should be noticed that the allowed range of each variable is indicated on the appeared numerical keyboard. If an out of range value is entered, "Error!" message will be shown.

2.2.3 Syringe Table and Custom Syringes

If a non-standard syringe is used, the inside diameter of the syringe should be entered in millimeters. Syringes are arranged according to manufacturer and material, and then according to size (Appendix A).

2.2.4 Target Volume

Specify the volume that should be injected. The pump will run at the rate specified until this volume has been reached the target volume.

2.2.5 Nonvolatile Memory

All operational data entered into the pump from the HMI screen will be stored, including the program.

2.2.6 Smooth injection

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

2.2.7 Adjusting the Pusher Block

Using two keys for electrospinning unit in "Injection" menu that move the pusher block forward or backward can adjust its position rapidly.

2.2.8 High Voltage Cable

Before turning on the machine, make sure that the cable is connected to nozzle(s). Connecting the high voltage cable to every part of the machine (except the nozzle) causes transmission of high voltage to the machine and can fail it. Also it can damage the high voltage power supply.

Note: Before starting the machine, make sure that the high voltage power supply is off.

2.2.9 Visual/Audible Alarm

In addition to visual alarm, the machine has an audio alarm that will sound in required times.

2.2.10 Package contents

Electroris® package contents are a power cable, earth cable, user manual, two syringes in two sizes, and two needles in two different gauges, alligator clips, Allen wrench in two different sizes, the polymer solution and two 5A fuses.

Chapter 3 Installation

3.1 Physical installation

The following conditions must be noticed at the place where you work:

- A dry, clean and hard surface for keeping the machine.
- Suitable earth connection
- Minimum of about 15 cm clearance around the machine.
- Suitable environmental conditions
- A proper ventilation

3.2 Checking before turning on the machine

Due to the use of high voltage to form nanofibers, be sure the machine is properly connected to the earth. Lack of proper earth connection can cause damage to electrical systems in a few seconds, as well as it can also have associated risks.

Given the importance of proper earth connection, wiring system of the laboratory should be equipped with the earth system. Also, power outlet and electrical wires with earth should be used.

Before turning on the machine, be sure that the connection of HV cables to suitable places is accurate. Connecting HV cable to anywhere of the machine, except suitable places, can cause transmission the high voltage to the electronic systems and fail them. It can also cause damage the HV.

When you turn on the machine, the electricity will enter to the HV. When you turn on any of the HVs, the power of HV will be transferred to the system. It can increase the risk of electric shock and damage to the machine because of the lack of user preparation.

Note: Be sure that the high voltage power supply is off before turning on the machine.

3.3 Turning on the machine

- Connect the Earth cable.
- Plug in the power cord.
- Turn on the Miniature Circuit Breaker (MCB) switch located at the rear of the machine.
- Use the black key on the right side of the machine to turn on the Electronic control panel.
- Press the black On/Off key in front of the machine to turn on the HMI screen.
- At this time, the display will be turned on and “Home Page”, in which there are a schematic illustration of lab-scale Electroris® and the menus, will be shown.
- Put the syringe(s) containing polymer solution(s) in the syringe pump (in “V” shape holder)

- Use ◄ ► keys in Injection menu to move the pusher block of the syringe pump and put it just behind the syringe(s).
- Connect the high voltage cable to the syringe(s).
- Adjust the electrospinning distance and the rotating speed of drum collector in Distance, Drum menu.
- Adjust the scan speed, start and end position (scan range) in Scan menu.
- Adjust the temperature of the chamber, ON/OFF time of heater and ventilation system in HV, Heater and Vent. menu.
- Close all doors.
- Touch Run button on "Home Page" to start the injection and wait until the droplet is appeared at the tip of needle.

HMI home page

- Use the On/Off key on the HMI in HV, Heater and Vent. menu and then the On/Off key on the high voltage power supply to turn it on, at this time the red LED will be turned on and the electrospinning process is started.

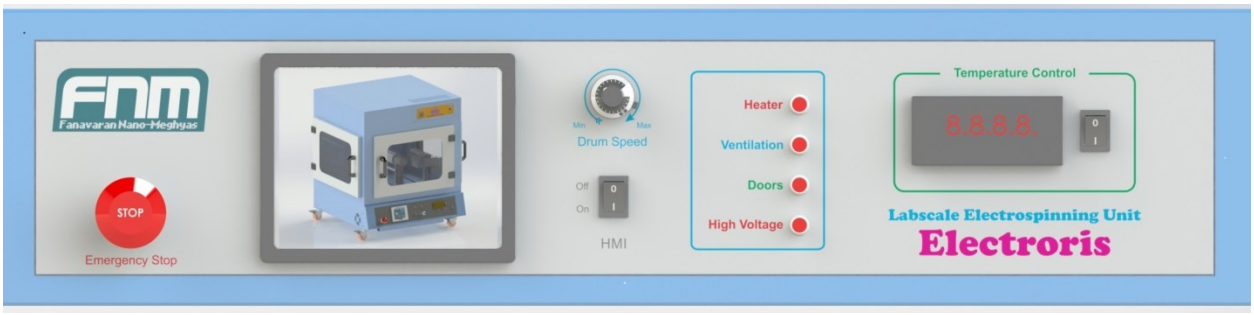
Note: Before turning on the HVPS, please be careful that the high voltage cable is not connected to the body of the machine. Additionally, set the voltage of HVPS at the minimum value by rotating the 10-turn potentiometer counterclockwise, before turning on.

Chapter 4 Performance

4.1 Components

4.1.1 Human Machine Interface (HMI)

The Electroris panel consists of an HMI screen that is a 4.3-inch touch screen. There is a display to adjust and show the chamber temperature, four LEDs (Heater, Ventilation, Doors and High Voltage), a 10-turn potentiometer to adjust the rotation speed of drum collector, On/Off key for turning on/off the HMI screen and an emergency button to stop the machine in emergency situations.



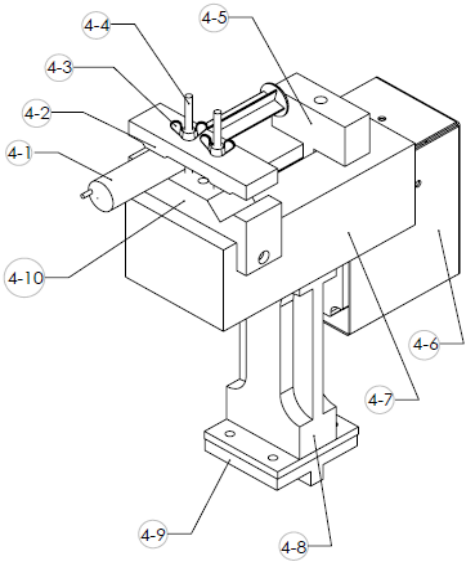
The panel of Fnm lab-scale electrospinning machine

HMI screen is used to enter data and electrospinning parameters and changing the machine settings. Data entry will be discussed in detail later in this chapter.

HMI home page

HMI home page screen contains several menus, the schematic image of electrospinning unit, and the switches indicator. The mentioned switches have two modes, when the machine is working the squares in front of them turn to green, however, if the doors are open, the injection is stopped, the high voltage is not applied or the emergency button is pushed, the machine will not operate and their related switches will turn to red, as well.

4.1.2 Syringe pump



4.1. Syringe
4.2. Syringe clamp
4.3. Thumbscrew
4.4. Clamp screw
4.5. Pusher block
4.6. Stepper motor case
4.7. Plastic case
4.8. Syringe pump system base
4.9. Interface part between syringe pump and distance system rail
4.10. Syringe holder base

4.1.2.1 Loading the Syringe

1. Adjust the syringe pusher block (4.5) by entering "Injection" menu on "Home Page" and pressing  .
2. Raise the spring loaded syringe retainer (4.3) and swing it out of the way.
3. Lay the loaded syringe in the 'V' shaped syringe block.
4. Swing the syringe retainer so it holds the syringe in place.
5. Move the pusher block (4.5) by entering 

menu on "Home Page" and pressing  so it makes contact with the syringe plunger.
6. Tighten down thumbscrews on syringe block bracket so that it captures flanges on syringe barrel.
7. Tighten thumbscrew into place when switch is set.

4.1.2.2 Proper syringe selection

Min Rate (Microliter/hour) = 0.5 * Syringe diameter (mm) ^ 2
Max Rate (Milliliter/hour) = 0.80 * Syringe diameter (mm) ^ 2

Example:

A: syringe diameter: 1mm Min rate: 0.5 µl/h; Max rate: 0.8 ml/h
B: syringe diameter: 10mm Min rate: 50 µl/h; Max rate: 80 ml/h
C: syringe diameter: 17mm Min rate: 144 µl/h; Max rate: 231 ml/h

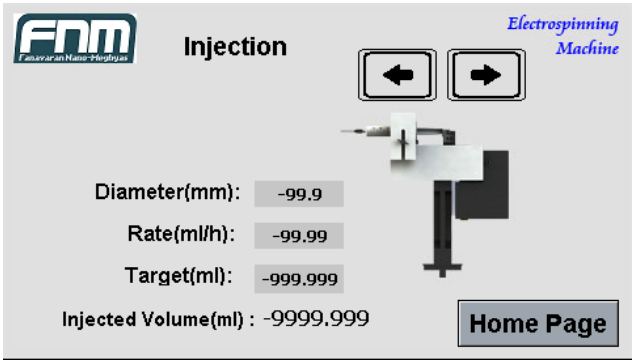
4.1.2.3 Syringe pump (injection) system

The syringe pump can take one or two syringes made by nonconductive materials (plastic or glass syringes) and sizes below 50 ml. The inner diameter of the syringe(s) should be entered at Diameter(mm): -99.9 on Injection menu and the internal microprocessor calculates the cross-sectional area to calibrate the pump for that syringe.

Note: The electricity can be transferred to the syringe, so the syringe should not be contaminated by the solution. If the syringe is contaminated, you will hear the discharge noise. At this time, the "high voltage" should be turned off and cleaned off the contaminated area immediately.

In the syringe pump, one or two syringes can be used. Using two syringes increases the amount of produced nanofibers. However, because of interaction between the formed polymer jets on the nozzles tip, using more than one syringe can alter the nanofiber size and its morphology. So, it is better to use one syringe to optimize the process.

By pressing "Injection" button (Injection) the following page will be shown:



Injection menu

Diameter (Diameter(mm): -99.9): It is the most important parameter in calculating the flow rate, so it is necessary to measure and enter it correctly. When the syringe is changed, the new diameter value must be set. Units are in millimeters (mm). Enter the inner diameter (ID) of the syringe you want to use. If you do not know your syringe diameter, refer to appendix A 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. For setting it, press the rectangular box in front of Diameter(mm): and enter the diameter of syringe.

Rate (Rate(ml/h): -99.99)**:** The appropriate value for injection rate should be set here which depends on polymer solution properties like molecular weight of polymer, viscosity and the concentration of solution.

Target (Target(ml): -999.999**):** The desirable amount of polymer solution to be injected can be set here.

Minimum and maximum injection rate: According to the selected syringe, the maximum and minimum injection rate can be varying. It is suggested using a 5-ml syringe (for rates less than 10 ml/h) or a 2-ml syringe (for rates less than 1 ml/h) to increase the injection accuracy. For higher rates, you have to use a syringe larger than 5 ml.

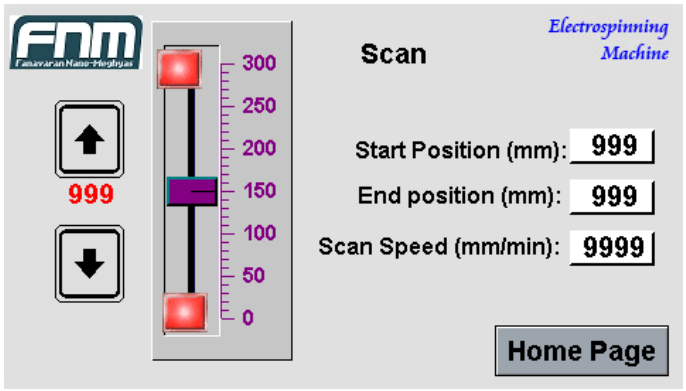
Description: The minimum and maximum rates largely depend on the syringe diameter. If the entered injection rate is more than the defined rate for the system, the "Error!!!" message will be shown. So you have to use another syringe for your application.

Finishing the solution: When the pedal (Pusher Block) reaches to the end position, the system will automatically stop in order to avoid damaging the screws and the motor, so the pedal must be moved backwards manually by pressing the positional buttons ( ) and the syringe must be changed.

Note: Because of different sizes of syringes, automatically determining the end of injection is difficult. So, it is recommended that the maximum volume is set at the amount of solution. For example, if the syringe contains 2 milliliters of the solution, the maximum volume should be set at 2, to turn the machine off automatically after finishing the solution.

4.1.3 Nozzle Scan System

By pressing "Scan" button (Scan) the following page will be shown:

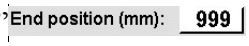


Scan menu

In this page, 3 parameters are adjustable:

"Start Position (mm)" 

: Adjust the starting point of scan by entering the value in the front box. It cannot be more than end position.

"End Position (mm)" 

: Adjust the ending point of scan by entering the value in the front box. It cannot be less than start position.

To move the scan system manually,  or  should be pushed.

"Scan Speed (mm/min)" 

: Adjust the scan speed by entering the value in the front box. It cannot be more than 1800 mm/min.

Example 1: Start Position = 100; End Position = 250; Scan Speed = 500

According to the example, the scanning is done from the starting point (100 mm) to the end point (250 mm) with the rate of 500 mm/min.

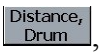
Example 2: Start Position = 150; End Position = 150; Scan Speed = 0

According to the example, only adjusting the nozzle is done at the point of 150 mm and remains constant.

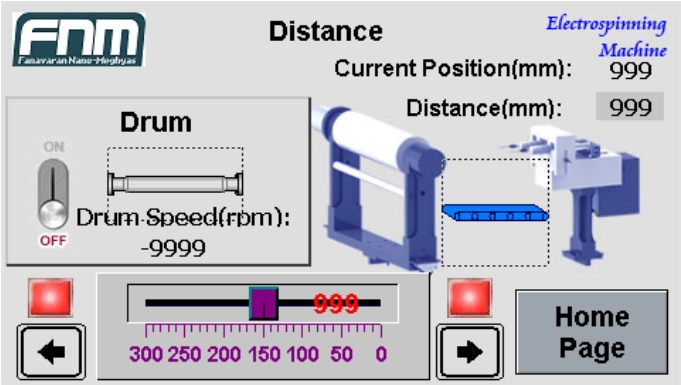
4.1.4 Distance adjustment system

Distance between the nozzle tip and the collector is called "electrospinning distance" based on the conditions, it is usually from 10 to 20 cm, more or less. In most systems, the collector is connected to the earth; however, the negative voltage can be connected to the collector (Connecting negative high voltage to the collector needs some technical considerations).

Note: According to different sizes of nozzles, the electrospinning distance can be more/less than the calculated value, so it must be measured manually by the user.

By pressing 

, the following page will be shown:



Distance & Drum menu

Current Position(mm): Shows the current position (distance) of syringe pump toward the drum collector.

Adjusting the electrospinning distance should be done by pressing the rectangular box in front of Distance(mm): . The distance is changed manually by pressing ◄ or ► buttons in Distance, Drum menu.

4.1.5 The drum (collector) rotation speed

Due to the type of electrospinning system, the minimum and maximum drum rotation speed can be variable. In high speed systems (up to 2500 rpm), the minimum rotation speed is about 350 rpm.

Moving the scroll in ON/OFF turns ON/OFF the drum collector.

Note: The rotation speed of drum collector should be adjusted by a 10-turn potentiometer located on the Electroris® panel.

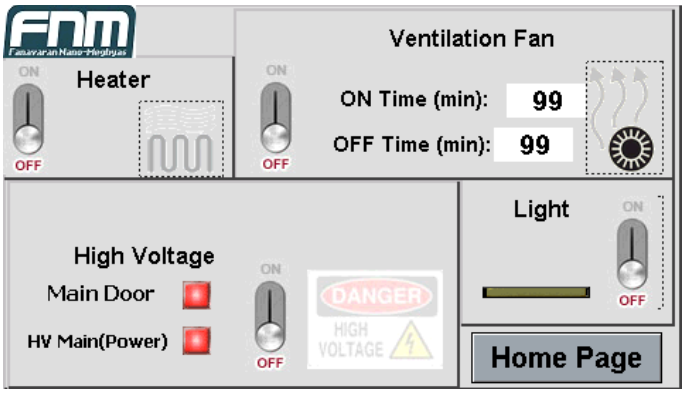
4.1.6. High voltage, heater and ventilation system

To turn ON/OFF the heater, in "Heater" section the scroll in ON/OFF should be set on "ON" and then the On/Off key next to the heating control system display should be turned on. The maximum temperature of chamber can be set at 45 °C. The red LED on the panel indicates that the heating system is "ON" and the blue LED shows that the ventilation system is "ON". The right key is used to turn this system ON/OFF. The ventialtion fan is turned ON/OFF by moving ON/OFF scroll in "Ventilation Fan" section. The time in which the ventilation fan works, is shown in front of ON Time (min): and it is changeable by pressing the front rectangular box. The system off time is

shown in the rectangular front box (OFF Time (min):) and it can be changed by pressing the box and entering value via the exhibited virtual keyboard.

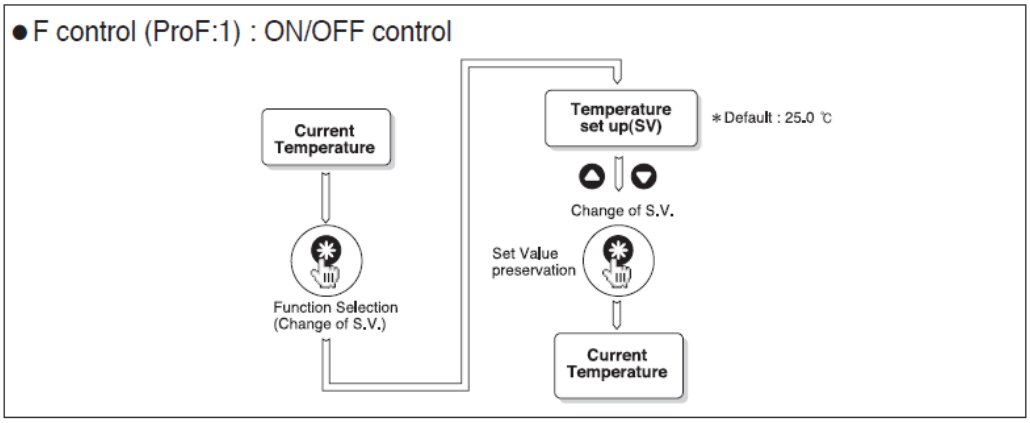
To turn ON/OFF the chamber light 

should be put on "ON" mode in "Light" section.



HV (High Voltage), Heater, and Vent Menu

Because the temperature can directly affect the viscosity and surface tension of polymeric solutions, it is one of the most important parameters in electrospinning process, especially in research works.

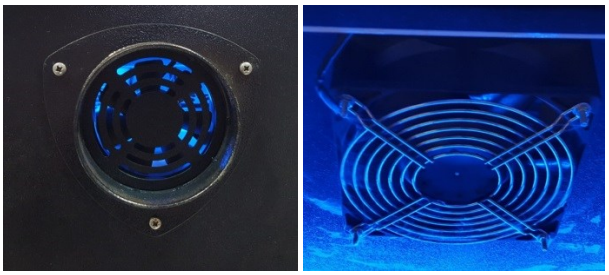


Note 1: The maximum adjustable temperature is 45 °C. Although it is possible to be more than 45°C, it is recommended to set the temperature below 45 °C to avoid damaging the electronic parts and power supply system.

Note 2: In this system, you cannot set the temperature of chamber less than the ambient temperature.

Ventilators: Since the formation of nanofibers is done by evaporating the polymer solvent, any factor that reduces the evaporation can impair the formation of nanofibers. Because the chamber

is closed, after a short time, the solvent vapor saturates the chamber and the evaporation process will be slow. So, it is necessary to bring the solvent out of the chamber without affecting the temperature. Hence, a small ventilation fan is placed behind the machine. It is controlled by a thermostat timer and is automatically turned on/off.



Ventilator at the rear of the machine

Description: If it is necessary to work at room temperature, it is better that the desired temperature is set below the room temperature rather than turning off the heating system (that makes the ventilation fan turn off).

Set mode

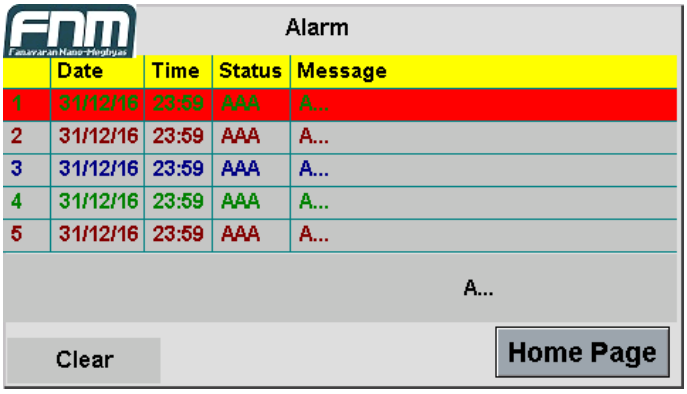
Press "*" key for minimum 3 seconds. The Electroris is set in below values:

0.typ: Heat	4.tsh: 45	8.tof: 3
1.d1f: 1	5.tsl: 10	9.aoc: 1
2.dly: 0	6.5a0: 1	
3.rst: 0	7.ton: 1	

For more information about digital thermostat see appendix A.

4.1.7 Alarms

In case of occurring any unexpected event, the reason will be recorded in "Alarms" page. These events are like opening the doors, suppressing high voltage, emergency stop, reaching the syringe to end limit, finishing the process.

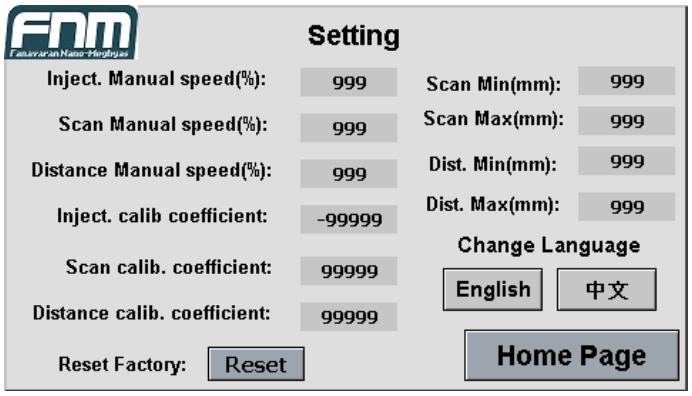


Alarms page

4.1.8 Setting Menu

All of Electroris® settings such as injection, scan, distance, all calibrations related to the machine and language settings are located in setting menu as following.

Note: This menu needs password to enter and is not accessible for users. The settings in this menu are adjusted by FNM Co. and they can be changed by the company if the machine needs repair.



Setting menu

4.2 Safety in working with the machine

4.2.1 Earth connection

The machine should be connected to the earth appropriately to prevent damaging electronic parts of Electroris® especially high voltage power supply.

4.2.2 Emergency stop

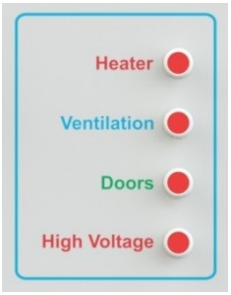
When an unexpected event occurs during the machine operation (such as arc in high voltage power supply) or the operation is interrupted, the "Emergency" button should be pressed to prevent damaging the machine or the user. At this time, the activity of all parts of the machine stops. To restart the machine, "Emergency" button should be rotated in clockwise rotation.

Emergency Stop button

Note: According to the independent power and discrete wiring, be sure the emergency disconnect switch to be tested often.

4.2.3 LED lights on the panel

There are 4 LED lights on the panel which can be on or off based on some conditions. "Heater" (red light) and "Ventilation" (blue light) LEDs will be turned on during heater and ventilation operation, respectively. "High Voltage" LED (red light) is turned on during the electrospinning process and it shows the operation of the high voltage power supply. If one of the machine doors is open, "Doors" LED (yellow light) will be turned on and the HVPS does not apply due to the safety reasons.



LED lights on Electroris® control panel

4.3 High Voltage Power Supply (HVPS)

The machine has a positive high voltage power supply (35 kV). Two different types (OV or OC series) of HVPS can be mounted on this machine.

OV Series with an output high voltage indicator (Accuracy=0.1 kV).

OC series with an output high voltage indicator (Accuracy=0.1 kV) and an output current display (Accuracy=1 micro-amp).

There is a 10-turn potentiometer as a voltage regulator to increase or reduce the voltage from 1 to desirable voltage (Max: 35 kV).

4.3.1 Turning on the HVPS

Touching 

in "High Voltage" section turns on the high voltage power supply (from 

menu on HMI screen). Use the "On/Off" key on the HVPS.

Note: For more safety, before turning on the HV, set the potentiometer at a low voltage and then adjust it at the desired value. In this case, any unwanted connection will be identified and fixed at lower voltages.

Voltmeter: accuracy 0.1 kV (100 V).

For more safety, there are some safety switches on each door of the machine that cause to stop the HV when one of the doors is open.

Note: If HVPS is on, but the voltmeter shows zero voltage, check the doors to be closed.

Ampere meter (in OC series): There is an ampere meter to show the current at the high voltage output that provides interesting information about electrospinning process (Accuracy: 1 µA).

Note: Due to low electricity consumption in the electrospinning process, any increasing in the current shows the discharge. In this case, the machine should be turned off and the discharge situation, especially connection sites in the syringe pump, should be checked.

Chapter 5 Safety

5.1 Risk of electric shock

Improper use of the high voltage power supply can provide a risk of electric shock. Before starting to work with HV, all safety measures should be considered. All connections, especially the earth, should be investigated. Make sure they are connected correctly.

The high voltage power supply in electrospinning machine can vacate the high voltage from a few centimeters to any conductive point such as human body. So, you should not open the door of the machine while the HV is working. Also, you should not connect the cable of HV to any place except the collector and spinneret.

Note: Compliance with safety tips for you and your colleagues is your responsibility.

5.2 Safety equipment and emergency procedures

5.2.1 General Information

Chemistry laboratories are equipped with one or more eye to wash fountains and safety showers. Each person who uses such laboratories must be familiar with the locations of this equipment and know how to use it. Properly equipped laboratories will also have fire extinguishers; do not attempt to use a fire extinguisher unless you have been trained in its use by a qualified firefighter. Your laboratory has a plan for everyone to follow if an evacuation is necessary. Be sure that you know the main and the alternate evacuation routes as well as the procedures for assembling outside the building and accounting for each person who was in the laboratory.

In case of an emergency, as much as possible, follow procedures that have been established and that you have practiced. The first and most important step in any emergency procedure is this:

Before helping another person, evaluate the potential danger to yourself. If you try to help and are injured, you cannot be of much further help to someone else.

When an emergency occurs, the following actions are recommended:

- Report the nature and location of the emergency to your instructor and, if necessary, to the appropriate fire or medical facility. State your name, location, and phone number you are using. Tell where you will meet the emergency vehicle. If individuals are involved, report how many; whether they are unconscious, burned, or trapped; whether an explosion has occurred; and whether there is/has been a chemical or electrical fire.
- Tell others in the area about the nature of the emergency.

- Do not move any injured individual unless they are in immediate danger from chemical exposure or fire. Keep them warm. Unnecessary movement can severely complicate neck injuries and fractures.
- Meet the ambulance or fire crews at the place you indicated. Send someone else if you cannot go.
- Do not make any other telephone call unless they relate directly to the control of the emergency.

5.2.2 Fire Prevention

The best way to fight a fire is to prevent it. You can prevent fire and reduce its severity considerably through proper housekeeping and thoughtful reflection about what you are doing.

This includes:

Maintaining unobstructed aisles and exits, storing only limited quantities of flammable material, promptly disposing of waste, and separating flammable liquids from combustible materials, such as cardboard boxes and paper towels.

Stand back, take a look, and ask:

- Are there any frayed wires?
- Is a stirrer with a sparking motor being used to stir a flammable liquid?
- Are those bottles too close to the edge of the bench?
- Is the workspace cluttered?
- Do I understand each of the potential hazards in what I am about to do?
- Am I prepared in advance to take preventive steps?

5.2.3 Dealing with a Fire

When a fire occurs, the following actions are recommended:

● A fire contained in a small vessel can be often suffocated. For example, use a watch glass to suffocate a fire in a beaker by covering the mouth of the beaker. Do not pick up a vessel that is on fire. Do not cover it with dry towels or cloths; use a wetted material. Remove nearby flammable materials to avoid spreading the fire.

● Activate the fire alarm. Notify co-workers and your instructor. Call the fire department.

● If the fire is burning over an area too large for the fire to be suffocated quickly and simply, everyone should evacuate the area except those trained and equipped to fight fires. Use the stairs to leave the building, do not use the elevators. Follow evacuation procedures that have been established and that you have practiced during prior fire drills.

● It is easy to underestimate a fire. Never attempt to use a fire extinguisher unless you have been trained in its usage, and know that it is likely to extinguish the fire. If you have been

trained in the use of a fire extinguisher, locate yourself between the fire and an escape route (e.g. a door) and fight the fire from this position, but be sure you can escape. Small fires just starting can be often extinguished, but not always. If not extinguished, a fire can quickly threaten your life and your co-workers.

5.2.4 Personal injuries involving fires

When a person's clothing is on fire, you may need to lead him/her to the safety shower. Some people instinctively run randomly if their clothes are on fire, which fans the flames and increases their injuries. If possible, stop an individual from running.

If the shower is not readily available, douse the individual. Get him/her to stop, drop, and roll; that is, to lie down and roll to put out the fire. Then, try to extinguish any small, still-burning flames by patting them out. Beat out the flames around the head and shoulders. Then, work downward toward the feet. Next, cover the victim with a coat, blanket, or whatever is available but leave the head uncovered.

Do not use fire blankets until the fire is extinguished.

While wearing gloves if necessary, remove any clothing contaminated with chemicals. To prevent contamination of the eyes, use scissors when removing pullover shirts or sweaters. Place clean, wet and cold cloths on burned areas. Wrap the victim to avoid shock and exposure. Get medical attention promptly.

If the victim is standing, wrapping the body with a fire blanket or other material can force flames toward the face and neck and, if wrapped tightly, can press melted globs of what once was polymeric clothing fabric into the flesh. Thereby, it accentuates the severity of injury to the victim.

5.3 Chemicals on Skin, Clothing, and Eyes

For small liquid spills that only affect a small area of skin, immediately flush with flowing water for at least 15 minutes. Remove any jewelry to facilitate removal of possible residual liquid. If there is no visible injury, wash the entire area with warm water and soap. Check the MSDS to see whether any delayed effects should be expected. It is advisable to seek medical attention for even minor chemical burns. Hydrofluoric acid spills require special treatment; Solid chemicals that are spilled on the skin can usually be brushed off with no adverse consequences. The brushed-off solid should, of course, be put into the appropriate hazardous waste container. If the solid adheres to your skin, call your instructor.

Larger spills of a liquid on the skin and any spills of liquid on clothing can have serious consequences. Do not waste time by attempting to wipe or flush off the spill; get to the safety shower immediately. Quickly step under the showerhead and in the falling water spray; remove all contaminated clothing, shoes, and jewelry while the safety shower is on. Don't waste time with modesty. Try to avoid spreading the chemical further over your skin, especially into your eyes. Don't contaminate your eyes by removing pullover shirts or

sweaters—someone else should cut the garment off with scissors while you are still in the shower. Flood the affected body area with temperate water for at least 15 minutes. Resume if pain returns. Do not use creams, lotions, or salves. Get medical attention without delay.

Launder contaminated clothes separately from other clothing or discard, as recommended in the MSDS.

Note: Never work with chemicals in a laboratory unless it is equipped with a safety shower that has been tested within the past six weeks.

A record, usually a tag affixed to the safety shower, should state the most recent test date and the tester's initials. For splashes into the eye, immediately flush the eye with temperate potable water from a gently flowing source for at least 15 minutes. Use your thumb and forefinger to hold your eyelids away from the eyeball, move your eyes continuously up and down and sideways, to flush out thoroughly behind the eyelids and behind the eyeball itself. An eyewash fountain should be used, but if one is not available, injured persons should be placed on their backs and water gently poured into the corners of their eyes for at least 15 minutes. After any first aid treatment to the eyes, promptly visit a member of a medical staff or an ophthalmologist who is acquainted with the management of chemical injuries to the eyes.

Note: Do not touch a person in contact with a live electrical circuit. Disconnect the power first! Otherwise, you may be too seriously injured.

5.4 Spills cleanup

Clean up all spills promptly, efficiently, and properly. Call your instructor for help. Warn all individuals who may be at risk to be exposed to the hazard, and minimize its spread. The toxicity of the substance is often more important than the volume of the spill.

If a flammable material is spilled, warn everyone to extinguish all flames immediately to turn off spark-producing equipment such as brush-type motors, and leave the area. You should do any work with a flammable toxic material in a laboratory hood; if a spill occurs, close the hood and call your instructor.

The smaller area is involved, the less the damage is and the easier the cleanup. Follow your instructor's directions.

Many small liquid spills on the floor or laboratory bench (e.g., less than 200 ml) can be absorbed with paper towels, sand, or special absorbent. Of course, whatever is used becomes contaminated and must be handled as a hazardous waste. Be particularly careful that flammable liquids absorbed during cleanup are not present in the fire hazard.

Most spills of solids can be brushed up and disposed of in appropriate solid waste containers, but exercise care to avoid reactive combinations with a chemical that was put in the container earlier. Do not leave materials used to clean up a spill in open trash-cans. Follow your instructor's directions.

Dike larger liquid spills on the floor by surrounding the involved area with an absorbent retaining material. Commercially available or homemade spill control kits can be useful. If possible, use an absorbent material that will neutralize the liquids (limestone or sodium carbonate for acids, sodium thiosulfate solution for bromine, etc.). Commercial absorbents (e.g., Oil-Dri and Zorb-All), vermiculite, or small particles (about 30 meshes) of kitty litter or other satisfactory clay absorbents can be used. Dry sand is less effective.

Use a dustpan and brush, and wear protective gloves to clean up dry spills and liquid spills that have been absorbed by an absorbent. Wear leather or other protective gloves while cleaning up broken glass. Then, clean the contaminated area with soap and water, and dry it. Place a warning sign that says "Wet and slippery floor," or sprinkles some absorbent on the spot.

However, note that vermiculite, kitty litter, and some other absorbents can create a slipping hazard if they are scattered on a wet surface.

5.5 Apparel in the Laboratory

- Wear appropriate eye protection (i.e. chemical splash goggles) in the laboratory.
- Wear disposable gloves, as provided in the laboratory, when handling hazardous materials.
- Remove the gloves before exiting the laboratory.
- Wear shoes that adequately cover the whole foot; low-heeled shoes with non-slip soles are preferable. Do not wear sandals, open-toed shoes, open-backed shoes, or high-heeled shoes in the laboratory.
- Avoid wearing shirts exposing the torso, shorts, or short skirts; long pants that completely cover the legs are preferable.
- Secure long hair and loose clothing (especially loose long sleeves, neck ties, or scarves).
- Remove jewelry (especially dangling jewelry).
- Synthetic finger nails are not recommended in the laboratory; they are made of extremely flammable polymers which can burn to completion and are not easily extinguished.

5.6 Hygiene Practices

- Keep your hands away from your face, eyes, mouth, and body while using chemicals.
- Food and drink, open or closed, should never be brought into the laboratory or chemical storage area.
- Never use laboratory glassware for eating or drinking purposes.
- Do not apply cosmetics while you are in the laboratory or storage area.
- Wash hands after removing gloves, and before leaving the laboratory.
- Remove any protective equipment (i.e. gloves, lab coat or apron, chemical splash goggles) before leaving the laboratory.

5.7 Emergency Procedure

- Know the location of all the exits in the laboratory and building.
- Know the location of the emergency phone.
- Know the location of the following things and know how to use them:
- Fire extinguishers
- Alarm systems with pull stations
- Fire blankets
- Eye washes
- First-aid kits
- Deluge safety showers

In case of an emergency or accident, follow the established emergency plan as explained by the teacher and evacuate the building via the nearest exit.

Chapter 6 Maintenance

6.1 Safety measures and maintenance

- Before using the machine, read the instructions carefully.
- Do not open the machine without coordination with Fnm Co.
- Use a proper input power cord with the earth for the machine.
- Before using the machine, make sure the proper earth connection.
- Put the machine in a suitable place and climatic conditions (dry, clean, and flat).
- For proper ventilation, avoid putting the fan attached to the wall or other objects.
- To clean the machine, do not use solvents that cause damage to the framework and keyboard of the machine. It is recommended to use a mild detergent for cleaning the machine.

6.2 Necessary studies before turning on the machine

6.2.1 Earth Connection System

Due to high voltages required to produce polymer nanofibers, it is necessary to connect the machine to the earth. Lack of a proper earth connection can cause damage to the electronic systems of the machine in a few seconds, and also can carry electrical shock risks to the operator.

Given the importance of a proper earth connection, the laboratory wiring system should be equipped with an earth wire.

6.2.2 Investigating connection to the HVPS cable

Before turning on the machine, make sure that the HV cables are connected properly to the desired places. Connecting the cable to anywhere of the machine, except the needle, causes transmission high voltage to the electronic systems and results in failure. It can also cause damage to the HVPS.

6.3 Checking Parts

No.	Part Name
1	Checking systems calibrations
2	Checking the switches for all doors
3	Checking the ventilation fan
4	Checking heating system

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- If the HMI panel does not command, you should check that the emergency switches are not active. 298 299
- If electrospinning process is not done despite applying a voltage, you should: 300
  - Check the connection of HV cable to the tip of nozzle(s). 301
  - Check that the viscosity of the solution is not very low or high. 302
  - Check the amount of temperature and humidity of the chamber. 303
- If the high voltage power supply do not activate, make sure the green LED (Doors) on the panel is off. On the contrary, if this LED is on, you should check the doors and its switches. If "Doors" LED is off and the doors are closed, the high voltage power supply should be checked by FNM experts. 304 305 306 307

In order to fix potential problems, before contacting the company, use the guide below: 308

Problem	Reason	Solution/suggestion
The machine does not have electricity.	Power cord is not plugged in.	Plug in the power cord with caution.
The machine power cord is plugged in but it is not "on".	The machine is "off".	Check the miniature switch at the rear of machine. It should be on "ON" mode. Then the HMI screen should be turned on by "ON/OFF" key next to the HMI screen.
The machine does not located at "Set Zero" state by pressing "Run" button on HMI home page before the electrospinning process starts.	• The first reason: lack of moving of the scanning or distance system • The tray sticks to the lower part of machine or any other external device prevents moving of scan / distance system. • Failure of distance / scan motors. • failure or withdrawal of belt connected to the motor • The second reason: software problem in sending or receiving commands.	The first solution: • The external device should be out or the tray should be moved. • In case of failure of the scan / distance motor, you should contact the company. • In case of disconnecting or withdrawing of the belt, you should contact the company. • The second solution: Contact the company.
The pusher block of syringe pump goes forward, but the solution does not go out from the nozzle.	Clogging of the nozzle by the dried polymer solution.	By a piece of thin wire, open the clogging nozzle(s) or replace it.
The amount of injected polymer solution is wrong.	Value of the syringe diameter is not correct.	Measure the syringe diameter with a caliper accurately and then enter it. (All calculations related to the injection rate are based on the

		diameter.) (See page 1, section "1.1.2 Calibration")
The pusher block of syringe pump does not go backward.	The pusher block reaches to the end and stucked.	Using hands, press back the pusher block and simultaneously press  in "Injection" menu until the key is released into the syringe pump.
The drum does not rotate.	• The drum is off. • The drum rotation speed is low (less than 350 rpm). • The socket of drum is not connected. • The drum is stucked.	• Turn on the drum collector from  menu and then turn the potentiometer volume on the panel. • Connect the socket and tighten its screws. • Rotate the drum by hand to make sure it is not stucked. **Note:** According to the above solutions, in the absence of rotation, to prevent damage to the motor, turn the machine off and contact us.
Lack of solution injection and the following message: "Injected volume reaches to max limit"	The injection of solution has reached the target volume which is specified in "Injection" menu.	Press the "Stop" button on HMI home page to reset the injected value to zero.
The HV is on, but by turning the volume, the voltage is still zero.	The door of machine is open. **Note:** At the beginning, by pressing "Run" button on HMI home page the machine will be in "Set Zero" mode and then the syringe pump is located in adjusted distance from the collector, at this time the HVPS will be turned on and the electrospinning will be started.	Check all the doors. **Note:** Be careful that by closing all doors, the electrical field will be established between the nozzle(s) and the collector; so before closing the doors, make sure the high voltage volume is low and high voltage (e.g. 35 KV) is not applied to the system suddenly.
By opening the doors, the HV will not be "off".	The door switches maybe stuck or corrupted. The jack behind the HV is out.	Check all the door switches. Connect the jack (To do this, screws behind the HVPS in the should be opened).
The heater does not reach high temperature.	• Very high temperature has been selected. • To prevent damage to the heater, the machine has been turned off.	• Select a low temperature. Extreme temperatures (above 45 °C) are not recommended for the machine. • Wait until the heater thermostat re-connects.

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Appendix A: Syringe inside Diameter

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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

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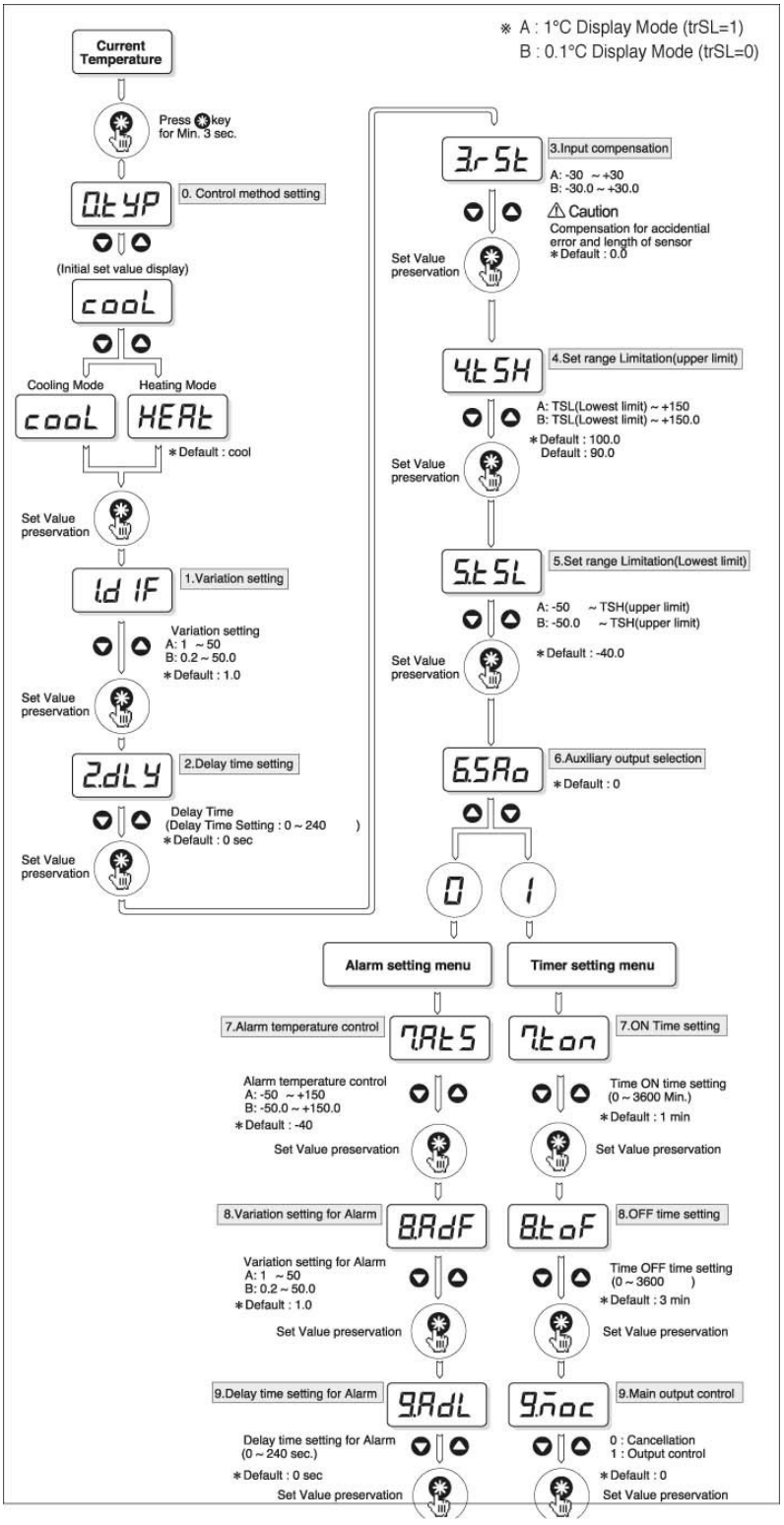
Appendix B: Set mode of Digital Temperature Controller



Appendix C: Syringe Needle Conversion Chart

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Needle	Nominal Outer Diameter			Nominal Inner Diameter			Nominal Wall Thickness		
Gauge	inches	mm	*tol. inches (mm)*	*inches*	*mm*	*tol. inches*	*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	"	"	"	"

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