KANOMAX FMT
A Kanomax Company

NanoParticle Nebulizer
Model 9110: User Manual

Part Number: 2679001 Version 1.3

NanoParticle Nebulizer Model 9110: User Manual

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The following is a history of the NanoParticle Nebulizer Model 9110 User Manual (part number 2679001):

Version	**Date**	**Change**
Version 1.0	December 2014	
Version 1.1	June 2016	Updated photographs, installation and operation instructions and company name. Added troubleshooting instructions.
Version 1.2	September 2017	Updated figures and screenshots. Added information describing how to set UPW pressure and flow rate from the touch-screen display.
Version 1.3	September 2020	Updated figures and screenshots. Added information describing how to configure the peristaltic pump model from the touch-screen display.

Limitation of Warranty and Liability

Kanomax FMT, Inc. offers a full 12-month repair or replacement warranty on all products sold. Warranty covers defects resulting from design or manufacturing. If any such product proves defective during this warranty period, Kanomax FMT, Inc., at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product. This warranty is offered on a return to factory basis, with return shipping expense expressly at the cost of the customer. Kanomax FMT, Inc. will pay the return shipping on any materials repaired or replaced. Any repaired or replaced item assumes the remainder of the initial warranty period. Kanomax FMT, Inc. warrants only to the extent of replacement or repair of our products, and does not assume any responsibility for consequential damages. No warranty is offered on accounts with past due balances. In order to obtain service under this warranty, Customer must notify Kanomax FMT, Inc., of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. The Customer shall be responsible for packaging and shipping the defective product to the service center designated by Kanomax FMT, Inc. with shipping charges prepaid.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Kanomax FMT, Inc. shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Kanomax FMT, Inc. representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; or c) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

THIS WARRANTY IS GIVEN BY KANOMAX FMT, INC. WITH RESPECT TO THE LISTED PRODUCTS IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED. KANOMAX FMT, INC. AND ITS VENDORS DISCLAIM ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. KANOMAX FMT, INC. RESPONSIBILITY TO REPAIR OR REPLACE DEFECTIVE PRODUCTS IS THE SOLE AND EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER FOR BREACH OF THIS WARRANTY. KANOMAX FMT, INC. AND ITS VENDORS WILL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IRRESPECTIVE OF WHETHER KANOMAX FMT, INC. OR THE VENDOR HAS ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES.

Service Policy

Knowing that inoperative or defective instruments are a detriment to our customers' satisfaction, our service policy is to give prompt attention to any known problems. If you discover any malfunction of the NanoParticle Nebulizer, contact Kanomax FMT, Inc. at 651-762-7762 (USA). If you are outside of the USA, please call your authorized distributor.

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About This Manual

Intended Audience

The NanoParticle Nebulizer Model 9110 User Manual is intended to be used by qualified personnel (such as technicians and engineers) in a laboratory setting.

Scope of User Manual

This user manual contains detailed instructions for the installation and set up of the NanoParticle Nebulizer Model 9110. The manual also contains an explanation of how the nebulizer works.

Definitions

- AC: Alternating Current
- AFIMC: Annular Flow Ion Mobility Classifier
- CDA: Clean Dry Air
- CMP: Chemical Mechanical Planarization
- DNVR: Dissolved Non-volatile Residue
- EU: European Union
- FCPC: Fast Condensation Particle Counter
- IPv4: Internet Protocol Version 4
- kPa: Kilo Pascals
- LNS: Liquid NanoParticle Sizer
- mA: Milliamperes
- NPN: NanoParticle Nebulizer
- NVR: Non-volatile Residue
- PEEK: Polyether Ether Ketone (high purity, chemical resistant plastic)
- PFA: Perfluoralkoxy (high purity, chemical resistant plastic)
- PLC: Programmable Logic Controller
- PNVR: Precipitated Non-volatile Residue
- PSD: Particle Size Distributions
- psi: Pounds per Square Inch
- PTFE: Polytetrafluoroethylene (high purity, chemical resistant plastic)
- TCP: Transmission Control Protocol
- UPW: Ultrapure Water
- USB: Universal Serial Bus
- VAC/VDC: Volts Alternating Current/Volts Direct Current

Safety and Handling Procedures

Read this section to learn safe handling procedures for the NanoParticle Nebulizer.

There are limited user-serviceable parts inside the NanoParticle Nebulizer: all repair and maintenance must be performed by a qualified service technician.

When working with the NanoParticle Nebulizer:

- Do not remove any parts from the instrument unless this manual tells you to do so.
- Do not remove the instrument housing or covers while power is supplied to the instrument.

Safety Signals

The following warning symbols and labels are used in the documentation and on the NanoParticle Nebulizer. Follow the procedures described in this manual to use the instrument safely.

Warning

Warnings are used for the following purposes:

- To indicate that unsafe use of the instrument could result in serious injury to you or cause irrevocable damage to the instrument.
- To indicate that if you do not follow the procedures described in this manual, you may damage the instrument.
- To draw attention to important information about the operation and maintenance of the NanoParticle Nebulizer.

High Voltage Sticker

A High Voltage warning sticker attached to the NanoParticle Nebulizer warns you that un-insulated voltage within the instrument may be sufficient to give you an electric shock. Do not make contact with any part inside the instrument.

Grounding Connection Sticker

A Grounding Connection sticker attached to the NanoParticle Nebulizer indicates that the nebulizer is connected to earth ground and cabinet ground.

Warnings

Please familiarize yourself with the following warnings before operating the NanoParticle Nebulizer:

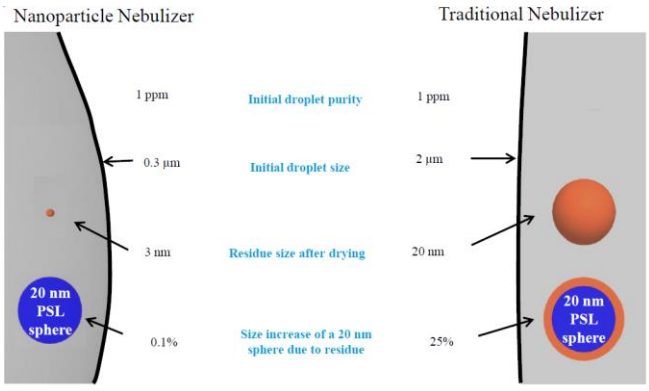
- The NanoParticle Nebulizer must be used following manufacturer's specifications otherwise safety cannot be guaranteed.
- All service work must be performed by qualified service technicians - only qualified service technicians should remove the cover.
- When the nebulizer is running, there are hot surfaces inside the device. Do not remove the cover at any time unless you are a qualified service technician.
- To prevent electric shocks, ensure that all electrical outlets are grounded.
- The aerosol particles created by the Model 9110 NanoParticle Nebulizer may pose a health risk if inhaled. If not connected to other instrumentation, vent the aerosol output to a fume hood.
- Follow the instructions for all inlet and outlet connections. Incorrect connections will cause the nebulizer to malfunction.
- The air or nitrogen supplied to the nebulizer must be clean, dried, oil-free and regulated at 50-60 psi.
- During normal operation, do not tilt the nebulizer at angles >10°.
- You must drain the nebulizer before you move or ship it. Do not ship an undried/undrained nebulizer back to Kanomax FMT, Inc.: doing so might damage the device and invalidate the warranty.
- Do not subject an undrained nebulizer to freezing temperatures: doing so might damage the device and invalidate the warranty.

How the NanoParticle Nebulizer Works

The NanoParticle Nebulizer aerosolizes aqueous suspensions of particles with reduced interference from non-volatile residue (DNVR) present in the sample. The liquid sample is metered into the instrument via a peristaltic pump, combined with a known volumetric flow rate of ultrapure water, and nebulized into fine droplets. An impaction pin positioned within 1.0 mm of the nebulizer nozzle removes the largest liquid droplets. The remaining wet aerosol has a nominal average droplet size of ~ 300 nm. The aerosol is conditioned at an elevated temperature to evaporate liquid, leaving only the particles and precipitated non-volatile residue from the sample. The aerosol is then combined with clean, dry air. Up to 1.5 L/min of dry aerosol flow can be drawn from the aerosol outlet.

Using a traditional nebulizer to create an aerosol of colloidal particles often results in interference from any dissolved non-volatile residue present in the sample. After droplet evaporation, non-volatile residue creates particles of precipitated residue regardless of whether the droplets contain colloidal particles or not. When there is a particle in a droplet, precipitated non-volatile residue forms a coating on the particle. This coating is problematic when you aerosolize small particles (< 30 nm) or particles where the surface properties are of concern (such as toxicology studies). The NanoParticle Nebulizer mitigates precipitated non-volatile coating by minimizing the size of the nebulized droplet, thereby reducing the influence of precipitated non-volatile residue on the final aerosol properties (shown in Figure 1). Figures 2&3 are schematic diagrams illustrating the main components of the NanoParticle Nebulizer.

Figure 1: NanoParticle Nebulizer minimizing non-volatile residue particle coating



(Illustration taken from presentation given by TSI Inc. at Pittcon 2012,)

Figure 2: Schematic Diagram of the NanoParticle Nebulizer Model 9110, Diluted Flow.

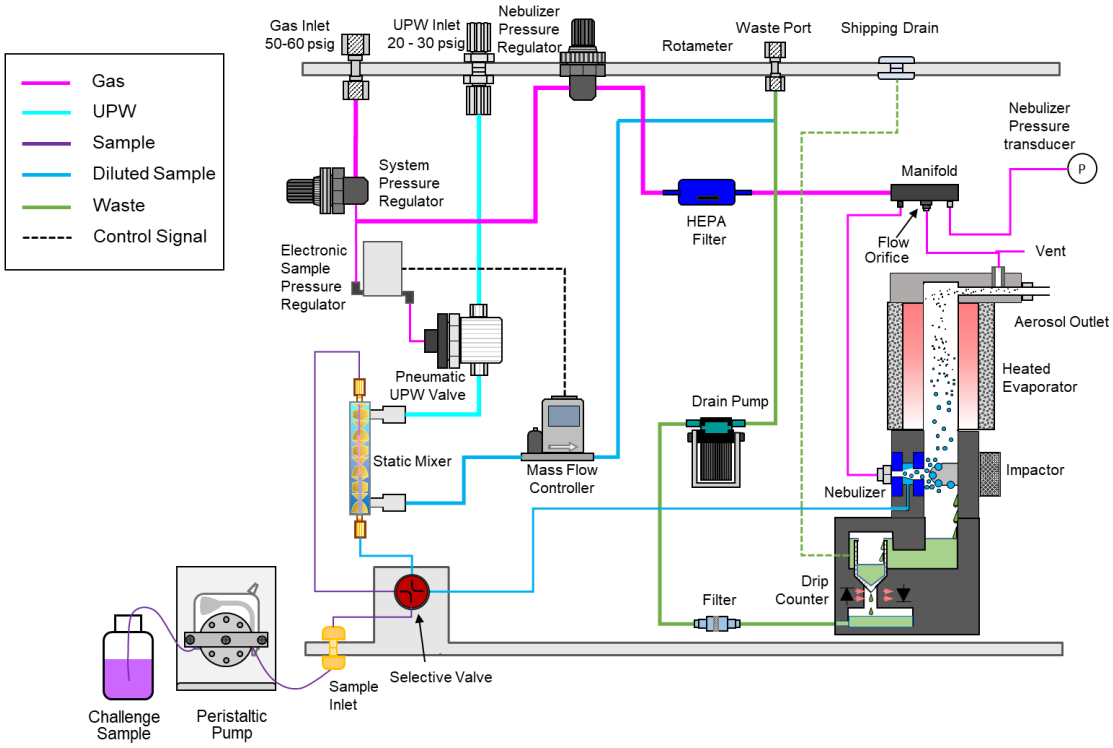
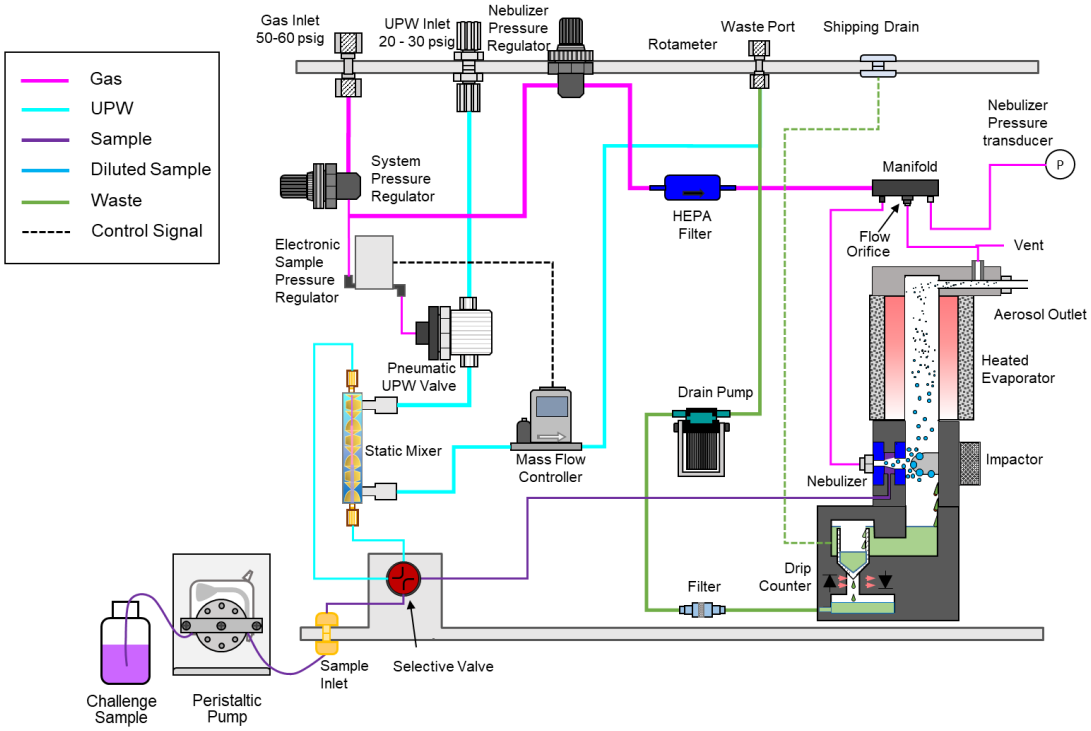


Figure 3: Schematic Diagram of the NanoParticle Nebulizer Model 9110, Direct Flow.



The NanoParticle Nebulizer offers the following advantages over existing nebulizer technology:

- Produces droplets less than 1µm in diameter.
- Limits the influence of precipitated non-volatile residue on nebulized particles.
- High sample flow rate.
- Continuous on-line flow rate to the nebulizer.
- Ability to inject a small sample directly into the nebulizer.
- Does not require a conductive solution (unlike electrospray aerosolization).
- Integrated heated evaporator.
- Drip counter to monitor nebulizer sample flow rate.
- Temperature and pressure logging of on-line sample flow.
- Feedback control of evaporator and nebulizer housing temperatures to aid in stability.
- Online sample dilution with UPW minimizes contamination by non-volatile residue.

Applications

- Analyzing Chemical-Mechanical Polishing (CMP) slurries.
- Characterizing the filtration performance of liquid filter media.
- Analyzing drugs and other medical nanoparticles in water.
- Analyzing environmental water samples.

The NanoParticle Nebulizer is intended to be used as part of a Liquid NanoParticle Sizer (LNS) system. The principle application of the NanoParticle Nebulizer is to characterize the size-distribution of particles within a colloid. This is most commonly accomplished using a particle size spectrometer. The configuration of a particle size spectrometer and NanoParticle Nebulizer is defined as a Liquid NanoParticle Sizer (LNS) and is protected by patents US 8,272,253 and US 8,573,034, The LNS system is available from Kanomax FMT, Inc. Licensing is available for customers who already own aerosol spectrometer instrumentation.

Acknowledgement

The ultrafine nebulization method used in this device is based on technology licensed from CT Associates, Inc. (CTA). We offer our sincere thanks to Don Grant, Gary Van Schooneveld, and Mark Litchy for their invention, their clever insights to this unique technology, and the gracious feedback they have provided during the development of this product. Patent numbers 8,272,253 and 8,573,034 have been issued to CTA and licensed by Kanomax FMT, Inc. Patent number 7,852,465 has been issued to Kanomax FMT, Inc.

How to Install the NanoParticle Nebulizer Model 9110

The NanoParticle Nebulizer can be operated using online sample dilution or direct sample injection.

Installation Overview

Following is an overview of the steps required to get your NanoParticle Nebulizer up and running. Please read the detailed instructions (beginning below) for each step before you set up the instrument.

- Unpacking the NanoParticle Nebulizer.
- Connecting the waste outlet.
- Connecting the air supply.
- Connecting the power.
- Connecting the water supply.
- Connecting the sample inlet.
- Connecting the aerosol outlet.

Unpacking the NanoParticle Nebulizer

To unpack the NanoParticle Nebulizer, follow these instructions:

1. Carefully remove the nebulizer from its shipping container. Save the original packing materials for use when shipping the nebulizer back to Kanomax FMT, Inc. for service, or for moving the nebulizer to a different location.

Warning. If the NanoParticle Nebulizer is returned to Kanomax FMT, Inc. in anything other than the original shipping container, you will be charged for any damage that occurs during shipping. If you do not have the original shipping container, contact Kanomax FMT Inc. at 651-762-7762. (Customers in Asia please call +81 6-6877-0183.)

2. Place the nebulizer on a level surface.
3. Make sure there is an unrestricted air flow around the device. Kanomax FMT, Inc. recommends at least a 2-inch air gap on both sides and the top of the instrument.
4. Allow the nebulizer to reach ambient temperature, if necessary.
5. Make sure all the items listed in the packing list were included in the NanoParticle Nebulizer shipment. If any of the items are missing, or damaged, please call Kanomax FMT, Inc. at 651-762-7762. (Customers in Asia please call +81 6-6877-0183.) Or, submit a help ticket to Support@KanomaxFMT.com.

Equipment You Need

To install the NanoParticle Nebulizer, you will require the following items:

- 9/16 wrench.
- A length of ¼ inch OD tubing sufficient to reach from the instrument to your waste drain (12 ft maximum length).
- A length of ¼ inch OD polyethylene tubing sufficient to reach from the instrument to your air supply.
- For online sample introduction:
    - A length of ¼ inch OD x 0.156" ID High Purity PFA tubing sufficient to reach from the instrument to your water supply.
    - PFA tubing flaring tool, tube gripper, and heat gun.
    - Ultrapure Water supply. Note: Water pressure should be 20-70 psi at 100 ml/min.
- Conductive tubing for transporting the generated aerosol (shipped with the LNS aerosol size spectrometer).
- A supply of clean, dry, compressed air at 2 slpm. Note: The air pressure should be 50-60 psi.
- Access to a suitable liquid waste outlet.
- 120-240 VAC power at 50/60 Hz.

Note: No PFA tubing is supplied with the NanoParticle Nebulizer.

Flaring a Tube

The installation procedure for online analysis requires you to flare a PFA tube. You can either use a heat flaring tool provided by Entegris (customer service numbers: 952-556-4196 or 800-394-4083) or a cold flaring tool provided by Saint Gobain Performance Plastics (customer service numbers: 714-630-5818 or 800-833-5661). The following instructions describe the hot-flare method:

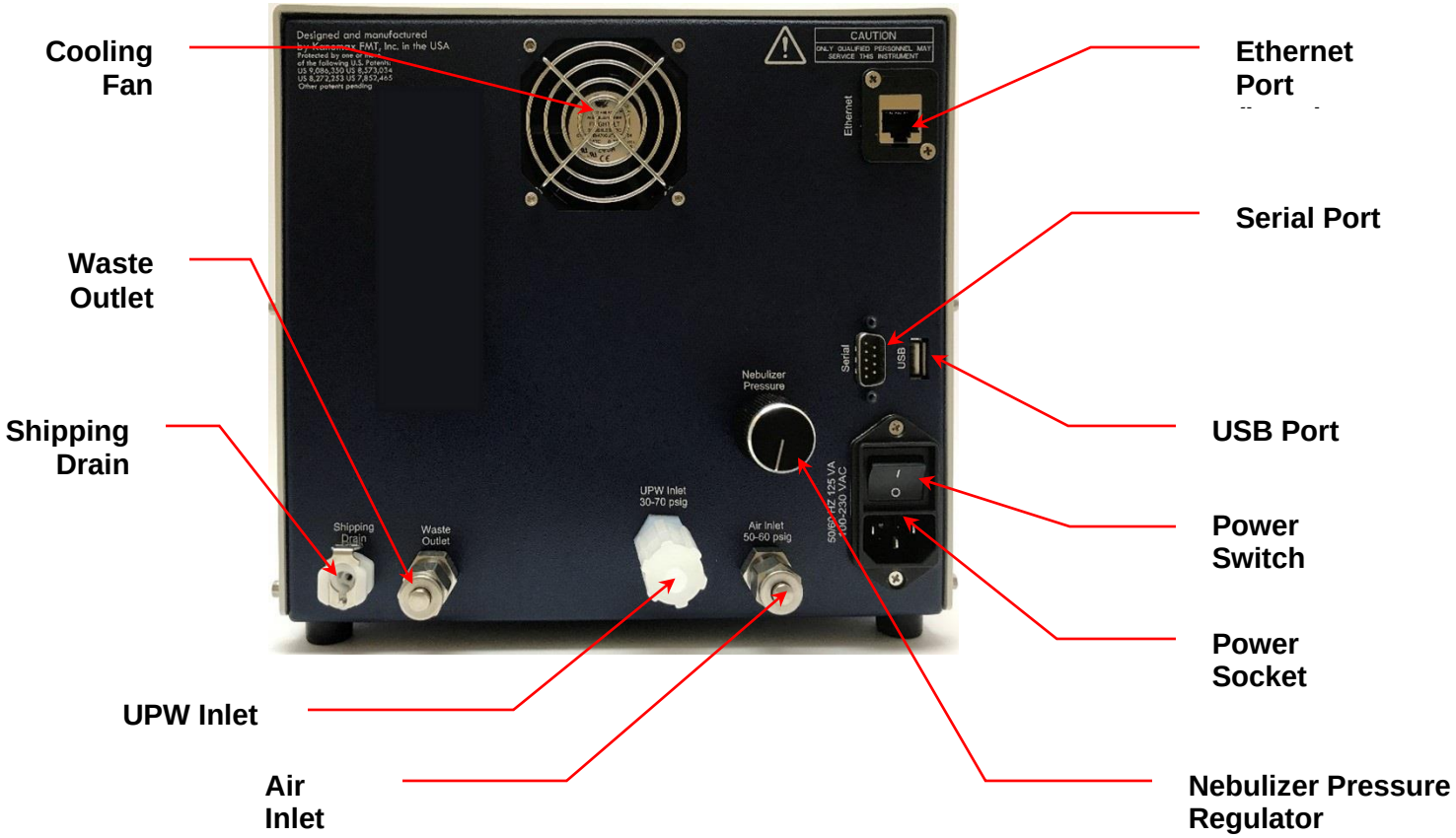
1. Place a flare nut onto the end of a length of PFA tubing.
2. Hold the tubing with a tube gripper.
3. Rotate one end of the tubing evenly over the heat gun.
4. As soon as the end of the tubing becomes clear, push it onto a flaring tool in your required size. Note: If you remove the tubing from the flaring tool too soon, the end shrinks. If you overheat the tube, the tubing will buckle.
5. Hold in place until the tubing is cool (at least two minutes).
6. Pull the tubing from the flare. It is now ready to attach to a fitting.

Installing the NanoParticle Nebulizer

Figures 4 and 5 show the front and back panels of the NanoParticle Nebulizer.

Figure 4: Front Panel of the NanoParticle Nebulizer.

Figure 5: Back Panel of the NanoParticle Nebulizer.

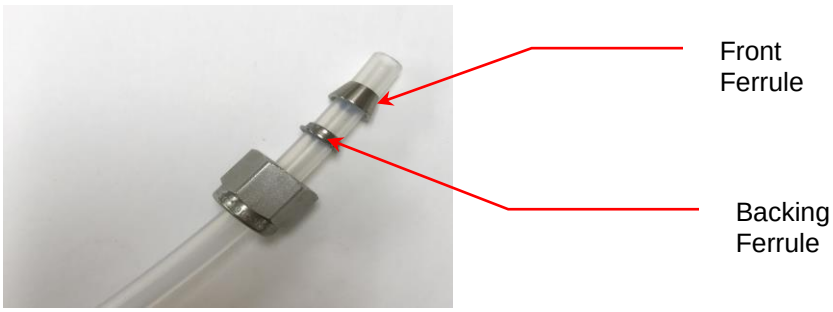


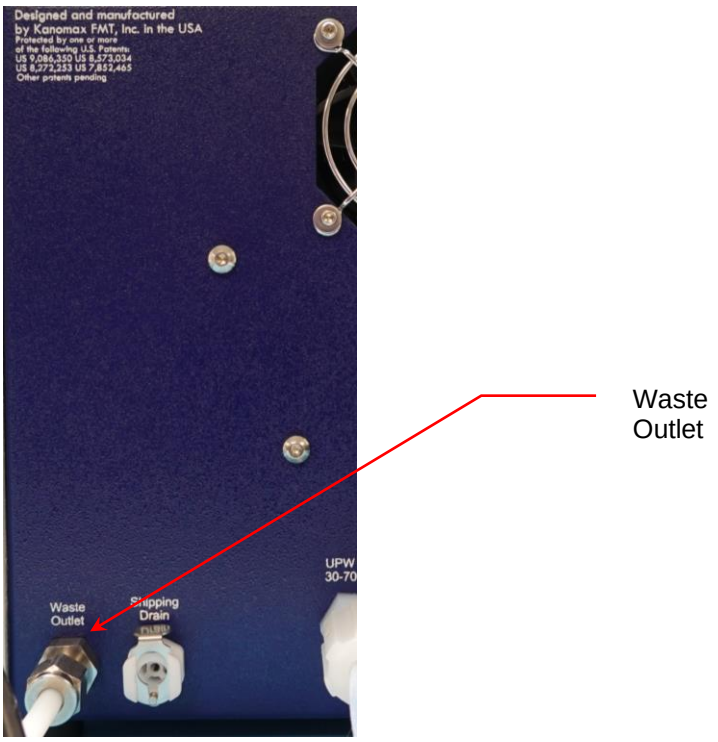
Connecting the Water Drain

Excess sample from the nebulization module is removed from the instrument using a solenoid pump. For online sampling, the excess total flow that is not delivered to the nebulization module is combined inside the device downstream of the pump.

Follow these instructions to connect the water drain:

1. Remove the protective cap from the **Waste Outlet** on the back panel.
2. Using a 6 ft length of ¼ inch OD polyethylene tubing with a Swagelok fitting on one end, insert the tubing into the **Waste Outlet** fitting on the back panel.





3. Using an adjustable wrench, tighten the Swagelok nut one turn past hand-tight to swage the ferrules onto the tubing. Once the ferrules have been swaged the fitting only requires slight tightening upon reassembly. **Warning**: Do not over-tighten the fitting or you will damage the tube and/or fitting.
4. Place the other end of the tube over your drain. Do not connect the waste line to a container where the pressure will fluctuate beyond ambient conditions.

Connecting the Compressed Air or Nitrogen Supply

The air or nitrogen supplied to the NanoParticle Nebulizer must be clean, dried, oil-free and regulated at 345-414 kPa (50-60 psi) at 2 slpm. Follow these instructions to connect the compressed air supply:

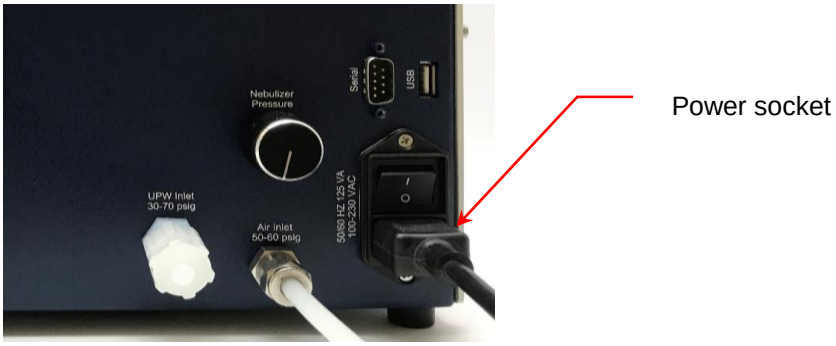
1. Remove the protective cap from the **Air Inlet** on the back panel.
2. Using a length of ¼ inch OD polyethylene tubing with a Swagelok fitting on one end, insert the tubing into the **Air Inlet** fitting on the back panel.

3. Using an adjustable wrench, tighten the Swagelok nut one turn past hand tight to swage the ferrules onto the tubing. Once the ferrules have been swaged, the fitting only requires slight tightening upon reassembly.
4. Connect the other end of the tube to your air supply.
5. Turn on the air at the source. The incoming pressure must be regulated at 345-414 kPa (50-60 psi).

Connecting the Power

To connect the power supply, follow these instructions:

1. Plug the supplied power cable into the AC power socket on the back panel of the nebulizer.



2. Plug the cord into an earth-grounded AC power source (100 to 240 VAC, 50 to 60 Hz, 0.6 A).
   Warning: Ensure that the ground is secure. Connection to an improperly grounded electrical source is a severe shock hazard.

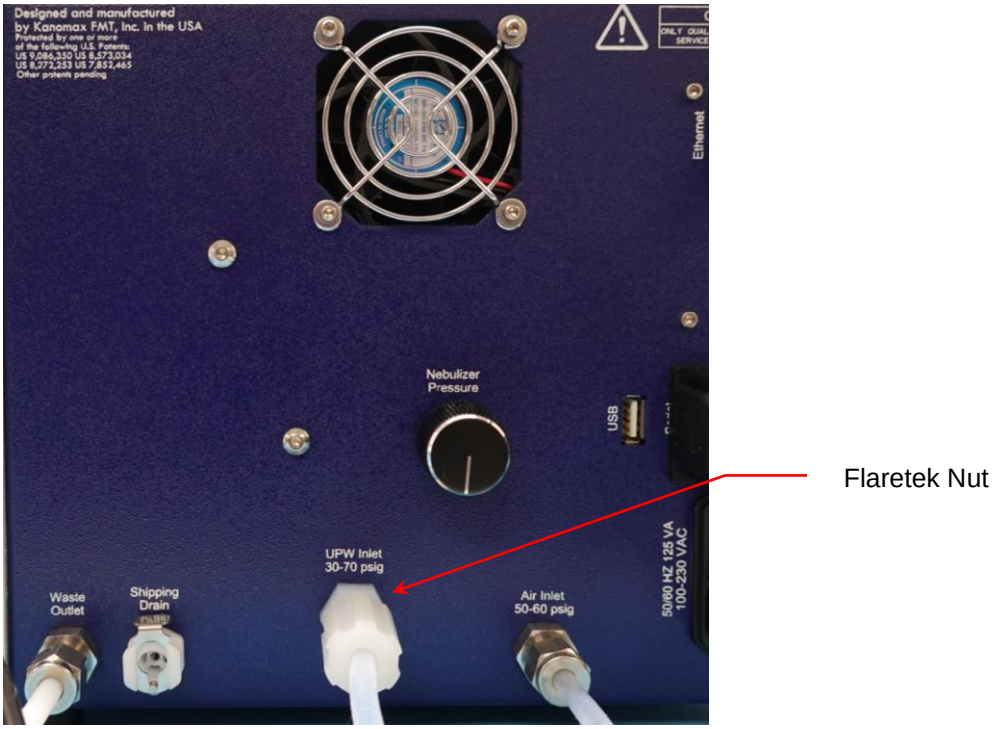
Connecting the Ultrapure Water Supply

Ultrapure water must be supplied to the nebulizer through a ¼-inch diameter Teflon PFA tube specially adapted to fit the **UPW Inlet** fitting on the front panel of the nebulizer. To prepare the PFA tube for attachment to the **UPW Inlet** fitting, take the following precautions:

- Make sure your hands are clean.
- Do not touch the end of the water supply tube - you may contaminate it.

To connect the ultrapure water supply, follow these instructions:

1. Cut the end of the PFA tubing evenly with a clean tube cutter.
2. Place a Flaretek nut over the end of the PFA tube before attempting to flare the end.
3. Flare the tube (see instructions on page 10).
4. Flush ultrapure water through the tube for several minutes to remove any debris created by the flaring process.
5. Remove the protective nut and plug from the **UPW Inlet** fitting. Keep this Flaretek nut and plug for use when moving or shipping the nebulizer. (See shutdown instructions on page 49).
6. Push the flared end of the tube onto the **UPW Inlet**.
7. Slide the Flaretek nut into place and hand-tighten.



8. Turn on the ultrapure water supply. Water then flows through the instrument and out through the waste line. Ensure that the **UPW Inlet** has no leaks. If you see any leaks, tighten the fitting.

Connecting the Aerosol Output

Raw online sample introduction is useful for monitoring particle concentrations in high purity water streams. If you are using the Kanomax Liquid NanoParticle Sizer system, follow the instructions below. For all other systems refer to the manufacturer supplied user manual.

To connect the aerosol line, follow these instructions:

1. Remove the protective cap from the **Aerosol Output** fitting on the front panel.
2. Using the provided conductive tubing, connect the aerosol output from the NanoParticle Nebulizer to the inlet of a particle size spectrometer or other analytical instrumentation with an inlet flow rate of 1.0 – 1.5 l/min. Use the shortest practical length of tubing to minimize particle losses through diffusion.

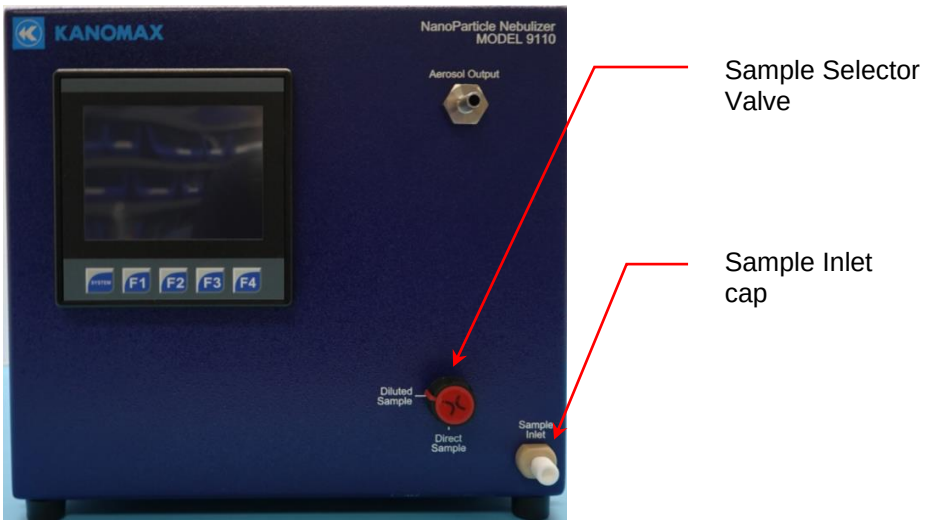
Note: The Aerosol Output outlet is at near-atmospheric pressure with an internal vent. If the measurement device draws more than 1.5 L/min, ambient aerosol will be drawn into the sample stream. The device must draw more than 1 L/min to prevent condensation from forming in the aerosol lines.

Warning: The aerosol particles created by the Model 9110 NanoParticle Nebulizer may pose a health risk if inhaled. If not connected to other instrumentation, vent the aerosol output to a fume hood.

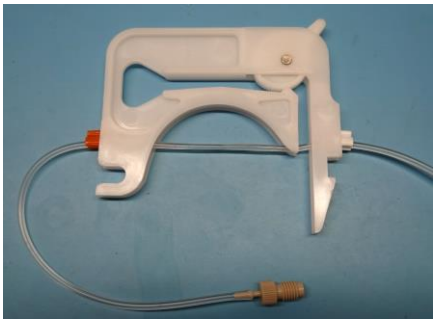
Connecting the Sample Inlet

To connect the Sample Inlet, follow these instructions:

1. On the front panel, turn the Sample Selector Valve to DIRECT.

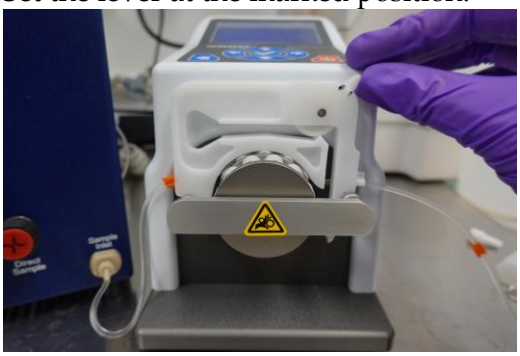


2. Remove the 1/4-28 plug protective cap from the **Sample Inlet** fitting.
3. Install the supplied 1/4-28 tube adapter to the **Sample Inlet** and hand tighten.
4. Connect the supplied peristaltic pump Tygon tubing to the adapter and verify that the adapter is fully inserted into the pump tubing.
5. Slot the tubing into the tube holder (with adjustable pressure lever) shipped with the supplied peristaltic pump. Place the white tube positioner on the far right of the tubing against the tube holder. Stretch the tubing and put the orange positioner into the far-left slot.



6. Hook the tube holder onto the pump and snap down into place.

7. Set the lever at the marked position.



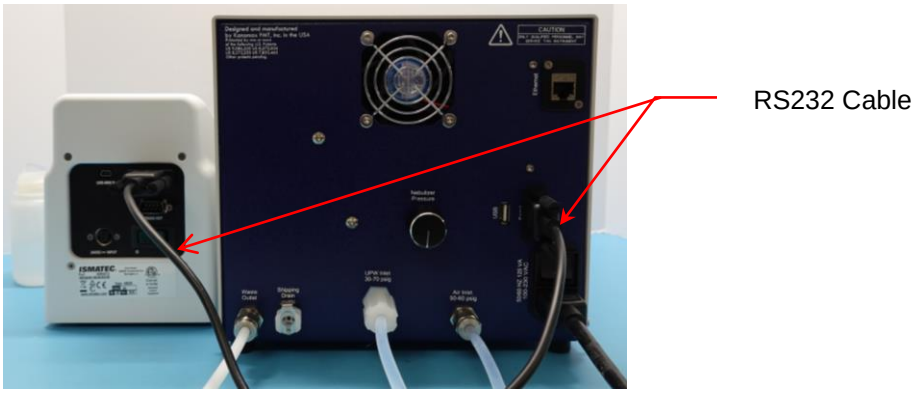
8. Place the end of the tubing in a suitable drain container.

Controlling the External Injection Pump with the NanoParticle Nebulizer

The external injection (peristaltic) pump can be controlled by the NanoParticle Nebulizer. To connect the pump and the NanoParticle Nebulizer, follow these instructions:

1. Plug the provided RS 232 cable into the **Serial** port on the back panel of the NanoParticle Nebulizer.

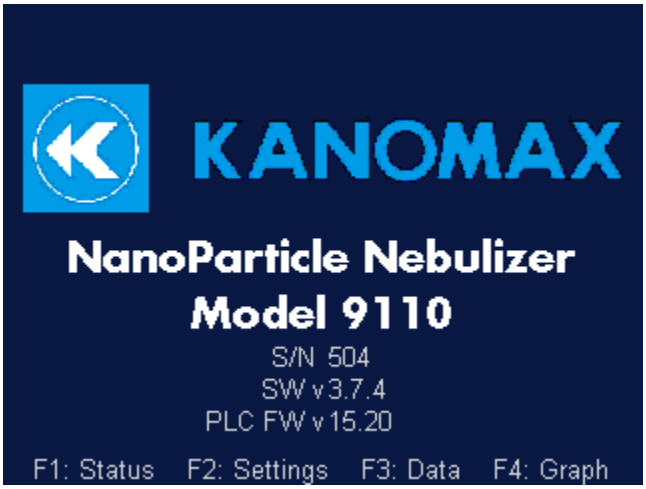
2. Plug the other end of the cable into the **RS232 IN** port on the back panel of the peristaltic pump.



Warming Up the Nebulizer

Using the rocker switch on the back panel, turn the power on. You see the instrument splash screen (shown below) and the nebulizer automatically begins its warm-up procedure. The warm-up procedure may take up to 15 minutes. Press **F1** to view the warmup status on the Device Status screen.

Figure 6: NanoParticle Nebulizer Display Screen.



If you experience any problems installing your NanoParticle Nebulizer, please contact Kanomax FMT, Inc. at 651-762-7762. (Customers in Asia please call +81 6-6877-0183.)

Operation Instructions

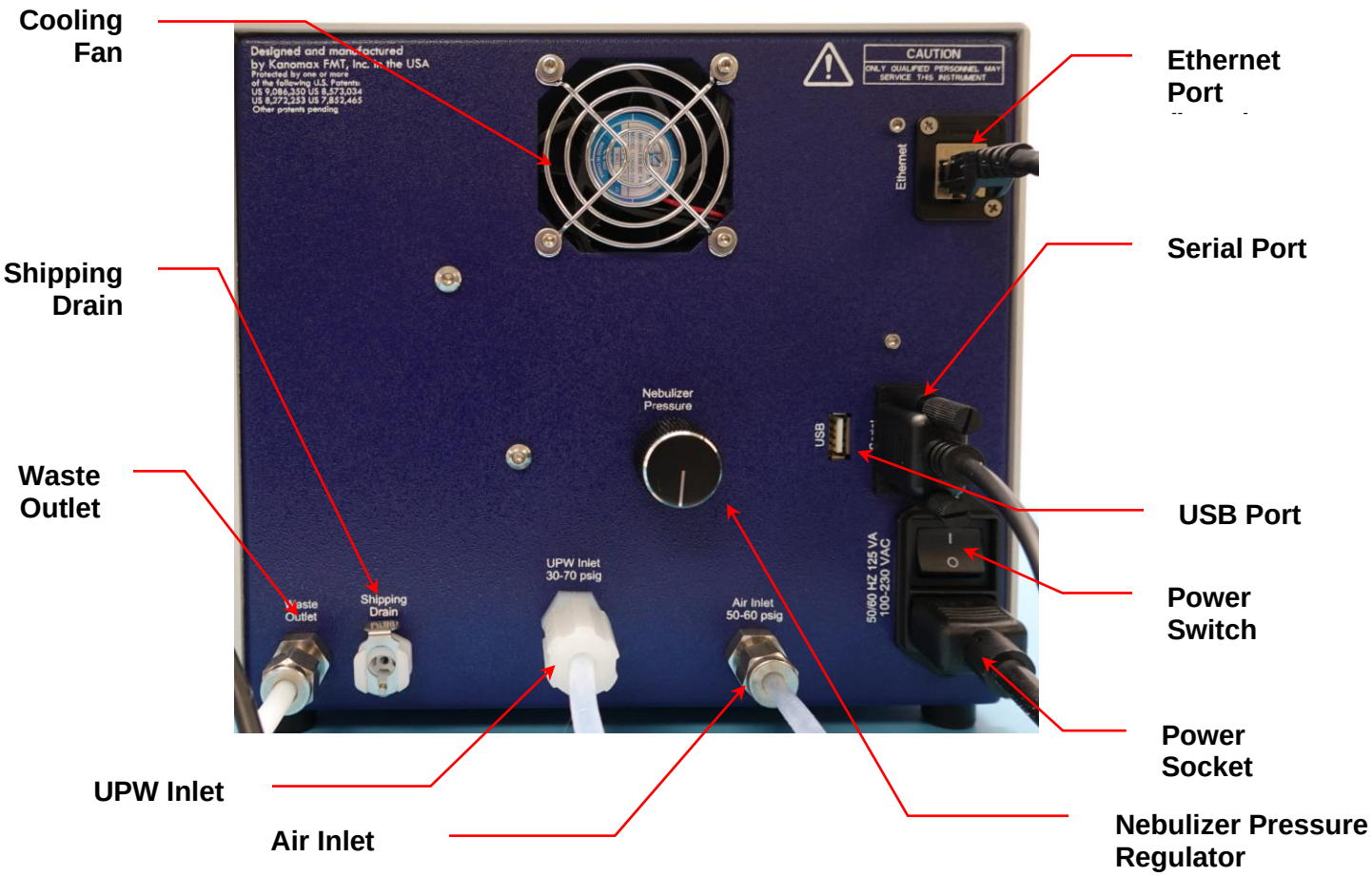
Once all installation procedures have been completed, you are ready to begin standard operation of the NanoParticle Nebulizer.

The Back Panel

Components of the NanoParticle Nebulizer back panel include the following:

- Nebulizer Pressure Regulator.
- Shipping Drain, Waste Outlet, UPW inlet, and Air Inlet.
- Data Communication ports.

Figure 7: NanoParticle Nebulizer Back Panel.

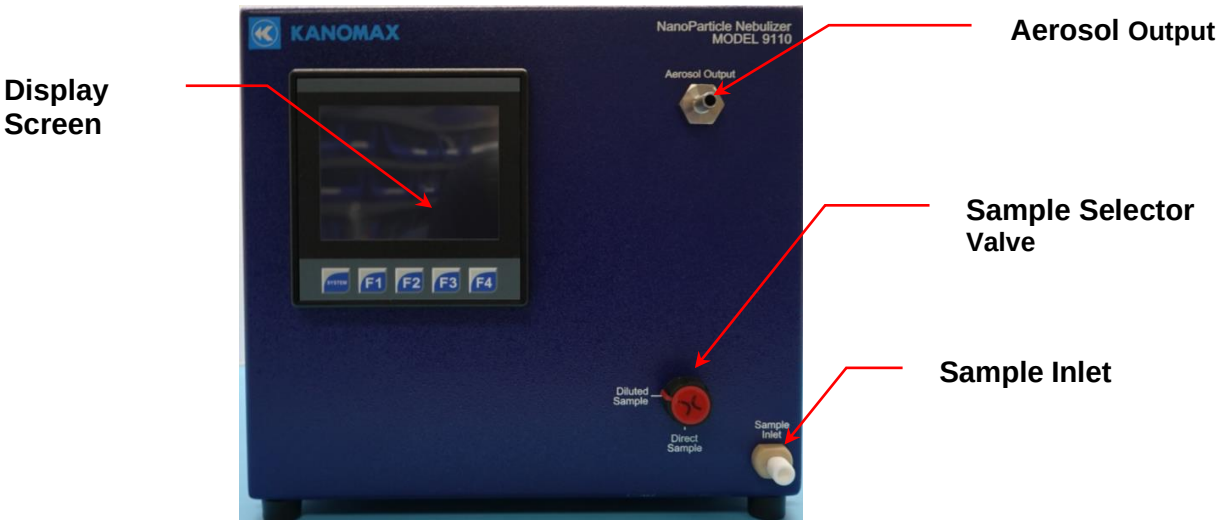


The Front Panel

Components of the NanoParticle Nebulizer front panel include the following:

- Aerosol Output, Sample Inlet, and Sample Selector Valve.
- Touch-screen Display.

Figure 8: NanoParticle Nebulizer Front Panel.



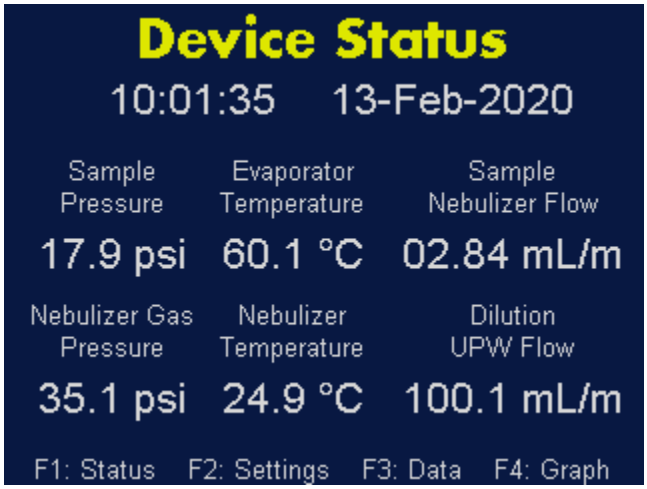
The NanoParticle Nebulizer is operated using the touch-screen display and the F1, F2, F3, and F4 buttons. The F buttons perform the following functions:

- F1: Press F1 to view instrument status.
- F2: Press F2 to view/change instrument settings.
- F3: Press F3 to view/change data collection options.
- F4: Press F4 to view onscreen graphs.
- System: the System button is for factory use only and is non-functional for the customer.

Checking the Status

Press **F1** to see the Device Status screen. The current time and date (hh:mm:ss, dd-mm-yyyy) is displayed below the screen heading. Any status readings displayed in red indicate that the status is outside the acceptable range or the set point has not been reached.

Figure 9: NanoParticle Nebulizer Device Status Screen.



The Device Status screen displays the following instrument statuses:

- Sample Pressure: Online Sample Pressure in psi. The nominal value is 18 psi. Note: This pressure is only valid during online measurements.
- Sample Temperature: Displays the sample temperature in °C. Note: This temperature is only valid during online measurements.
- Sample Nebulizer Flow: Displays the sample flow to the nebulization module in ml/min.
- Nebulizer Gas Pressure: Displays the nebulizer gas pressure in psi. The nominal value is 35 psi. Adjust the nebulizer gas pressure using the Nebulizer Pressure regulator on the back panel.
- Nebulizer Temperature: Displays the nebulizer temperature in °C. The nominal value is 19 °C, but may need adjustment based on the ambient temperature and the sample temperature. Adjust to a point where the temperature is stable. Note: The nebulizer temperature should nominally be set to 5°C lower than the UPW temperature.
- Evaporator Temperature: Displays the evaporator temperature in °C. The nominal value is 60°C

Changing the Nebulizer Pressure

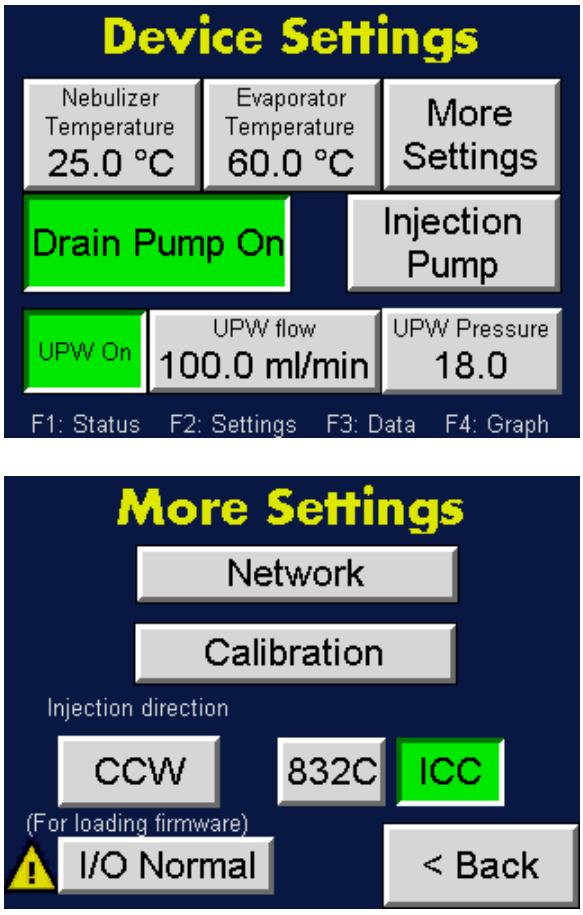
To adjust the Nebulizer pressure, follow these instructions:

1. Press **F1** to view the status screen.
2. Turn the **Nebulizer Pressure** regulator on the back panel until the **Nebulizer Gas Pressure** reads 35 psi on the Device Status screen.

Changing the Instrument Settings

Press **F2** to see the **Device Settings** screen.

Figure 10: NanoParticle Nebulizer Device Settings Screens



The Device Settings screen displays the following:

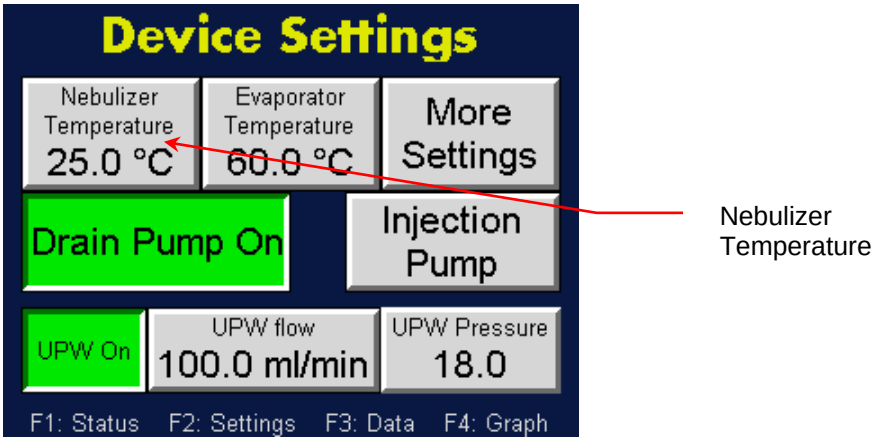
- **Nebulizer Temperature** allows you to set the nebulizer temperature.
- **Evaporator Temperature** allows you to set the evaporator temperature.
- **Drain Pump On/Off** allows you to turn the pump on and off to lengthen its life.
- **Injection Pump** allows you to access the settings for injection pump remote control.

- **More Settings** allows you to see options for Calibration, setting the injection pump direction and loading new firmware.
- **UPW On/Off** allows you to turn UPW supply on and off to avoid flooding before the instrument is warmed up.
- **UPW flow** allows you to set the online dilution flow rate.
- **Pressure Setpoint** allows you to set the sample pressure.

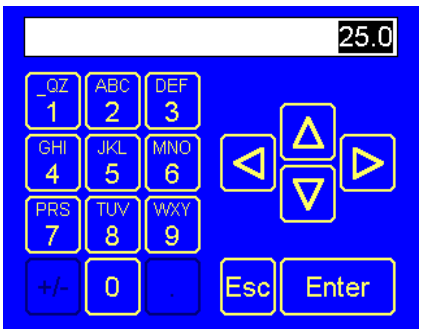
Adjusting the Nebulizer Temperature

The Nebulizer Temperature should nominally be set 5 °C lower than the UPW temperature. If the Nebulizer Temperature status indicator is red, the temperature is not within 2 °C of the temperature set point (as seen on the Status screen). To adjust the Nebulizer temperature, follow these instructions:

1. Press **F2**.
2. On the **Device Settings** screen, touch **Nebulizer Temperature**.



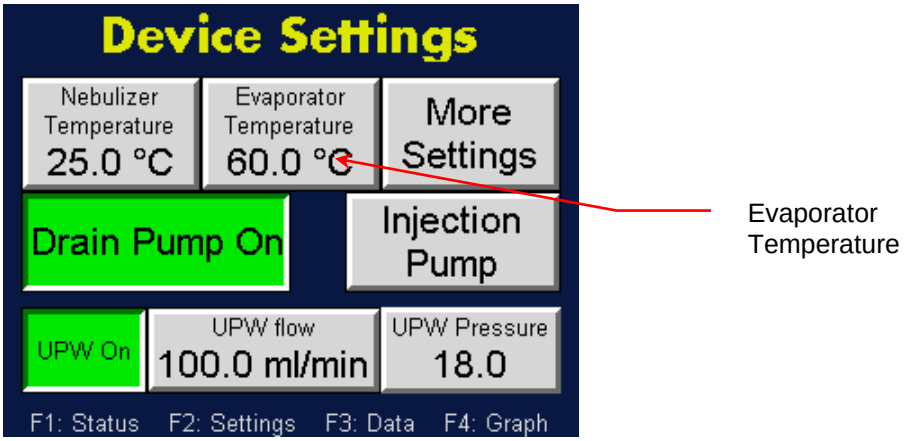
3. On the resulting on-screen keyboard, touch the numbers to enter the required temperature and then touch **Enter**. The updated set point appears on the Device Settings screen. Note: △ ▽ buttons index the temperature. ◁ ▷ buttons set the cursor. ± sets the sign on the number.



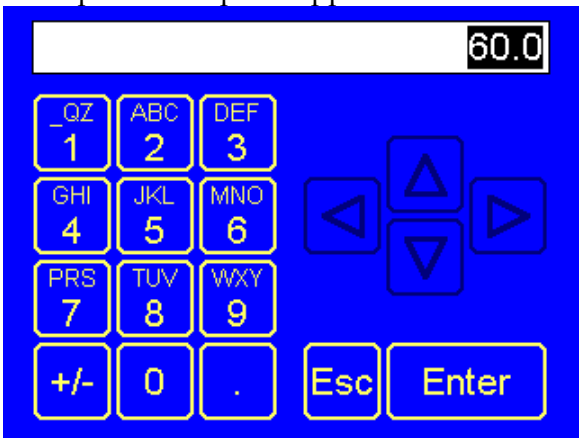
Adjusting the Evaporator Temperature

If the Evaporator Temperature status indicator is red, the temperature is not ±2 °C of the temperature set point (as seen on the Device Settings screen). To adjust the evaporator temperature, follow these instructions.

1. Press **F2**.
2. On the **Device Settings** screen, touch **Evaporator Temperature**.



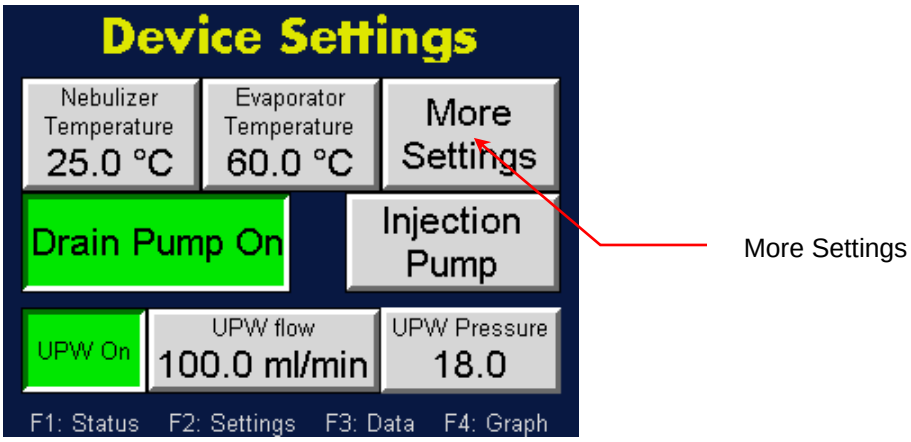
3. On the resulting on-screen keyboard, touch the numbers to enter the required temperature and then touch **Enter**. Note: △ ▽ buttons index the temperature. ◁ ▷ buttons set the cursor. ± sets the sign on the number. The updated set point appears on the Device Settings screen.



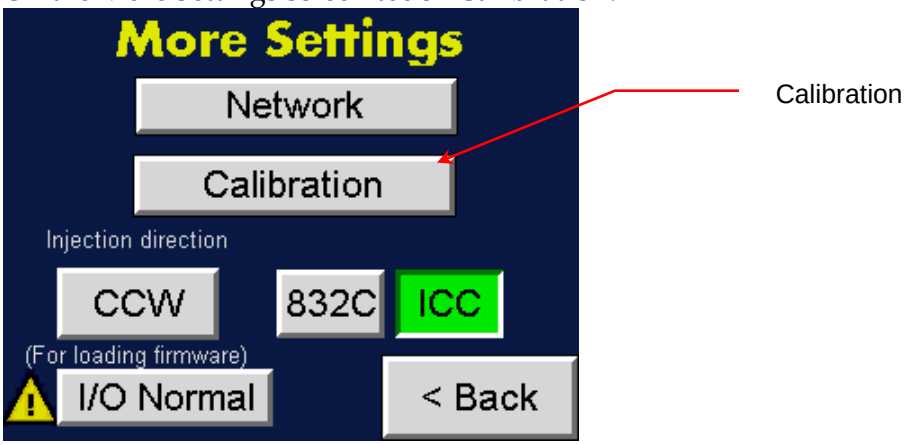
Changing the Date and/or Time

To change the date and time, follow these instructions:

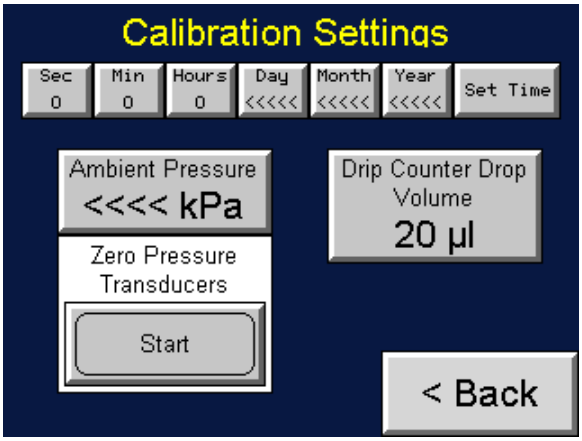
1. Press **F2**.
2. On the **Device Settings** screen touch **More Settings.**

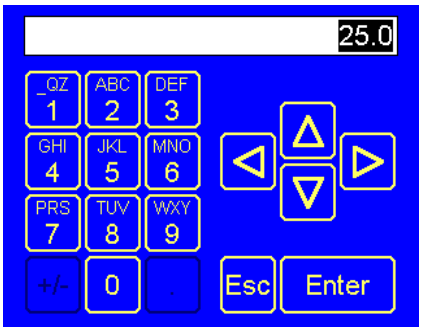


3. On the More Settings screen touch **Calibration**.



4. On the **Calibration Settings** screen touch **Sec** to change the seconds, **Min** to change the minutes, **Hours** to change the hours, **Day** to change the day, **Month** to change the month, and **Year** to change the year. Use the on-screen keypad to enter a value for any of the parameters you wish to change, then touch **Enter**.





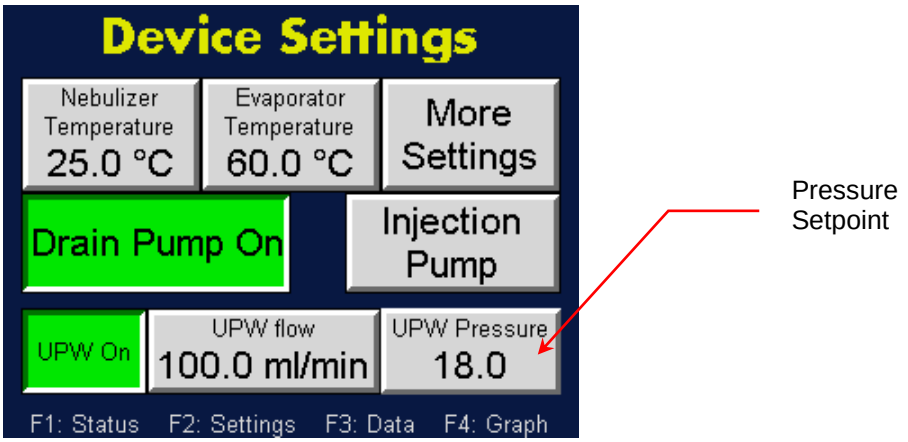
Note: △ ▽ buttons index the temperature. ◁ ▷ buttons set the cursor. ± sets the sign on the number.

5. Press **Set Time**. The date and time appear below the heading on the Device Status screen.

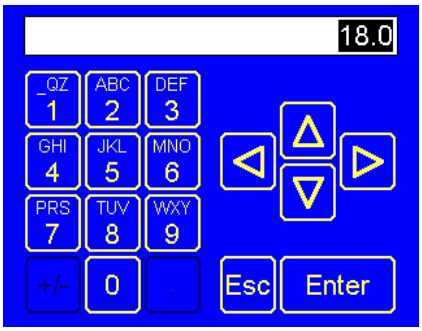
Changing the Sample Pressure/Dilution Flow

To adjust the Sample Flow pressure, follow these instructions:

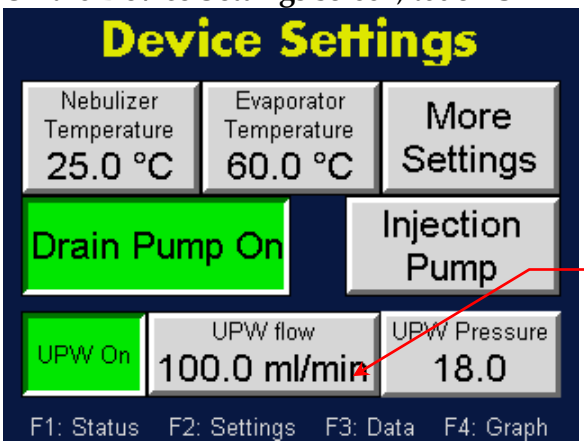
1. Press **F2.**
2. On the **Device Settings** screen, touch **Pressure Setpoint**.



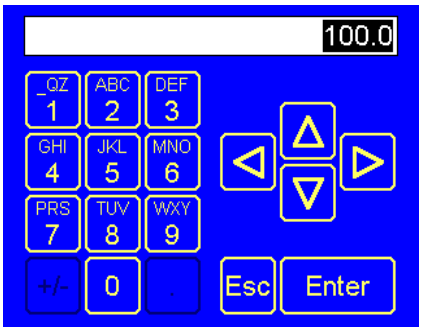
3. On the resulting on-screen keyboard, touch the numbers to enter the required temperature and then touch **Enter**. Note: △ ▽ buttons index the temperature. ◁ ▷ buttons set the cursor. ± sets the sign on the number. The updated set point appears on the Device Settings screen.



4. On the **Device Settings** screen, touch **UPW flow**.



5. On the resulting on-screen keyboard, touch the numbers to enter the required flow rate and then touch **Enter**. Note: △ ▽ buttons index the flow. ◁ ▷ buttons set the cursor. ± sets the sign on the number.

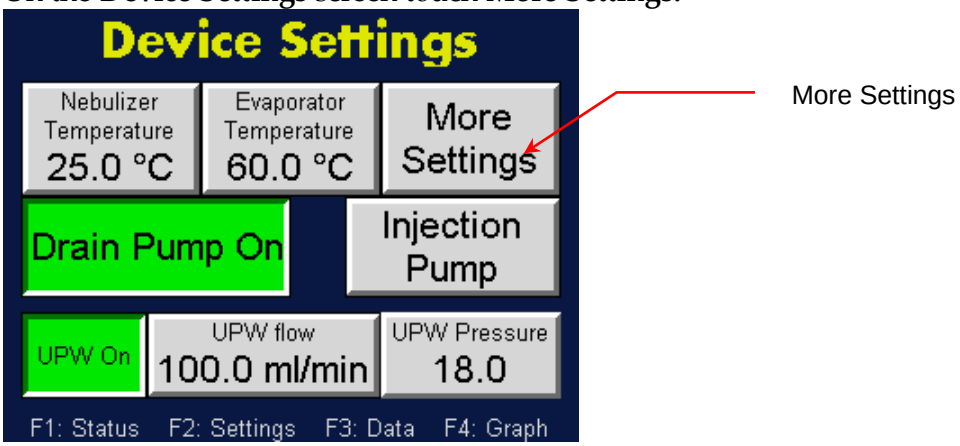


Setting the Drip Counter Drop Volume

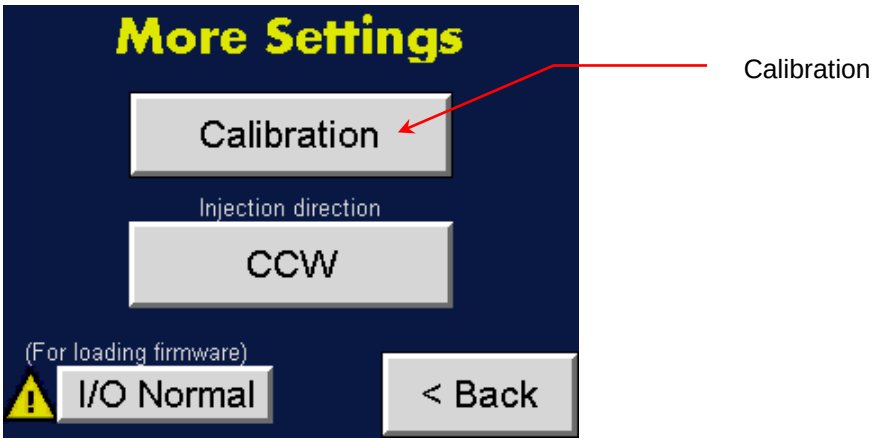
The Drip Counter Drop Volume is set at the factory and is used to calibrate the drip flow meter used to indicate the flow rate to the nebulizer module. If necessary, the Drip Counter Drop Volume can be calibrated using the direct injection method. To calibrate the drip counter drop volume, follow these instructions:

1. Turn the sample switch to **Direct**.

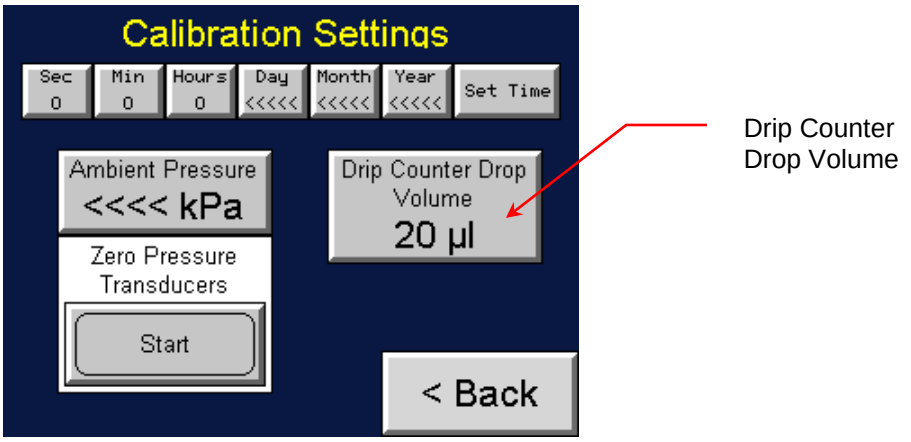
2. Inject a set volume flow rate using the peristaltic injection pump at 2 ml/min of UPW into the Direct Injection Inlet.
3. After 2 minutes, record the nebulizer flow rate displayed on the Device Status screen.
4. Press **F2.**
5. On the **Device Settings** screen touch **More Settings.**



6. On the **More Settings** screen touch **Calibration**.



7. Calculate the new Drip Counter Drop Volume using the following formula:
   Drip Counter Drop Volume (New) = Drip Counter Drop Volume (Old) x Pump flow / displayed nebulizer flow rate
8. On the **Calibration Settings** screen, touch **Drip Counter Drop Volume**.



9. Use the on-screen keyboard to change the Drip Counter Drop Volume to the Drip Counter Flow (new) value calculated in step 7 above.

Note: △ ▽ buttons index the temperature. ◁ ▷ buttons set the cursor. ± sets the sign on the number.

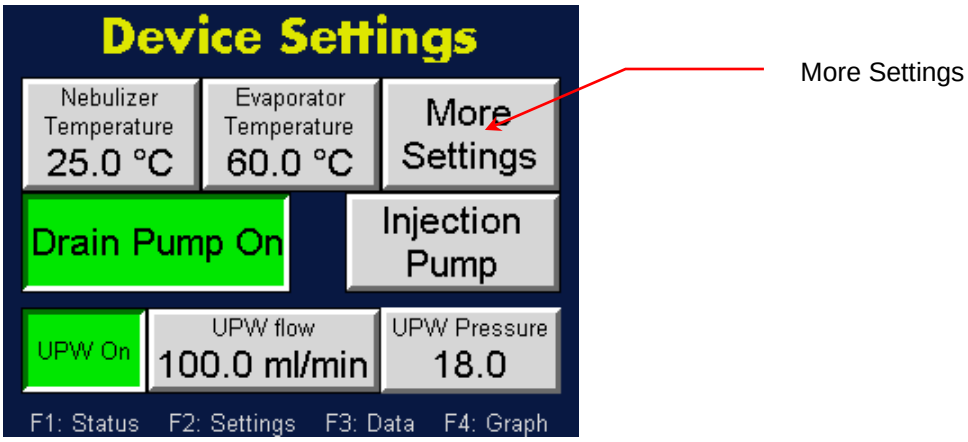
10. Wait two minutes and then check the Nebulizer Flow on the Device Status screen. It should match the peristaltic pump flow. (Note: 2 ml/min suggested in step 2 above.)

Setting the Nebulizer Pressure to Zero

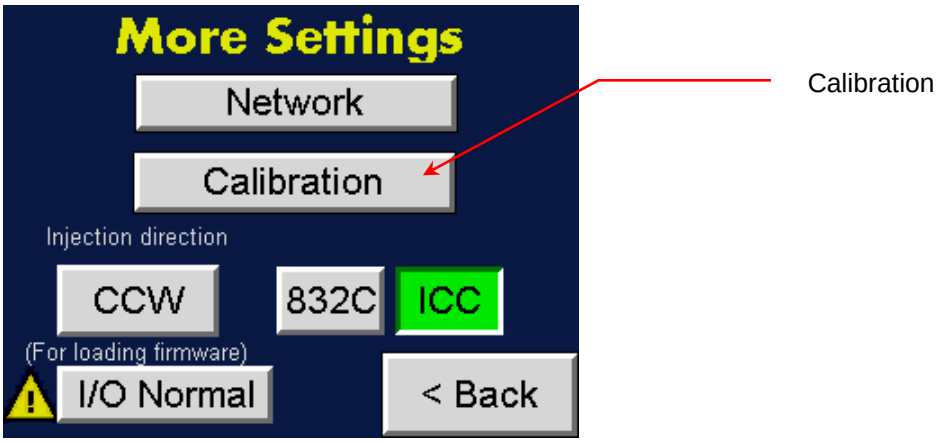
If the air and water supplies to the instrument are turned off, the nebulizer pressure on the Device Status screen should be 0. If it is not, you must recalibrate the baseline of the pressure transducer (reset the Nebulizer Pressure to zero).

To reset the nebulizer pressure, follow these instructions:

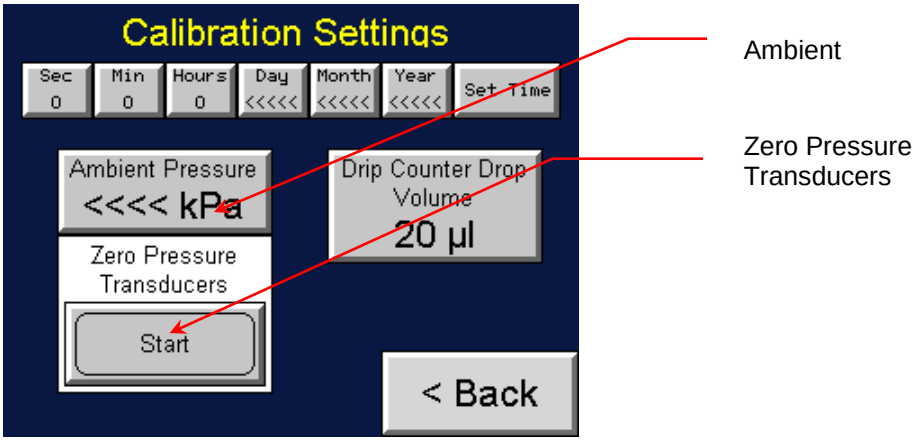
1. With the air and water supplies turned off, press **F2.**
2. On the **Device Settings** screen, touch **More Settings**.

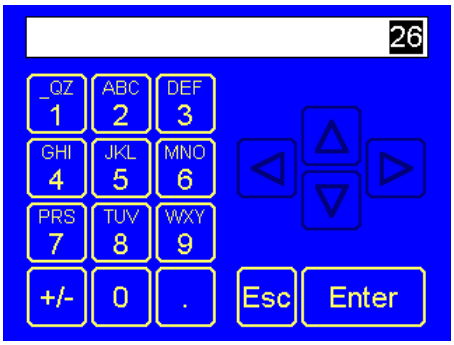


3. On the More Settings screen, touch **Calibration.**



4. On the **Calibration Settings** screen touch **Ambient Pressure**. Use the on-screen keyboard to enter the ambient pressure value and then press **Enter**.



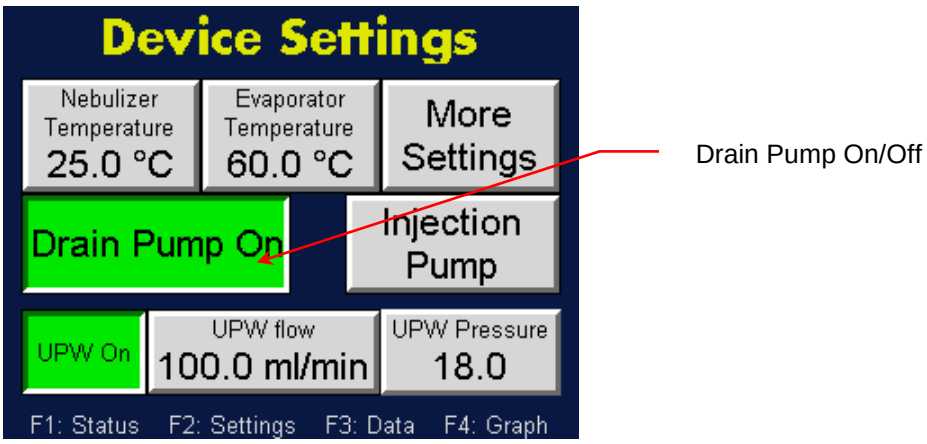


5. On the **Calibration Settings** screen, touch **Zero Pressure Transducers Start**. The zero is reset. (Press **F1** and check that the **Nebulizer Pressure** is 0 on the Device Status screen.)
6. **Press F2**>**More Settings**>Calibration. On the **Calibration Settings** screen touch **Zero Pressure Transducers** to end the reset.

Managing Internal Pump Life

The NanoParticle Nebulizer contains a solenoid-type liquid pump to remove sample that has been nebulized but removed from the aerosol before evaporation (only 0.1% of the nebulized sample is aerosolized and measured by the device). The pump has a finite life which can be extended by turning off the pump when no liquid is being delivered to the system. To turn the drain pump on/off, follow these instructions:

1. Press **F2**.
2. On the **Device Settings** screen, touch the **Drain Pump On/Off** toggle button to turn the pump on or off.



Managing the External Injection Pump

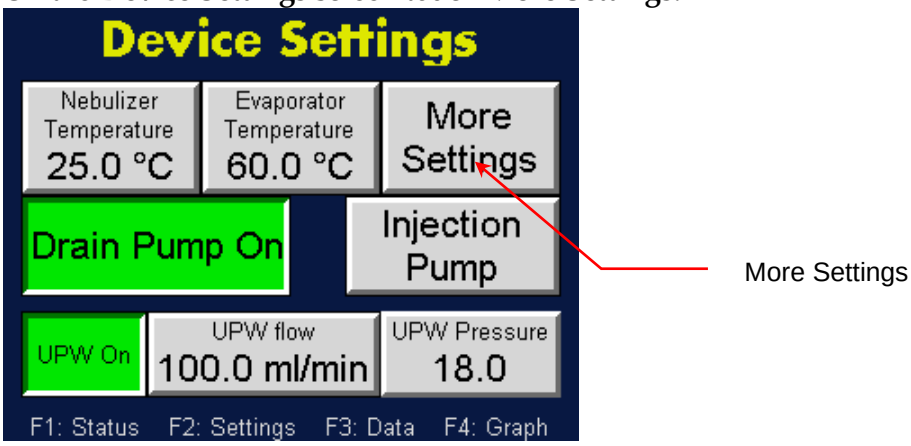
The NanoParticle Nebulizer can control the external sample injection pump. The pump can operate at either steady flow or with a programmed cycle. The following options are available for managing the injection pump:

- Selecting external pump model.
- Setting external pump direction.
- Set pump control source.
- Choose manual or automatic pump control.
- Set flow parameters for manual and automatic flows.

Setting the Injection Pump Model

To set the injection pump model, follow these instructions:

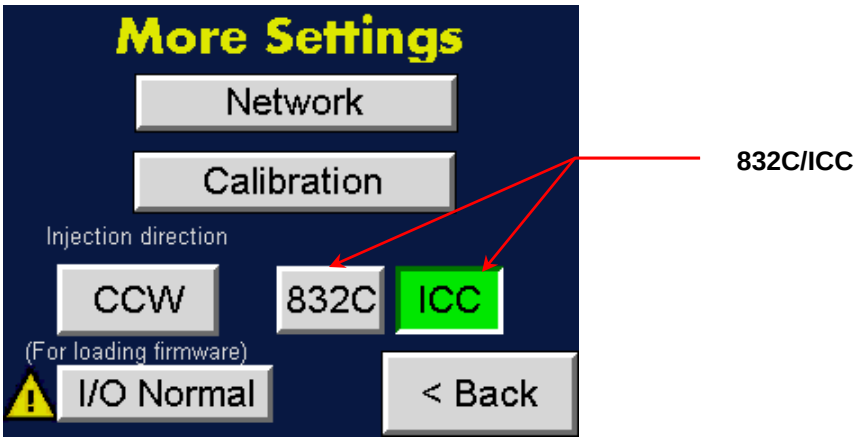
1. Press **F2**.
2. On the **Device Settings** screen touch **More Settings.**



3. There have been two peristaltic pump models provided with the LNS system, the ICC two-channel on the left, and the 832C single channel on the right.

ICC  **832C** 

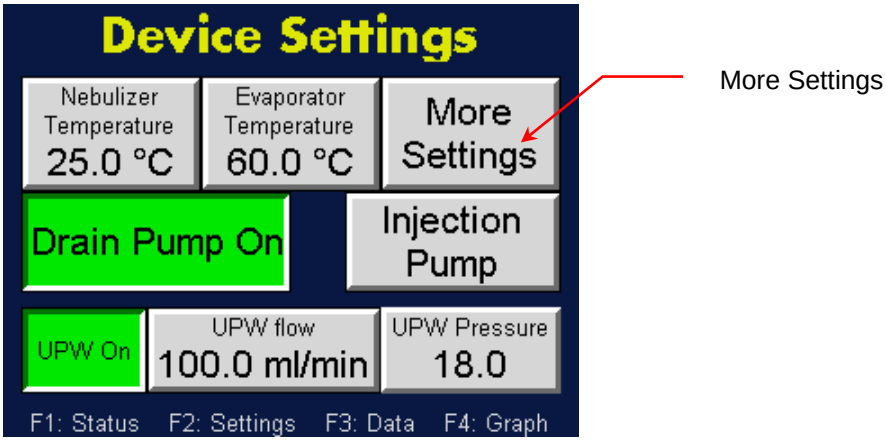
4. On the **More Settings** screen touch the 832C button for 832C single channel peristaltic pump, or ICC for the ICC two-channel peristaltic pump according to the model shipped with the LNS system.



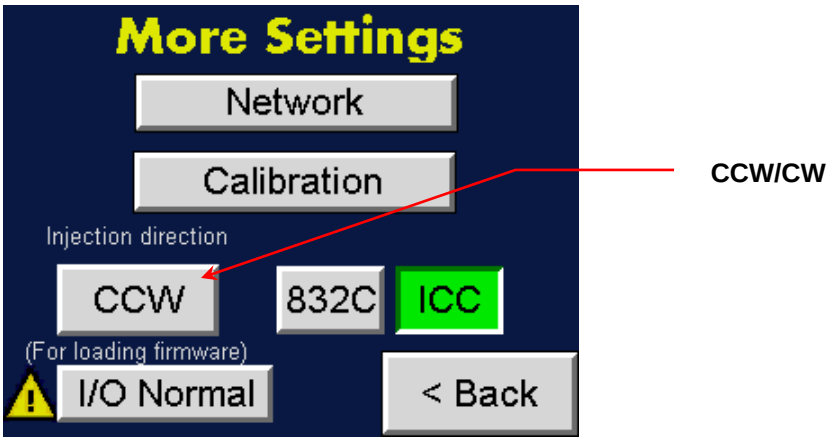
Setting the External Pump Direction

To set up the external pump direction, follow these instructions:

1. Press **F2.**
2. On the **Device Settings** screen, touch **More Settings.**



3. On the **More Settings** screen touch the **CCW/CW** toggle button to change the direction of injection into the nebulizer. CCW indicates a counter-clockwise direction; CW indicates a Clockwise direction.

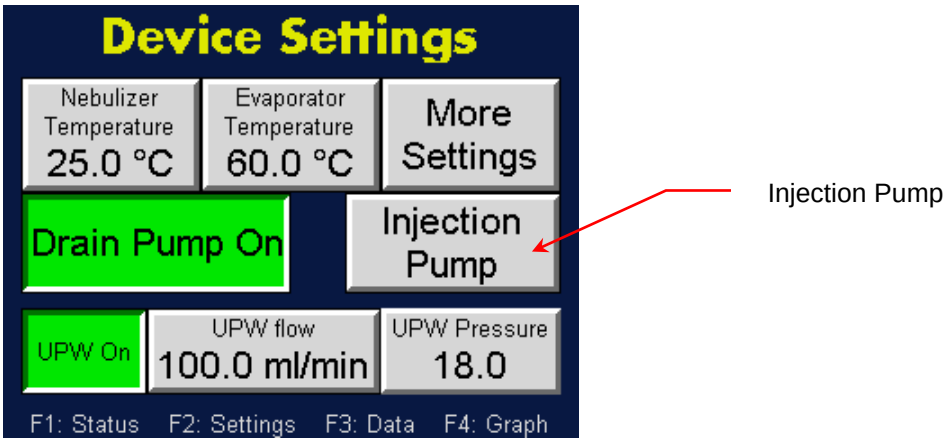


Setting Manual or Instrument Control for the Injection Pump

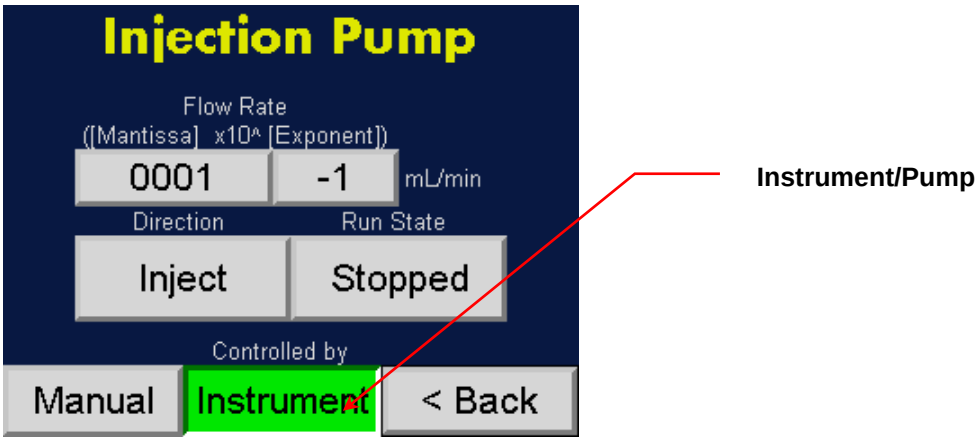
The external peristaltic pump can be controlled manually using the buttons on the pump or it can be controlled automatically by the NanoParticle Nebulizer.

To set the injection pump control, follow these instructions:

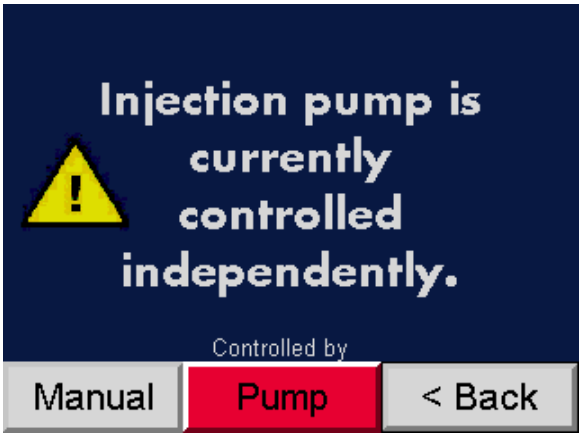
1. Press **F2.**
2. On the **Device Settings** screen touch **Injection Pump**.



3. The **Controlled by** button toggles between **Instrument** and **Pump**. When the injection pump is controlled by the NanoParticle Nebulizer the green **Instrument** button should be active.



When the injection pump is controlled manually using the buttons on the pump itself the red **Pump** button should be active. Note: When you switch from the Instrument to the Pump mode a caution message is displayed.

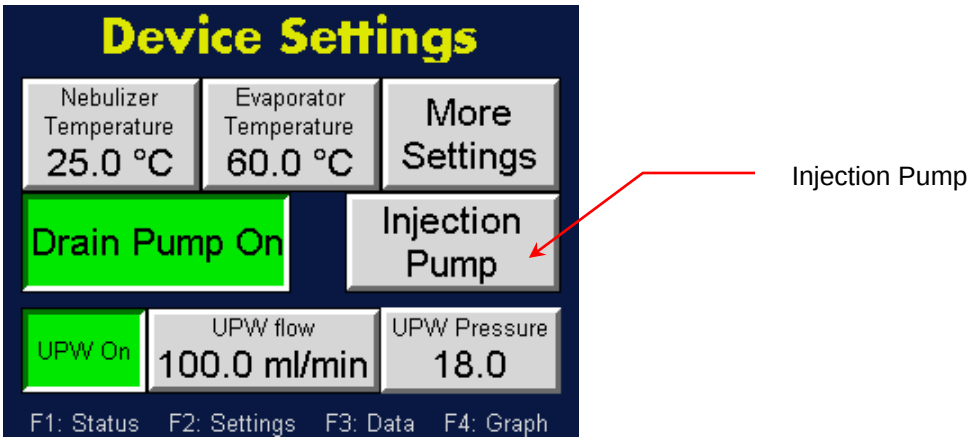


Setting Instrument Control Settings (Manual or Automatic) for the Injection Pump

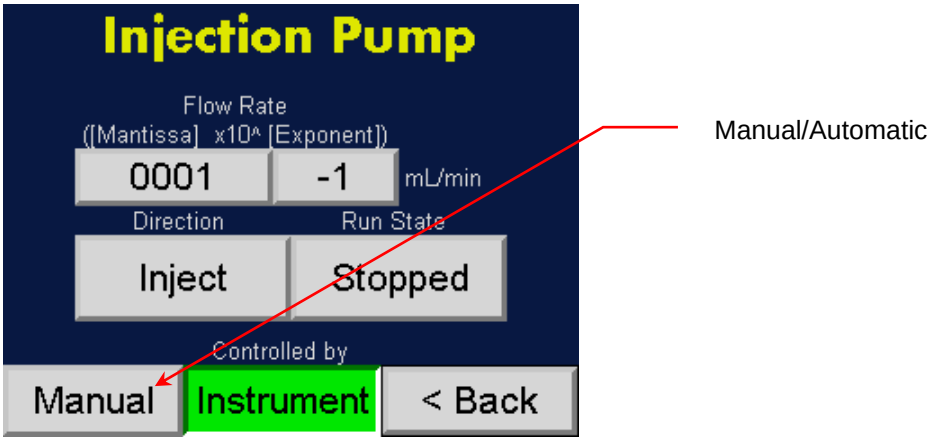
When the external injection pump is controlled by the Nanoparticle Nebulizer, you can select manual or automatic control and then set the flow rate, run state, and direction of flow.

To specify manual or automatic control, follow these instructions:

1. Press **F2**.
2. On the **Device Settings** screen touch **Injection Pump Control**.

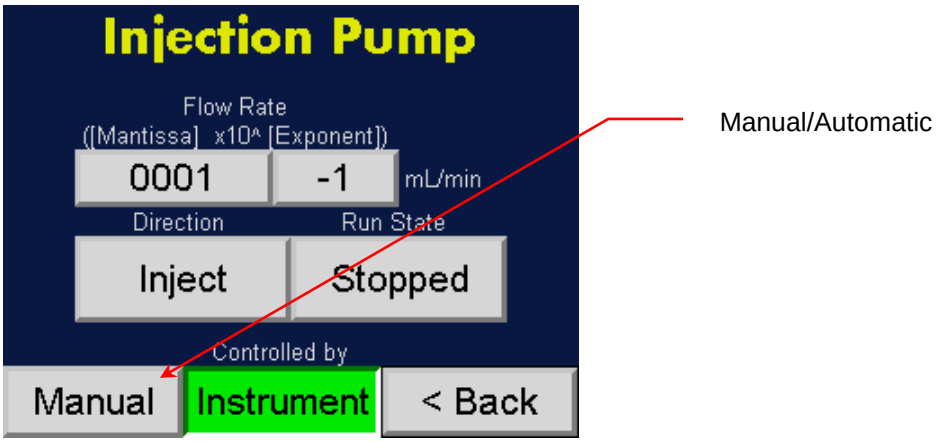


3. On the **Injection Pump** screen touch the **Manual/Automatic** button to toggle between the two settings.



To specify Manual control settings, follow these instructions:

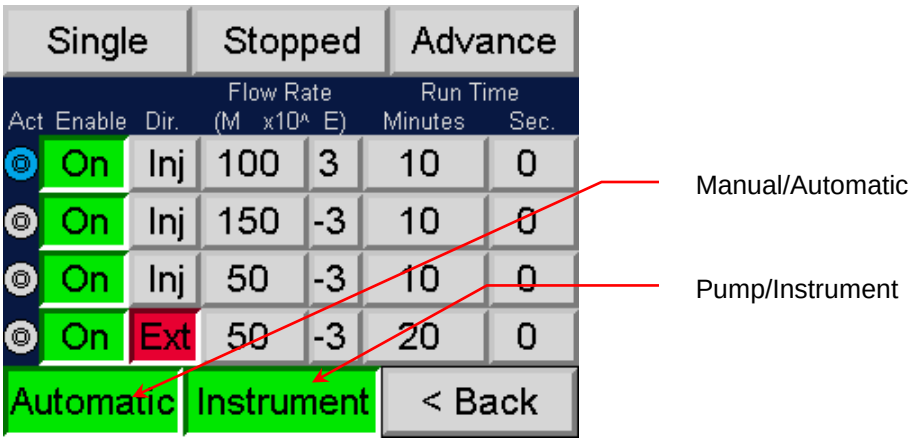
1. Press **F2** > **Injection Pump Control**. On the **Injection Pump** screen, the Manual/Automatic toggle button should display **Manual**.



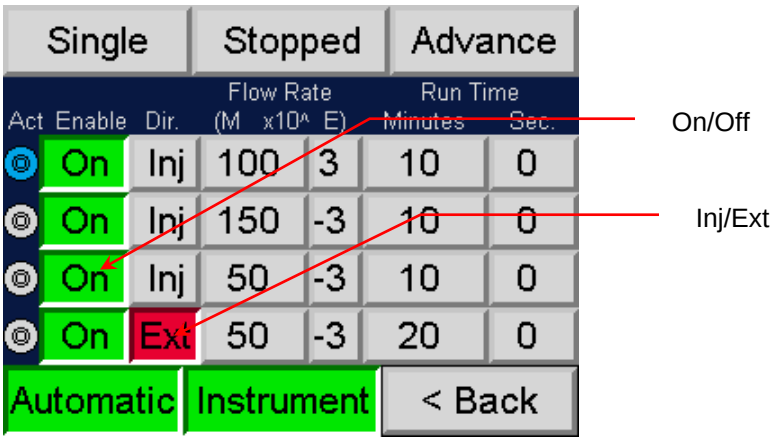
2. Set the **Flow Rate** by touching the **(Mantissa)** and **10^(Exponent)** buttons and using the on-screen keyboard to enter values. Example: 100x10^{-3} ml/min sets the pump to operate at 0.100 ml/min.
3. To set the **Direction** of flow touch the **Inject/Extract** toggle button to choose **Inject** (flow runs from the pump to the NanoParticle Nebulizer) or **Extract** (flow runs from the NanoParticle Nebulizer to the pump or a bottle).
4. To set the **Run State** touch the **Running/Stopped** toggle button to start or stop the flow.

To specify Automatic control settings, follow these instructions:

1. Press **F2** > **Injection Pump Control**. On the **Injection Pump** screen the Manual/Automatic toggle button should display **Automatic** and the Pump/Instrument toggle button should display **Instrument**.



2. To activate specified pump settings touch the On/Off toggle button in the **Enable** column to display **On**. Note: If **Off** is selected, those settings are skipped. **Act** indicates which settings are currently active.



3. To specify the pump settings touch the buttons in the columns.
   a. Change the pump flow direction by touching the **Inj/Ext** (Injection/Extraction) button in the **Dir** column.
   b. Set the flow rate by entering the Mantissa (**M**) and exponent (**E**) values in the Flow Rate column. Example: $100x10^{-3}$ sets the pump to operate at 0.100 ml/min.
   c. Set the run time for the pump by entering the minutes and seconds in the **Run Time Minutes** and **Sec** columns. Use the on-screen keyboard to enter the values.
   d. Choose to run a single cycle or repeat the cycle by touching the **Single/Repeat** toggle button**.**

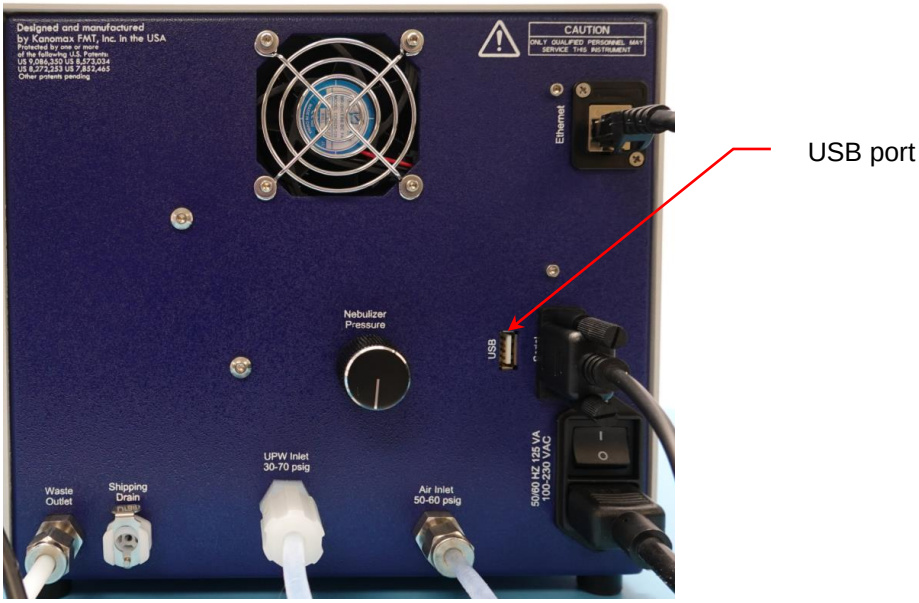
4. While you make your selections, the **Running/Stopped** toggle button displays **Stopped**. Press Stopped to begin the sequence and the button displays **Running**.
5. To advance the sequence to the next row, touch **Advanced**.

Loading the Firmware

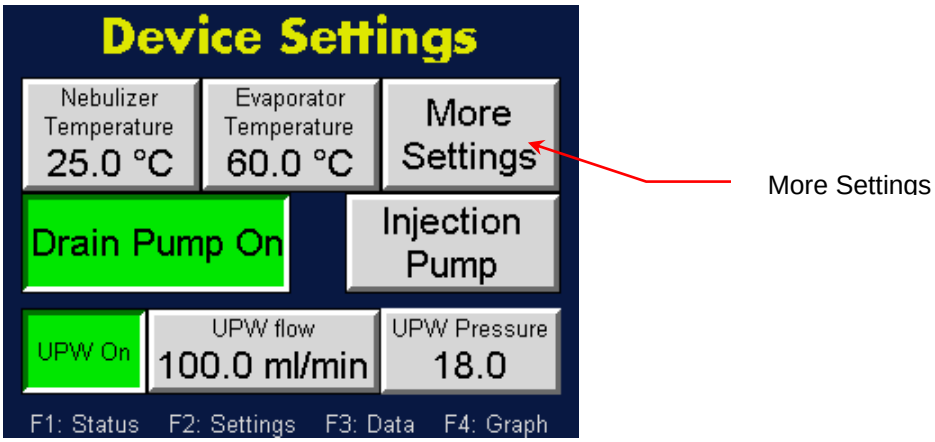
You can update the NanoParticle Nebulizer firmware from a USB drive.

To update the instrument firmware, follow these instructions:

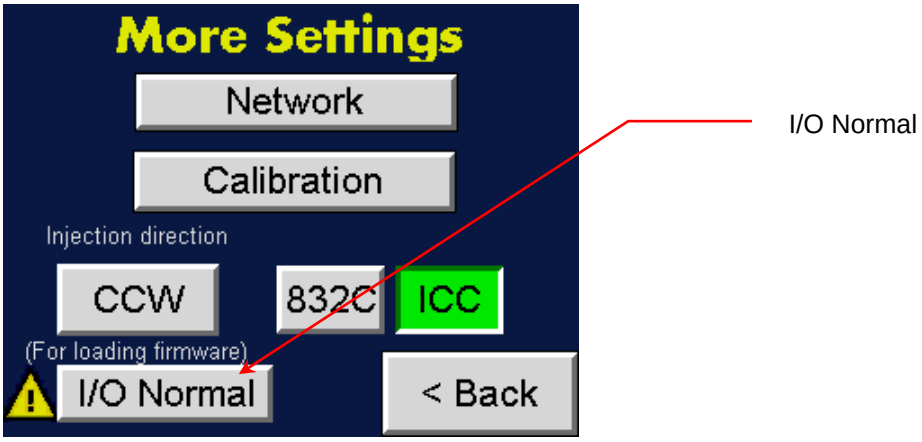
1. Load the firmware file onto a USB drive and insert into the USB port on the rear panel.



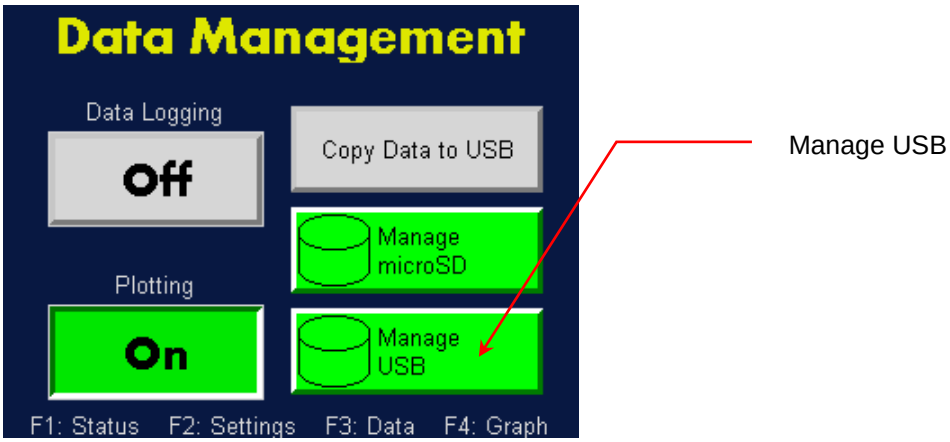
2. Press **F2** to see the **Device Settings** screen then touch **More Settings**.



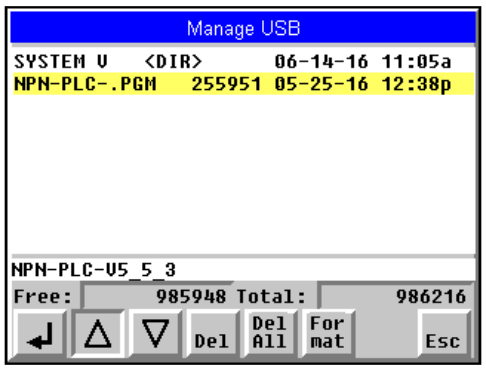
3. On the **More Settings** screen, touch **I/O Normal**.



4. On the Data Management screen touch **Manage USB.**



5. On the Manage USB screen, use the △▽arrows to highlight the firmware file. Touch ↵ to start loading the firmware.
   Note: Touch **OK** if you see an on-screen warning.



6. When the firmware update has completed, remove the USB drive. Power off and then power on the NanoParticle Nebulizer.

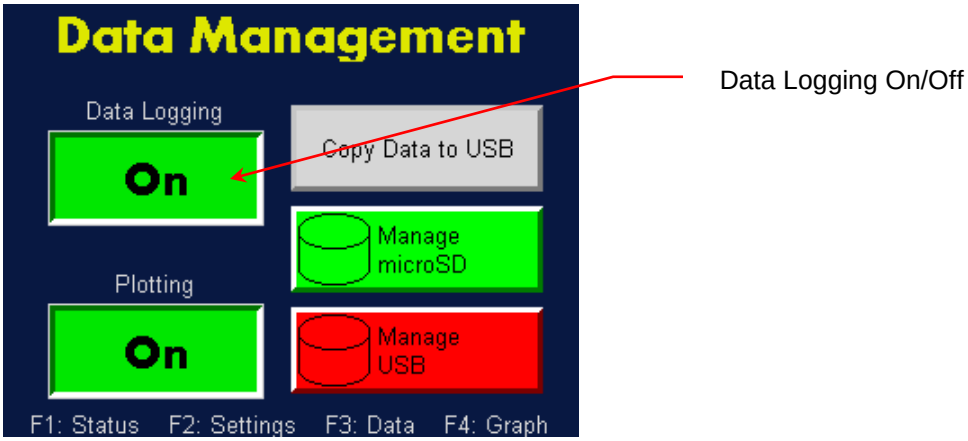
Data Collection and Data Plotting

When the data logging function is turned on, the NanoParticle Nebulizer stores status data in its internal memory. You can transfer the stored data to an external Flash memory drive.

Turning Data Logging On/Off

To turn data logging on/off, follow these instructions:

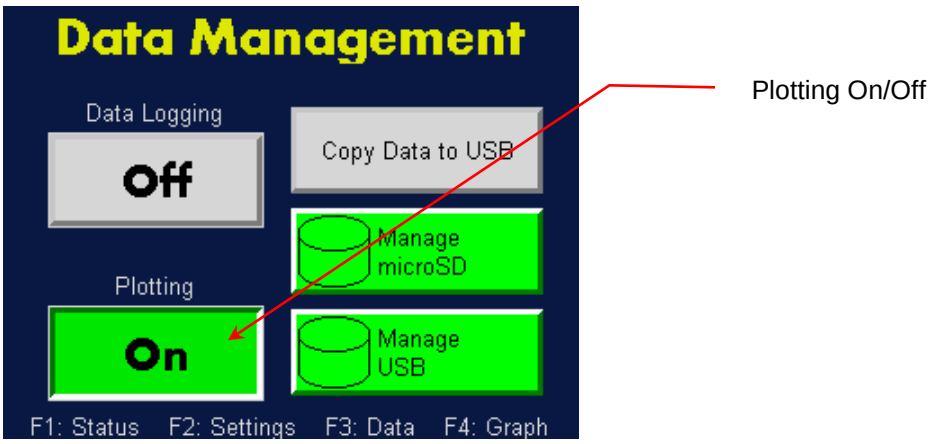
1. Press **F3**.
2. On the **Data Management** screen touch the **Data Logging On/Off** toggle button to turn data logging On or Off.



Turning Data Plotting On/Off

To turn data plotting on or off, follow these instructions:

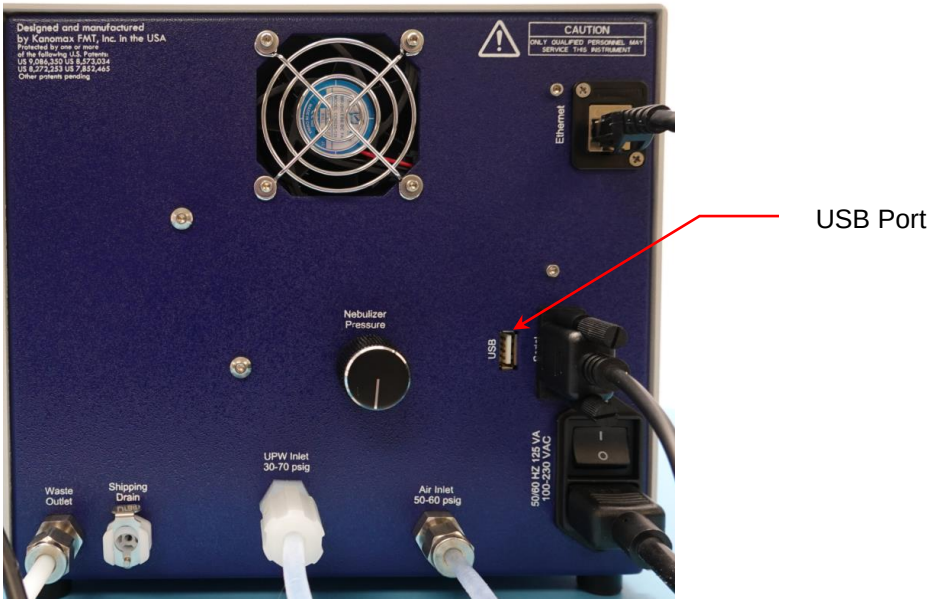
1. Press **F3.**
2. On the **Data Management** screen touch the **Plotting On/Off** toggle button to turn Plotting On or Off.



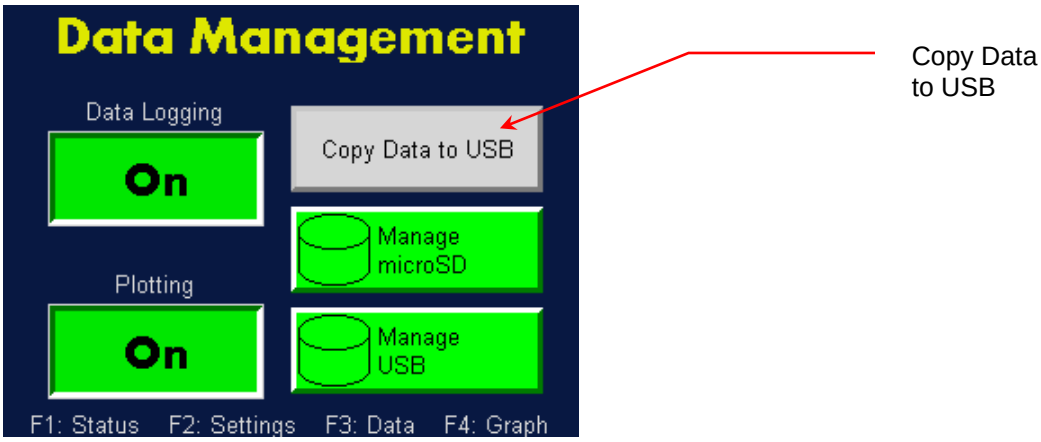
Transferring Data to a USB drive

To transfer data to an external USB drive, follow these instructions:

1. Insert a USB drive into the back panel of the NanoParticle Nebulizer.



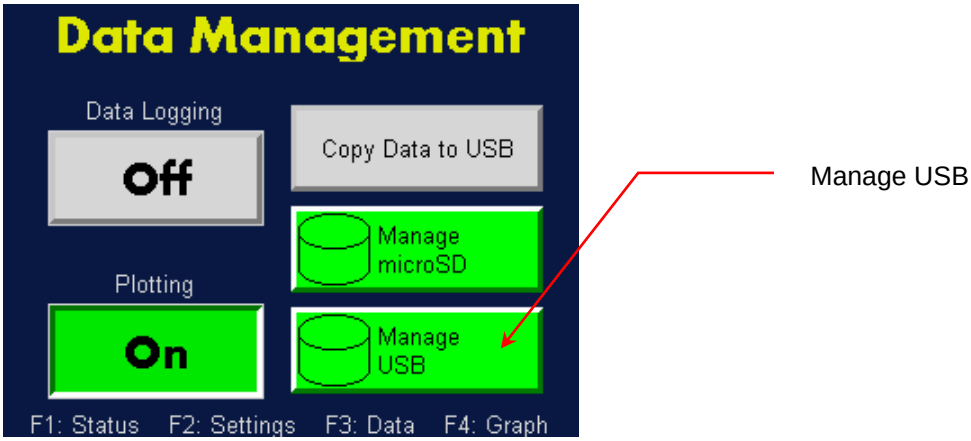
2. Press **F3.**
3. On the **Data Management** screen touch **Copy Data to USB**.



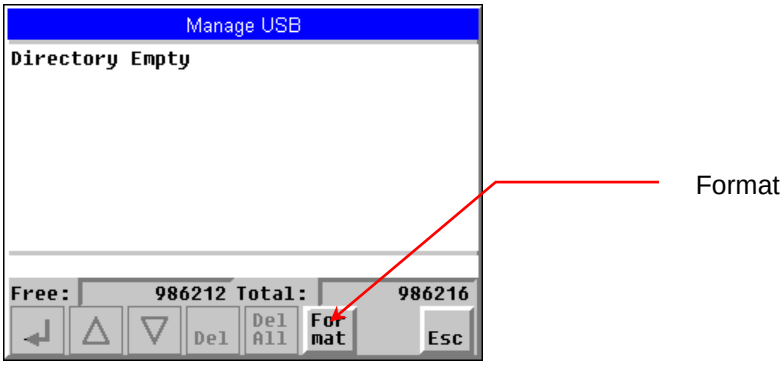
Formatting a USB Drive

To format a USB drive, follow these instructions:

1. Press **F3**.
2. On the Data Management screen touch **Manage USB**.



3. On the Manage USB screen touch **For/mat**, then touch **OK.** Touch **Cancel** to cancel the formatting. Note: any data stored on the USB drive will be erased.

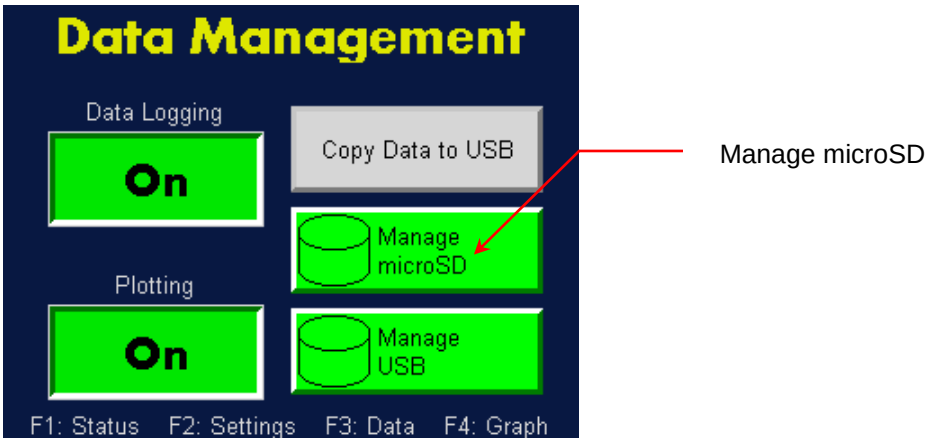


Managing Internal Memory

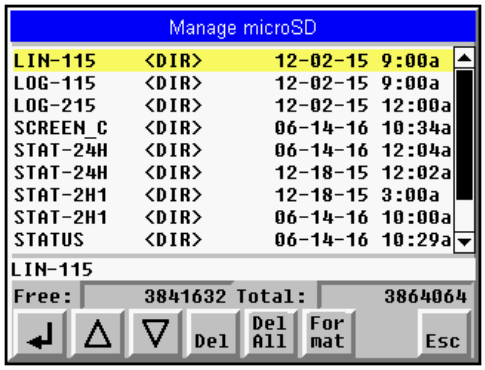
To manage the internal memory you can view the data record files, check the available memory and the total memory used, format the drive, and delete the stored data.

To manage the stored data, follow these instructions:

1. Press **F3.**
2. On the **Data Management** screen touch **Manage microSD**.



3. A list of data folders is displayed on the Manage microSD screen. Use the △▽ arrows to scroll between the folders and then press ↵ (Enter) to see the contents of the folder. Note: The data files for each day that data was collected are displayed in comma delimited records.
   Free: indicates the amount of memory available in kB.
   Total: indicates the memory usage in kB.
   Del deletes the selected folder or data file.
   Del All deletes all folders or data files.

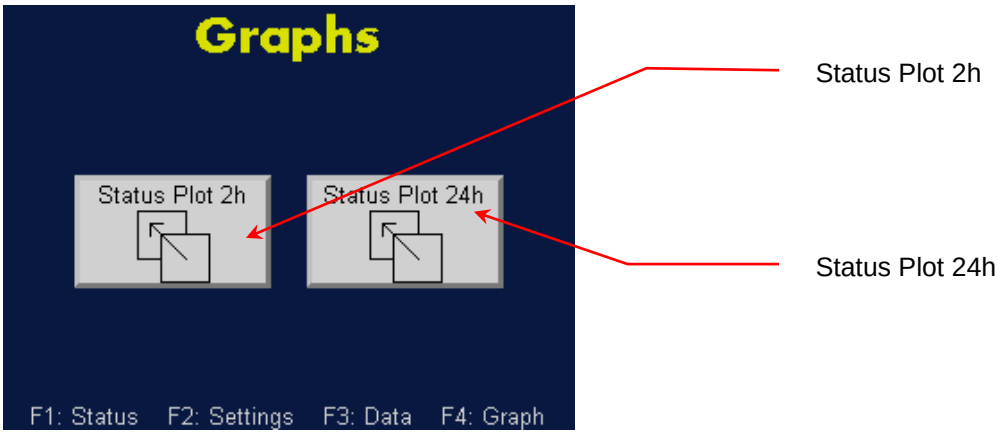


Viewing Graphs

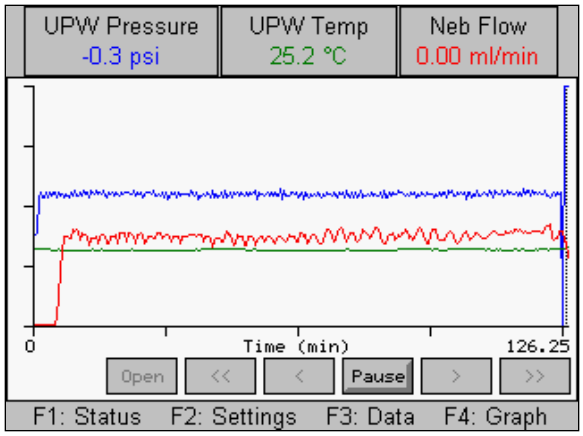
When the data plotting function is turned on, the NanoParticle Nebulizer displays either a two-hour or a 24-hour status graph.

To view graphs, follow these instructions:

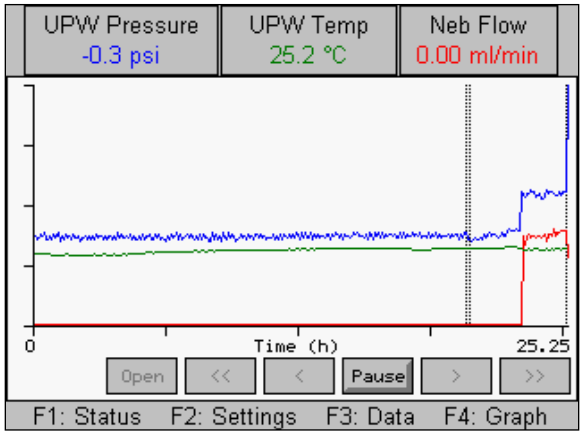
1. Press **F4** to see the Graphs screen.



2. Touch **Status Plot 2h** to see a plot of UPW pressure, UPW temperature and Nebulizer flow over a two-hour period.



Touch **Status Plot 24 h** to see a plot of UPW pressure, UPW temperature and Nebulizer flow over a twenty four-hour period.



Note: UPW Pressure is plotted with a blue line, UPW Temp is plotted with a green line and Neb Flow is plotted with a red line.

Sample Introduction

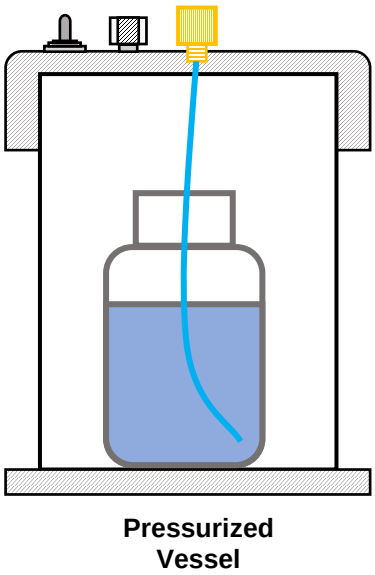
The NanoParticle Nebulizer has two options for introducing the sample to be nebulized: diluted and direct. The Sample Selector Valve allows you to choose either Diluted Sample or Direct Sample.

For the Diluted Sample option, the NanoParticle Nebulizer reduces the amount of Dissolved Non-volatile Residue (DNVR) present in the nebulized stream by diluting the incoming sample using ultrapure water and an internal dilution module. This process eliminates the possibility of DNVR introduction from vials, sample measurement/transfer, and exposure to air.

Injection of a sample into the NanoParticle Nebulizer can be accomplished by a peristaltic pump, syringe drive pump, or pressurized vessel. Note: A peristaltic pump is shipped with the NanoParticle Nebulizer. The peristaltic pump adds the most particles and the pressurized vessel the least. The injection rates for either a syringe or peristaltic pump should match the average flow rate measured by the 9110 under normal operating conditions. For pressurized vessel introduction, the vessel pressure should match the normal online sample pressure (18 psi). Figure 11 shows a pressure vessel configuration.

Note: The vessel must withstand the total pressure which can be supplied by the compressed air system. Use of a blow-off safety valve is highly recommended.

Figure 11: Pressure Vessel Configuration with the NanoParticle Nebulizer.



How to Shut Down the NanoParticle Nebulizer for Moving or Shipping

If you need to move the NanoParticle Nebulizer to another lab or facility or ship it for service, read this section to familiarize yourself with the precautions you should take and the procedures you should follow.

Performing any of the following improper handling techniques may damage the instrument and will invalidate the warranty:

- Shipping/transporting an undried/undrained instrument.
- Tipping > 10° during normal operation.
- Subjecting an undried/undrained instrument to freezing temperatures.

To prepare the NanoParticle Nebulizer for shipping, follow these instructions:

1. Turn off the water supply to the NanoParticle Nebulizer and wait a few seconds for the water pressure to drop to zero (confirm that the pressure is zero by looking at the Device Status screen).
2. Keep the power turned on and the compressed air flowing into the **Air Inlet** on the back panel.
3. Connect the CDA/N_2 adapter fitting (provided with the instrument) to the UPW inlet port and apply clean dry air or nitrogen at 30 psi to the port. Run for 2 hours.
4. Remove the tubing and cap the **UPW Inlet** on the front panel.
5. Remove the **Shipping Drain** cap. Water will drain from the fitting. Tilt the device towards the back to allow the nebulizer module reservoir to empty completely. Note: If necessary, you can install tubing to take the waste flow to a suitable drain.
6. Disconnect the air or nitrogen supply line and the water waste line and turn off the power.
7. Place all the caps that you received with the instrument on the inlets and outlets to prevent material from entering the instrument. The NanoParticle Nebulizer is now prepared for shipping or moving.
   Note: If you did not save the original protective caps, find suitable alternatives.
8. Place the instrument in its original packing materials for shipping.

If you have any questions about shipping or moving the NanoParticle Nebulizer, contact Kanomax FMT, Inc. at 651-762-7762. (Customers in Asia please call +81 6-6877-0183.)

Troubleshooting

All repair and maintenance of the NanoParticle Nebulizer must be performed by a qualified service technician.

When working with the nebulizer:

- Do not remove any parts from the instrument unless this manual tells you to do so.
- Do not remove the instrument housing or covers while power is supplied to the instrument.

Table 1: Troubleshooting Guide

Problem	Cause	Action
Nebulizer Flow is 0.	UPW pressure is out of range.	Press F1 to see the Device Status screen, check that the UPW Pressure is 18 ± 0.2 psi. If the pressure is not correct, adjust the pressure (see Changing the Sample Pressure/Dilution Flow on page 27). If the pressure does not reach the correct operating level, verify the UPW supply pressure is >30 psi.
	Drip Sensor is wet.	Check beneath the nebulizer to see if drops are forming at the drip counter. If drops are forming, the sensor is probably wet. Turn off the UPW supply and allow the instrument to dry for 24 hours. Turn the UPW supply back on. If the sensor is still wet, inspect the waste pump. (See Inspecting the Waste Outlet Pump on page 53.)
	Nebulizer is clogged.	Check beneath the nebulizer to see if drops are forming at the drip counter. If no drops are forming the nebulizer may be clogged. (See Unblocking Orifices on page 52).
Bubbles observed in flowmeter.	UPW pressure is out of range.	Press F1 to see the Device Status screen. Check that the UPW Pressure is 18 ± 0.2 psi. If the pressure is not correct, adjust the pressure. (See Changing the Sample Pressure/Dilution Flow on page 27). If the pressure does not reach the correct operating level, verify the UPW supply pressure is >30 psi.

	Nebulizer is clogged.	See Unblocking Orifices on page 52.
Water leaking from NanoParticle Nebulizer.	Loose fitting.	Check all fittings and tighten any that are loose. Note: Do not over-tighten.
	Water flowing from base of NanoParticle Nebulizer. Waste pump not operating properly	See Inspecting the Waste Outlet Pump on page 53.
Water pressure > or < 18 ± 0.1 psi.	UPW or gas supply pressure changed.	See Changing the Sample Pressure/Dilution Flow on page 27.
Nebulizer gas pressure not reading 35 psi.	Gas supply pressure changed.	See Changing the Nebulizer Pressure on page 23.
Evaporator temperature does not reach set point (nominally 60°C).	Nebulizer evaporator may be flooded.	Check the drain pump operation. (See Inspecting the Waste Outlet Pump on page 53.)
Water present in aerosol output fitting.	Nebulizer evaporator may be flooded.	Check the drain pump operation. (See Inspecting the Waste Outlet Pump on page 53.)
NanoParticle Nebulizer unable to hold set point temperature (22°C).	Extreme ambient temperature conditions or defective cooling components.	Contact Kanomax FMT, Inc. for instructions.

NanoParticle Nebulizer does not recognize external USB Flash drive	**Media Card not Present** is displayed on **Manage Data>Manage USB** screen**.**	Power cycle the NanoParticle Nebulizer.
Aerosol output is erratic.	Drip counter trap may not be set.	Verify that the Shipping Drain is capped.
	Flow and or pressure at Aerosol Output is not in the specified range.	The aerosol output must be near ambient pressure (+/- 1 cm H_2O) and within 1-1.5 L/pm.

Unblocking Orifices

Occasionally orifices or tubes within the NanoParticle Nebulizer become blocked which may be indicated by a low Nebulizer flow rate. If you suspect a blockage, follow these instructions:

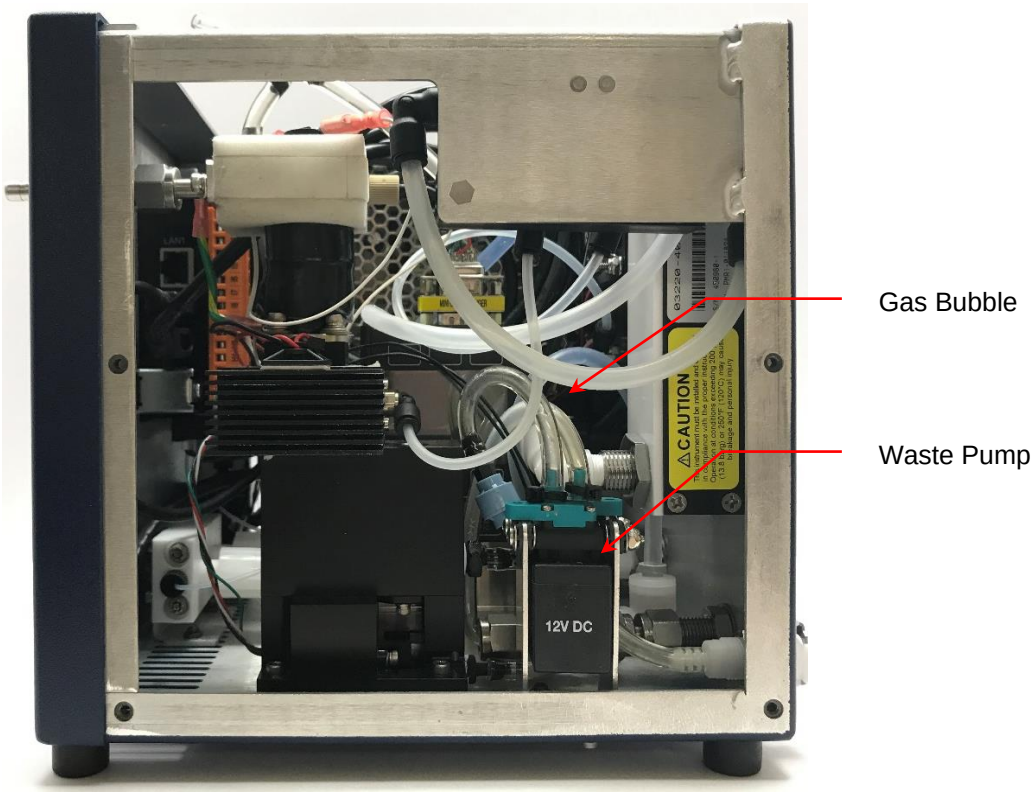
1. Turn the Sample Selector Valve knob on the front panel to **Diluted**.
2. Remove the water inlet tubing and run compressed air through the instrument.
3. If the problem is not resolved, turn the Sample Selector Valve knob to **Direct** and remove the direct injection plug to force air back through the nebulizer supply tubing.
4. If a clog persists, turn off the gas supply and inject water into the sample inlet for 1 hour with the Sample Selector Valve knob turned to **Direct**.

If the nebulizer flow rate does not recover, it is possible that the internal orifices are clogged and the device must be returned to Kanomax FMT, Inc. for service. Note: Advanced users may wish to adjust the internal impactor pin, although this step may damage the instrument. Contact Kanomax FMT, Inc. for evaluation and instructions.

Inspecting the Waste Outlet Pump

If the Waste Outlet is leaking you may need to service the waste pump. To service the pump follow these instructions:

1. Remove the eight screws holding the cabinet cover in place and save for reuse.
2. Locate the waste pump inside the NanoParticle Nebulizer.



3. The waste line should have gas bubbles present.
   a. If no gas bubbles are present, verify that the pump is receiving power (feel the body for clicks every second). If no clicks are felt, measure the supply voltage to the pump. Note: the drain toggle must be on.
   b. The gas bubbles should only travel towards the Waste Outlet: they should not move back and forth. If gas bubbles rock back and forth there is probably debris in the drain pump valves. The debris can be removed by forcing liquid through the pump (using a syringe) or cleaned by disassembling the pump. Note: Disassembling the pump will void the pump warranty.

Appendix A: NanoParticle Nebulizer Model 9110 Specifications

Table 2: NanoParticle Nebulizer Specifications

Peak droplet diameter	< 1.0 micrometer (nominally 0.2 micrometer)
Droplet dN/dLogDp > 10μm	< Peak dN/dLogDp x 10^{-5}
Inspection volume rate	0.2-1.0 μL/min
Total Liquid Flow Rate (online)	50-200 mL/min
Nebulizer Flow Rate (direct)	0.5-3.0 mL/min
Aerosol Flow Rate	1.0 – 1.5 L/min
Response time to concentration change	< 90 seconds
Inlet Water Pressure (online)	200-500 kPa (29 – 72 psig)
Compressed air flow rate/pressure	3 std L/min CDA or Nitrogen, (345-414 kPa, 50-60 psi)
Wetted Surface Materials	PFA Teflon, PTFE, sapphire, 316L, stainless steel, PEEK
Ambient Temperature Range	15-35°C, 59-95°F
Ambient Relative Humidity Range	0-85%
Maximum Water Temperature	80°C, 176°F
Dimensions (WxDxH)	23 (9) x 23 (9) x 35.5 (14) (46 (18) with fittings)
Weight	6 kg (13..2 lb)
Power	Universal 100 - 230 VAC 50/60 Hz, 90 W max
Output	RJ-45 for Modbus, USB FlashDrive
Internal storage	Micro SD
Ultrapure Water Inlet	¼ inch PFA Flaretek®
Waste Outlet	¼ inch SS Swagelok®
Compressed Air inlet	¼ inch SS Swagelok®
Detector vacuum	¼ inch SS Swagelok® port
Display	3.5 inch TFT Color, touch panel

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