

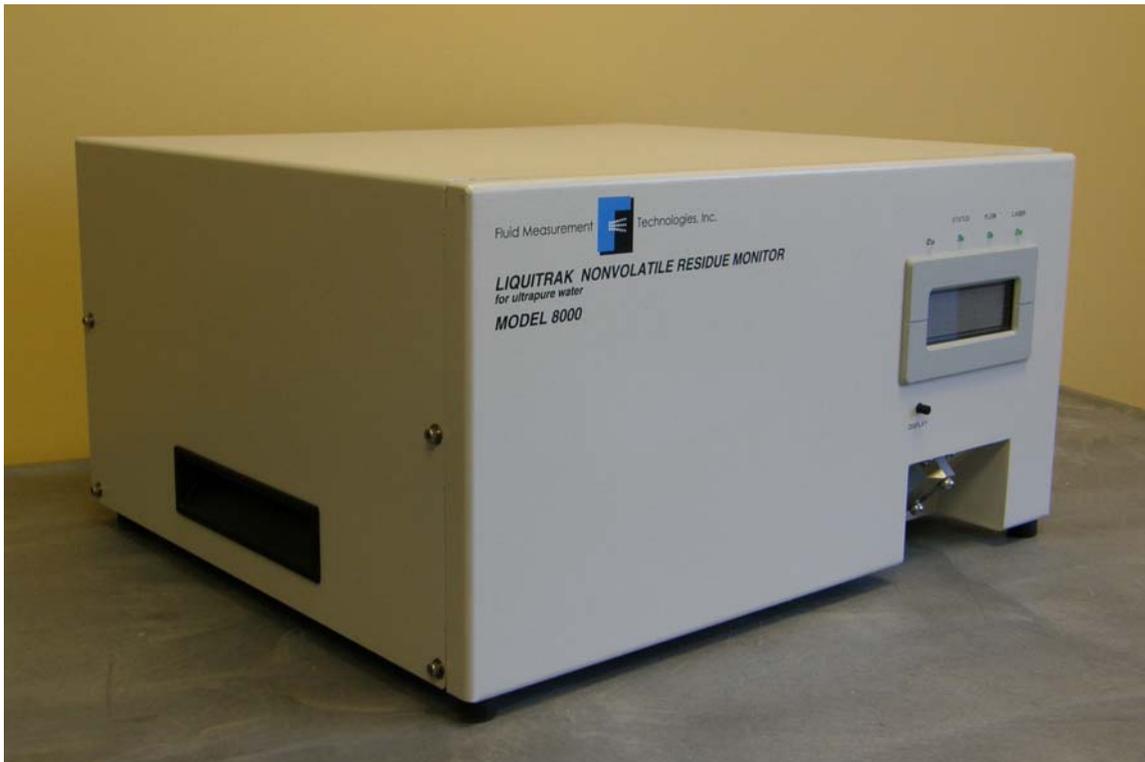
Fluid Measurement



Technologies, Inc.

# LiquiTrak® Nonvolatile Residue Monitor

## Model 8000:User Manual



LiquiTrak® Nonvolatile Residue Monitor Model 8000 User Manual  
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Version 1.7	September 2011	Added information about flash drive. Updated packing list. Updated shutdown procedures.
Version 1.8	June 2014	Corrected errors in the shut down procedure, firmware commands and the specifications page.

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### **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 NRM 8000, contact 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 NRM Model 8000 User Manual is intended to be used by qualified personnel (such as technicians and engineers) in a semiconductor facility or laboratory setting.

### Scope of User Manual

This User Manual contains detailed instructions for the installation and set up of the NRM, including connecting the hardware and installing the software. The manual also contains an explanation of how the NRM works.

### Definitions

- NRM: NonVolatile Residue Monitor
- UPW: Ultrapure Water
- EU: European Union
- RAE: Residue After Evaporation
- CPC: Condensation Particle Counter
- WCPC: Water-based Condensation Particle Counter
- EEPROM: Electrically Erased Programmable Read Only Memory
- KCl: Potassium Chloride
- ppt: parts per trillion
- ppt rms: ppt root mean squared
- psi: pounds per square inch
- kPa: Kilo Pascals
- PFA: Perfluoralkoxy
- VAC/VDC: Volts Alternating Current/Volts Direct Current
- AC: Alternating Current
- USB: Universal Serial Bus
- mA: Milliamperes

# Safety and Handling Procedures

Read this section to learn safe handling procedures for the NRM Model 8000.

There are no user-serviceable parts inside the NRM 8000 - all repair and maintenance must be performed by a qualified service technician.

When working with the NRM 8000:

- 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 NRM 8000. 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 NRM 8000.

### Note

Notes are used to indicate important information.



### High Voltage Sticker

A High Voltage warning sticker attached to the NRM 8000 warns you that uninsulated 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 NRM 8000 indicates that the NRM 8000 is connected to earth ground and cabinet ground.

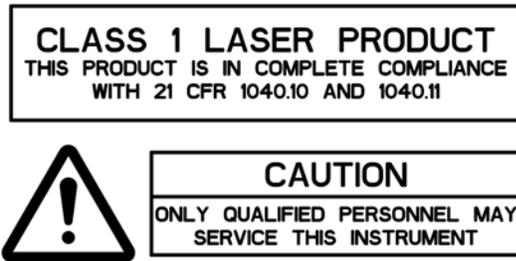
### Laser Safety Warning

A laser safety warning label, like the one shown below, is positioned on the insulating foam that surrounds the optical assembly. The label warns of hazardous laser radiation if the optical assembly is opened and the instrument is powered on. The optical assembly is not user serviceable.



### Class I Laser Sticker

When operated according to the manufacturer's instructions, the NRM 8000 is a Class I laser product as defined by U.S. Department of Health and Human Services standards under the Radiation Control for Health and Safety Act of 1968. A certification and identification label like the one shown below is positioned on the back panel of the NRM 8000.



### Serial Number Label

A serial number label similar to the one shown below is positioned on the back panel of the NRM 8000.



### CE Declaration of Conformity

The CE on the Serial Number Label indicates that the NRM 8000 **meets the Health and Safety requirements** and is in conformity with the following EU Directives:

- EU EMC Directive 89/336/EEC
- EU Low Voltage Directive 72/23/EEC

Using the relevant section of the following EU standards and other normative documents:

EMC	EN55011:1998:1999:2002
	EN61326-1:1997:1998:2001:2003
Safety	EN61010-1:2002 (2 <sup>nd</sup> Edition)

### Warnings



Please familiarize yourself with the following warnings before operating the NRM 8000:

- The NRM 8000 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 NRM 8000 cover.
- When the NRM 8000 is running, there are hot surfaces inside the detector. 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.
- Follow the instructions for all inlet and outlet connections. Incorrect connections will cause the NRM 8000 to malfunction.
- The air or nitrogen supplied to the NRM 8000 must be filtered (particle-free), dried, oil-free and regulated at 50 psi.
- Do not remove the wick. The wick is fragile and should only be removed by a qualified service technician - unauthorized wick removal will void any warranty and necessitate return of the NRM 8000 to the factory.
- During normal operation, do not tilt the NRM 8000 at an angle  $>10^\circ$ . If you tilt the NRM 8000 at an angle  $>10^\circ$ , water will flow into the NRM optics and you will invalidate the warranty.
- You must drain the NRM 8000 before you move or ship it. Do not ship an undried/undrained NRM 8000 back to Fluid Measurement Technologies, Inc. Doing so will damage the detector and invalidate the warranty.
- Do not subject an undrained NRM 8000 to freezing temperatures. Doing so will damage the detector and invalidate the warranty.

### How the NRM 8000 Works

The NRM 8000 monitors Ultrapure Water (UPW) quality continuously, in real time, by measuring the amount of nonvolatile residue (also known as Residue After Evaporation or RAE). The NRM 8000 begins giving you a readout after only 15 minutes of operation.

Although the measurement technique used by the NRM 8000 is the same as that of the NRM 7700 (introduced in 1992), the NRM 8000 has been redesigned to incorporate updated electronics and a Water-based Condensation Particle Counter (WCPC). The WCPC replaces the alcohol-based Condensation Particle Counter (CPC) used in the NRM 7700. The NRM 8000 is an improvement over the NRM 7700 for the following reasons:

- Instead of alcohol, the WCPC uses the same ultrapure water that the NRM 8000 is monitoring. No external water reservoir is needed.
- The WCPC has a wider measurement range than the original CPC and diffusion screens are no longer required.
- By using less internal tubing, and eliminating most of the diffusion losses, the NRM 8000 has a response time almost ten times faster than the NRM 7700.

The NRM 8000's measurement technique incorporates the following basic processes:

1. UPW entering the NRM 8000 from your supply is nebulized to generate an aerosol of water droplets.
2. Filtered, heated air or nitrogen dries each water droplet, leaving behind a particle of residue agglomerates.
3. A WCPC measures the concentration of residue agglomerates. The concentration is calibrated to give you a readout in parts per trillion (ppt), displayed on the front panel of the NRM.

Figure 1, on page 6, is a schematic diagram illustrating the main components of the NRM 8000. Figure 2, on page 7, is a detailed schematic of the flow. The measurement technique is described in more detail beginning on page 8.

Figure 1: Schematic Diagram of the NRM 8000

Note: In the schematic diagram below, nitrogen is shown as the drying agent, but compressed air can also be used.

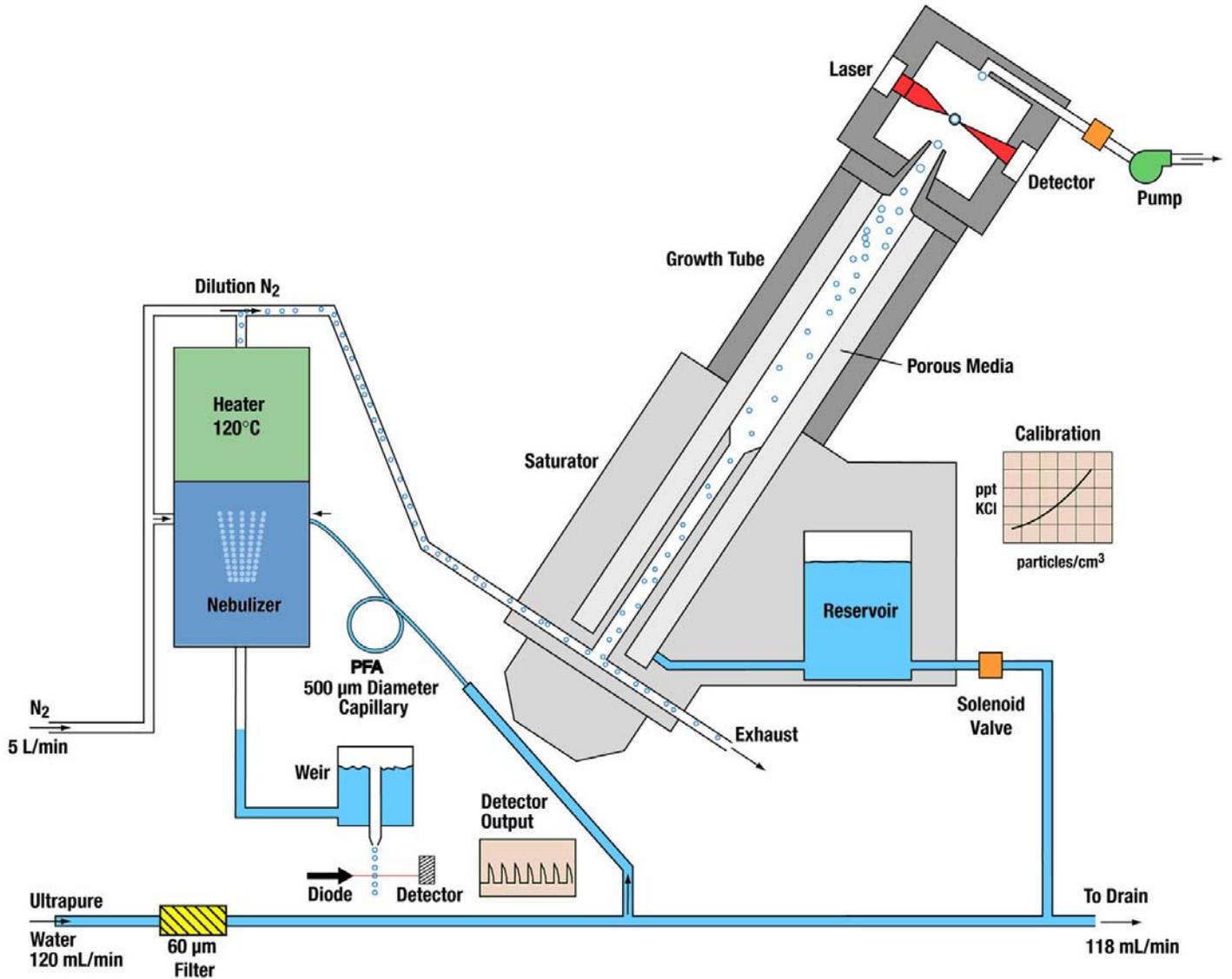
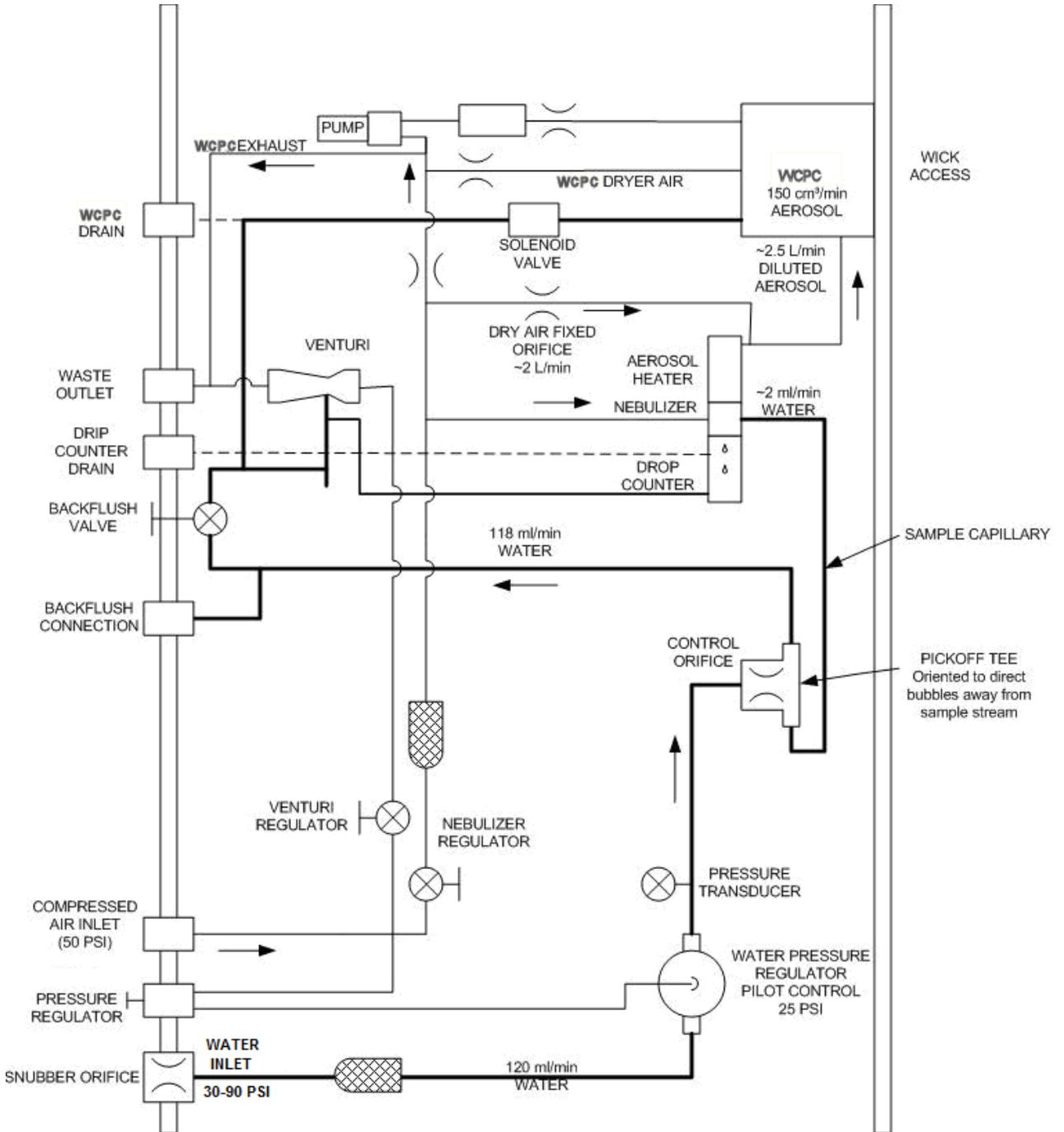


Figure 2: NRM 8000 Flow System



### How the Nebulizer Creates an Aerosol of Water Droplets

Ultrapure water flowing at approximately 120 mL/min enters the NRM 8000 through the WATER INLET connection on the back panel. The water passes through a sintered stainless steel filter (60  $\mu\text{m}$  pore size) that removes any large debris and then flows to an air actuated pressure regulator (shown in Figure 2 on page 7).

The pressure regulator allows you to control the water pressure. If someone inadvertently turns off the air supply, the pressure regulator closes and prevents water from entering the NRM - eliminating the potential of internal water leaks. By turning the WATER PRESSURE knob, you adjust the air pressure and therefore automatically adjust the water pressure - shown as a digital display (in psi) on the front panel.

From the pressure regulator, the water flows to the nebulizer through a tee fitting and a section of PFA microbore tubing. The PFA tubing gradually lowers the water pressure and prevents any out-gassing of dissolved gases in the incoming water. Within the nebulizer, the water and compressed air/nitrogen (supplied at a constant flow rate and pressure) combine to form a stable, poly-dispersed aerosol of ultrapure water droplets.

### Measuring the Flow Rate

The flow rate of water flowing through the nebulizer is used as an indicator that the NRM 8000 is set up and operating correctly. Instead of using a conventional flow meter, the NRM 8000 incorporates a new, patented method of measuring the flow rate. Of the water flowing through the nebulizer, 95% leaves it as part of a waste stream. The waste water is collected by a weir and stand-pipe system and then delivered as a steady stream of water droplets of identical size. These droplets fall through a simple light beam. As each droplet breaks the beam, a detector senses a scattered light signal, or pulse, and a counter keeps track of the pulses. An algorithm converts the pulse count to a flowrate (in mL/min.) which is shown on the front panel display.

### How the Nebulized Droplets are Dried

The ultrapure water droplets produced by the nebulizer are rapidly heated at 120°C. Each water droplet is evaporated to dryness, leaving behind a particle of residue consisting of dissolved inorganic material. Every nebulizer droplet results in a residue particle: the cleaner the ultrapure water, the smaller the amount of residue within each droplet, and the smaller the resulting residue particle.

After the heating, additional compressed air or nitrogen, is introduced from the supply to prevent re-condensation and to quickly move the residue particles to the WCPC.

## How the WCPC Counts the Residue Particles

The WCPC uses a patented technology to count residue particles. Water is used as the working fluid and mixing or adiabatic expansion techniques are not needed.

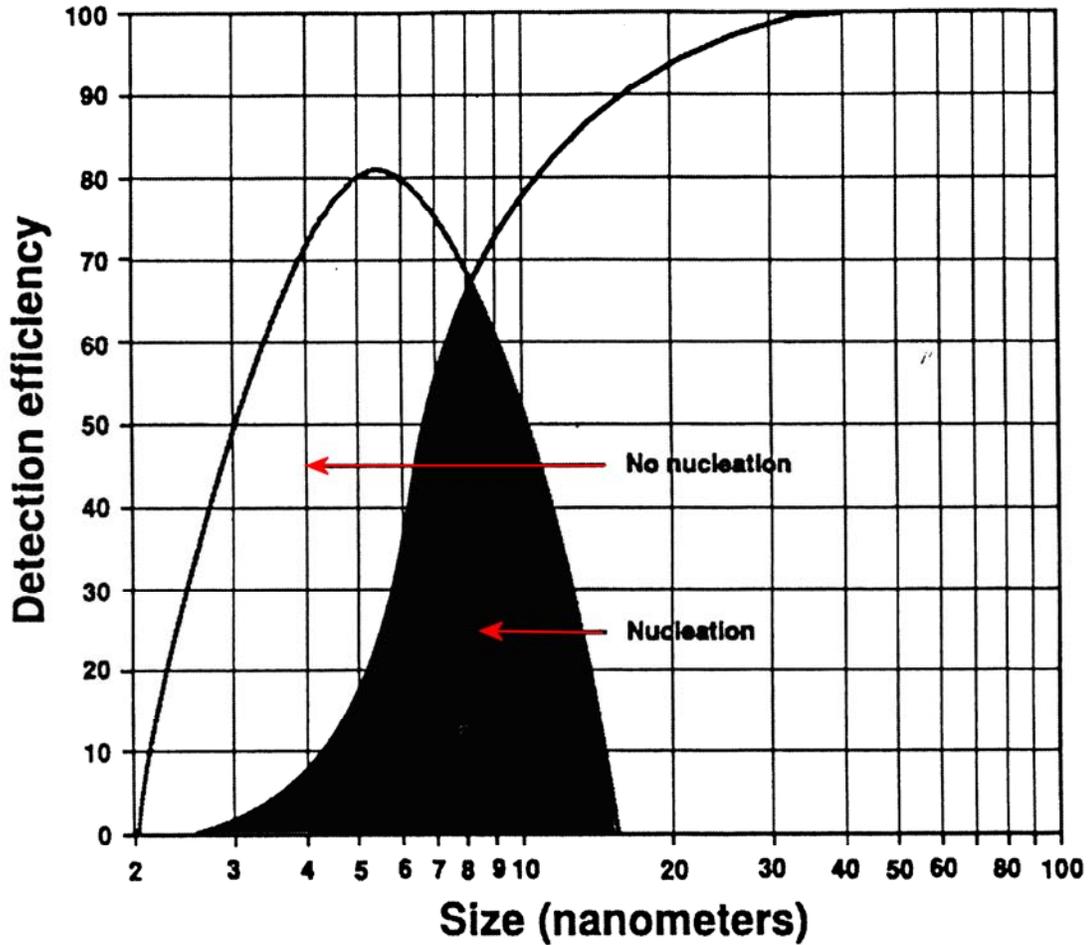
A condensation nucleation technique deposits water on the residue particles to grow them to a size that can be detected with a conventional optical counting system. The stream of residue particles is uninterrupted and follows a laminar flow path from the sample inlet to the optical detector. The WCPC particle counting process is as follows:

1. The residue particles are mixed with water vapor in the Saturator and then temperature equilibrated.
2. The residue particles pass to a growth tube where the wetted walls (composed of a porous medium) are heated to raise the vapor pressure. The high diffusivity of the water vapor allows the vapor to reach the center of the sample stream at a faster rate than the thermal diffusivity of the vapor can equilibrate to the higher temperatures near the walls – creating a supersaturated condition along the radius of the flow stream. These unstable conditions facilitate water condensation on the residue particles.
3. The residue particles that are larger than the detection limit of the WCPC particle critical size act as condensation nuclei as they pass up the growth tube.
4. The enlarged particles are detected by the optical detector.

### Particle Detection Efficiency

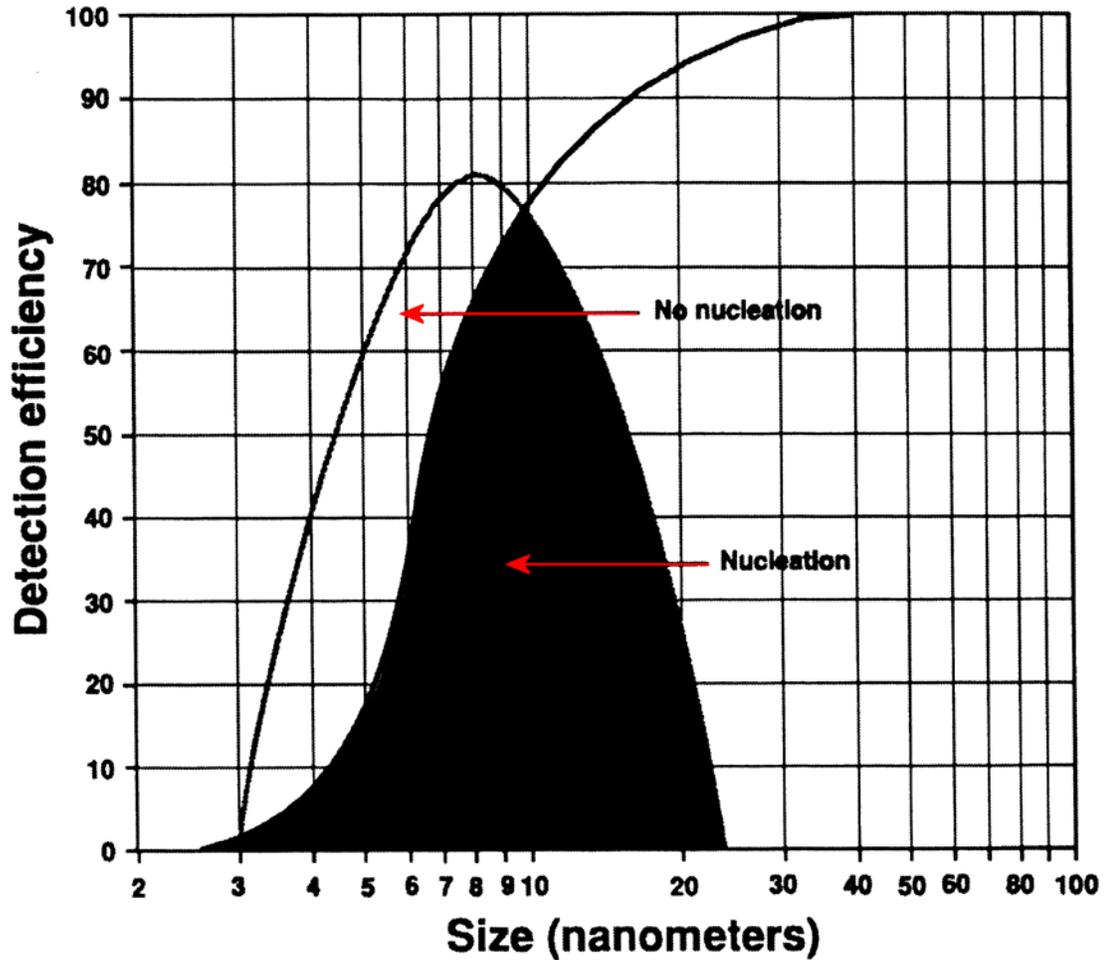
Like all particle counters, the lower detection efficiency of the WCPC is defined by a curve ranging from 0% efficiency (at some size), to 100 % efficiency (at a larger size). Figure 3, on page 10, shows a typical detection efficiency curve for the WCPC. The 50% efficiency point occurs at approximately 6.5 nanometers (half the particles at 6.5 nm act as sites of nucleation for subsequent particle growth in the WCPC's supersaturated water vapor, and half do not). The nebulizer produces a Gaussian size distribution of residue particles. Figure 3 shows the Gaussian curve superimposed on the WCPC detection efficiency curve.

Figure 3: WCPC Detection Efficiency Curve Superimposed on the Residue Particle Gaussian Size Distribution.



Particles to the left of the WCPC’s efficiency curve do not initiate nucleation and therefore are not counted by the WCPC. Particles to the right of the efficiency curve act as sites for nucleation and therefore are counted. If the ultrapure water becomes “dirtier,” or if the water contains an increased level of Potassium chloride (KCl) during calibration, each droplet from the nebulizer remains the same size, but contains more residue. Therefore, when the ultrapure water droplet dries, the resulting residue particle is larger. The Gaussian size distribution of the residue particles shifts to the right when superimposed on the WCPC’s efficiency curve. Figure 4, on page 11, shows this shift of the Gaussian Curve.

Figure 4: As the Water Becomes More Contaminated, the Gaussian Size Distribution Shifts to the Right.



### Calibrating the NRM 8000

The raw particle count must be converted from #particles/cm<sup>3</sup> to parts per trillion (ppt). This is achieved by calibrating the NRM 8000 with known amounts of Potassium Chloride (KCl). KCl in its dry form is an ideal compound for calibrating the NRM because:

- KCl has a purity level > 99.98%.
- KCl is non-toxic.
- KCl has a density that approximates to silica, one of the primary sources of nonvolatile residue found in ultrapure water.

During the calibration procedure, KCl is added to ultrapure water just upstream of the NRM using a custom-designed, motorized, syringe injection

system. The motorized syringe technique means the flow of water through the NRM is uninterrupted and the background impurity level is kept to a minimum. A calibration curve is plotted using a minimum of nine calibration points because nine points are necessary to accurately calibrate the NRM over its operating range. When the calibration curve is plotted, 18 points (spanning the NRM's operating range) are loaded into the NRM's Electrically Erased Programmable Read Only Memory (EEPROM).

Calibrating the NRM is a complex procedure - contact Fluid Measurement Technologies, Inc. at 651-762-7762 for all service and calibration issues. FMT Inc. and its authorized distributors offer annual on-site calibration. An NRM 8000 calibration usually takes two days to complete.

## How to Install the NRM 8000

### Installation Overview

Following is an overview of the steps required to get your NRM 8000 up and running. Please read the detailed instructions (beginning on page 14) for each step before you set up the NRM 8000.

1. Carefully unpack the NRM 8000. Save the original packing materials for use when shipping the NRM 8000 back to Fluid Measurement Technologies, Inc. for service, or for moving the NRM 8000 to a different location. (For details, see Unpacking the NRM 8000 on page 14.)



**Warning.** If the NRM 8000 is returned to 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 FMT, Inc. at 651-762-7762.

2. Check the packing list (see Table 1 on page 14) to make sure you received all essential components.  
**Note:** If any components are missing, or appear to be damaged, contact Fluid Measurement Technologies, Inc. at 651-762-7762.
3. Familiarize yourself with the way the NRM 8000 works. (For details, see How the NRM 8000 Works on page 5.)
4. Ensure you have all the necessary equipment for installing the NRM 8000. (For details, see Equipment You Need on page 16.)
5. Set up the NRM 8000 by connecting it to appropriate inputs, outputs and outlets and powering it on. (For details, see Setting up the NRM 8000 on page 16.)

## Unpacking the NRM 8000

To unpack the NRM 8000, follow these instructions:

1. Carefully remove the NRM 8000 from its shipping container. Save the original packing materials for use when shipping the NRM 8000 back to Fluid Measurement Technologies, Inc. for service, or for moving the NRM 8000 to a different location.



**Warning.** If the NRM 8000 is returned to 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 FMT, Inc. at 651-762-7762.

2. Place the NRM 8000 on a level surface.
3. Make sure there is an unrestricted air flow around the NRM. Fluid Measurement Technologies, Inc. recommends at least a 2-inch air gap on both sides and the top of the NRM. (Dimensions are shown in Table 2 and Figure 5 on page 15).
4. Allow the detector to reach ambient temperature, if necessary.
5. Make sure all the items listed in Table 1, were included in the NRM 8000 shipment. If any of the items are missing, or damaged, please call Fluid Measurement Technologies, Inc. at 651-762-7762

**Table 1: NRM 8000 Packing List**

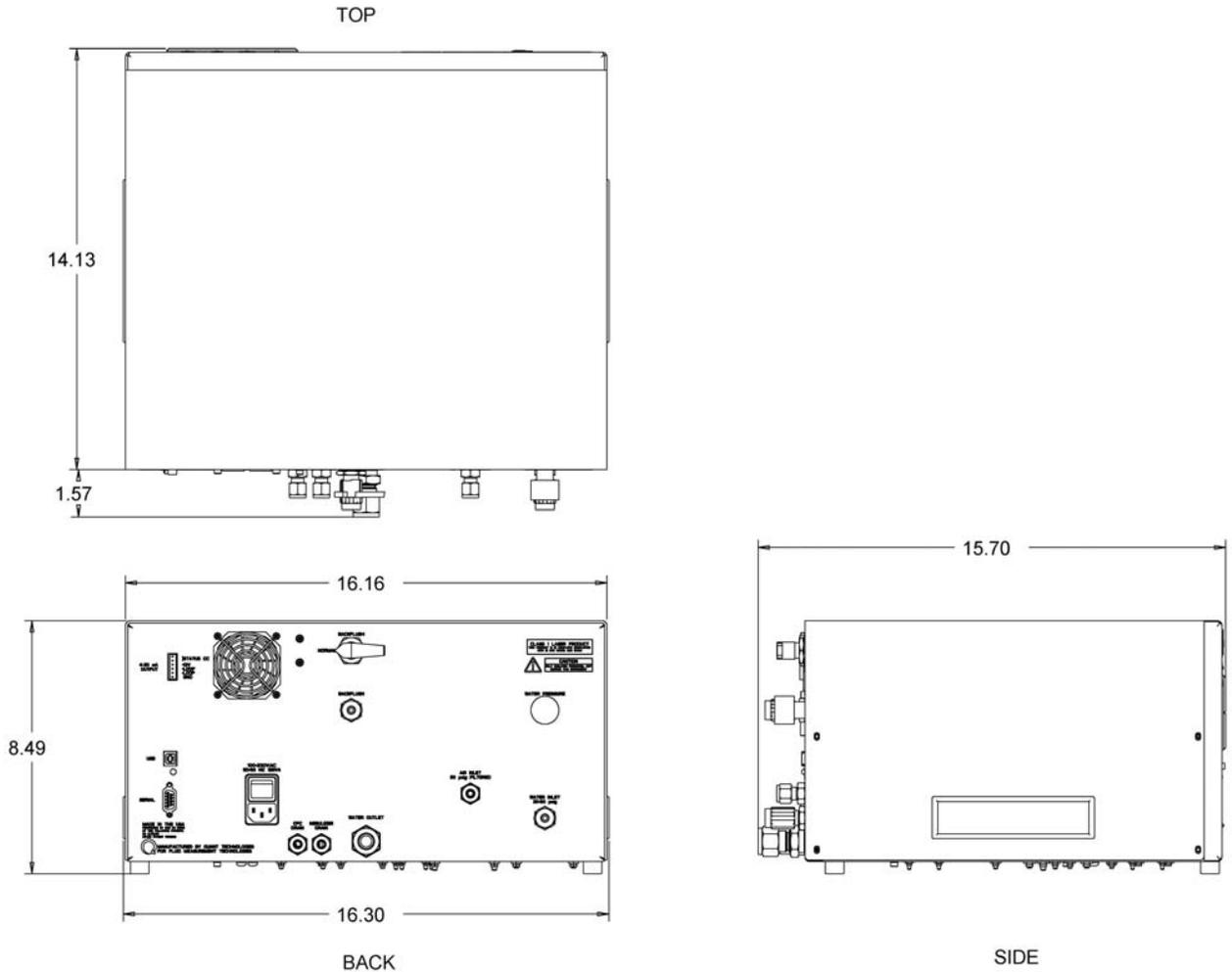
Part Number	Description	Quantity
Model 8000	Liquitrak® Nonvolatile Residue Monitor	1
1978000	User Manual, Printed	1
2679100	USB Flash Drive containing the NRM User Manual, NRM Monitoring Software (part # 1978100), and communication drivers	1
962003	USB 2.0 Cable	1
962002	RS 232 Serial Cable	1
2679050	Quick Installation Guide	1
1303053	Power Supply Cable (USA only)	1
3305007	7/64" Allen Wrench	1
2008001	Terminal Connector	1
2679000	Certificate of Calibration	1

Table 2: NRM 8000 Dimensions

Dimension	English	Metric
Height	8.49 in	21.57 cm
Width	16.16 in	41.05 cm
Width + Handle	16.30 in	41.40 cm
Depth	14.13 in	35.89 cm
Depth (including fittings)	15.7 in	39.88 cm
Depth of fittings	1.57 in	3.99 cm

Figure 5: Physical Space Requirements for the NRM.

Note: All dimensions shown in inches. Metric conversions are shown in Table 2.



### Equipment You Need

To ensure you have all the tools and equipment you need to install the NRM 8000, check the following list before you begin. If necessary, use the Flaretek and Swagelok nuts attached to the appropriate fittings on the back of the NRM. You will require the following items:

- A bench or instrument cabinet at the point of installation.
- An electrical power supply 115VAC to 230VAC.
- Water from the supply you want to monitor entering the NRM through a ¼-inch (outside diameter) Teflon PFA tube. **Note:** The tube must have a Flaretek nut in place and be flared for a Flaretek connection.
- Cleaned, dried compressed air, or nitrogen, regulated to 50 psi, entering the NRM through a ¼-inch (outside diameter) plastic tube fitted with a Swagelok nut.
- A ½-inch (outside diameter) plastic tube, fitted with a Swagelok nut, to drain waste water from the NRM.
- An adjustable wrench.
- A clean tube cutter.

**Note:** No tubing is supplied with the NRM.

### Setting up the NRM 8000

Setting up the NRM 8000 includes the following procedures:

- Connecting a compressed air or nitrogen supply. (For details, see Connecting the Compressed Air or Nitrogen Supply on page 17.)
- Attaching a drain for the waste water. (For details, see Connecting the Water Drain on page 18.)
- Connecting the NRM 8000 to your ultrapure water supply. (For details, see Connecting the Ultrapure Water Supply on page 18.)
- Connecting the power supply and powering on the NRM 8000. (For details, see Connecting the Power Supply and Adjusting the Water Inlet Pressure on page 19.)

All the installation procedures are performed at the back of the NRM - be sure you have enough room to perform them. Figure 6 below, shows the connectors and fittings on the back panel of the NRM.



**Warning.** The NRM 8000 can be tilted at an angle of up to 10° during normal operation. Do not tilt more than 10°. If you tilt at an angle >10°, water will flood the optics. If you plan to move or ship the NRM 8000, it must be drained first. Performing any of the following improper handling techniques may damage the instrument and will invalidate the warranty:

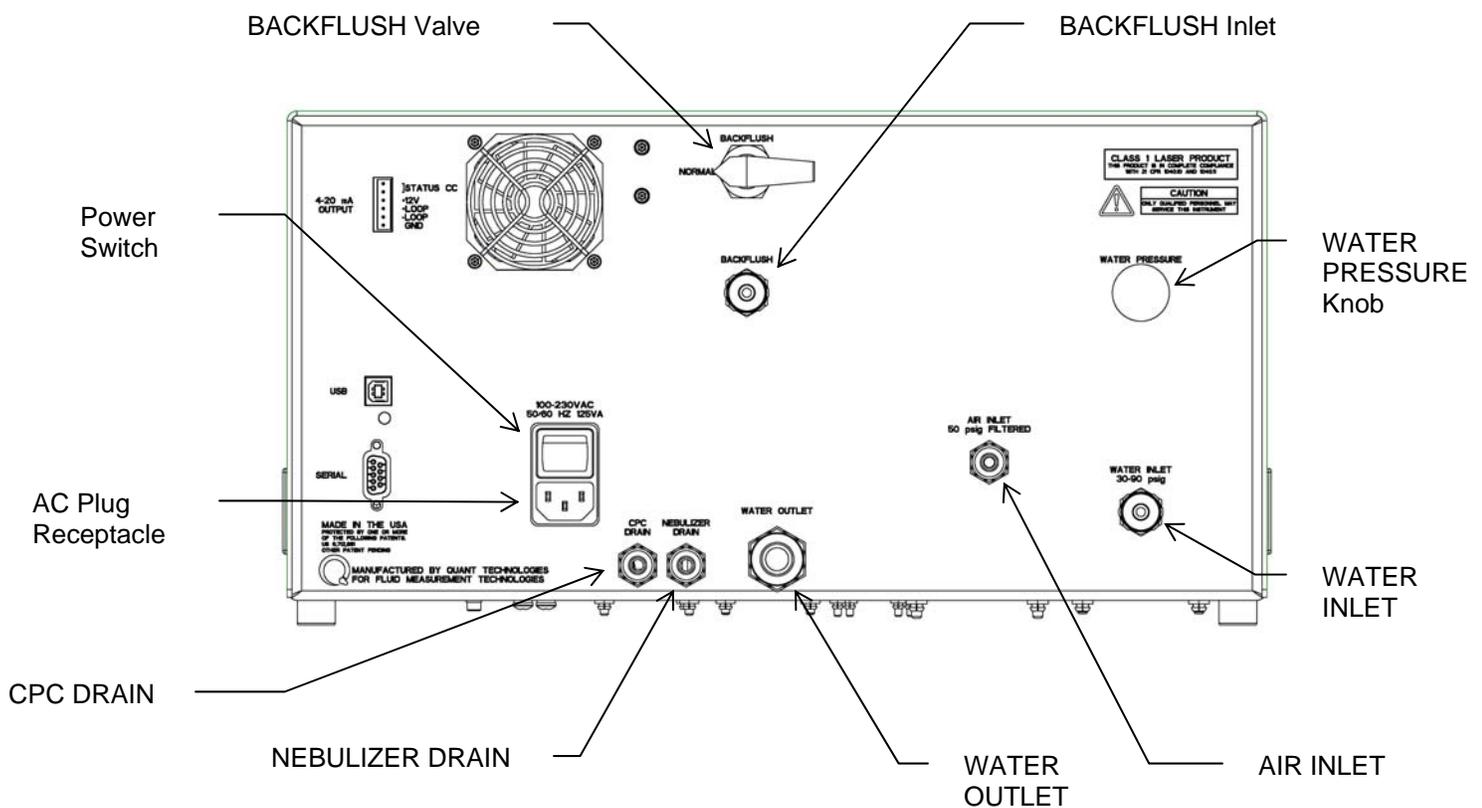
- Shipping/transporting an undried/undrained instrument.

- Tilting > 10° with the power on.
- Subjecting an undried/undrained instrument to freezing temperatures.



**Warning.** A fragile ceramic wick is located behind the wick access port. This ceramic wick should only be removed by a qualified service technician - unauthorized wick removal will void any warranty and necessitate return of the NRM 8000 to the manufacturer.

**Figure 6: Back Panel of the NRM.**



### Connecting the Compressed Air or Nitrogen Supply

The air or nitrogen supplied to the NRM 8000 must be filtered, dried, oil-free and regulated at 345 kPa (50 psi). Follow these instructions to connect the compressed air or nitrogen supply:

1. Remove the Swagelok nut and ferrule from the AIR INLET on the back panel. If you don't already have a nut connected to your tubing, use the Swagelok nut provided with the NRM 8000.

2. Make sure the compressed air, or nitrogen, is supplied to the NRM through a 1/4 inch (outside diameter) plastic tube. Insert the tube into the stainless steel Swagelok fitting on the back panel.
3. Using an adjustable wrench, tighten the Swagelok nut one-half turn past hand tight.
4. Turn on the air, or nitrogen, at the source. The incoming pressure must be regulated at 345 kPa (50 psi).

### Connecting the Water Drain

Most of the water entering the NRM 8000 drains away through the WATER OUTLET. A venturi within the NRM 8000 forces waste water out through the drain tube.

Follow these instructions to connect the water drain:

1. Remove the Swagelok nut from the WATER OUTLET on the back panel. If you don't already have a nut connected to your tubing, use this Swagelok nut.
2. Insert the 1/2-inch (outside diameter) plastic tube into the outlet's Swagelok fitting on the back panel.
3. Using an adjustable wrench, tighten the Swagelok nut one-half turn past hand-tight.

### Connecting the Ultrapure Water Supply

Water must be supplied to the NRM 8000 through a 1/4-inch diameter Teflon PFA tube specially adapted to fit the WATER INLET fitting. To prepare the PFA tube for attachment to the WATER 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 tube 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 using either:
  - A heat flaring tool provided by Entegris. (Customer service numbers: 952-556-4196 or 800-394-4083).
  - A cold flaring tool provided by Saint Gobain Performance Plastics. (Customer service numbers: 714-630-5818 or 800-833-5661).Follow the manufacturer's instructions for the flaring method you choose.
4. Flush ultrapure water through the tube for several minutes to remove any debris created by the flaring process.

5. Remove the Flaretek nut and transit plug from the WATER INLET fitting. Keep this Flaretek nut and plug for use when moving the NRM or returning the NRM to the factory. (See shutdown instructions on page 27).
6. Insert the tube into the WATER INLET fitting as far as it will go.
7. Hand-tighten the Flaretek nut.
8. Turn on the ultrapure water supply. Water then flows through the NRM 8000 and out through the waste line. Ensure the WATER INLET has no leaks. If you see any leaks, tighten the fitting.

### Connecting the Power Supply and Adjusting the Water Inlet Pressure

When the power supply is connected and the NRM 8000 has warmed-up, you can adjust the water pressure. To connect the power supply and adjust the water inlet pressure, follow these instructions:

1. Plug the supplied power cable into the AC plug receptacle on the back panel of the NRM 8000 (shown in Figure 6 on page 17).
2. Switch the power on. The NRM 8000 automatically begins its warmup procedure. The front panel display (shown in Figure 7 on page 20) informs you of the current status. **Note:** The warmup procedure can take up to 15 minutes to complete.
3. When the front panel displays a reading in ppt, press the DISPLAY button once. After pressing DISPLAY, the front panel shows raw particle counts in #/cm<sup>3</sup> and incoming water pressure in psi.
4. Adjust the WATER PRESSURE knob on the back panel until the water pressure reading on the front panel is 25 psi.

If you experience any problems installing your NRM 8000, please contact Fluid Measurement Technologies, Inc. at 651-762-7762.

## Operation Instructions

Once all installation procedures have been completed, you are ready to begin standard operation of the NRM 8000.

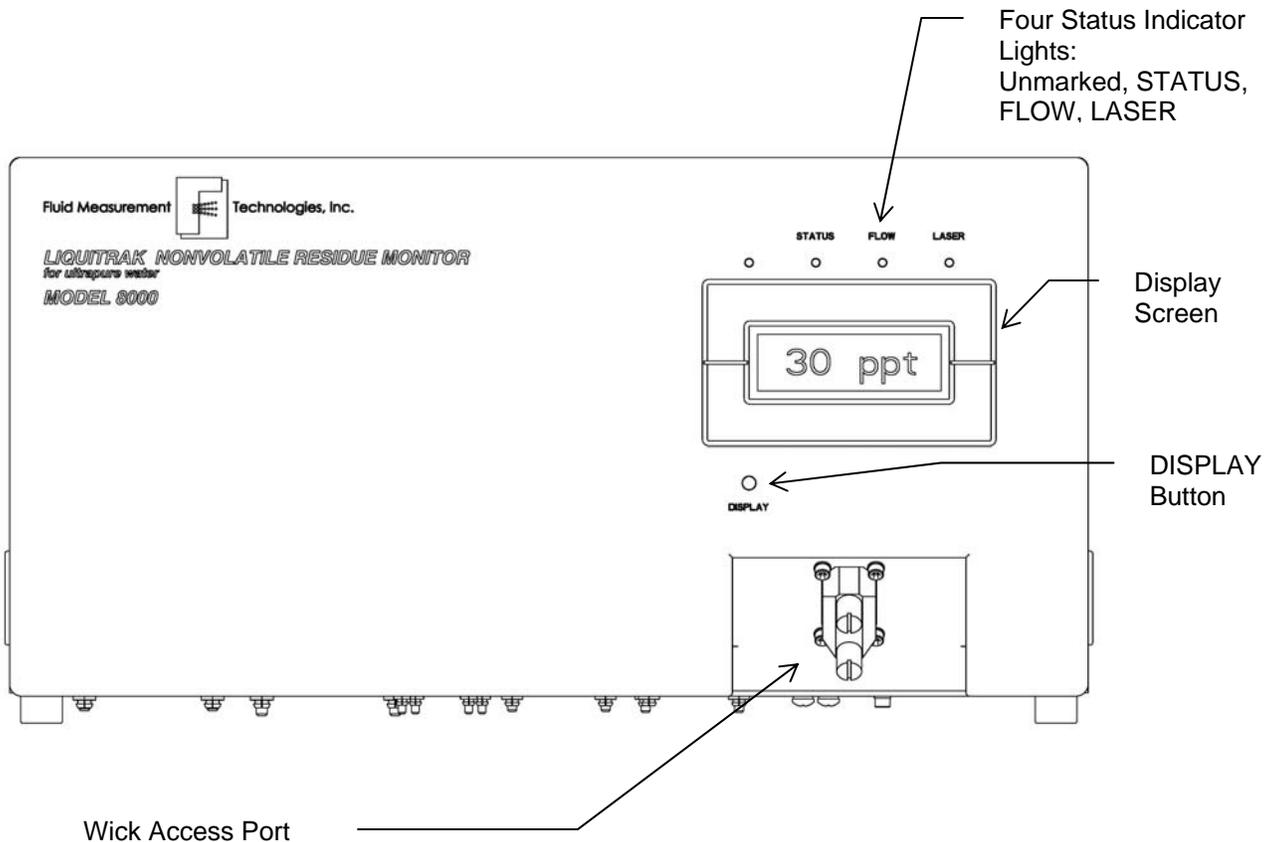
### The Front Panel

The front panel of the NRM 8000 is shown in Figure 7 below and described on the following pages.



**Warning.** Behind the wick access port is a fragile ceramic wick. Do not remove this wick - the wick should be replaced once every 12 months by a qualified service technician. Unauthorized wick removal will void any warranty and you will have to return the NRM to the manufacturer for repair.

Figure 7: NRM 8000 Front Panel.



### DISPLAY Button

Use the DISPLAY button to select the type of data or status information shown on the graphics display.

1. As the NRM 8000 warms up, use the DISPLAY button to toggle between the Warmup screen and the Status screen.
2. When the NRM warm up is complete, the Status Indicator light stops flashing and displays a steady green. Press the DISPLAY button to change the information shown on the graphics display – toggle between five different screens of information. An explanation of each screen is given on the following pages.

### Concentration(ppt) and Nebulizer Flow Rate Screen

The Concentration(ppt) and Nebulizer Flow Rate screen (shown in Figure 8 below) is the default display for the NRM 8000. It indicates residue concentrations and the nebulizer flow rate.

**Figure 8: Concentration Screen and Nebulizer Flow Rate**



The NRM 8000 collects residue concentration data in  $\#/cm^3$  every tenth of a second. This raw particle count data is accumulated and used to calculate and report residue concentration as parts per trillion (ppt). The displayed concentrations are based on the most recent five seconds of data and are updated each second. The displayed values range from 0 to 60,000 ppt.

During normal operation, the nebulizer flow rate should show a value between 1.5 mL/min and 3.0 mL/min. It can take up to 15 minutes for the nebulizer flow rate to stabilize after the NRM 8000 warms up.

### Raw Particle Count and Water Pressure Screen

The Raw Particle Count and Water Pressure screen, shown in Figure 9 on page 22, displays the raw particle count (from the WCPC) and the incoming water pressure. This screen is used by service technicians to determine whether the WCPC is functioning correctly, and to set the incoming water pressure.

Figure 9: Raw Particle Count and Water Pressure Screen



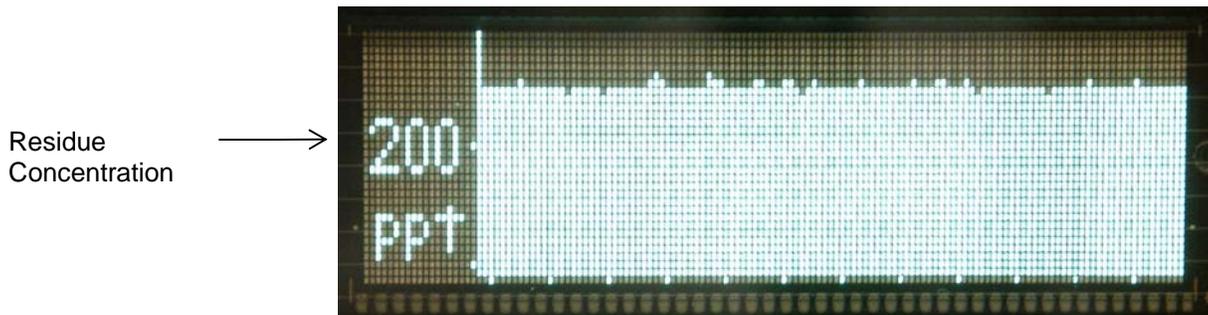
The raw particle count is a count of the number of residue particles formed as each nebulizer droplet is dried. It is not a particle count of particles present in the water (as measured by a conventional liquid-borne particle counter).

You can watch the water pressure value change on the display screen as you adjust the incoming water pressure with the WATER PRESSURE valve on the back panel (shown in Figure 6 on page 17). The water pressure should be between at least 30 psi.

#### Residue Concentration Screen

The Residue Concentration screen, shown in Figure 10 below, displays a bar graph of measured residue concentrations over a two-hour period. This graph allows you to monitor the residue data being collected.

Figure 10: Residue Concentration



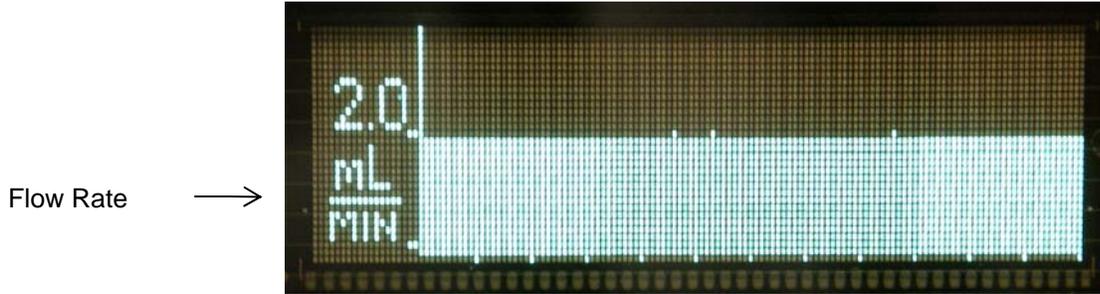
Every 60 seconds, new data is added on the right of the graph and the oldest data is dropped from the left. Each 60-second update is the average of 60 one-second readings stored in an internal buffer. The vertical scale on the graph is units of ppt residue concentration and automatically updates to include the highest recorded concentration over the two-hour period. The 60-second ppt value is reported over the Analog and Serial communications interfaces.

The NRM 8000 has no internal memory and therefore does not store data. To collect and store data, you must use the NRM 8000 software (see NRM 8000 Software on page 33).

### Nebulizer Flow Rate Screen

The Nebulizer Flow Rate screen, shown in Figure 11 below, displays a bar graph of the nebulizer flow rate over a two-hour time period. This graph allows you to check that water is flowing correctly through the nebulizer.

Figure 11: Nebulizer Flow Rate



Every 60 seconds, new data is added on the right of the graph, pushing old data off the left. The vertical scale is in units of mL/min and automatically updates to include the highest recorded flow rate over the two-hour period. The nebulizer flow rate is reported over the Serial communications interface.

### Status Screen

The Status screen, shown in Figure 12 below, displays information about the operating condition of the NRM. The values change as the NRM completes its warmup cycle. The Status Screen is used primarily by qualified service technicians.

Figure 12: Status Screen



Table 3 (on page 24) displays the parameters shown on the Status Screen, a brief description of each, and their normal ranges.

Table 3: Status Screen Parameters

Display Abbreviation	Explanation	Range
Neb	Nebulizer Temperature	35 ± 3°C (typical)
Optc	Optics Temperature	60 ± 1°C
GT	Growth Tube Temperature	60 ± 1°C
Sat	Saturator Temperature	25 ± 1°C
Evap	Residue Drying Temperature	120 ± 5°C
Photo	Photometric Reading	0 - 8000
AP	Atmospheric Pressure	990 millibars (typical)
Flow	Flow Rate through the WCPC	150 ± 5 cc/min

### Status Indicator Lights

The Status Indicator Lights (shown in Figure 7 on page 20) indicate the current operating status. The Status Lights are as follows:

- **Unmarked** light. **Flashes blue once** for each water droplet that falls through the nebulizer flow rate detector. A constant flashing blue indicates normal operation.
- **Status** light.
  - A **steady green glow** indicates the instrument has warmed to its operating temperature and the laser is running at its normal operating power.
  - A **slow blinking** (one blink per second) indicates that the operating temperatures are not within their normal operating range. If this condition persists after you have waited 30 minutes, contact Fluid Measurement Technologies, Inc. at 651-762-7762.
- **Flow** light.
  - A **steady green glow** indicates that the current sample flow rate is within 10% of its nominal value of 150 cm<sup>3</sup>/min.
  - A **rapid flashing** indicates that the flow >110% of its nominal flow. If this condition persists after you have waited 30 minutes, contact Fluid Measurement Technologies, Inc. at 651-762-7762.
  - A **slow flashing** indicates that the flow rate has dropped below 90%. If this condition persists after you have waited 30 minutes, contact Fluid Measurement Technologies, Inc. at 651-762-7762.
  - Light off** indicates that the pump is switched off.
- **Laser** light. A **steady green glow** indicates normal operation. If there is no green light, the laser is malfunctioning. In that situation, contact Fluid Measurement Technologies, Inc. at 651-762-7762.

### The Back Panel

The installation procedures are performed at the back of the NRM 8000. The back panel is shown in Figure 6 on page 17. Components of the back panel include the following:

- The AIR INLET, WATER INLET, WATER PRESSURE and WATER DRAIN fittings. (For details, see How to Install the NRM 8000 on page 13).
- The Data Communication ports on the left side of the back panel. (For details, see Data Acquisition beginning on page 29).
- The CPC DRAIN and NEBULIZER DRAIN ports. (For details, see How to Shut Down the NRM 8000 for Moving or Shipping on page 27).
- The BACKFLUSH valve. (For details, see Removing Water Flow Blockages below).

#### Removing Water Flow Blockages

The normal ultrapure water waste flow rate is approximately 150 mL/min. A low nebulizer flow rate or inadequate flow from the waste line may indicate a blockage, although this is an extremely rare occurrence. If an NRM 8000 orifice or tube becomes blocked, use the following backflush procedure to remove the blockage:

1. Turn off the water supply to the NRM 8000 and wait a few seconds for the water pressure to drop to zero. Confirm that the pressure is zero by looking at the Raw Particle Count and Water Pressure screen (see page 21).
2. Keep the NRM power turned on and the compressed air or nitrogen flowing.
3. Turn the BACKFLUSH valve from NORMAL to BACKFLUSH.



**Warning.** If you do not turn the valve to BACKFLUSH, water floods the NRM and causes significant damage.

4. Remove the Flaretek nut and cap from the BACKFLUSH Flaretek fitting.
5. Disconnect the water line from the WATER INLET fitting and connect it to the BACKFLUSH Flaretek fitting.
6. Prepare to collect the water that flows out of the WATER INLET fitting during the backflush procedure. For example, connect a piece of PFA tubing to the WATER INLET.
7. Turn on the water supply - water will now flow out of the WATER INLET fitting.
8. Allow the water to flow for about 5 minutes.
9. Turn off the water supply and disconnect the water line from the BACKFLUSH fitting.
10. Turn the BACKFLUSH valve from BACKFLUSH to NORMAL.

11. Replace the Flaretek nut and cap you removed in step 4.
12. Connect the water supply line to the WATER INLET Flaretek fitting and turn on the water supply. Note: It may take several minutes for the flow rates and drip counter to come back to regular operation. If, after waiting for 30 minutes, the flow rate and drip counter do not return to normal operating rates, contact Fluid Measurement Technologies, Inc. at 651-762-7762.

### How to Shut Down the NRM 8000 for Moving or Shipping

If you need to move the NRM 8000 to another lab or facility, or if you need to ship it for service work, read this section to familiarize yourself with the precautions you should take and the procedures you should follow.



**Warning.** The NRM 8000 can tolerate being tilted at an angle of up to 10° during normal operation. Do not tip more than 10°. If you tip the NRM 8000 at an angle >10°, water floods the optics. If you plan to move or ship the NRM, it must be drained first.

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 NRM 8000 for shipping, follow these instructions:

1. Turn off the water supply to the NRM 8000 and wait a few seconds for the water pressure to drop to zero (confirm that the pressure is zero by looking at the Raw Particle Count and Water Pressure Screen described on page 21).
2. Keep the NRM 8000 power turned on and the compressed air or nitrogen flowing into the AIR INLET on the back panel. Note: During this time, the solenoid valve for the WCPC's water reservoir will repeatedly open (with a characteristic "clicking" sound).
3. Turn the BACKFLUSH Valve from NORMAL to BACKFLUSH.



**Warning.** If you do not turn the valve to BACKFLUSH, water floods the NRM and causes significant damage.

4. Remove the Flaretek nut and cap from the BACKFLUSH Flaretek fitting.
5. Disconnect the water line from the WATER INLET fitting.
6. Attach a second clean air supply to the BACKFLUSH fitting.
7. Prepare to collect the small amount of water that flows out of the WATER INLET fitting. For example, connect a piece of PFA tubing to the WATER INLET.
8. Turn on the clean air supply and adjust the pressure to approximately 5 psi – the air will clear the water out of the WATER INLET fitting.
9. Allow the air to flow for about five minutes.
10. Turn off the air supply and disconnect the air line from the BACKFLUSH fitting.

## **NRM 8000: Shutting Down and Moving**

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11. Place a paper towel by the CPC DRAIN and NEBULIZER DRAIN ports on the back panel to collect the small amount of water that will drain.
12. Unscrew the CPC DRAIN and NEBULIZER DRAIN caps and keep them in a safe location for later use.
13. Turn the BACKFLUSH valve from BACKFLUSH to NORMAL.
14. Wait 24 hours. Then replace the caps on the CPC DRAIN and NEBULIZER DRAIN ports and turn off the air or nitrogen.
15. Replace the Flaretek nut and cap you removed in step 4.
16. Disconnect the air or nitrogen supply line and the water waste line and turn off the power.
17. Disconnect the power cord.
18. You should have saved the Flaretek nut and cap you removed when you installed the NRM. Place these on the WATER INLET port to prevent material from entering the port. The NRM is now prepared for shipping or moving.  
**Note:** If you did not save the original Flaretek nut and cap, find suitable alternatives or the NRM may become contaminated during transport.

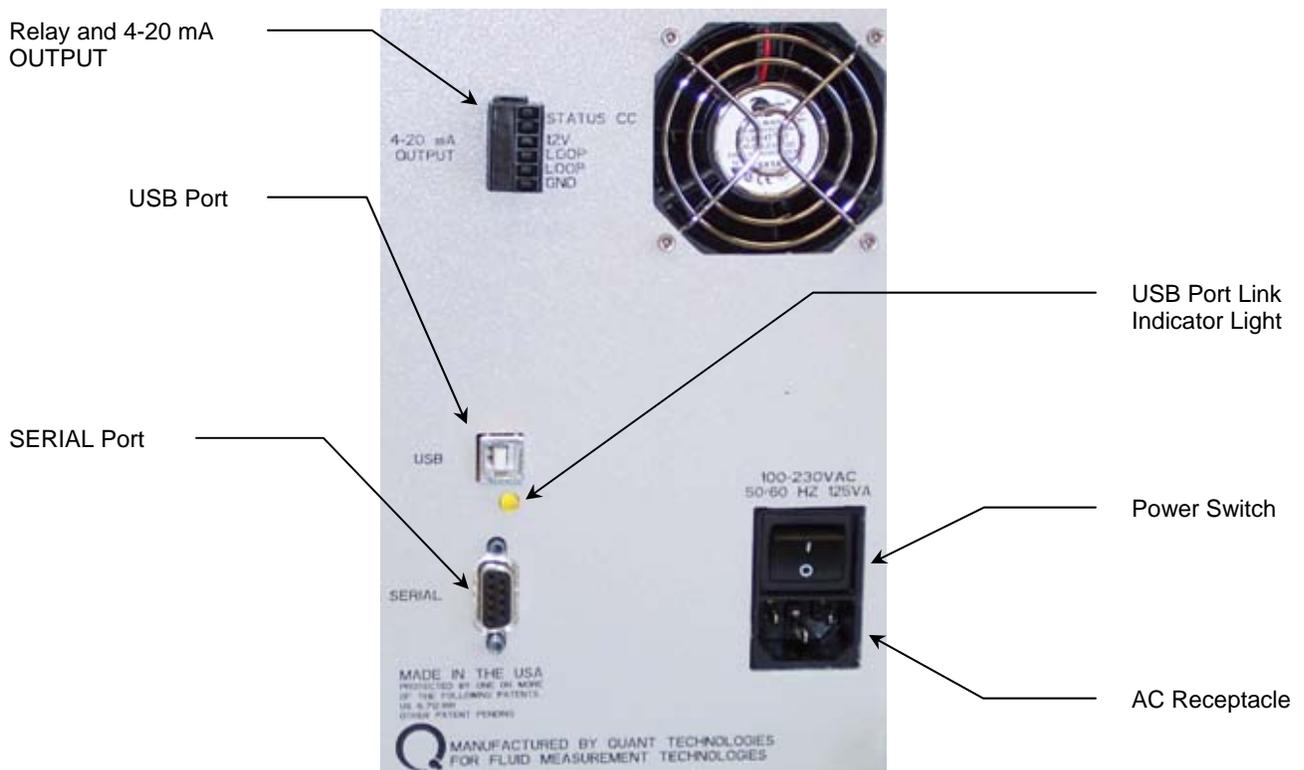
If you have any questions about shipping or moving the NRM 8000, contact Fluid Measurement Technologies, Inc. at 651-762-7762.

## Data Acquisition

NRM 8000 data is collected via Analog and Digital outputs. Figure 13 below shows the communication ports on the NRM 8000 back panel.

The NRM 8000 collects particle count data and stores the collection time each tenth of a second. This data is accumulated and used to calculate and report ppt and raw residue particle concentration. The NRM 8000 has no internal clock or any data storing capability beyond 60 seconds.

Figure 13: Communication Ports.



### 4-20 milliamp (mA) OUTPUT

The 4-20 mA analog output is updated every 60 seconds with a ppt value. The ppt value is the average of the 60 previous one-second ppt values and is shown on the display bar graph.

### Relay and 4-20mA Output Connector

**Table 4: Relay and 4-20 mA connections**

Pin #s	Connector	Description
1-2	Status CC	Status contact closure. These relay contacts close when the status LED is on.
3	12 VDC	Voltage source available for powering external 4-20mA loop interface (50ma max)
4	LOOP	Positive 4-20mA loop connection
5	LOOP	Negative 4-20mA loop connection
6	GND	Cabinet ground and power return for +12VDC source
		<b>Note:</b> +Loop and –Loop are an isolated transmitter pair and operate over a 8-30vdc range.

### Common Connections

The 2-wire 4-20 mA connector is a 2-wire transmitter (NRM) energized by the loop current where the loop source voltage is included in the receiver and the transmitter (NRM) floats. The +Loop and –Loop connections are connected to the receiver.

The 3-wire 4-20 mA connector is a 3-wire transmitter energized by a supply voltage at the transmitter (NRM). The transmitter sources the loop current and the transmitter common (GND) is connect to the receiver common. The 12VDC source is connected to the +LOOP and the receiver is connected to –LOOP and GND.

### Status Relay

The Status Relay contact on the back panel of the NRM 8000 allows you to monitor fault conditions. If the contact is closed, all of the following conditions are met:

- The NRM is powered on and has completed its warm-up.
- The WCPC aerosol pump is running and the aerosol flow rate is in range.
- The WCPC nozzle pressure is within range.
- The ambient absolute pressure is in range.
- The internal operating temperatures are within range.
- No laser fault is detected.
- The water pressure is >10 psi.
- No WCPC out-of-water fault exists.

If the contact is open, one or more of the conditions has not been met.

## USB and Serial Communication Ports

To allow flexible data collection and instrument control, the NRM 8000 provides the following data ports:

- **Serial.** Standard RS-232 type serial communications. This port is provided through the 9-pin D-Sub connector on the back panel of the NRM 8000 (shown in Figure 13 on page 29). The connector pin-out is given in Table 5 below. Note: This can be converted to provide an Ethernet connection if needed.
- **USB.** Universal Serial Bus communications. This port provides an alternate path for the serial interface mentioned above. To a host computer, this acts like an additional serial port.

**Table 5: Serial Connector Signal Communications**

PIN Number	Signal	Direction
2	RXD	Input to NRM
3	TXD	Output from NRM
5	GND	--

The Serial and USB data ports share a common communications channel to the NRM 8000 microcontroller, but data can only be received from one port at a time. The NRM 8000 sends a data record to the Serial or USB port once every 60 seconds. The USB link light flashes whenever data is transmitted.

- When a connection is linked to the USB port, the USB link indicator light is on and communications can be received from the USB Port, but not from the Serial port. The link indicator light flashes off whenever data is transmitted.
- When no connection is linked to the USB port, the USB link indicator light is off and communications can be received from the Serial port. The link indicator light flashes on whenever data is transmitted.

Once the Serial or USB connection is made between the NRM and a host computer, the NRM software can send and receive the firmware commands listed in Appendix D on page 47.

## Data Records

The data records (N records) reported via the RS-232 or USB ports contain residue concentration in ppt and particle concentration accumulated over the reporting time (which defaults on power up to 60 seconds). The N record also reports a long average value that is an average over the six previous ppt values in the N record. (See Appendix C, page 46, for more information about the N record.)

### Communications Parameters

All serial communications within the NRM use the following communications parameters:

- Baud Rate: 115,200
- Bits/Character: 8
- Stop bits: 1
- Parity: None

Communication protocols used in the N record:

- All data communication is preformed through ASCII based character codes.
- All multi-field responses are comma separated values (CSV).
- All input commands and output responses are terminated with a carriage-return (CR).
- All input Line-feeds (LF) codes are ignored.

### NRM 8000 Software

The NRM 8000 is a stand-alone instrument and can operate without being connected to a computer - the display gives a real time readout that can be used to monitor performance. However, using the NRM 8000 software allows you to collect data over time to monitor trends and incidents. Using the NRM 8000 software you can:

- Collect data on a local computer attached to the NRM 8000 with either a standard RS-232 serial cable (supplied) or a standard USB cable.
- Troubleshoot the NRM 8000 using the READ and SET commands described in Appendix D, beginning on page 47.
- Perform a calibration.

### Hardware and Software Requirements

The following items are **required** for successfully running the NRM software:

- A personal computer. Note: Clock speed and internal RAM are not critical for successful operation.
- A hard drive with >20MB free space. If you intend to store data over a long period of time (months or years), you will need at least a 100MB hard drive.
- A CD drive.
- Microsoft Windows® XP or Windows® 7 Operating system.

The following items are **recommended** for successfully running the NRM 8000 software:

- A USB port and a USB memory storage device for transferring the NRM 8000 data file.
- An uninterruptible power supply sized for your computer (250-450 VA) to prevent interruptions to data collection caused by power fluctuations.

If you have any questions about these requirements, contact Fluid Measurement Technologies, Inc. at 651-762-7762.

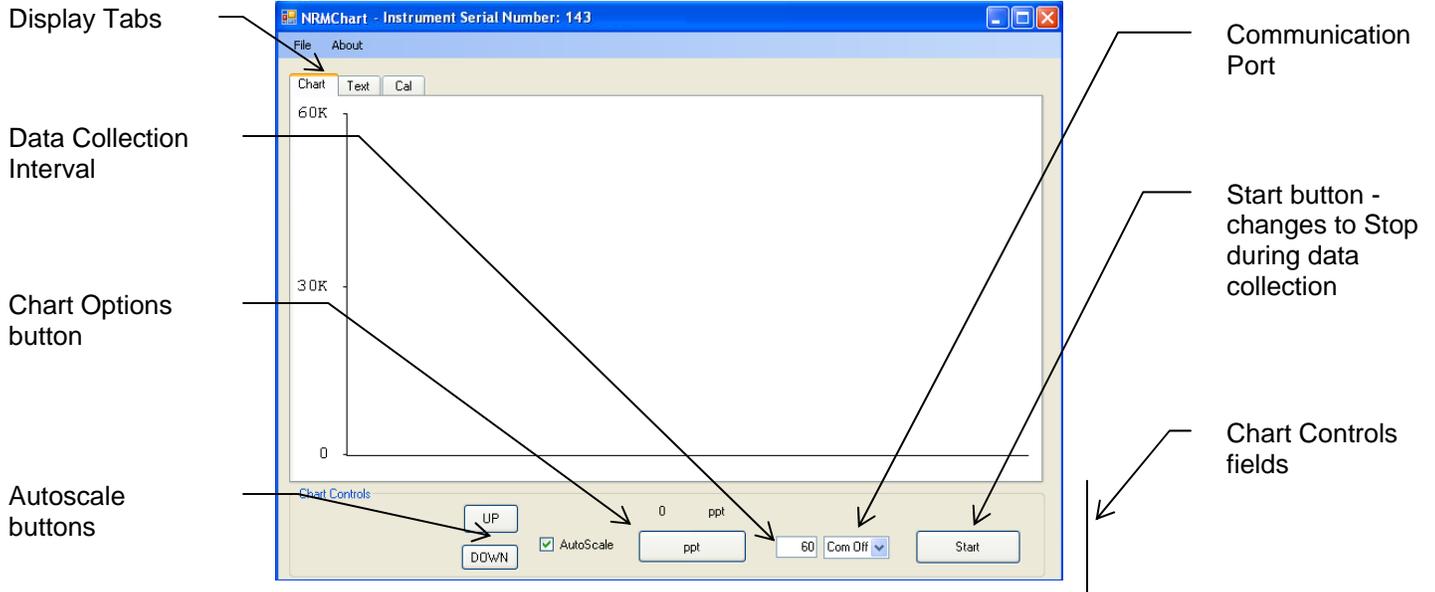
### How to Install and Start the Software

Follow these instructions to install the NRM 8000 software:

1. Connect the PC to the NRM 8000 using either the supplied RS232 cable (part # 962002) or the USB 2.0 cable (part # 962003).
2. Start the computer.
3. Insert the supplied USB flash drive into a USB port on the computer. Using Windows® Explorer, locate the USB flash drive and double-click on the Setup.exe icon.

4. Follow the instructions from the NRM Chart Setup Wizard. When the installation is complete, an icon labeled NRMChart appears on the desktop.
5. Remove the USB flash drive from the USB port.
6. Launch the NRM program by double-clicking on the NRMChart icon. You will see the main screen. An example of the main screen is shown in Figure 14 below.

Figure 14: Main Screen.



### How to Begin Data Collection

Follow these instructions to begin data collection:

1. Specify a communications port. (See detailed information on page 39.)
2. Check the data collection interval and reset if necessary. (See detailed information on page 39.)
3. Specify a location to store the data. (See detailed information on page 39.)
4. Click the Start button to begin collecting data. (See detailed information on page 39.)
5. Turn off autoscaling if necessary. (See detailed information on page 39.)

## Software Options

The following list is a summary of the options available on the main screen. Detailed information about these options can be found on the following pages.

- **Chart** tab. Allows you to select one of five available chart styles. The Chart Controls options at the bottom of the screen allow you to control the charts by doing the following:
  - Cancelling the auto-scaling option and manually adjusting the y axis.
  - Selecting the chart to be displayed.
  - Selecting the data collection interval (default is 60 seconds).
  - Selecting the communications port.
  - Starting and stopping data collection.
- **Text** tab. Displays the N records being transmitted to the serial communications port every 60 seconds as well as the reply to any READ and SET commands you have entered. (See Appendix D, beginning on page 47, for more information about the N record and the READ and SET commands.)
- **Cal** tab. Used to Read and Write calibration data to the NRM.  
 **Warning.** The calibration option should only be used by a qualified service technician. If you change the NRM calibration, you may see an error message and the NRM display and transmit values will be incorrect.
- **File** menu. Allows you to select where data will be stored on your computer.
- **About** menu. Tells you which version of the NRM Software you are running.

### Chart Tab

Use the Chart tab to display data in chart form and the Chart Controls options at the bottom of the screen to customize the charts. Click the chart options button to toggle through the following available options until you reach the one you want:

- ppt (See detailed information on page 36.)
- ppt Avg (See detailed information on page 36.)
- Neb Flow (See detailed information on page 37.)
- UPW Press (See detailed information on page 38.)
- Conc (See detailed information on page 38.)

The chart controls options are described beginning on page 39.

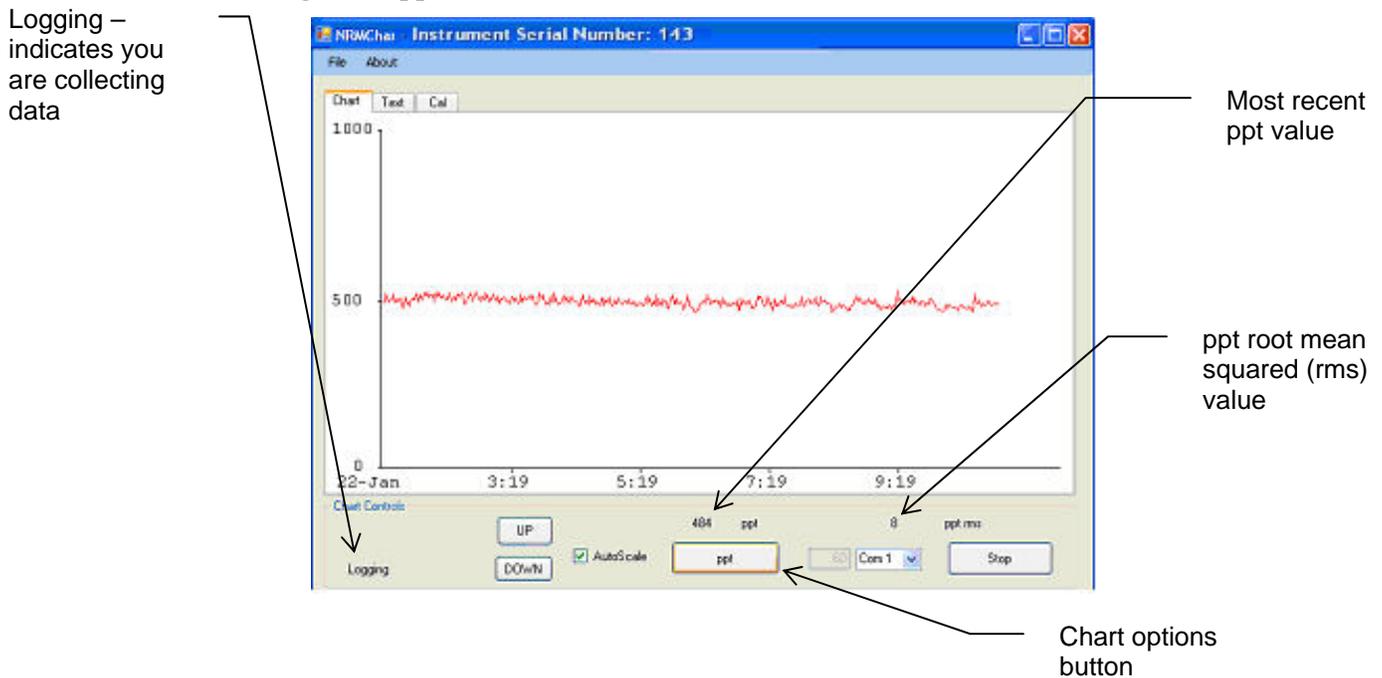
**Note:** The ppt rms values are displayed regardless of which chart is selected.

ppt

The default option, the ppt chart displays the data in parts per trillion. The ppt data is averaged over five intervals of collected data and the ppt root mean squared (rms) value of these five data points is displayed on the screen. Most ultrapure water systems have a stable ppt level and therefore an rms value <10.

Figure 15 is an example of a ppt chart. When you have selected the data logging option from the File menu, **Logging** is displayed on the screen. If you cannot see the word **Logging**, you are not collecting data. (For details see Log the NRM Data to a File on page 39.)

Figure 15: ppt Chart

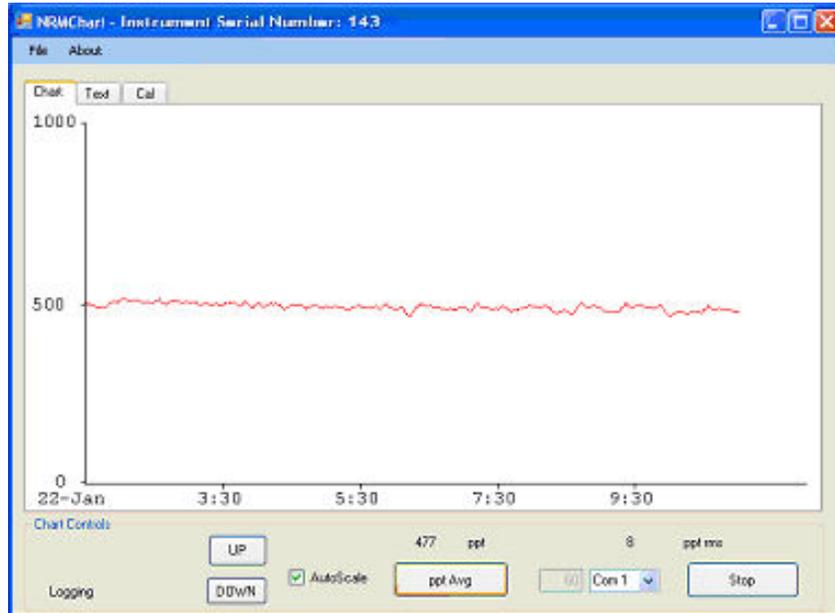


ppt Average (ppt Avg)

If your ppt value is unstable, use the ppt Average chart to smooth out the data. The ppt data is averaged over five intervals of collected data and shown on the ppt Average chart.

Example: If the Data Collection interval is 60 seconds, the ppt Average data is displayed every five minutes. Figure 16, on page 37, shows an example of a ppt Average chart.

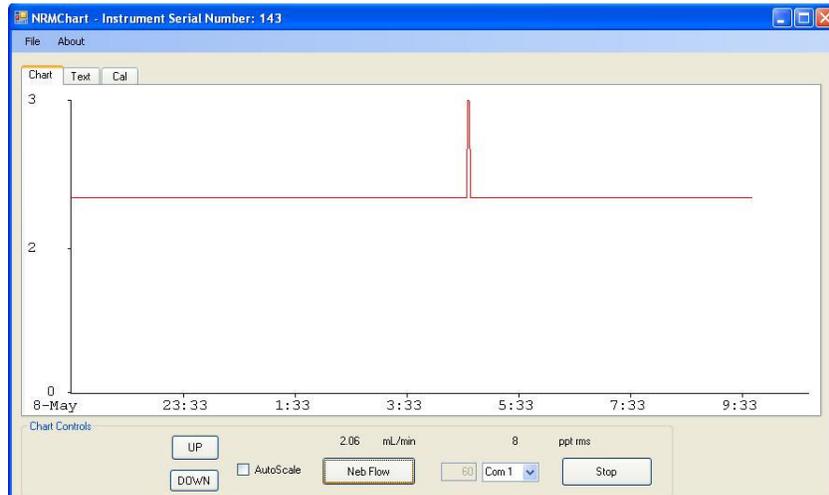
Figure 16: ppt Average Chart



### Nebulizer Flow (Neb Flow)

The Nebulizer Flow chart displays the flow rate (in mL/min) of ultrapure water through the nebulizer. Figure 17 is an example of a Nebulizer Flow chart.

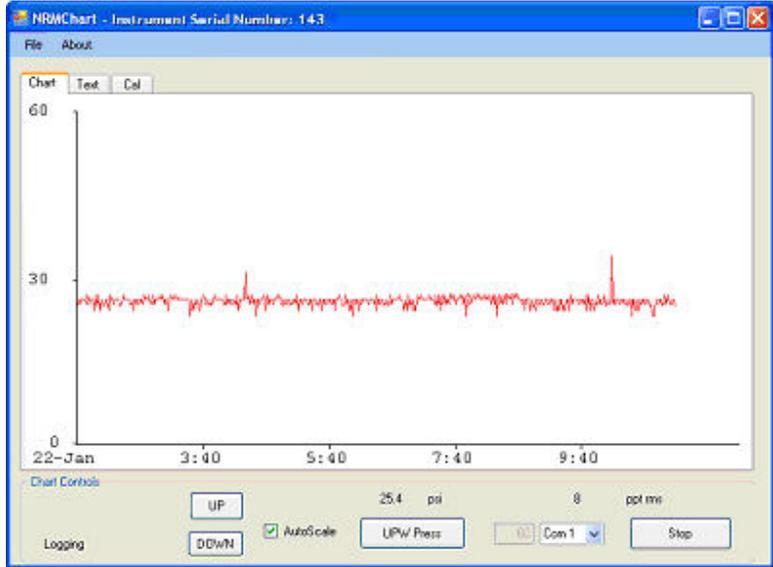
Figure 17: Nebulizer Flow Chart



### Ultrapure Water Pressure (UPW Press)

The Ultrapure Water Pressure chart displays the ultrapure water pressure (in psi) over the data collection interval. Figure 18 shows an example of an Ultrapure Water Pressure chart.

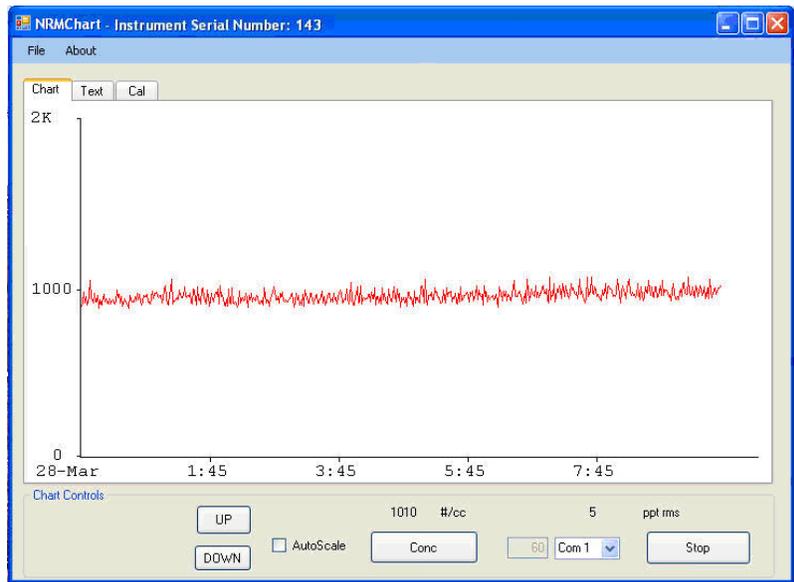
Figure 18: Ultrapure Water Pressure Chart



### Concentration (Conc)

The Concentration chart displays the raw residue count (in particles/cm<sup>3</sup>) from the WCPC. It is primarily used by the service technician for troubleshooting purposes. Figure 19 shows an example of a Concentration chart.

Figure 19: Concentration Chart



### Chart Controls

#### Specify a Communications Port

The default value for the data communications is **Com Off**, indicating that the Communications port is off. Choose a communications port option from the drop-down menu. If you are not sure which communications port to select, first choose **Com 1** (the most commonly used port). If you are using a USB cable, choose **Com 2**. If your choice of communication port is successful, data is displayed on the screen after the first data collection interval.

The supplied USB flash drive (part # 2679100) contains several communications drivers. If you see a message (after connecting the USB cable) requesting an additional driver, insert the USB flash drive into a USB port on your computer and the appropriate driver will download.

If you do not see data, your computer is malfunctioning and you should contact your internal technical support.

#### Set the Data Collection Interval

The data collection interval is applied to all data collected with the NRM 8000 software. The default value for the data collection interval is 60 seconds – the recommended interval. To change the data collection interval, click 60 and then enter a value of your choice. That value will become the new data collection interval (in seconds).

#### Log the NRM 8000 Data to a File

You can specify a location to store the NRM 8000 data. Select **Log** from the **File** menu. Choose the directory where you want the data stored and a file name for the stored data, select **Save** and return to the main screen. **Note:** Data is stored as comma separated values (csv) for easy manipulation by Microsoft Excel.

#### Collect Data

To begin collecting data, click the **Start** button. The first data point is shown on the left side of the screen after the data collection interval has passed.

#### Set the Autoscaling

Autoscaling is set as the default and allows you to fit the data to the chart. Without autoscaling, you may have data peaks that go off the chart.

To turn off autoscaling, follow these instructions:

1. Click the autoscaling field on the main screen.
2. Use the UP and DOWN arrows to adjust the y-axis scale.

## Text Tab

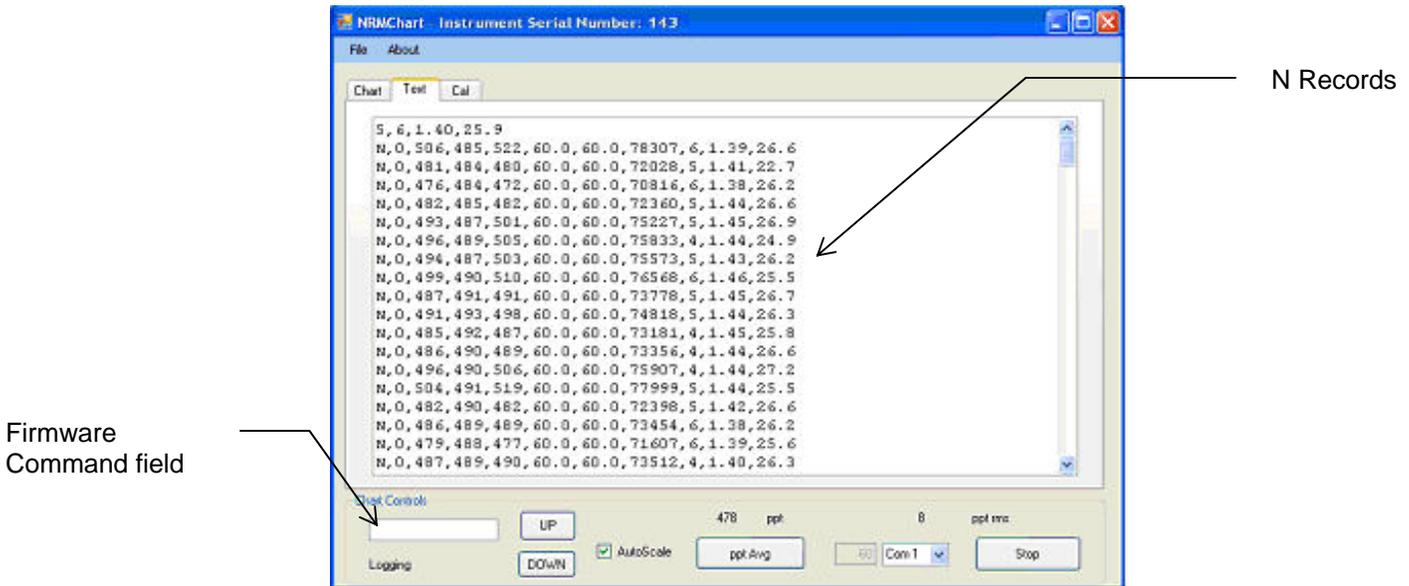
The text tab allows you to display the data in text form instead of in chart form. The N records are collected at the specified data collection intervals and displayed in a series. An example of the Text tab showing a series of N records is shown in Figure 20 below. For more information about the N record, see Appendices C and D.

The Text tab also displays responses to the Firmware READ and SET Commands. These responses are recorded whenever you enter a READ or SET command in the Firmware Command field (shown in Figure 20 below) and press the Enter key. READ and SET command data is shown interspersed with the N records. The available READ and SET commands are listed in Table 6 on page 41 and are described in more detail in Appendix D, beginning on page 47.



**Warning.** Only a qualified service technician should use the SET commands. If these commands are used incorrectly, the operation of the NRM 8000 is adversely affected.

Figure 20: Text tab



**Table 6: Firmware Commands**

<b>Command</b>	<b>Explanation</b>
RL	<b>Read Laser</b>
RRA	<b>Read Record raw Analog</b>
RRC	<b>Read Record Control</b>
RRN	<b>Read Record NRM data</b>
RRS	<b>Read Record Status</b>
RTO	<b>Read power-On Time</b>
RV	<b>Read Version</b>
S4S	<b>Set 4-20ma Span</b>
S4Z	<b>Set 4-20ma Zero</b>
SBS	<b>Set Nebulizer Set Point</b>
SBV	<b>Set Nebulizer Flow Volume Scale Factor</b>
SCT	<b>Set Calibration Table</b>
SDO	<b>Set Detector Offset</b>
SDS	<b>Set Dead-time Span</b>
SDT	<b>Set Detector Threshold</b>
SDZ	<b>Set Dead-time Zero</b>
SE	<b>Set Evaporator On/Off</b>
SES	<b>Set Evaporator Set Point</b>
SFS	<b>Set Flow Set point</b>
SFZ	<b>Set Flow Zero value</b>
SG	<b>Set Growth heater on/off</b>
SGS	<b>Set Growth tube temperature Set point</b>
SL	<b>Set Laser on/off</b>
SLS	<b>Set Laser Set point</b>
SM <sub>x,t</sub>	<b>Set Mode x=mode t=sample time in tenth of second</b>
SO	<b>Set Optics heater on/off</b>
SOS	<b>Set Optics temperature Set point</b>
SP	<b>Set Pump on/off</b>
SR <sub>x,y</sub>	<b>Set 4-20ma Range x=min PPT y=max PPT</b>
SS	<b>Set Saturator temperature controller on/off</b>
SSS	<b>Set Saturator temperature Set point</b>
SZ	<b>Set auto Zero function</b>

## Cal Tab



The Cal tab should only be used by a qualified service technician to calibrate the NRM 8000. Do not use the Cal tab during normal operation of the NRM 8000 – you may inadvertently change the NRM 8000’s calibration settings. For reference, an example of the data on the Cal tab is shown in Figure 21 below.

Figure 21: Cal Tab data.

PPT	Conc #/cc	PPT	Conc #/cc
10	5	1000	1750
20	11	2000	3250
30	16	3000	4700
60	33	6000	8950
100	54	10000	14300
200	108	20000	26900
300	175	30000	38700
600	680	60000	73000

Read button – used by the service technician to populate the calibration data.

Write button – used by the Service Technician to update the calibration data.

Calibration data.

### Troubleshooting

There are no user-serviceable parts inside the NRM 8000. All repair and maintenance must be performed by a qualified service technician.

When working with the NRM:

- 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.

You can use the READ and SET commands described in Appendix D, beginning on page 47, for basic troubleshooting.

Occasionally orifices or tubes within the NRM 8000 become blocked. This is indicated by a low Nebulizer flow rate or an inadequate waste water flow. If this occurs, perform the Backflush procedure described in Removing Water Flow Blockages on page 25.

### Appendix A: Acknowledgements

#### Acknowledgments

The NRM 8000 owes its extraordinary specifications to the continuous, laminar flow Water-based Condensation Particle Counter from Aerosol Dynamics Inc. of Berkeley, CA. We currently license the WCPC technology from Aerosol Dynamics. We give our sincere thanks to Susanne V. Hering PhD and Mark R. Stolzenburg PhD, both of Aerosol Dynamics, for their invention and their clever insights to this unique technology.

## Appendix B: NRM 8000 Specifications

**Table 7: NRM 8000 Specifications**

Displayed Measurement Range	1 – 60,000 ppt
Response time to impurity change	< 90 seconds
Sample Flow Rate	Between 1.5 and 3.0 mL/min (Calibrated Drip Counter Flow Meter)
Total Flow Rate	150 mL/min
Inlet Water Pressure	207-621 kPa, 30-90 psig (The water drain must be open to the atmosphere and able to take a flow of 150 mL/min.)
Compressed air flow rate/pressure	25L/min at 345 kPa, 50 psig Note: Compressed air must be dry and particle free. Nitrogen can be substituted for compressed air.
Residue Drying Temperature	120°C, 248°F
Wetted Surface Materials	Sapphire, PFA Teflon®, PTFE, 316L Stainless Steel
Detector Working Fluid	Water supplied by the UPW system
Ambient Temperature Range	15-35°C, 59-95°F
Ambient Relative Humidity Range	0-85%
Maximum Water Temperature	80°C, 176°F
Dimensions (WxDxH)	21.6(h)x41.4(w)x39.8(d) cm, 8.5(h)x16.3(w)x15.7(d) inches. Note: Depth measurement includes the fittings on the back panel.
Weight	8Kg, 18 lbs
Power	Universal 100-230 VAC, 50/60 Hz, 125 VA
Outputs	USB, RS-232 and 4-20 mA, Ethernet adapter available
Ultrapure Water Inlet	¼ inch PFA Flaretek®
Waste Outlet	½ inch SS Swagelok®
Compressed Air inlet	¼ inch SS Swagelok®
Software	Data acquisition program included, Windows® XP or Windows® 7 platform required

Flaretek® is a registered trademark of Entegris, Inc.

Swagelok® is a registered trademark of Swagelok Company.

Teflon® is a registered trademark of E.I. DuPont de Nemours and Company, Inc.

Windows® is a registered trademark of Microsoft Corporation.

Specifications subject to change without notice.

### Appendix C: Data Reporting Records

The NRM 8000 displays data in real time on the front panel display. You can collect data records over time and export them in text form using the NRM 8000 software. Data records in text form include the following:

- N Records.
- S Records. Used by qualified service technicians for troubleshooting.
- A Records. Used by qualified service technicians for troubleshooting.
- C Records. Used by qualified service technicians for troubleshooting.

#### N Record (Data)

N records are collected according to the interval you have specified (such as every 60 seconds) and displayed in a series on the Text tab. They are displayed indefinitely as long as data collection is set up and the NRM 8000 is powered on. They can also be displayed if you enter the command RRN in the Firmware Command field. They display information about the functioning of the NRM 8000. A more detailed description is given in RRN – Read Record NRM Data on page 48.

#### S Record (Status)

S records are displayed on the Text tab when you enter the command RRS in the Firmware Command field. They display status information. A more detailed description is given in S Record (Status) on page 51.

#### A Record

A Records display the current raw analog values on the Text tab when you enter the command RRA in the Firmware Command field. They are used by qualified service technicians for diagnostic purposes. A more detailed description is given in A Record on page 50.

#### C Record

C records display the current control values for flow and temperature and are displayed on the Text tab when you enter the command RRC in the Firmware Command field. They are used by qualified service technicians for diagnostic purposes. A more detailed description is given in C Record on page 51.

## Appendix D: Firmware Commands

Table 8 is a quick reference of all the firmware commands. More detailed information about each command can be found on the referenced pages.

**Note:** The commands are not case sensitive.

**Table 8: Firmware Commands**

<b>Command</b>	<b>Explanation</b>
<b>Read Commands</b>	
RL	Read <b>L</b> aser (see page 50)
RRA	Read <b>R</b> ecord raw <b>A</b> nalog (see page 50)
RRC	Read <b>R</b> ecord <b>C</b> ontrol (see page 51)
RRN	Read <b>R</b> ecord <b>N</b> RM data (see page 48)
RRS	Read <b>R</b> ecord <b>S</b> tatus (see page 51)
RTO	Read power- <b>O</b> n <b>T</b> ime (see page 52)
RV	Read <b>V</b> ersion (see page 52)
<b>Set Commands</b>	
S4S	Set <b>4</b> -20ma <b>S</b> pan (see page 54)
S4Z	Set <b>4</b> -20ma <b>Z</b> ero (see page 55)
SBS	Set <b>N</b> ebulizer <b>S</b> et <b>P</b> oint (see page 55)
SBV	Set <b>N</b> ebulizer <b>F</b> low <b>V</b> olume <b>S</b> cale <b>F</b> actor (see page 56)
SCT	Set <b>C</b> alibration <b>T</b> able (see page 56)
SDO	Set <b>D</b> etector <b>O</b> ffset (see page 58)
SDS	Set <b>D</b> ead-time <b>S</b> pan (see page 58)
SDT	Set <b>D</b> etector <b>T</b> hreshold (see page 58)
SDZ	Set <b>D</b> ead-time <b>Z</b> ero (see page 59)
SE	Set <b>E</b> vaporator <b>O</b> n/ <b>O</b> ff (see page 59)
SES	Set <b>E</b> vaporator <b>S</b> et <b>P</b> oint (see page 59)
SFS	Set <b>F</b> low <b>S</b> et <b>P</b> oint (see page 60)
SFZ	Set <b>F</b> low <b>Z</b> ero <b>V</b> alue (see page 61)
SG	Set <b>G</b> rowth <b>H</b> eater <b>O</b> n/ <b>O</b> ff (see page 61)
SGS	Set <b>G</b> rowth <b>T</b> ube <b>T</b> emperature <b>S</b> et <b>p</b> oint (see page 62)
SL	Set <b>L</b> aser <b>O</b> n/ <b>O</b> ff (see page 62)
SLS	Set <b>L</b> aser <b>S</b> et <b>P</b> oint (see page 63)
SM,x,t	Set <b>M</b> ode <b>x</b> =mode <b>t</b> =sample time in tenth of second (see page 53)
SO	Set <b>O</b> ptics <b>H</b> eater <b>o</b> n/ <b>o</b> ff (see page 63)
SOS	Set <b>O</b> ptics <b>T</b> emperature <b>S</b> et <b>p</b> oint (see page 64)
SP	Set <b>P</b> ump <b>O</b> n/ <b>O</b> ff (see page 64)
SR,x,y	Set 4-20ma <b>R</b> ange <b>x</b> =min PPT <b>y</b> =max PPT (see page 65)
SS	Set <b>S</b> aturator <b>T</b> emperature <b>C</b> ontroller <b>O</b> n/ <b>O</b> ff (see page 65)
SSS	Set <b>S</b> aturator <b>T</b> emperature <b>S</b> et <b>P</b> oint (see page 66)
SZ	Set <b>A</b> uto <b>Z</b> ero <b>F</b> unction (see page 66)

### Read Commands

Read Commands are used to display specific data values. The values, associated parameters, responses returned by the NRM 8000 and examples are given on the following pages. The RRN command creates N records. The other Read commands are supplemental and intended for use by a qualified service technician.

#### RRN - Read Record NRM Data

RRN returns the current data values in the N record format. N records are collected every 60 seconds (or whatever time period you have specified for the data collection interval) and displayed in a series on the Text tab. They can also be displayed if you enter the command RRN in the Firmware Command field.

<b>RRN</b>		
Command	RRN	
Response		N Record.

The N record displays 11 columns of data.

#### Example of N Record

N,0,393,393,207,6,6,3117,97,3.15,20.04

Reading from left to right, the columns in the example (and on the screen) represent the following:

Record type	Flag	Real ppt	Avg ppt	Particle Concentration	Sample Time	Live Time	Counts
N	0	393	393	207	6	6	3117
Photo	Nebulizer Flow	UPW Pressure					
97	2.15	20.4					

**Note:** The values are raw analog values. An explanation of the values can be found on page 49.

When the N record is exported, a Log record is created in csv format. The Log record adds the date, and time at the beginning of the record and the Root Mean Squared (RMS) value at the end.

Example: N Record, N,0,393,393,207,6,6,3117,97,3.15,20.04

Log record: 5/24/2014 23:59,N,0,393,393,207,6,6,3117,97,3.15,20.04,6

### Explanation of N Record Values:

- **Flags.** Status Flags (Hexadecimal). The number in the N record may be a combination of the values of more than one flag.

#### Explanation of Status Flags

Weighting	Description
-----------	-------------

- |     |   |
|-----|---|
| 0   | No flag.  |
| 1   | Over range (concentration).   |
| 2   | The aerosol flow was out of range for some portion of the sample.   |
| 4   | Nozzle flow error occurred during the sample.   |
| 8   | Absolute pressure out of range for some portion of the sample.  |
| 10  | Saturator, Growth Tube, Optics, Nebulizer or Evaporator temperatures were out of range during the sample. |
| 20  | WCPC is in the warmup period.   |
| 40  | Reserved.   |
| 80  | The laser error occurred during some portion of the sample.   |
| 100 | Low water pressure (<5psi).   |
| 200 | Out-of-water condition occurred during the sample.  |
- **Real ppt.** ppt concentration.
  - **Avg ppt.** Long average ppt concentration – average of the five most recent records.
  - **Particle Concentration.** Aerosol Concentration in #/cm<sup>3</sup>
  - **Sample Time.** Sample interval (elapsed time) in 1.0 second resolution (1-3600 seconds).
  - **Live Time.** Live time (0.001 – 3600 seconds) in each sample interval.
  - **Counts.** Accumulated particle counts during the sample interval.
  - **Photo.** Raw Photometric 0-8090.
  - **Nebulizer Flow.** Nebulizer flow in mL/min (“---” indicates no drip counts during the sample).
  - **UPW Pressure.** Ultrapure Water Pressure in psi (instantaneous value at reporting time).

## Appendix D: Firmware Commands

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### RL - Read Laser

RL returns the laser power in % and the current in milliamps.

<b>RL</b>		
Command	RL	
Response	p,c	p = power (0-100%) c = current in milliamps (0-300)
<b>Example</b>		
Command	RL	Read Laser command
Response	97, 35	Laser power = 97% Current = 35 mA

### RRA - Read Record Analog

RRA returns the current raw analog values in the A record format. This command is intended for diagnostic use only by a qualified service technician.

<b>RRA</b>		
Command	RRA	
Response		A Record

The A record displays 17 columns of data.

#### Example of A Record

A,3227,3213,310,894,1616,4095,2832,2401,563,95,16,2047,820,821,1057,1863

Reading from left to right, the columns in the example (and on the screen) represent the following:

Record Type	Flow Control Pressure Transducer	Absolute Inlet Pressure	Water Pressure	Evaporator Temp Sensor	Nebulizer Temp Sensor	Float Switch
<b>A</b>	<b>3227</b>	<b>3213</b>	<b>310</b>	<b>894</b>	<b>1616</b>	<b>4095</b>
Internal Reference Voltage	Laser Power	Laser Current	Photo	Dead Time	Saturator Temp	Growth Tube Temp
<b>2832</b>	<b>2401</b>	<b>563</b>	<b>95</b>	<b>16</b>	<b>2047</b>	<b>820</b>
Optics Temp	Nozzle Pressure Drop	Cabinet Temp				
<b>821</b>	<b>1057</b>	<b>1863</b>				

**Note:** The values are raw analog values.

## Appendix D: Firmware Commands

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### RRC - Read Record Control

RRC returns the current control values (flow and temperature) in the C record format. This command is intended for diagnostic use only by a qualified service technician.

<b>RRC</b>		
Command	RRC	
Response		C Record

The C record displays 19 columns of data.

#### Example of C Record

C,2821,2824,2771,2047,2047,1307,821,820,2251,821,821,1535,1616,1615,1068,895,892,3601

Reading from left to right, the columns in the example (and on the screen) represent the following:

Record Type	Pump Ctrl	Pump A-D	Pump Drive	Saturator Control	Saturator A-D	Saturator Drive
<b>C</b>	<b>2821</b>	<b>2824</b>	<b>2771</b>	<b>2047</b>	<b>2047</b>	<b>1307</b>
Growth Tube Control	Growth Tube A-D	Growth Tube Drive	Optics Control	Optics A-D	Optics Drive	Nebulizer Control
<b>821</b>	<b>820</b>	<b>2251</b>	<b>821</b>	<b>821</b>	<b>1535</b>	<b>1616</b>
Nebulizer A-D	Nebulizer Drive	Evaporator Control	Evaporator A-D	Evaporator Drive		
<b>1615</b>	<b>1068</b>	<b>895</b>	<b>892</b>	<b>3601</b>		

**Note:** The values are raw analog values.

### RRS - Read Record Status

RRS returns the current status values in the S record format. This command is intended for diagnostic use only by a qualified service technician.

<b>RRS</b>		
Command	RRS	
Response		S Record.

The S record displays 8 columns of data.

## Appendix D: Firmware Commands

### Example of S Record

S,150,970,25.0,60.0,60.0,35.0,120.0

Reading from left to right, the columns in the example (and on the screen) represent the following:

Record Type	Flow	Atm Press	Saturator Temp	Growth Tube Temp	Optics Temp	Nebulizer Temp	Evaporator Temp
S	150	977	25	60	60	35	120.2`

**Note:** The values are raw analog values.

### RTO - Read Time On

RTO reports the time the NRM was powered on.

RTO		
Command	RTO	
Response	hhh:mm	hhh – number of hours the NRM is on mm – number of minutes the NRM is on
Example		
Command	RTO	Read Time-on command
Response	456:40	456 hours 40 minutes

### RV - Read Version

RV returns the instrument model number, firmware version, and serial number.

RV		
Command	RV	
Response	NRM 8000 Ver v.vv S/N nnnn	v.vv ranges 0.01-9.99 (3 digits) nnnn ranges 100-99999999
Example		
Command	RV	Read Version command
Response	NRM 8000 Ver 1.06 S/N 141	Version # 1.06 Serial # 141

### Set Commands

Set commands are used to set instrument parameters and data collection modes. You will use the Set Mode (SM) command to control data collection. The other Set commands, described on the following pages, are supplemental and intended for use by a qualified service technician. You can also enter a Set command without a parameter, to check the current setting. The response displayed on the screen is the current setting of the parameter or mode.



**Warning.** Using any Set commands other than the SM command can adversely affect the calibration of the instrument. We recommend you do not use any of the Set commands other than SM, but if you do, please use extreme caution. The Set commands may cause interruptions in data reporting.

If you use a Set command other than SM, first query and record the current parameter or mode. You will then be able to return to those specific settings after executing the command.

#### SM - Set Mode

SM is used to set the data collection mode and the sample interval. At the end of each sample interval, the data is reported and, if in a continuous mode, the data is cleared internally and the next sample is started. The seven available modes are shown in the following list:

- 0. Idle. No data collection.
- 1. Collects one sample interval of data and reports data at completion.
- 2. Continuously collects data and reports data at end of every sample interval.
- 3. Collects one sample interval of data but also includes an S record at the end of the sample interval.
- 4. Continuously collects data and reports data at end of every sample interval. Also includes an S record at the end of each sample interval.
- 7. Collects one sample interval of data, but also includes an S, A and C record at the end of the sample interval. For diagnostic use only.
- 8. Continuously collects data and reports data at end of every sample interval, but also includes an S, A, and C record at the end of each sample interval. For diagnostic use only.

To stop data collection, enter SM,0 in the Firmware Command field.

## Appendix D: Firmware Commands

<b>SM</b>		
Command	SM,n,tttt	n = mode (0,1,2,3,4,7,8) tttt – sample interval in tenths of a second (1-36,000)
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SM,2,60	The response indicates continuous data collection (response mode 2) at 6 second sample intervals.
Response	OK	
Command	SM	Parameters not changed. Current setting displayed on record.
Response	2,60	Response mode 2, 6 second sample time.

### S4S - Set 4-20mA Span

S4S is used to set the full-scale current output, allowing a full-scale calibration value for the analog current loop output. When the S4S command is entered, the analog output is set to full-scale, allowing the full-scale current to be set at 20mA. Adjust the S4S number to a number from 8,000-10,000 until the analog output reads 20mA. This value is only held until the next reported 'N' data record. To hold the span value longer than 60 seconds (or your specified data collection interval), enter the SM,0 command.

<b>S4S</b>		
Command	S4S, xxxx	x = 8000-10000
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	S4S,9500	Sets the 4-20 mA span value to 9500. Current loop output to full-scale response.
Response	OK	
Command	S4S	
Response	9500	Parameters not changed. Current setting displayed on record.

## Appendix D: Firmware Commands

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### S4Z - Set 4-20mA Zero

S4Z is used to set the zero level (4mA) of the analog current loop outlet, allowing the zero point calibration value to be set for the analog current loop output. When the command is entered, the analog output is set to zero scale allowing the current to be set to 4mA. Adjust the S4Z number between 0 and 200 until the analog output reads 4mA. This value is only held until the next reported 'N' data record. To hold the zero value longer than 60 seconds (or your specified data collection interval), enter the SM,0 command.

<b>S4Z</b>		
Command	S4Z, xxx	x = 0-200
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	S4Z,50	Sets the 4 mA span value to 50. Current loop output set to zero-scale response.
Response	OK	
Command	S4Z	
Response	50	Parameters not changed. Current setting displayed on record.

### SBS - Set Nebulizer Set Point

SBS is used to set the control temperature set point for the nebulizer. The set point temperature is provided in 1/10°C. The factory default setting is 350 (35.0°C).

<b>SBS</b>		
Command	SBS, xxx	x = 0-400
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SBS,350	Sets the Nebulizer temperature to 35.0°C.
Response	OK	
Command	SBS	
Response	350	Parameters not changed. Current setting displayed on record.

## Appendix D: Firmware Commands

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### SBV - Set Nebulizer Flow Volume

SBV is used to set the calibration factor for the drip flowmeter. The parameter supplied with the NRM is the droplet volume (uL/drop).

<b>SBV</b>		
Command	SBV, xxx	xxx = 1-1000
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SBV,60	Sets the Nebulizer flow to 60 uL/drop
Response	OK	
Command	SBV	
Response	60	Parameters not changed. Current setting displayed on record.

### SCT - Set Calibration Table

SCT is used to set and report the ppt calibration table. The calibration table consists of 16 ppt/Concentration pairs. The ppt values are fixed and the aerosol concentration values are provided as input calibration values by the Service Technician during calibration. An example of a calibration table is shown in Figure 21 on page 42. To check the calibration points, you can read back the entire calibration table by entering the SCT command without entering any parameters.

## Appendix D: Firmware Commands

SCT		
Command	SCT,p,c	p = 10, 20,30 ,60, 100, 300, 600, 1000, 2000, 3000, 6000, 10,000, 20,000, 30,000 or 60,000 (ppt) c = 1-500,000 (#/cc)
Response	OK	Response issued after parameters changed.
Example		
Command	SCT,20,800	
Response	OK	
Command	SCT	
Responses	10,6 20,16 30,30 60,88 100,195 200,570 300,1090 600,3250 1000,6600 2000,13300 3000,18500 6000,33000 10000,50000 20000,71000 30000,87000 60000,125000	Parameters not changed. You can read back the entire calibration table. Note: If the calibration table is non-monotonic (not in ascending order), the message "Calibration table is invalid" is appended to the end of the table. Review the table for the error.



**Warning.** This command affects the NRM 8000 calibration. Fluid Measurement Technologies, Inc. recommends that you **do not use** this command unless instructed to do so by a qualified service technician. The NRM must be completely warmed up (it must have been powered up for at least 30 minutes), before performing this function.

## Appendix D: Firmware Commands

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### SDO - Set Detector Offset

SDO is used to set the offset value of the photo detector.

<b>SDO</b>		
Command	SDO,xxxx	x = 0-4095
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SDO,2040	Sets the photo detector offset value to 2040
Response	OK	
Command	SDO	
Response	2040	Parameters not changed. Current setting displayed on record.

### SDS - Seat Dead-Time Span

SDO is used to set the full-scale value for the dead-time measurement circuit.

<b>SDS</b>		
Command	SDS,xxxx	xxxx = 3000-4095
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SDS,4000	Sets the full-scale value for the dead-time measurement circuit to 4000.
Response	OK	
Command	SDS	
Response	4000	Parameters not changed. Current setting displayed on record.

### SDT - Set Detector Threshold

SDT is used to set the threshold value in millivolts for particle pulse detection or to return the value of the current setting if no parameter is supplied.

<b>SDT</b>		
Command	SDT,xxx	xxx = 0-120
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SDT,50	Sets the threshold value to 50millivolts.
Response	OK	
Command	SDT	
Response	50	Parameters not changed. Current setting displayed on record.

## Appendix D: Firmware Commands

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### SDZ - Set Dead-Time Zero

SDZ is used to set the Zero value for the dead-time measurement circuit. The command echoes the value of the current setting if no parameter is supplied.

<b>SDZ</b>		
Command	SDZ,xxx	xxx = 0-100
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SDZ,11	Sets the Zero value to 11.
Response	OK	
Command	SDZ	
Response	11	Parameters not changed. Current setting displayed on record.

### SE - Set Evaporator Heater

SE is used to turn the Evaporator Heater on or off. The Heater is always in the "on" condition when the instrument is first powered up.

<b>SE</b>		
Command	SE,x	x = 0 turns heater off x = 1 turns heater on
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SE,0	Turns the heater off.
Response	OK	
Command	SE	
Response	0	Parameters not changed. Current setting displayed on record.

### SES - Set Evaporator Temperature Set Point

SES is used to set the control temperature set point for the evaporator. The set point temperature is provided in 1/10° C. This parameter is not stored and reverts to the default values on the next power-up cycle - the factory default value is 1200 (120.0°C).

## Appendix D: Firmware Commands

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### SES

Command	SES,xxxx	xxxx = 0-1250
Response	OK	Response issued after parameters changed.

### Example

Command	SES,1200	Sets the control temperature set point for the Evaporator to 120.0°C.
Response	OK	
Command	SES	
Response	1200	Parameters not changed. Current setting displayed on record.

### SFS - Set Flow Set Point

SFS is used to set the flow control set point which represents 0.15 L/min internal aerosol flow for the flow control system. The default parameter is used as a control point to control the internal vacuum pump. The bit value of the absolute pressure sensor is also recorded.

1. Enter a parameter after entering the command.
2. The differential orifice pressure is compared to the control point and adjustments are made to the pump drive to maintain a match between the two.
3. The absolute pressure value is continuously measured and used to correct the control point for changes in inlet pressure.

SFS		
Command	SFS,xxxx,yyyy	xxxx = 0 – 4095 (bit value for the current absolute pressure value recorded) yyyy = 2000 – 4095 (optional absolute pressure bit value)
Response	OK	Response issued after parameters changed.
Example		
Command	SFS,2312,3200	Sets the set flow set point to 2312 and the absolute pressure value to 3200.
Response	OK	
Command	SFS	
Response	2312,3200	Parameters not changed. Current setting displayed on record.

## Appendix D: Firmware Commands

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### SFZ - Set Flow Zero

SFZ is used to set the flow control zero value. The issued parameter is used as the zero value for the flow system. When issued without a parameter, the command indicates the current flow zero value.

Note: The SZ command is usually used to set the flow zero value therefore SFZ is rarely used.

<b>SFZ</b>		
Command	SFZ,xxx	xxx = 1-350
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SFZ,164	Sets the flow control zero value to 164.
Response	OK	
Command	SFZ	
Response	164	Parameters not changed. Current setting displayed on record.

### SG - Set Growth Heater

SG is used to turn the growth tube heater on or off. The heater is always in the "on" condition when the instrument is first powered up.

<b>SG</b>		
Command	SG,x	x = 0 turns heater off x = 1 turns heater on
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SG,0	Turns the heater off.
Response	OK	
Command	SG	
Response	0	Parameters not changed. Current setting displayed on record.

## Appendix D: Firmware Commands

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### SGS - Set Growth Tube Temperature Set Point

SGS is used to set the control temperature set point for the WCPC growth tube. The set point temperature is provided in 1/10° C. This parameter is not stored and will revert to the default values (600 or 60.0°C) on the next power-up cycle.

<b>SGS</b>		
Command	SGS,xxx	xxx = 0-8000
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SGS,600	Sets the control temperature set point for the Growth Tube to 60.0.
Response	OK	
Command	SGS	
Response	600	Parameters not changed. Current setting displayed on record.

### SL - Set Laser

SL is used to turn the laser on or off. The laser is always in the “on” condition when the instrument is first powered up.

<b>SL</b>		
Command	SL,x	x = 0 turns laser off x = 1 turns laser on
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SL,0	Turns the laser off.
Response	OK	
Command	SL	
Response	0	Parameters not changed. Current setting displayed on record.

## Appendix D: Firmware Commands

### SLS - Set Laser Set Point

SLS is used by a qualified service technician to set the laser power. It can also be used to query the current operating point as well as the set point. If the WCPC detects an over-current condition (usually an indicator of a failing laser diode), the reported operating point is less than the set point.



**Warning.** The SLS command should only be used by a qualified service technician. If you use the SLS command, you may over-drive the laser diode causing it to be damaged or destroyed.

SLS		
Command	SLS,xxxx	x = 0-4095
Response	OK	Response issued after parameters changed.
Examples		
Command	SLS,1400	Sets the laser power to 1400.
Response	OK	
Command	SLS	
Response	1400	Parameters not changed. Displays current operating point and current set point.
Command	SLS,4000	Sets the laser power to 4000.
Response	Value exceeds laser set point.	Indicates value exceeds maximum allowed amount.

### SO - Set Optics Heater

SO is used to turn the optics heater on or off. The heater is always in the “on” condition when the instrument is first powered up.

SO		
Command	SO,x	x = 0 turns heater off x = 1 turns heater on
Response	OK	Response issued after parameters changed.
Example		
Command	SO,0	Turns the heater off.
Response	OK	
Command	SO	
Response	0	Parameters not changed. Current setting displayed on record.

## Appendix D: Firmware Commands

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### SOS - Set Optics Temperature Set Point

SOS is used to set the control temperature set point for the WCPC optics. The set point temperature is provided in 1/10° C. This parameter is not stored and will revert to the default values (600 or 60.0°C) on the next power-up cycle.

<b>SOS</b>		
Command	SOS,xxx	xxx = 0-800
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SOS,600	Sets the control temperature set point for the optics to 60.0.
Response	OK	
Command	SOS	
Response	600	Parameters not changed. Current setting displayed on record.

### SP - Set Pump

SP is used to enable or disable the pump that provides airflow through the NRM.

<b>SP</b>		
Command	SP,x	x = 0 turns the pump off x = 1 turns the pump on
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SP,0	Turns the pump off.
Response	OK	
Command	SP	
Response	0	Parameters not changed. Current setting displayed on record.

## Appendix D: Firmware Commands

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### SR - Set Range

SR is used to set the 4-20mA current-loop output range. Parameters allow for ranges spanning 0 to 60,000 ppt.

<b>SR</b>		
Command	SR,xxxxx,yyyyy	x = minimum PPT for 4ma output current y = maximum PPT for 20ma output current $0 \leq x < y \leq 60000$
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SR,0,60000	Sets the 4-10mA current-loop output range from 1-60000 ppt.
Response	OK	
Command	SR	
Response	60000	Parameters not changed. Current setting displayed on record.

### SS - Set Saturator

SS is used to turn the saturator temperature controller on or off. The controller is always in the “on” condition when the instrument is first powered up.

<b>SS</b>		
Command	SS,x	x = 0 turns controller off x = 1 turns controller on
Response	OK	Response issued after parameters changed.
<b>Example</b>		
Command	SS,0	Turns the controller off.
Response	OK	
Command	SS	
Response	0	Parameters not changed. Current setting displayed on record.

## Appendix D: Firmware Commands

### SSS - Set Saturator Set Point

SSS is used to set the control temperature set point for the WCPC saturator. The set point temperature is provided in 1/10°C. This parameter is not stored and will revert to the default values (200 or 20.0°C) on the next power-up cycle.

SSS		
Command	SSS,xxx	xxx = 0-800
Response	OK	Response issued after parameters changed.
Example		
Command	SSS,250	Sets the control temperature set point for the saturator to 25.0.
Response	OK	
Command	SSS	
Response	250	Parameters not changed. Current setting displayed on record.

### SZ - Set Auto Zero Function

This command executes an auto zero function that calibrates the flow and nozzle transducer offset values.



**Warning.** This command affects the NRM 8000 calibration. Fluid Measurement Technologies, Inc. recommends that you **do not use** this command unless instructed to do so by a qualified service technician. The NRM must have been powered up for at least 30 minutes before performing this function.

SZ		
Command	SZ,1	
Response	a,b	a = flow offset, 0-999 b = nozzle offset, 0-9999 Response issued after parameters changed.
Example		
Command	SZ,1	Starts the auto zero calibration.
Response	187,190	Indicates the flow offset is 187, and the nozzle offset is 190.
Command	SZ	
Response	187,190	Parameters not changed. Current setting displayed on record.

## Appendix D: References

D.B. Blackford, "A New NonVolatile Residue Monitor for the Semiconductor Industry," presented at the Ultrapure Water Executive Forum, Austin, Texas, 2007.

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