PART II: THE CCN SOFTWARE

11.0 Product Description

11.1 Introduction

The computer system for the Cloud Condensation Nuclei Counter (CCN) is a PC-104 stack unit with a Celeron 1 GHz processor, 500 Mb of memory, a Diamond Systems MM-16 AT multifunction interface card, and a Sealevel 2-port communication card. A 16-Gb solid-state hard drive is provided for program and data storage. The operating system is Windows XPEmbedded. Do not install any other programs, as conflicts may occur. Do not set or change time either manually or with a time-sync program while the VI is running, or the program will not operate properly.

Note: This computer configuration is accurate as of May 2009. Previous units and later units may have different components as parts become obsolete or are upgraded.

The software for the CCN counter is provided as a LabVIEW executable. The software revision level is shown in the status bar of the CCN counter program. This manual is intended for versions 5.0.0 and above.[iii] Help screens are available while running the instrument. They contain the most important information that is included in this manual.

Four programs are provided:

- **Single CCN.exe** operates the CCN unit. This is the main program.
- **CCN SS Settings Config Editor.exe** sets up the supersaturation tables, which are stored in `C:\CCN_SS_Settings.ini`.
- **CCN Calibration Editor.exe** sets the instrument-specific coefficients for the flow and pressure calibrations. These are stored in `C:\CCN_Calibration.ini`.
- **CCN Playback.exe** displays and replays saved data files.

The following sections discuss the details of each of these programs.

In addition to these standard programs, DMT offers an optional Particle Analysis and Display System (PADS) module for the CCN. This module allows integrated use of the CCN with other DMT instruments.

[iii] Screen shots in this document are taken from versions 5.0.3 (Single CNN.exe), 5.0.1 (SS Settings Config Editor.vi and CCN Calibration Config Editor.vi), and 5.0.2 (Single CCN Playback.exe).

12.0 SINGLE CCN.exe (Main Program)

The **Single CCN.exe** control program provides a completely automated system for running the CCN instrument under laboratory or flight conditions. The program loads and runs automatically after the operating system boots. The display is organized into a tab structure for control and monitoring of the system, as shown in Figure 26.
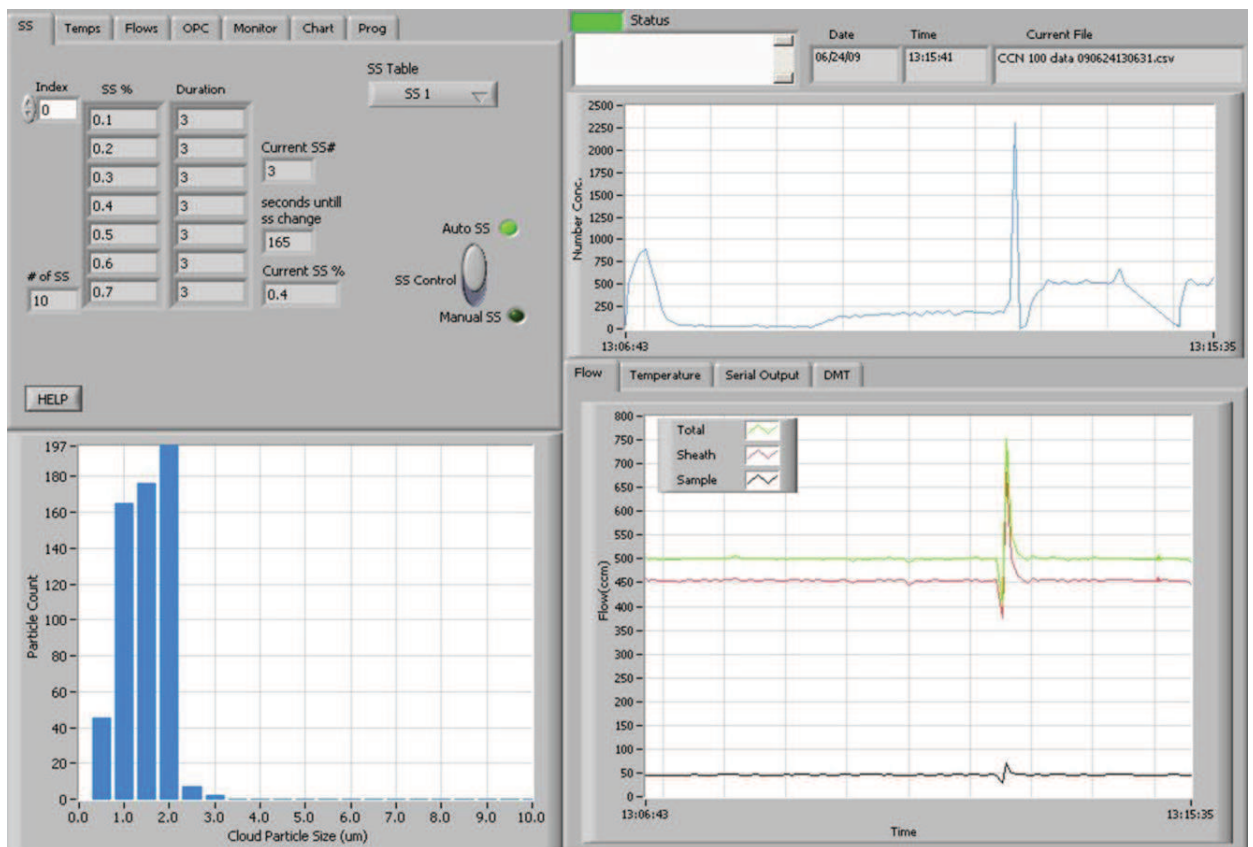

Figure 26: Main Screen of SINGLE CCN Program

In the upper right of the display are fields showing the date, time, and current data file that the program is writing to. The **Status** button indicates the instrument status (green = normal, yellow = an alert has been generated, red = an alarm has been generated). The **Status window** displays any alarms or alerts concerning the operation of the software or the instrument. During startup, the window shows the time available to select a supersaturation table.

The main screen is divided into four sections. In the upper left are the control tabs. Beneath the control tabs is a histogram display of particle counts by size. The histogram

display is for the current moment in time. In the upper right of the screen is a chart of particle number concentration with respect to time. Beneath this chart are additional time-series charts as well as a **Serial Output tab** and **DMT Service tab**, labeled "DMT," which can be used during troubleshooting. The remainder of this section discusses these various screen components in detail.

12.1 Control Tabs

12.1.1 SS Tab (Supersaturation Settings)

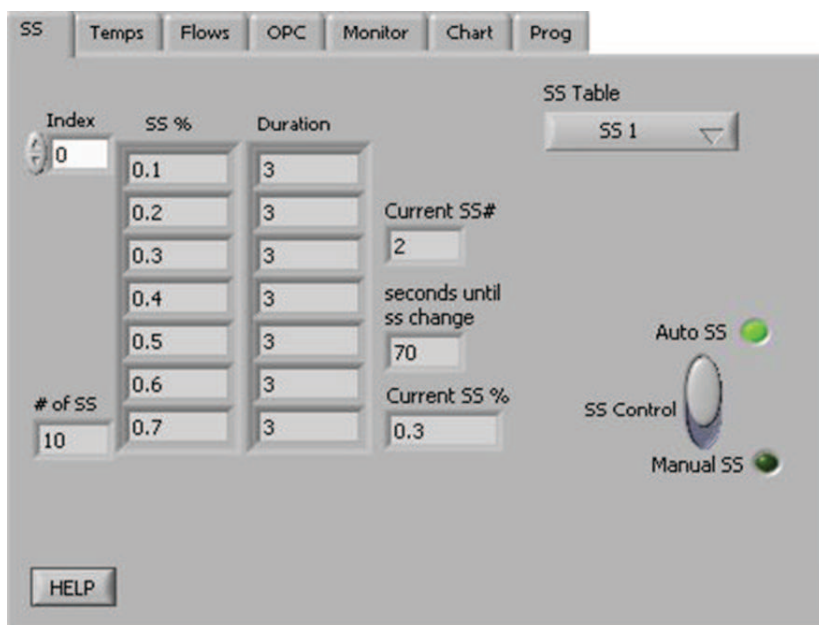The control program will start with the supersaturation tab setting active (see Figure 27).

Figure 27: Supersaturation (SS) Settings Tab Display

12.1.1.1 SS Tab Settings that Must be Configured in First 10 Seconds

After starting the program, the user has 10 seconds to select the desired supersaturation table from the **SS Table** pull-down menu. If no selection is made, the last SS table used is selected by default. After the 10-second timer expires, the supersaturation values, durations, and OPC bin settings are loaded and cannot be altered. Details on setting up the supersaturation tables are given in section 13.0.

During the first 10 seconds of program operation, the user can also select **Dry Start Up** or **Dry Shut Down**. This can be done using the radio buttons shown in Figure 28. (These buttons disappear from the display after the ten-second window has expired, as shown in Figure 27.)
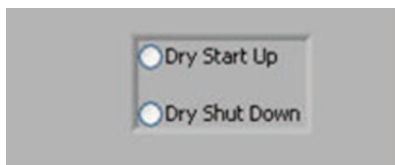

Figure 28: Dry Start Up and Dry Shut Down Buttons

Dry Start Up should only be selected when the unit has been totally dried out, such as after shipping. Selecting **Dry Start Up** will set the liquid supply pump to high and disable the CCN concentration alarm. After 4 – 12 hours, the unit will reset itself to normal mode.

Dry Shut Down should only be selected when the unit needs to be totally dried out prior to shipping. Selecting **Dry Shut Down** will prompt the user to shut the sheath flow metering valve and install Drierite on the inlet. The supply pump will be turned off and the drain pumps (i.e., the column and cold trap pumps) will be turned on high. The total flow will be set to 175 Vccm. The CCN concentration status and flow status alarms will be disabled. After 6 hours, the unit will turn off the TEC relay and display a message that the unit is dried out and ready to ship.

12.1.1.2 SS Tab General Settings

Index displays the supersaturation level that appears in the top row of the SS%-Duration table. In Figure 27, for instance, the top row has an index of 0, so this row corresponds to the first entry in the supersaturation table. If you were to change **Index** to 1, the top row would have an **SS%** value of 0.2 and a **Duration** of 3. Note that the top row is not necessarily the CCN's active supersaturation level—the instrument may have progressed through this supersaturation and currently be operating on another level.

Current SS% displays the instrument's current supersaturation, while **Current SS#** displays the current supersaturation level in the SS Table**.** In Figure 27, the CCN is currently operating on supersaturation level 2, which has a corresponding supersaturation of 0.3%. Note that if the CCN is changing between supersaturations, the actual supersaturation in the column may differ from the value displayed in **Current SS%** (see section 12.1.2).

# of SS displays the number of supersaturation levels in the current SS Table.

SS Table displays the currently selected SS Table. During the first 10 seconds of program operation, this button is a control that can be used to select a table; after that, it is an indicator that cannot be changed. Details on setting up the supersaturation tables are given in section 13.0.

Seconds until SS change counts down the remaining time in seconds for the current supersaturation selection. After the last selection completes, the instrument continues and loops back to the 1st selection.

Note: **Current SS#** and **Seconds until SS change** are not visible when **Manual SS** mode is turned on. See Figure 29.
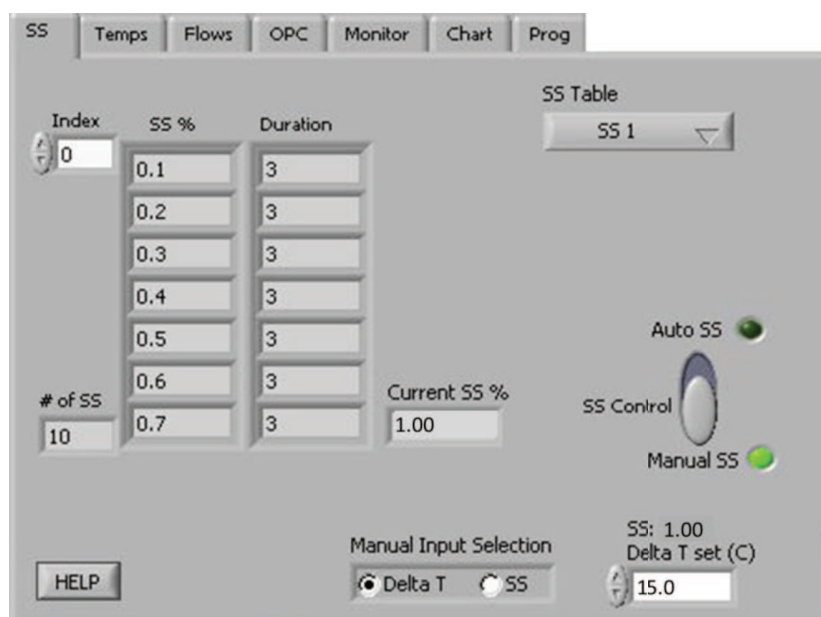

Figure 29: Supersaturation (SS) Settings Tab Display in Manual SS Mode

The **SS Control** switch specifies how supersaturations are set. In **Auto SS** mode, the CCN uses the SS Table to determine **Current SS%**. **Delta T(C)** is selected automatically based on this SS% value. In **Manual SS** mode, the user enters either the supersaturation or **Delta T Set (C)**, which in turn determines the supersaturation. In Manual SS mode, the **Manual**

Input Selection radio button (Figure 29, bottom middle) specifies whether the user will enter Delta T Set (C) or enter the supersaturation directly. If the manual input selection is Delta T Set (C), an **SS** indicator will appear above the **Delta T set (C)** control (bottom right), which enables the user to quickly see what SS% the currently selected Delta T Set (C) is equal to. The default value for Delta T Set (C) is the last setting the program was previously running when **Auto SS** mode is switched off. Note that while the SS Table remains visible during **Manual SS** mode, the program is not using it.

12.1.2 Temps Tab (Temperatures)

The **Temps** tab contains heater and temperature indicators and controls, as shown in Figure 30. *Note: To manually set the temperature gradient, Delta T Set (C), use the SS Tab*.
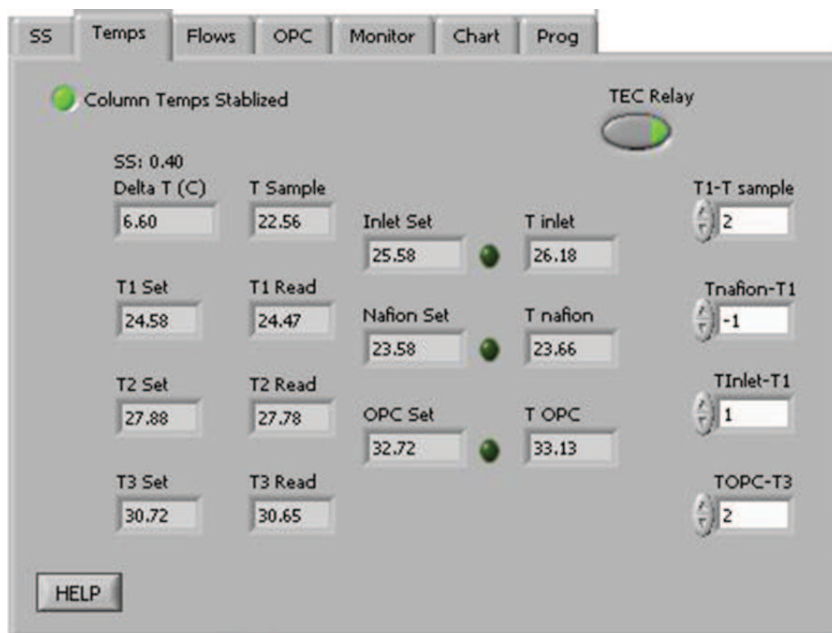

Figure 30: Temperature Tab Screen Showing Temperature Set Points and Read-Outs the CCN Temperatures

The temperature designations are as follows:

T1	Top of column temperature
T2	Middle of column temperature
T3	Bottom of column temperature
T OPC	Optical Particle Counter temperature
T Inlet	Temperature of the particle inlet at the head of the column
T Nafion	Nafion humidifier temperature

T Sample   Air sample temperature at the CCN manifold. (*Note: Regardless of the actual air temperature, T Sample will be close to ambient temperature, as the air warms to ambient by the time it reaches the manifold.*)

"Set" refers to a given temperature's set point, while "Read" refers to the observed value. (The **T inlet**, **T nafion** and **T OPC** fields display observed values.)

The three indicator lights to the right of the Inlet Set, Nafion Set, and OPC Set fields are for the Inlet heater, Nafion heater, and OPC heater, respectively. These lights are illuminated when the respective heater is ON.

The four temperature differentials are read from the `C:\CCN_SS_Settings.ini` file at startup and can be changed when the CCN is in **Manual SS** mode. Changes apply to the current session only. To change the permanent default values for these differentials, do so from the **CNN Calibration Editor.exe** program; see section 14.0.

T1 – Tsample is a temperature differential that determines the temperature of the top of the column relative to the sample air temperature. **TNafion – T1, Tinlet – T1,** and **TOPC – T3** determine the temperature of the Nafion humidifier, the inlet manifold, and the OPC relative to temperatures at points on the column. Recommended values for these temperature differentials are given below.

	Recommended Value	*Range*
(T1 – T Sample)	2.0° C	0 °C to 10 °C
(T Nafion – T1)	-1.0° C	-5 °C to 5°C
(T Inlet – T1)	1.0° C	0 °C to 5 °C
(T OPC – T3)	2.0° C	1 °C to 10 °C

The **Column Temps Stabilized** light indicates if T1, T2, and T3 are less than 0.4° from their set values. Even when the light is on, additional time may be needed before the entire unit is stabilized and data are consistent.

The light will turn off during SS% changes. For small SS% changes, the light will typically be off for less than one minute. If the **Column Temps Stabilized** light never comes on, refer to the Troubleshooting section.

TEC Relay switches the instrument's 28 VDC power buss on and off. This supplies power to the heaters, the TEC units, and the sample pump. The default value is on, but it can be useful to turn off **TEC Relay** during troubleshooting.

Delta T(C) is the temperature gradient used to calculate values for T1 Set, T2 Set, T3 Set, Inlet Set, Nafion Set, and OPC Set.

- In **Auto SS** mode, **Delta T(C)** is an indicator only, where **Delta T(C)** is determined by the **Current SS%** and the temperature gradient slope and intercept coefficients. (See sections 12.4.2.2 and 14.0.)

- In **Manual SS** mode, **Delta T(C)** becomes a control and can be set through the **Temps** tab or through the serial port; see section 12.4.1.

12.1.2.1   CCN Temperature Adjustment

The program will readjust the temperature set values if any of these four following conditions are met:

1. Delta T(C) changes
2. T Sample +2*(T1 - TSample) < T1 Set
3. T Sample > T1 Set
4. The unit has looped back to SS #1

Conditions 2 and 3 ensure that the temperature at the top of the column stays slightly above the temperature of the sample. If the top of the column temperature is not above the sample temperature, the air comes into the top of the column from the Nafion humidifier, which is at 100% RH, can condense and cause fog to form at the top of the column. Thus, if the sample temperature rises by more than the (**T1 Set – TSample**) value, the system will reset all of the temperatures up to maintain this temperature difference. If the sample temperature drops by twice the difference of the (**T1 – TSample**) value, the T1 value will be reset lower.

It is also important that the operating temperature of the CCN be higher than the dew point of the air being sampled. If the CCN is operated in a room with substantial air conditioning, and the temperature of the air in the room is less than the dew point of the sampled air, aerosol changes can occur.

When the CCN adjusts set temperatures, the new values are calculated using the equations below.

- **T1 Set** $_{new}$ = **Sample Temp Setpoint**[iv] + (**T1 – TSample**)

[iv] **Sample Temp Setpoint** is a temporary variable used by the software. It is equal to whatever **TSample** was when conditions 2 or 3 were last true.

- **T2 Set** $_{new}$ = **T1 Set** $_{new}$ + ½ **Delta T(C)**

- **T3 Set** $_{new}$ = **T1 Set** $_{new}$ + **Delta T(C)** * (1 – (**%TG**^{v})/100)

- **Nafion Set** $_{new}$ = **T1 Set** $_{new}$ + (**T Nafion** – **T1**)

- **Inlet Set** $_{new}$ = **T1 Set** $_{new}$ + (**T Inlet** – **T1**)

- **OPC Set** $_{new}$ = **T3 Set** $_{new}$ + (**T OPC** – **T3**)

In order to protect the laser diode in the OPC, if **OPC Set** $_{new}$ > 55 °C, then **Delta T(C)** is reduced using the following algorithm:

1.) **Delta T(C)** $_{new}$ = 50 + **Delta T(C)** - **OPC Set** $_{new}$
2.) All temperatures are readjusted using **Delta T(C)** $_{new}$
3.) Steps 1 and 2 are repeated until **OPC Set** < 55°

It is important that the OPC operate at a higher temperature than the bottom of the column, T3. This temperature differential ensures that the OPC optics will not fog. Studies at DMT have shown that the OPC temperature can be as high as 5 °C above T3 with no loss of concentration. At an OPC temperature of 7 °C above T3, there is a 20% loss of droplets.

If the supersaturation scans involve changing from a high supersaturation where the OPC temperature is high to a low supersaturation and low OPC temperature, adequate time must be allowed for the OPC to cool to 2°C above T3 before taking data. Otherwise there will be undercounting of the activated particles.

12.1.3 Flows Tab

The **Flows** tab contains indicators and controls associated with the system flows, as shown in Figure 31.

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^{v} **%TG** is a temperature-gradient adjustment factor. For details, see section 14.0.
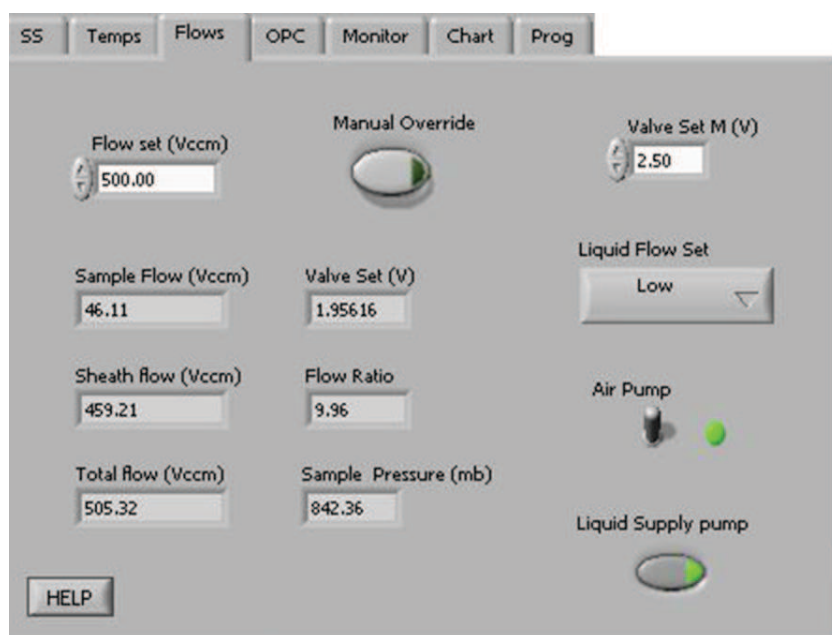
Figure 31: Flows Control Tab

Flow Set (Vccm) displays the set value for the current total flow. This value is read from the **SS_Settings.ini** file when the **SS Table** is selected, but can be changed at any time. The recommended flow range is near 500 volume CC/min (Vccm), although the instrument can process flows from 200-1000 Vccm.

> *Note:*
> *Flow affects unit SS%. The CCN unit was DMT factory calibrated with a Total Flow set to 500 Vccm, so Total Flow should be approximately this amount.*

Valve Set (V) displays the voltage sent to the proportional valve that regulates the total airflow through the CCN. Every proportional valve will use a different **Valve Set (V)** to maintain a given flow. **Valve Set (V)** is an indicator that cannot be changed.

Manual Override switches the manual valve set mode ON/OFF. In manual override mode, the **Valve Set (V)** will be ignored and a constant voltage, **Valve Set M (V),** will be used in its place.

Valve Set M (V) controls the voltage supplied to the proportional control valve. This parameter is only used when the instrument is in manual override mode.

Sample Flow (Vccm) displays the measured sample flow.

Sheath Flow (Vccm) displays the measured sheath flow.

Total Flow (Vccm) displays **Sheath Flow (Vccm)** + **Sample Flow (Vccm).** While the Total Flow ranges from 200-1000 volume cc/min (Vccm), the instrument has been calibrated at 500 Vccm, and actual flow should be close to this amount to ensure data accuracy.

Flow Ratio displays **Sheath Flow (Vccm) / Sample Flow (Vccm).** A manually controlled valve inside the instrument controls the split between the sample and sheath flows. The recommended flow ratio is 10:1.

Liquid Supply Pump switches the supply pump ON/OFF. The two drain pumps run continuously.

Sample Press (mb) displays sample pressure.

Air Pump switches the air pump ON/OFF. The default is ON. To prevent fogging of the OPC, if **T OPC** < **T3 Read** the air pump switch will be overridden and the air pump will be turned off. The user may also want to switch off the air pump during a leak test or when drying the OPC with canned air.

Liquid Flow Set controls the frequency of the solenoid pumps used in the water supply and drains. The pump frequency can be set to **Low, Medium,** or **High.**

- **Low** is good for normal operation. This supplies sufficient water to the column for ambient CCN measurement when the sample temperatures are below 33 ˚C.

- **Medium** is required for environments where the temperature is above 33 °C, or the sample air to the CCN is dried with a diffusion drier. This supplies the extra water used by the Nafion humidifier and the column at higher temperatures.
- **High** is useful if water supply has run dry or if it is necessary to wet the column quickly.

Liquid Supply Pump switches the supply pump ON/OFF. The two drain pumps—i.e., the column and cold trap pumps—run continuously.

12.1.4 OPC Tab (Optical Particle Counter)

The **OPC** tab contains controls and indicators for the operation of the OPC. Figure 32 shows this tab.
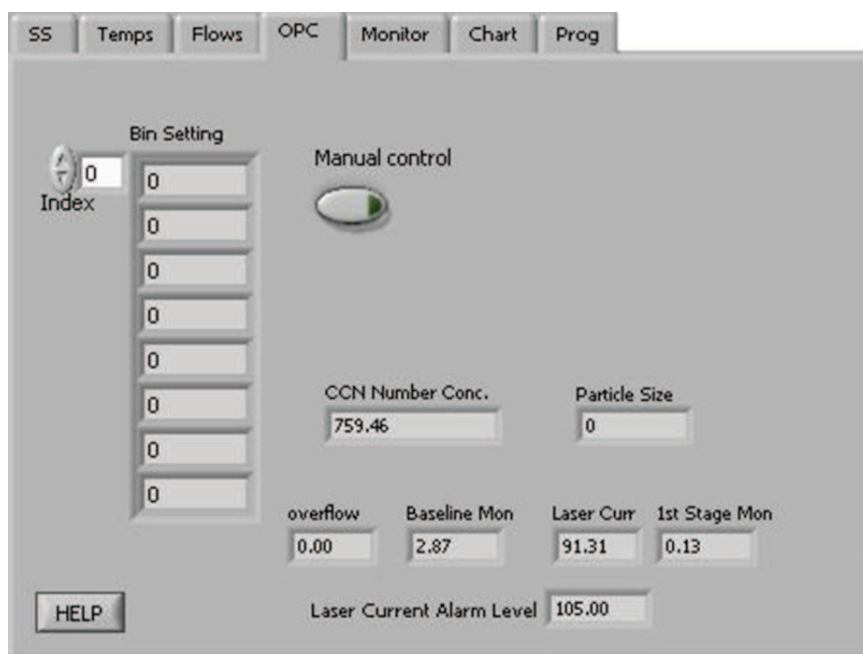

Figure 32: Optical Particle Counter Tab

The OPC measures the sizes of particles at the exit of the column. The particles are sized into 20 bins, with the bins' upper boundaries at 0.75 µm, 1.0 µm, 1.5 µm, 2.0 µm, and continuing in .5 µm increments until the last bin's upper boundary of 10 µm.

The **Bin Settings table** displays the bin settings for each supersaturation setting. The bin setting can be used to limit the **Number Conc.** calculation to reflect larger particles only. Bins lower than the **Bin Setting** do not have their particles included in the concentration

calculation. If all particles are to be included, **Bin Setting** should be 0, which is the default value. Bin settings are loaded when the **SS Table** is selected and cannot be changed. The program **CCN SS Settings Config Editor.exe** allows users to configure bin settings for different supersaturation settings.

Index displays the number of the first bin setting displayed in the array. In Figure 32, for instance, the first bin setting displayed corresponds to the first row (index 0) in the SS Table.

Particle Size displays the particle size that corresponds to the top value listed in the Bin Setting array.

Manual Control activates the slider bar that allows setting a manual **Bin #.**

CCN Number Conc. displays the number concentration using the counts from particle bins above the **Particle Size** and any **overflow** counts.

Overflow displays the number of particles counted that are larger than 10 μm.

Baseline Mon displays a voltage used by DMT for OPC diagnostic purposes.

Laser Curr displays the laser current (mA) used in the OPC. A sudden change in current could reflect a problem with the instrument. A reading of 60 – 120 mA indicates the instrument is functioning properly. See Appendix A for more details.

1st Stage Mon indicates whether the OPC is fogged. The normal operating range for this voltage is 0.1 - 0.75 volts. If the OPC is fogged, this voltage may be as high as 5 volts. If this happens, turn up the temperature on the OPC to 5˚ above T3. This can be done by clicking on the **Temps** tab, switching to **Manual SS** mode, and changing the **TOPC – T3**

temperature differential. Next, watch for a drop in the **1ˢᵗ Stage Mon** level. If the value drops as the OPC heater cycles on, it is an indication that the OPC is not heavily fogged and it usually will recover in an hour or two. To speed the drying of the OPC, turn the cycling of the OPC drying pump to the 2-second setting. This switch is labeled SW1 and is located in the middle of the Controller Printed Circuit Board; see Figure 10. After the OPC is dry, the switch should be reset in the 16-second position.

Laser current alarm level displays the level at which an alert will be given when the laser draws this amount or more of current. Such an alert indicates the laser is nearing the end of its life.

12.1.5 Monitor Tab (Alarm Monitoring)

The **Monitor** tab has indicators for monitoring and logging the status of systems. Figure 33 shows this tab. When buttons are lit, as in Figure 33, the instrument is functioning properly.
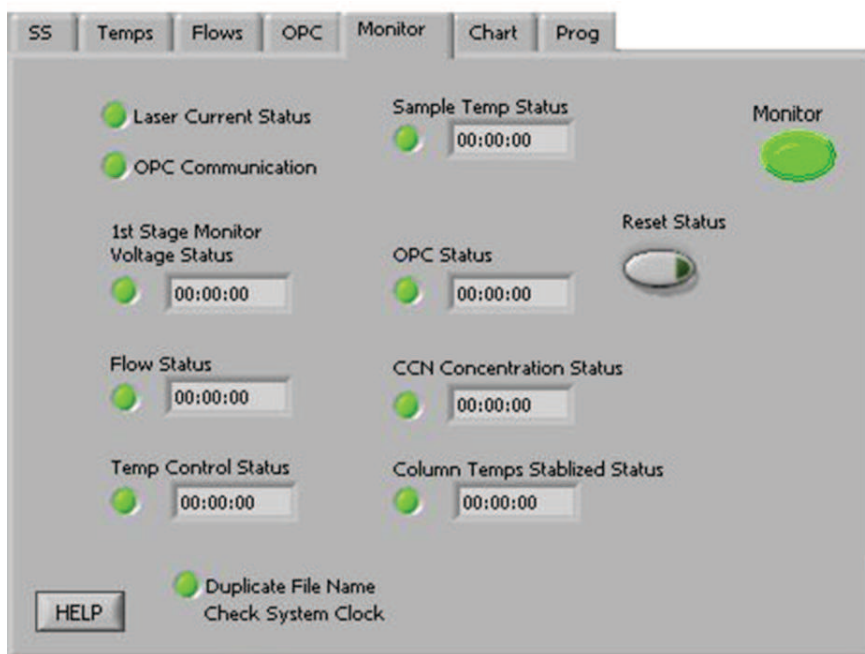

Figure 33: Monitor Tab

The status of the instrument is categorized as **Normal**, **Alert**, or **Alarm**. **Normal** indicates no alerts or alarms are present. **Alert** is triggered by a possible problem and takes no actions in the instrument. An alert is indicated by a yellow monitor button. **Alarm** is

triggered by a probable problem and will put the CCN in safe mode. Safe mode shuts off the **TEC relay** and **Liquid Supply Pump**. The relevant monitor button will turn red.

The timers in the status fields count how long the specified alert/alarm conditions have been met. They are reset to 00:00 if the conditions are not met, i.e. if no problem has been detected. If any timer exceeds its set threshold, an alert/alarm is triggered and the indicator light turns yellow for an alert and red for an alarm. Each alert is associated with a unique alert code. Alert codes are integers in the form of 2^n, where n = 0, 1, 2 ... 14. The sum of all triggered alerts is saved in the last column of the data file. This sum is then made negative if any alarms have been triggered.

More information is given below about specific status fields, their corresponding alert codes, and whether the system ultimately generates an alarm for this problem.

12.1.5.1   CCN Alerts and Alarms

Laser Current Status alerts if the laser draws too much current, indicating the laser diode is nearing the end of its useful life. Contact DMT. No alarm. Alert Code = 1.

OPC Communication alerts if the OPC is not communicating with the computer. No alarm. Alert Code = 256.

1st Stage Monitor Voltage Status counts when the 1st Stage monitor is > 4.7 V. Alerts after 5 minutes. No alarm. Alert Code = 2.

Flow Status counts when total flow deviates >20% from the set flow or when the flow ratio is not within 5-15. Alerts after 30 minutes. No alarm. Alert Code = 4.

Temp Control Status counts when at least one of T1, T2, T3, T Inlet, T Nafion, and T OPC is more than 10 degrees from its set point. Alerts after 10 minutes. Alarms after 20 minutes. Alert Code = 8.

Sample Temp Status counts when the sample temperature exceeds the 0-50 ˚C range. Alerts after 1 minute. Alarms after 5 minutes. Alert Code = 16.

OPC Status counts when the 1st Stage Monitor > 4.7 V and CCN counts are less than the configured threshold. DMT sets this threshold to the factory default of 10 counts/sec, but it can be changed by the user using the **CCN Calibration Editor.exe** program. No Alert. Alarms after 60 minutes. Alert Code = 32.

CCN Concentration Status counts when CCN counts are less than the configured threshold (factory default 10 counts/sec). Alerts after 20 minutes. Alarms after 120 minutes. Alert Code = 64.

Column Temps Stabilized Status counts when T1, T2, or T3 is >0.4 degrees from its set point. Alerts after 20 minutes. No alarm. Alert Code = 128.

Duplicate File Name Status alerts when a file already exists with the same name as the file that the CCN program wants to create. A new file will be created, which will have the same name as the original file but have "duplicate.xxx" appended to it. Check and fix, if necessary, the system clock. No alarm. Alert Code = 512.

Safe Mode flashes when an alarm has been triggered and the unit is in safe mode.

Reset Status clears all alerts/alarms and resets their timers to zero. This button will not turn the TEC relays back on. It does turn the liquid supply pump back on.

12.1.5.2   How to Interpret CCN Alarm Codes in Output Files

When the CCN is running, any alerts and alarms will be displayed individually in the **Status** window at the top of the main program screen. In the .csv and serial stream output, however, alerts and alarms are stored as a sum of all the alarm codes generated. For instance, say the CCN is generating an alarm code of 183. 183 = 128 + 64 + 1, which means that alerts have been generated for **Column Temp Stabilized**, **CCN Concentration**

and **Laser Current Status.** (Because the alarm code for each individual problem is a unique 2^n number, the sum of alarm codes will always indicate a unique set of issues.) A negative alarm code indicates problems severe enough that the instrument has gone into safe mode.

12.1.6 Chart Tab

The **Chart** tab, shown in Figure 34, contains controls for configuring the **Flows, Temperature,** and **CCN** charts.
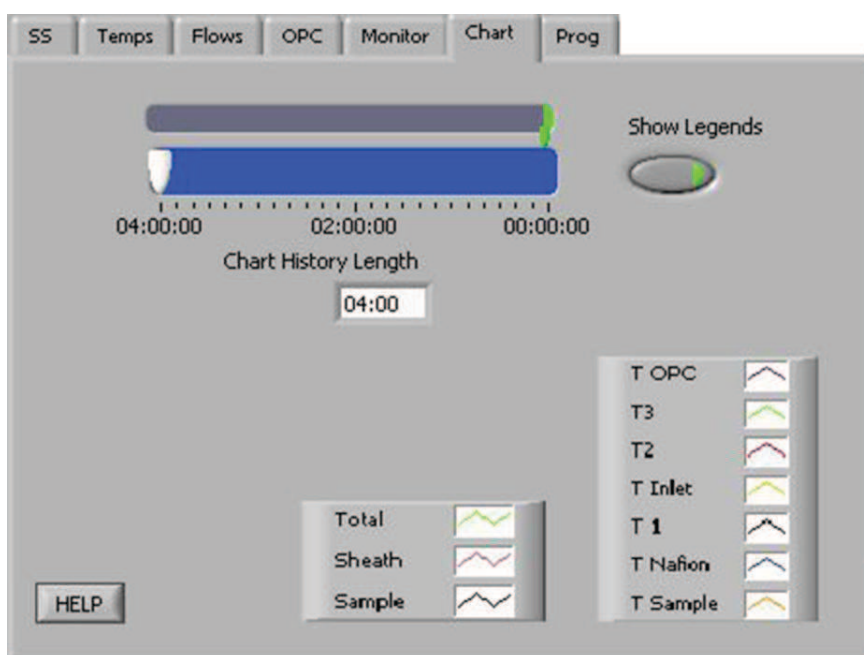

Figure 34: Chart Tab

Chart History Length controls the how far back the charts extend. The white slider on the blue background selects the history length, which has a default value of four hours. The green indicator shows the length of data available. Figure 34 shows the **Chart** tab before a session has started. No data is available yet, but the chart display is set to show up to four hours of data once it becomes available.

Show Legends controls the display of chart legends on top of the chart. If **Show Legends** is enabled, charts will show legend boxes such as those depicted in Figure 34.

DOC-0086 Rev I-2   7 5

12.1.7 Prog Tab (Program Control)

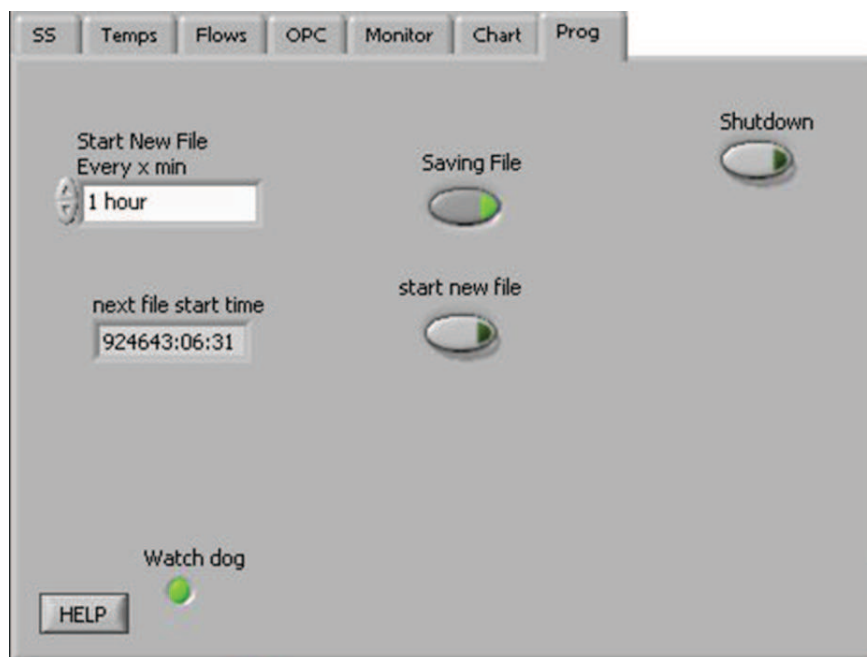The **Program Control** tab contains controls for file saving and data streaming, as shown in Figure 35.

Figure 35: Program Control Tab

Saving File controls whether the data is saved or discarded. This button is on by default. (See section 12.6 for information on file names and content.)

Start New File forces a new file to be started.

Start New File Every x min controls the length of data files. The default value is 60 minutes, and the allowed range is 1-180 minutes. The setting options work as follows. **1 hour, 2 hours,** and **3 hours** start the first file at when data recording begins and the remaining files on the hour. For instance, if you set **Start New File Every x min** to **2 hours** and start sampling at 7:56 a.m., the first file will begin at 7:56, the next at 9:00, and the next at 11:00. If you select **User Defined** and specify the number of minutes in the minutes pop-up field, however, files will not start on the hour. So, if you set **Start New File Every x min** to **User Defined** and set **minutes** to 120, files will begin at 7:56, 9:56, 11:56 and so on.

Shutdown stops the execution of the program and closes the files properly. This button should be used whenever exiting the program.

WARNING:

It is important to use the **Shutdown** button when shutting down the instrument; this will ensure that the pumps are shut off in order and the files are saved properly.

Watch dog alternates ON and OFF every second when the computer is cycling properly. The watch dog light on the instrument should blink at the same time as the indicator on the computer screen. (The watch dog light is located on the side of the CCN; see Figure 9.) If the indicator light is steady **OFF** or **ON**, reboot the computer.

12.2 Histogram

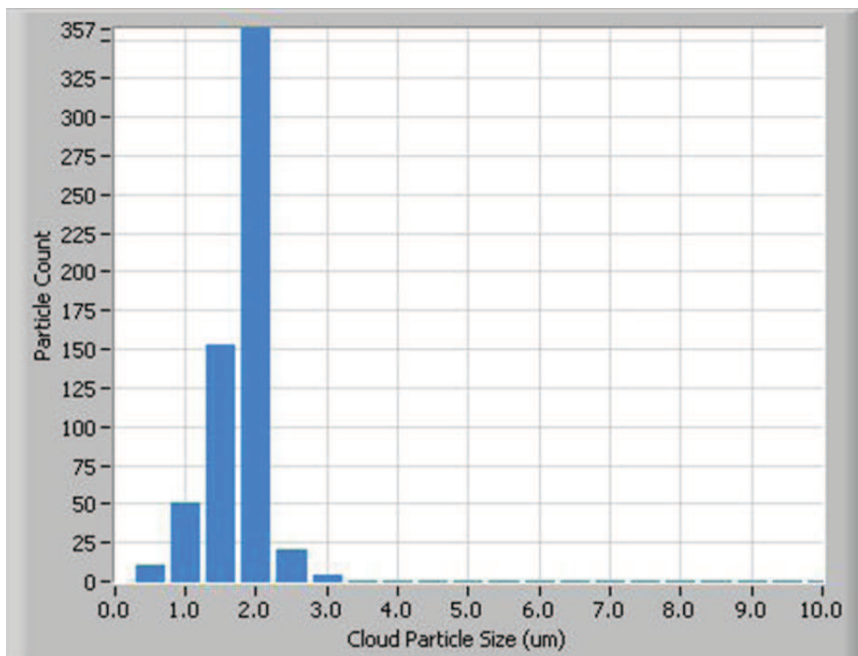Beneath the Control Tabs is the histogram of raw particle counts by size, as shown in Figure 36.

Figure 36: Histogram

For information on configuring the histogram display, see section 16.0.

12.3 Particle Concentration Time-Series Chart

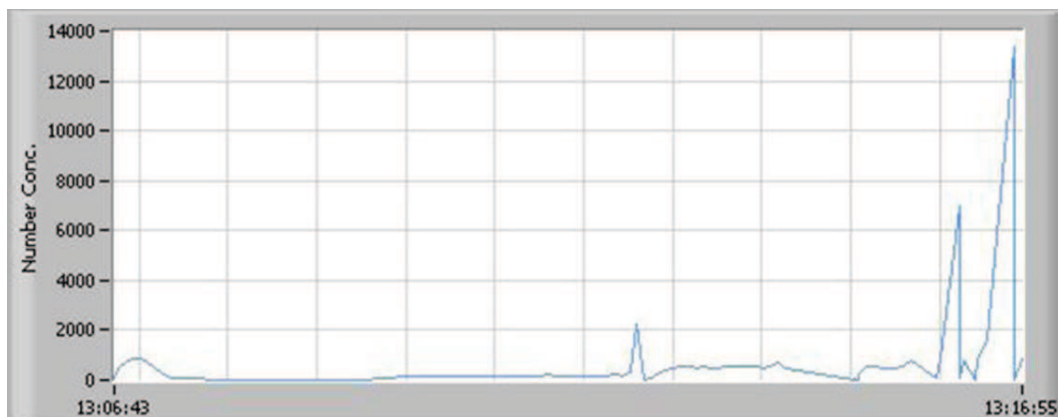In the upper right of the main CCN screen is the particle concentration chart, as shown in Figure 37.

Figure 37: Time-Series Concentration Chart

For information on configuring the chart display, see section 16.0.

12.4 Other Time-Series Charts and DMT Service Tab

In the bottom right of the main Single CCN screen are the flow time-series chart, the temperature time-series chart, and the DMT Service Tab.

- The **Flow Chart** plots Sample Flow, Sheath, Flow and Total Flow with respect to time.

- The **Temperature Chart** plots the temperatures of various CCN components over time. See section 12.1.2 for details and the normal range for these temperatures. The Temperature Chart also indicates the temperature of the sample air.

- The **Serial Output Tab** is described below.

- The **DMT Service Tab** is described below.

12.4.1 Serial Output Tab

Users have three options for how the CCN handles serial output:

- The instrument generates no serial output.
- The instrument generates a standard stream of serial output. *Note: This option must be used to interface with PADS.*
- The instrument generates a user-configured stream of serial output.

These options are described in more detail below. The radio buttons in the upper left of the **Serial Output** tab (Figure 38) allow users to select the option they prefer.
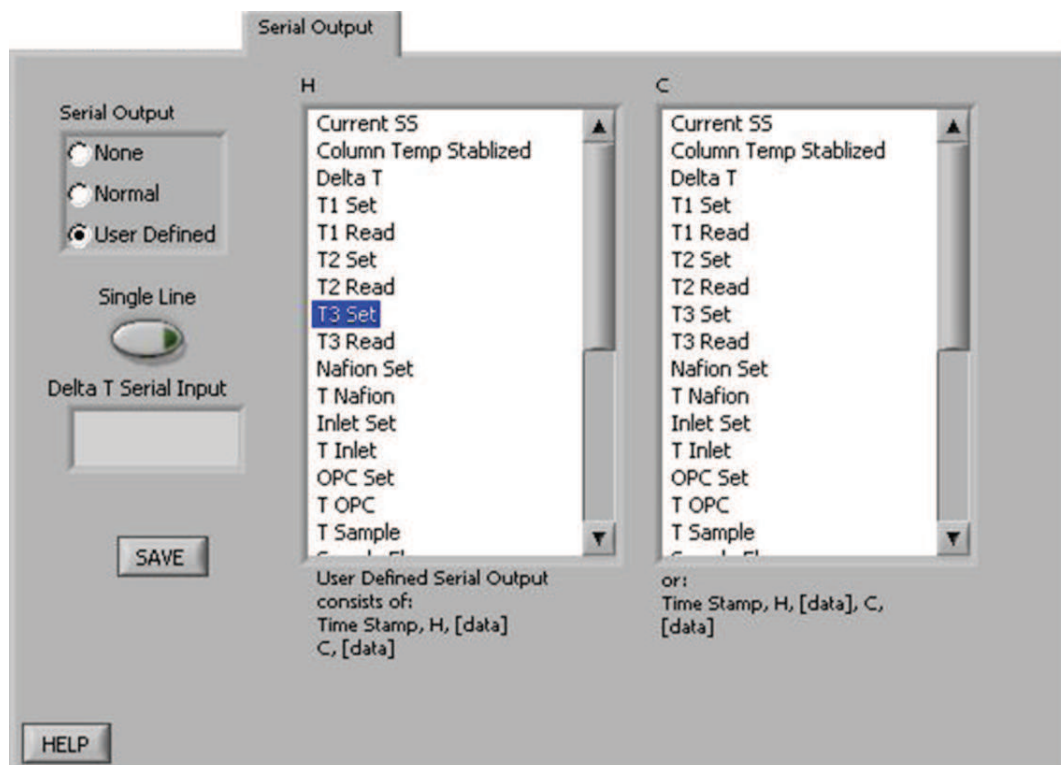

Figure 38: Serial Output Tab

If serial output is set to **None**, the white columns above will disappear from the **Serial Output** tab.

If serial output is set to **Normal**, the CCN will output two lines (Line H and Line C) of serial stream data. In this case, the columns displayed in the **Serial Output** tab are for informational purposes only; users cannot manipulate the display to configure the serial stream. The first serial stream will always start with a time stamp, followed by an "H," followed by the output channels displayed in the left column of Figure 38. (For a list of these channels, see section 12.6.1.) A carriage return separates the first set of data from the second, which starts with a "C" and continues with the output channels specified in the column on the right in Figure 38.

If serial output is set to **User Defined**, users can select the desired output channels from a list of all available channels. To include channels in the serial stream, select the channels by clicking on them. Holding down the <Shift> and <Control> keys allows you to select multiple channels at once. Note that the order of channels must follow that in the list of all available channels.
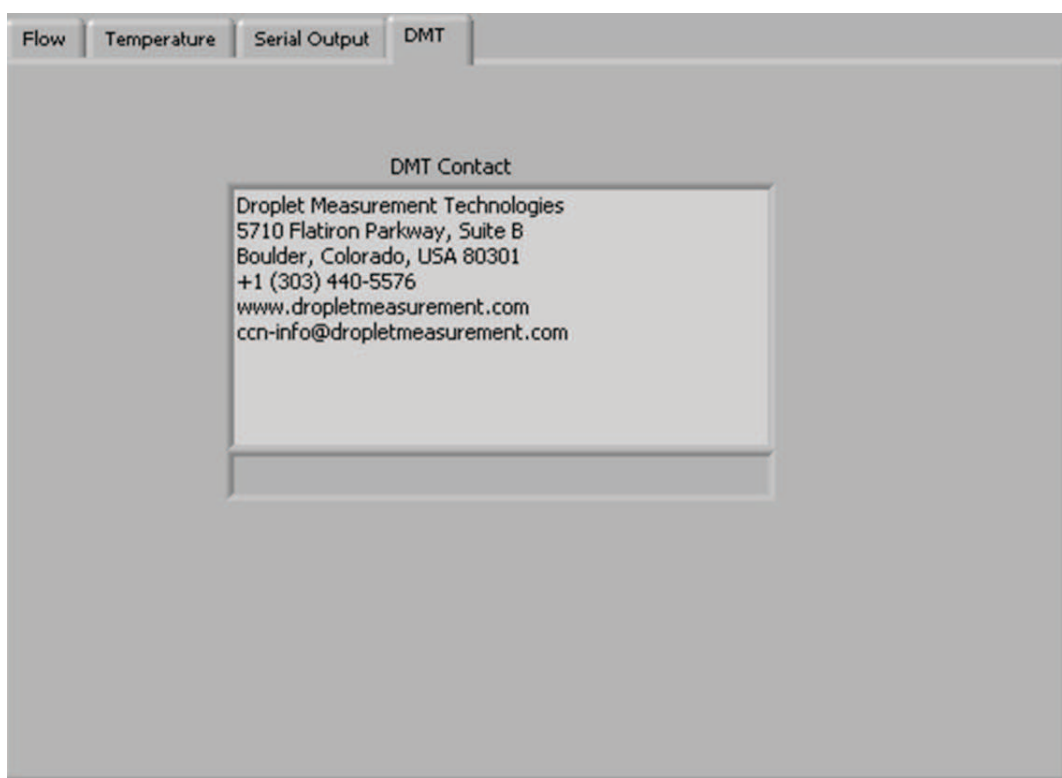
12.4.2 DMT Service Tab

Figure 39: DMT Service Tab

The DMT tab is used to access the CCN service tabs. These tabs are hidden and locked during normal operation. They can be accessed by clicking the text window in the middle of the screen and typing the password *Service*. When the password is entered correctly, tabs for **PID, Gains, Flow** and **Error/Exit** will appear (Figure 40). These tabs can be used to update the calibration parameters in real time, without having to restart the program. (In contrast, changes made to these same parameters using the **CCN Calibration Editor.exe** program require restarting **Single CCN.exe** before the updates will take effect.) The new values can be saved as defaults by pressing the **Save** button. If the **Save** button is not pressed, any values entered will only apply to the current session.

12.4.2.1 DMT Service Tab: PID Section

The PID screen, pictured in Figure 40, allows users to modify the CCN's proportional valve flow control loop. Specifically, the parameters on this tab determine how the CCN's proportional valve voltage will shift from its current state to a higher or lower one.[vi] During any such transition, the optimal change is one that is 1.) quick, 2.) smooth, and 3.) does not overshoot its target—i.e., does not raise or lower the voltage too far. The challenge, however, is that these three factors cannot be simultaneously optimized, as a very quick transition typically overshoots its target.
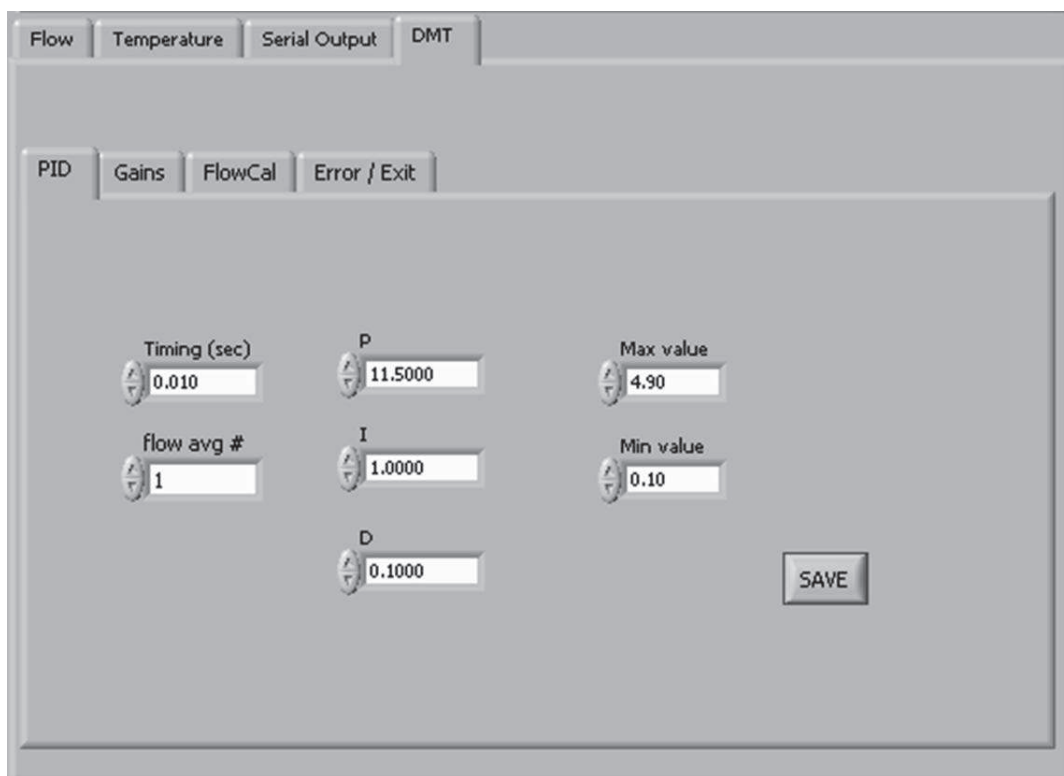

Figure 40: DMT Service Tab – PID Section

The proportional valve is controlled by a PID loop. **P** *(Proportional)*, **I** *(Integral)*, and **D** *(Derivative)* are variables used to control the valve's voltage transition. **P** determines the scale of the transition, and is akin to the multiplier that is used to get from the old voltage to the new voltage. **I** the speed of the response time, with a higher **I** yielding a faster transition. **D** determines how smooth the transition curve will be.

The default values that appear in the P, I, and D fields on the PID tab are adequate for stable flow control in most cases. However, under certain circumstances, it may be necessary to tune the PID loop for better control.

[vi] The proportional valve voltage determines how open or closed the proportional valve will be, which in turn regulates total sample flow.

Max and **Min value** refer to the proportional valve voltage window the PID loop can control. Each proportional valve has an operating range of about 1 V, but turn-on voltages between valves can vary from 1.25 - 3.5 V. Thus one proportional valve may operate at 1.25 – 2.25 V, while another operates at 2.5 – 3.5 V. Setting **Min** and **Max** values so they create a wide window (0.1 – 4.9 V) accommodates all proportional valves. Narrowing this window does not typically improve flow performance.
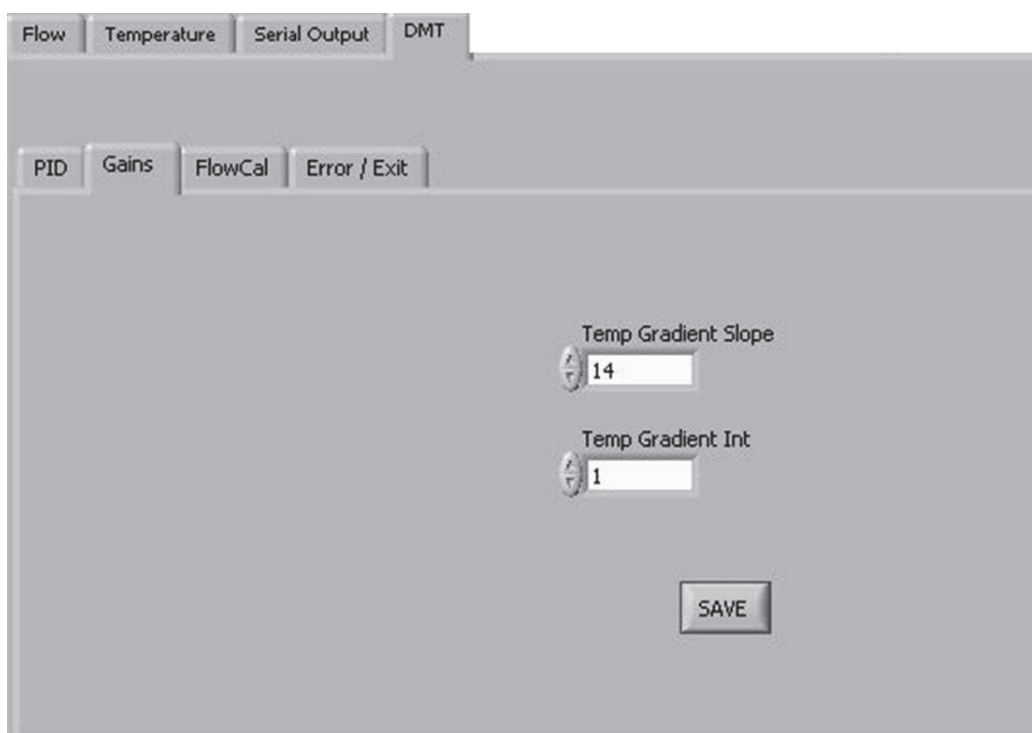
12.4.2.2   DMT Service Tab: Gains Section

Figure 41: DMT Service Tab – Gains Section

This tab allows users to enter the slope and intercept of the equation to convert SS% to Temperature Gradient. Refer to section 8.1 for the complete SS% calibration procedure.

12.4.2.3   DMT Service Tab: FlowCal Section

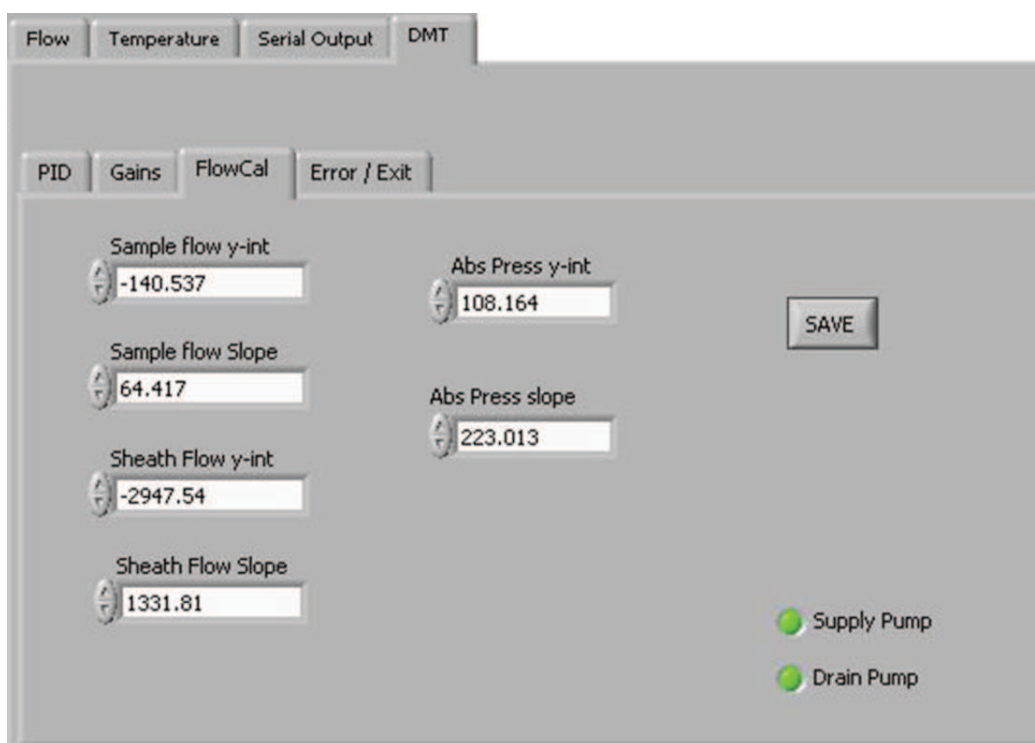The **FlowCal** tab is shown in Figure 42.

Figure 42: DMT Service Tab – FlowCal Section

This tab allows users to enter the slopes and intercepts of the equations to convert voltage to flow. To have the voltage of the transducer displayed in the CCN **Flows** tab, enter a slope of 1 and an intercept of 0. Refer to section 8.2 for the complete flow calibration procedure.

The **Supply Pump** and **Drain Pump** indicators blink during normal operation when the pumps are on.

12.4.2.4   DMT Service Tab Error / Exit

The **Error/Exit** tab is shown in Figure 43. Its windows and information can be helpful when troubleshooting with DMT's help, but they should not be modified without assistance.
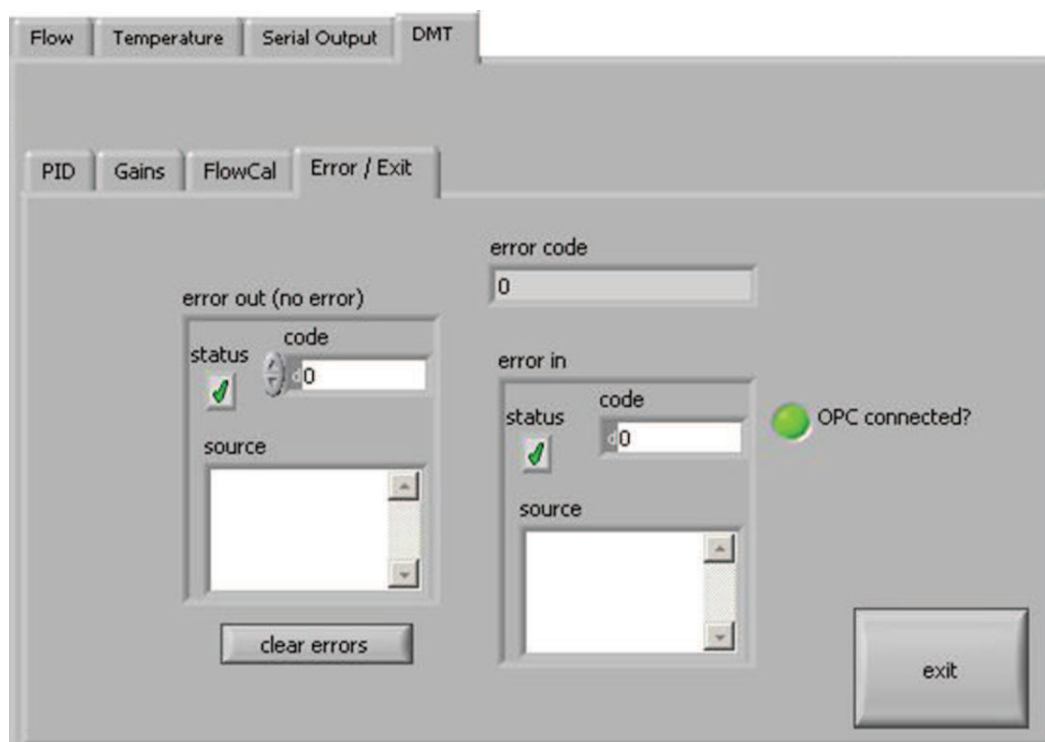
Figure 43: DMT Service Tab – Error/Exit Section

Press exit on this tab to exit the **DMT Service** tab and end service mode. Although the unit will function normally when in the service mode, it is recommended that users exit once service is completed to avoid accidental input. The service mode is also exited upon closing of the VI or rebooting the computer.

12.5 Program Input Files

The **Single CCN.exe** program requires two input files: `CCN_SS_Settings.ini` and `CCN_Calibration.ini`. The former stores the supersaturation settings for the instrument, while the latter stores instrument calibration and configuration information.

Both of these files are in the `C:\` directory, but they should not be modified directly. Instead, use the program **CCN SS Settings Config Editor.exe** to modify `CCN_SS_Settings.ini` and **CCN Calibration Editor.exe** to modify `CCN_Calibration.ini`.

12.6 Program Output Data

12.6.1 Serial Stream

A serial output stream of data is available for sending to a host computer or other device. A serial null modem cable must be used and is provided with the startup kit. The control for this is the **Serial Output** button found on the **Program Control** tab (section 12.1.7). The data appears on the DB-9 connector labeled "Data Out" and uses a RS-232 configuration with 9600 baud transmission and 8-N-1 data protocol. Connecting this port to another computer requires the use of a null modem between the computers so that pins 2 and 3 are swapped.

Users can select three options for serial stream output: no output, normal output, or user-defined output. See section 12.4.1 for details. The list of available serial stream output channels appears below. The two lines of data are separated by a carriage return. The "H" and "C" that begin the columns are simply the characters H and C (i.e., these are not the names of data channels).

First Data Line	Second Data Line
H	C
Time	Bin setting
SS setting	CCN Number Conc.
Temp Stable ?	ADC overflow
T1 read	Bin 1[vii]
T2 read	Bin 2
T3 read	Bin 3
Sample Temp	Bin 4
T inlet	Bin 5
T OPC	Bin 6
T Nafion	Bin 7
Sample flow	Bin 8
Sheath flow	Bin 9
Abs Press	Bin 10
Laser current	Bin 11
1ST Stage Monitor voltage	Bin 12
Temperature Gradient	Bin 13
Proportional Valve Voltage	Bin 14
Alarm Code	Bin 15
	Bin 16
	Bin 17
	Bin 18
	Bin 19
	Bin 20

[vii] All bin channels store are raw particle counts rather than concentrations.

For definitions of these channels, see the Glossary in Appendix A.

Note: The user can also change the temperature gradient via the serial port (labeled **DATA OUT**) when the **AUTO SS** button is off. To change the value, five characters must be entered (example: 10.00, or 10.0 and a carriage return). To see what SS the temperature gradient equals, press the **SS** tab and look in the lower right-hand corner for the display labeled SS.

12.6.2 Output Files

The CCN instrument provides on-board file storage that can be retrieved by Remote Desktop or over an Internet connection.

The frequency at which the program starts a new file can be set on the **Program** tab. Use the **New File Every (min)** control depicted in Figure 35. If the setting for this parameter is 20, the program will save a new file every 20 minutes using the file convention described below.

The files are named "`CCN data yyMMddhhmmss.csv`" and are created in the `C:\CCN data` directory. Note that the CCN data directory is not automatically created by the software and must be created to store the data. The format of yyMMddhhmmss is as follows:

- yy = the two digits for year
- MM = the two digits for month
- dd = the two digits for day
- hh = the two digits for hours
- mm = the two digits for minutes
- ss = the two digits for seconds

Example: May 6, 2004 at 4:18:27 would be 040506041827. This convention lists files created sequentially from start time, which provides an easy way to locate specific files.

Output files contain the following data channels:

Time	Sample Temp	Bin 8
SS Setting	Sample flow	Bin 9
TempStab?	Sheath flow	Bin 10
Delta T Set	Abs. Press	Bin 11
T1 Set	Laser Current (mA)	Bin 12
T1 Read	ADC overflow	Bin 13

T2 Set	Baseline Monitor	Bin 14
T2 Read	1st Stage Monitor	Bin 15
T3 Set	Bin Setting	Bin 16
T3 Read	Bin 1	Bin 17
Nafion Set	Bin 2	Bin 18
T Nafion	Bin 3	Bin 19
Inlet Set	Bin 4	Bin 20
T Inlet	Bin 5	Number Conc.
OPC set	Bin 6	Alarm Code
T OPC	Bin 7	

As with serial-stream data, all Bin channels store raw particle counts rather than concentration. For definitions of these channels, see the Glossary in Appendix A.

13.0 CCN SS Settings Config Editor.exe

The program **CCN SS Settings Config Editor.exe** allows the user to create up to four predefined tables for operating the CCN in a scanning mode with variable supersaturation and time periods. (Users can also enter manual values for SS% and Delta T Set (C); see section 12.1.1.2). Figure 44 shows the configuration editor program.
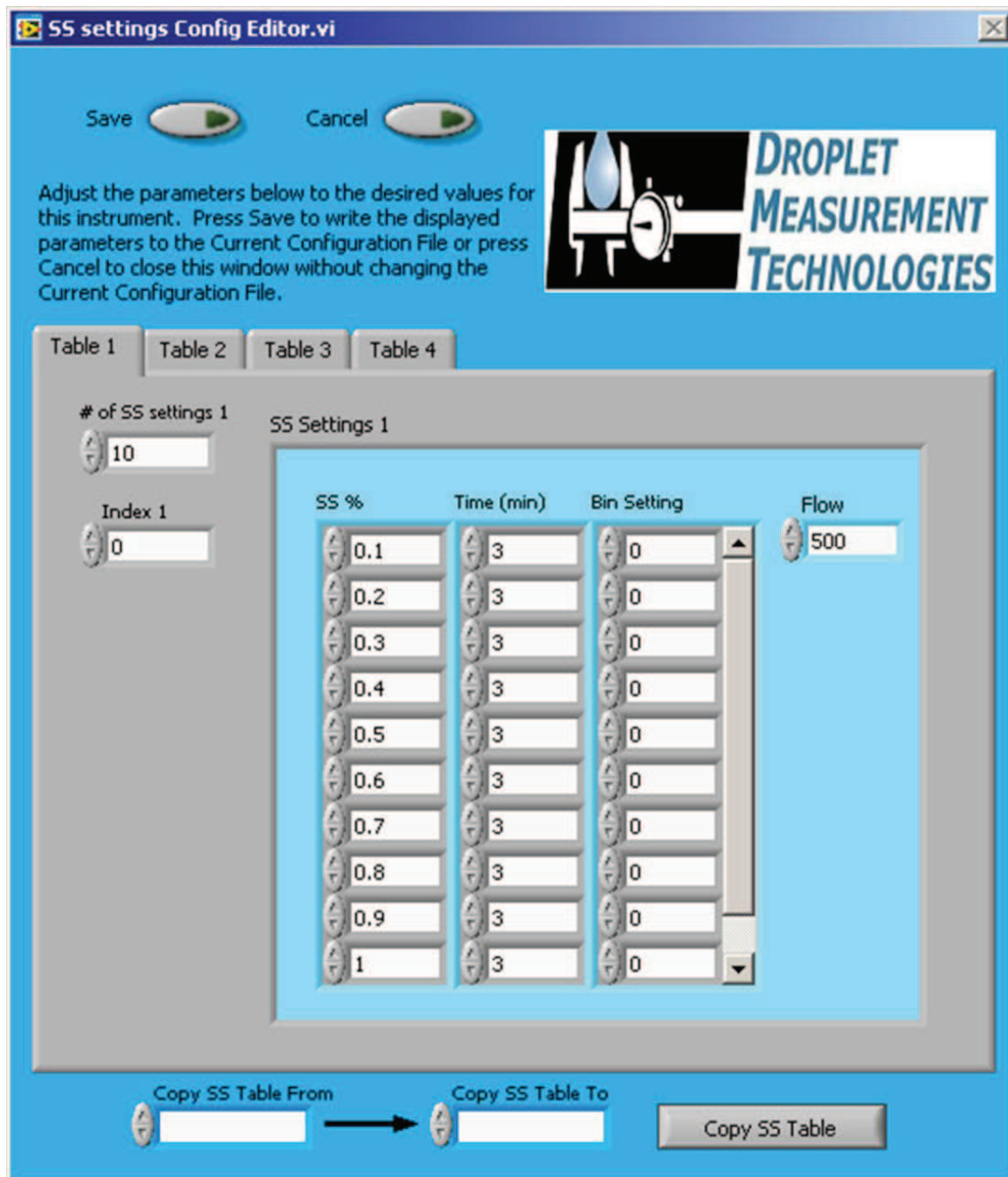
Figure 44: Program for Setting the Supersaturation Tables

When configuring supersaturation tables, it is recommended that the states progress from lower supersaturations to higher ones. The CCN instrument performs best with gradual increases in column temperature followed by a major cooling back to a low supersaturation.

Tables 1 through 4 allow preconfigured settings to be loaded into the operating program. These settings include the supersaturation rate, duration for the supersaturation setting, the bin settings to be used in the CCN concentration calculations, and the set total flow.

Once the table has been configured, click on **Save** to save this table, and move on to the next desired configuration. The tab provides the option of four different supersaturation tables. The fields at the bottom of the screen can be used to copy values from one table to another in the event that two tables share a portion of data. Following the configuration of all the desired tables, exit the **CCN SS Settings Config Editor** program.

14.0 CCN Calibration Editor.exe

The **CCN Calibration Editor.exe** program allows users to set calibration coefficients that determine equations for flows, temperature gradient, proportional valve settings and so on. The calibration coefficients for each of these measurements are stored in a table that is accessed by the program. These systems are calibrated before the unit leaves DMT, but it will be necessary to recalibrate them periodically. The USB memory stick that accompanied the CCN upon delivery contains spreadsheets that are useful during calibration.

Note that many of the calibration coefficients displayed in **CCN Calibration Editor.exe** can also be modified by using the **DMT Service** tab on the control program, **Single CCN.exe.** The control program only saves these changes if the **Save** button is pressed. In contrast, the calibration editor program always saves changes and the new values will be used upon startup of the control program.

14.1 Standard Screen

Opening **CCN Calibration Editor.exe** brings up the screen shown in Figure 45.

The left-hand column contains several controls for altering pressure coefficients. The flow measurements on the CCN for the sample and sheaths flows use a differential pressure transducer for each flow. In addition, an absolute pressure transducer is used for the sample pressure measurement. To calibrate the transducers, set the slope value to 1 for each of these parameters and the intercept to 0. In this way the values on the **Flows** tab will read out in volts. A new set of calibration coefficients can then be derived and entered into the program.
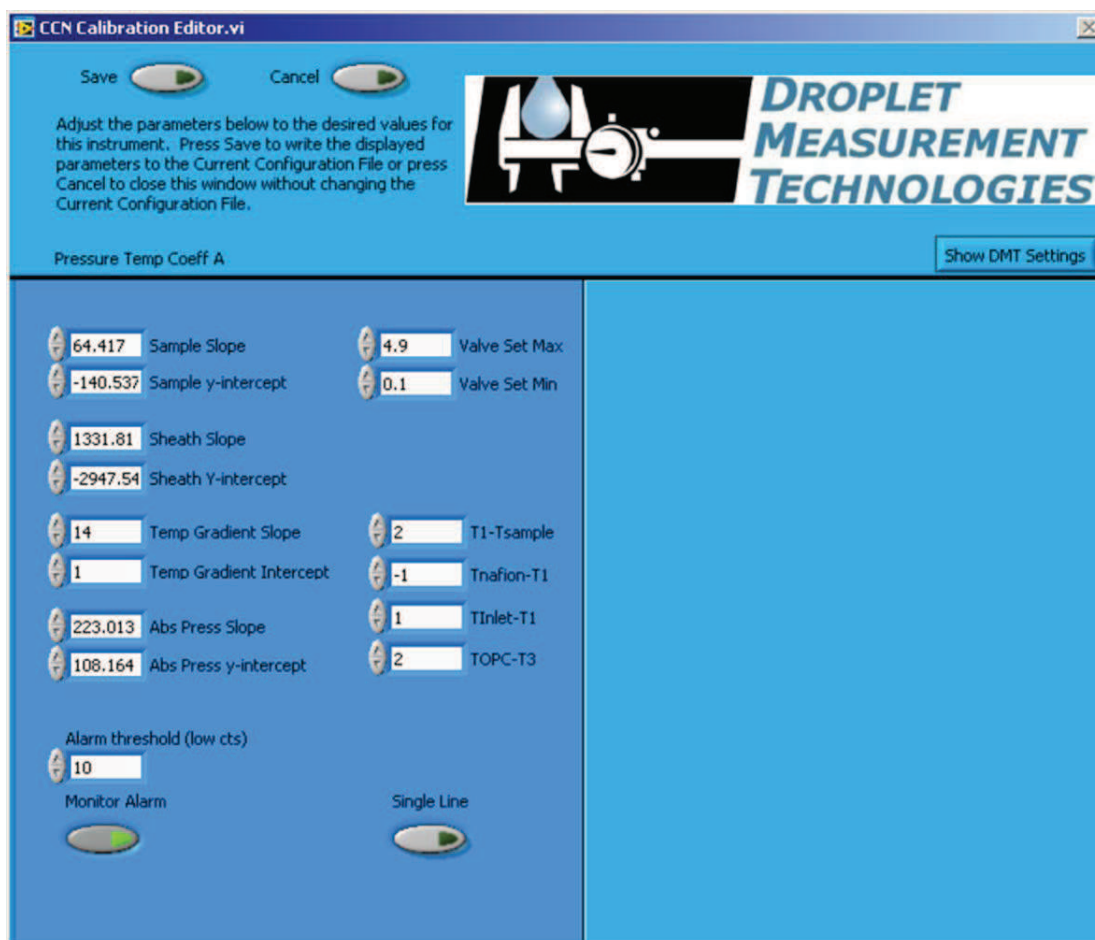
Figure 45: CCN Calibration Editor.exe

Temp Gradient Slope and **Intercept** calibrate the proper temperature gradient to achieve the desired supersaturation. Users who want to calibrate the CCN unit must contact DMT prior to making any adjustment.

Valve Set Min sets the lower limit of Proportional Valve Control Voltage. By default, this value is set to 0.1. It can be changed here or in the PID tab; see section 12.4.2.1.

Valve Set Max sets the upper limit of Proportional Valve Control Voltage. By default, this value is set to 4.9. It can be changed here or in the PID tab; see section 12.4.2.1.

T1 – Tsample is a temperature differential that determines the temperature of the top of the column relative to the sample air temperature. **TNafion – T1, Tinlet – T1,** and **TOPC – T3** determine the temperature of the Nafion humidifier, the inlet manifold, and the OPC relative to temperatures at points on the column. These differentials are in degrees Celsius. Under normal operations these differentials should not be changed, but increasing **TOPC – T3** can prevent fogging of the OPC.

Alarm Threshold (low cts) sets the threshold value for CCN Number Conc. Alert (see section 12.1.5). DMT sets this value to 10 counts per second, which is the factory default.

Monitor Alarm turns the monitoring feature on/off. Turning off monitoring disables the alarms and the **Monitor** tab. **Monitor Alarm** should always be ON.

Single Line allows users to specify whether serial stream data should be in a single line (no carriage return between data) or in a double line (a carriage return separating lines). See section 12.6.1 for details.

14.2 Screen with DMT Settings

Additional parameters can be viewed by clicking on the **Show DMT Settings** button, which is visible in the upper left of the screen. Pressing this button brings up the window shown on the right-hand side of Figure 46.
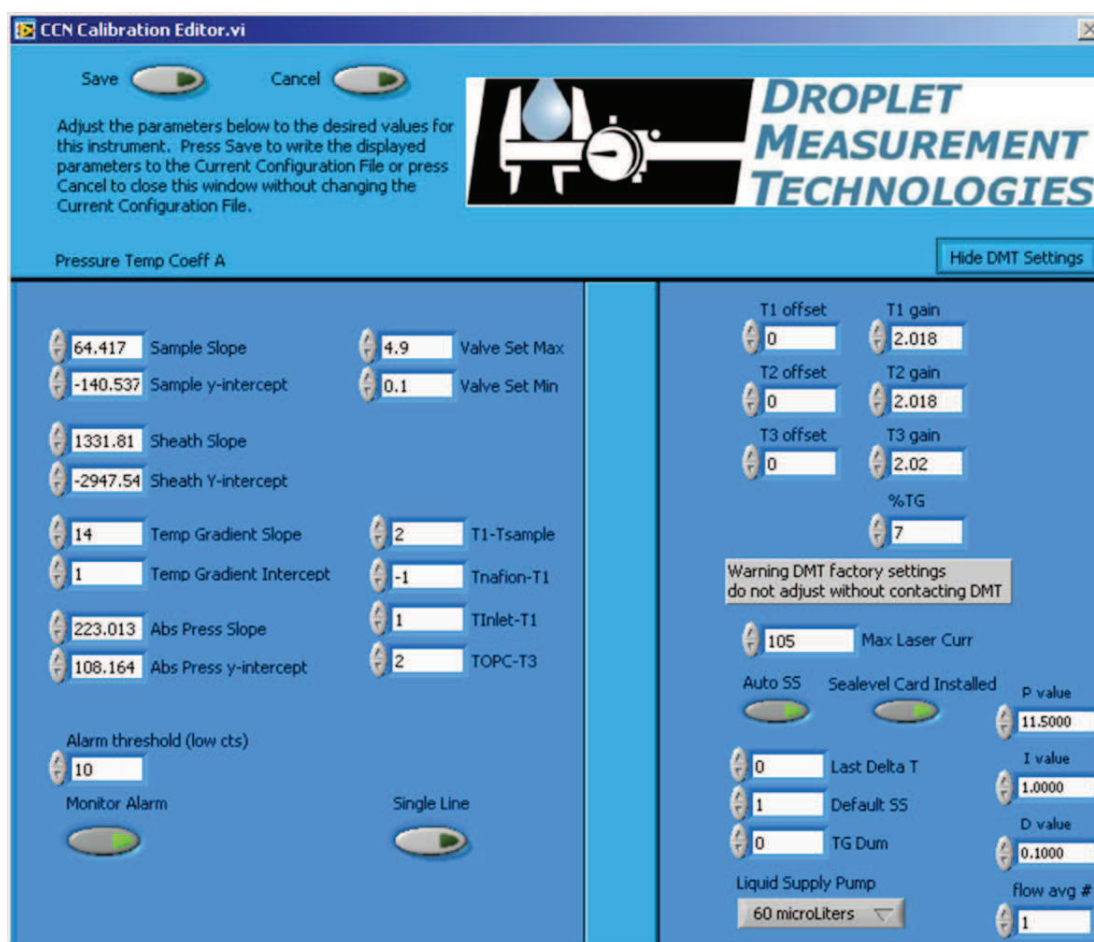
Figure 46: CCN Calibration Editor.exe with DMT Tabs

As noted on the screen itself, these settings should not be altered without contacting DMT first.

T1, T2, and **T3 Offsets** and **T1, T2,** and **T3 Gains** adjust the read points of T1, T2, and T3. These should never be adjusted by the user.

%TG enhances the response time between SS% changes. It causes the bottom temperature zone of the column to run a certain percentage lower temperature than a linear gradient. For example, if this percentage is set to 5% and there is a 10° temperature gradient, the bottom temperature zone of the column will be set at 9.5° (not 10°) hotter than the top temperature zone.

NOTE: the desired temperature gradient will still be displayed in the delta T box. But the actual set point of T3 will be offset lower by the %TG temperature gradient percentage. The %TG parameter should never be adjusted by the user.

Max Laser Curr indicates the alarm threshold for the laser current. If the actual current exceeds the value entered in this field, the CCN will generate an alarm.

Auto SS, Last Delta T, Delta SS, and **TG Dum** are parameters accessed by the CCN software. They should never be changed.

The **Sealevel Card Installed** indicator is illuminated whenever the Sealevel card is present. This indicator should be ON if your computer has this card. (Some older computers have four COM ports on board, and so this additional COM port is not needed.) If the **Sealevel Card Installed** indicator does not match the actual instrument configuration, the serial stream may have an incorrect baud rate.

Liquid Supply Pump indicates whether the CCN's supply pump has a 20 or 60 μl displacement capacity per cycle. It is set to match the specifications of the pump, and should not be changed unless a new pump is installed.

P, I, D, and **Flow Avg #** are used in the PID control loop. **Flow Avg #** is used in smoothing the PID function. For information on P, I, and D, see section 12.4.2.1.

15.0 CCN Playback.exe

The CCN Playback.exe program allows you to play back data files that the CCN created during an earlier session. The program display (Figure 47) is similar to that when the Single CCN program is running. The display includes the following:

- Tabular data on temperatures, flows, the OPC counter, and alarms
- A histogram displaying particle counts by particle size

- Time-series charts for particle concentration and flows, with particle concentration on top[viii]

There are also several differences between the displays in **Single CCN.exe** and **CCN Playback.exe**. The latter does not feature **Serial Output** or **DMT Service** tabs. It does include a **Selectable Chart** tab behind the histogram, which is described in section 15.2.
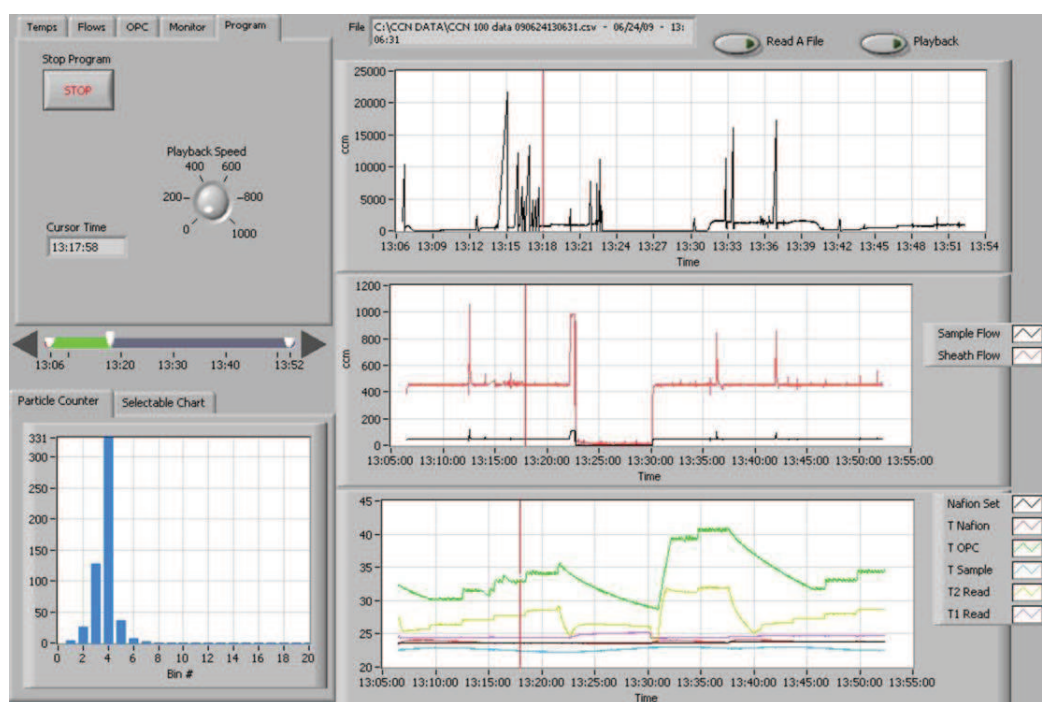

Figure 47: CCN Data Playback

The **Read a File** button in the top right opens a file explorer for selecting the data file to be read. The program then displays this file path in a window at the top of a screen. The currently displayed time is displayed on the **Program Tab**, and is indicated by a red cursor in time-series charts.

15.1 Changing the Current Time

Once a file is loaded, there are two options for displaying data. To move forward in time automatically, press the **Playback** button in the upper right of the window. The current time will advance forward automatically, and updated data will populate the display. The

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[viii] **Note:** The software currently mislabels the y-axis for the particle concentration chart. Units should be in particles/cc, not ccm. This bug will be fixed in an upcoming version of the program.

speed can be changed using the **Playback Speed** dial on the **Program tab**, visible in Figure 47 above.

Users can also change the current time manually using the timing controls on the left side of the screen. Figure 48 shows these controls in more detail.
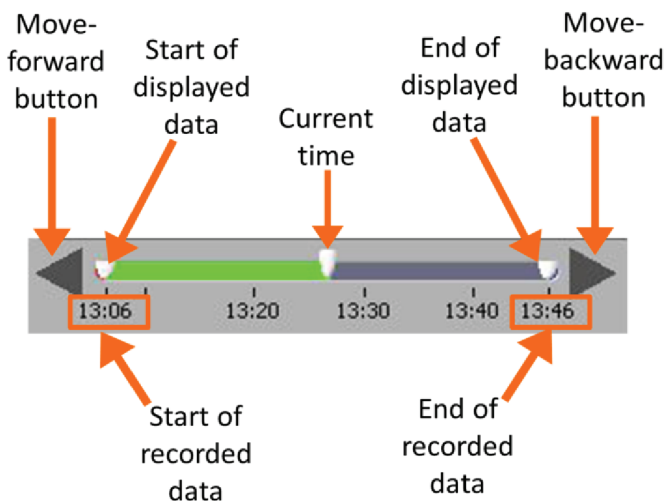

Figure 48: Playback Timing Controls

The arrow buttons can be used to advance or go back in time. The white controls that show the start and end of displayed data can also be used for zooming in on the data. To do this, move the two controls closer to each other, as shown in Figure 49.

Figure 49: Using Playback Controls for Zooming

15.2 Selectable Chart Options

Behind the **Particle Counter** is the **Selectable Chart Tab.** This tab, shown in Figure 50, selects channels to display in the bottom chart on the right side of the window. The default channels are the temperature values charted with respect to time.
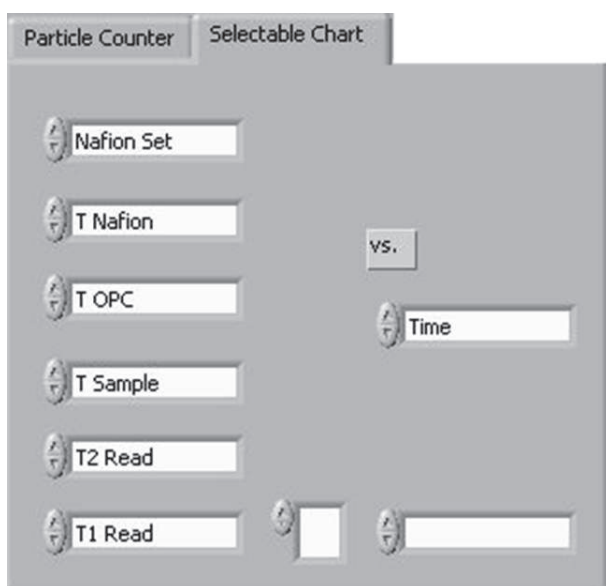
Figure 50: Selectable Chart Tab

16.0 Chart Options (for Single CCN and CCN Playback Programs)

In both the **Single CCN.exe** and **CCN Playback.exe** programs, you can right-click on charts such as the histogram and time-series charts to bring up additional options.

On many charts, you can change the scale by typing a different number into the starting and ending values on each axis. For instance, if you want to change the time period in one of the graphs above to end at an earlier time, you simply select the field with the old time, type in the new time, and hit the <Enter> key. In acquisition mode, you must disable autoscaling (see below) before you modify fields in this way.

Many charts also display options for scaling and copying the data when you right-click on them, which brings up a drop-down menu. These options are as follows:

> **Autoscale** This autoscales the relevant axis. In autoscaling mode, the minimum and maximum values of the axis are set automatically so that all data points can be seen in the display.

> **Copy Data** This copies the chart to the clipboard using a screen capture. This chart can then be pasted into other documents like Word or PowerPoint presentations.

Export Simplified Image   This copies a simplified image of the data to the clipboard or an output file. You can choose the format you desire—bitmap (.bmp), encapsulated postscript (.eps), or enhanced metafile (.emf). Note that when you select the .eps option, you must copy the data to a file. Unless you specify otherwise, output files will be saved in the time-and-date-specific output file directory for the current session.

Clear Graph   This erases the currently displayed data points from the graph.

17.0 Remote Operation of CCN Programs through a Network Connection (Remote Desktop)

The CCN instrument can be connected to using the instrument's Ethernet port, which is located with the other interface connections. The instrument can be connected to an Intranet or to a single computer with a network crossover cable.

Remote Desktop is a program that can be run on a host machine that will connect to the CCN instrument over the Internet. Remote Desktop is available online and must first be installed on the host machine. In order to connect to the CCN instrument, run **Remote Desktop** from the host machine. In the computer selection type **CCNStack** or the IP address of the CCN instrument, then click **Connect**. The user should be *administrator*, and the password for the CCN computer is *password*.

Once Remote Desktop connects to the instrument, you will have complete access to the active desktop on the CCN computer from the host machine. All CCN programs will then be accessible from the host machine. Files can be transferred from the CCN onboard computer to the host machine using the **right click copy** and **paste** features. To transfer files, navigate to the CCN data folder. Select the files to transfer, and copy them by right-clicking and selecting **Copy**. Then minimize the remote desktop function, navigate to the desired file location, and paste the files using the right-click function. After right-clicking to paste the files, it may take up to a minute for the program to respond.

Another option for copying files is to put them on a shared folder. You can share a folder on the remote machine by double-clicking on it and then selecting **Share This Folder** under the **File and Folder tasks.** This will bring up a window where you can select **Share This Folder** using a radio button. After clicking **OK**, navigate back to the host machine desktop. Bring up Windows Explorer and in the path field type "\\" followed by the IP address of the remote desktop computer. The shared folder should now be visible, and you can copy its files to any other location.

Virtual Network Computing (VNC) is not supported by this version of windows XP at this time. It is the responsibility of the user to set up the Remote Desktop of the CCN.

The following book is recommended for users needing assistance with networking to the CCN: *Microsoft Windows XP Networking Inside Out* by Curt Simmons, published by Microsoft Press.

> The CCN computer name is "*CCNStack*" and the password is "**password**".

Appendix A: Glossary

%TG: A temperature-gradient adjustment factor that enhances the response time between SS% changes. **%TG** causes the bottom temperature zone of the column to run a certain percentage lower temperature than a linear gradient. For example, if this percentage is set to 5% and there is a 10° temperature gradient, the bottom temperature zone of the column will be set at 9.5° (not 10°) hotter than the top temperature zone. Typically this number will be set to 7%.

1st Stage Monitor (V):   A monitor that indicates whether the optical particle counter (OPC) is fogged or dirty. When **1st Stage Mon** exceeds its threshold for a sustained period, the CCN computer generates an **Alarm Code.**

Abs Press: The absolute pressure in the CCN column. The absolute pressure is one factor that determines the instrument's supersaturation.

ADC Overflow: The number of particles that have been detected but rejected for counting because they were oversized. Oversized particles send out a peak digital signal that exceeds that given in a threshold table as the upper boundary of the uppermost sizing bin. These particles are included in **Number Conc.**

Alarm Code: The sum of any current alarm codes the CCN computer has generated. Each alarm code is a unique 2^n number that reflects a specific issue with the CCN. For instance, an alarm code of 4 indicates a problem with the total flow or with the sample-sheath flow ratio. An alarm code of 16 indicates a problem with the sample temperature. Problems with both the flow and the sample temperature would result in an **Alarm Code** value of 20 (= 4 + 16), providing no other alarm codes have been generated. A negative alarm code indicates problems severe enough that the instrument has gone into safe mode. See section 12.1.5.2 for more details.

Baseline Monitor: A voltage indicator used by DMT for diagnosing the OPC. A healthy reading is 2.5 – 3.2 V.

Bin [*i*]: The raw particle count in bin number *i*.

Bin Setting: A parameter that can be used to limit the **Number Conc** calculation to reflect larger particles only. Bins lower than the **Bin Setting** do not have their particles included in this calculation. If all particles are to be included, **Bin Setting** should be 0. The program **CCN SS Settings Config Editor.exe** allows users to configure bin settings for different supersaturation settings. **Bin Setting** is also a channel in the output data.

Chiller: Another name for the CCN's **cold trap.**

Cold trap: A device that condenses water out of the OPC exhaust, ensuring that water does not condense in the instrument's proportional valve or pump. See section 2.2.1 for details.

Column Temps Stabilized Status: An indicator on the **Monitor** tab that corresponds to the **Temp Stable?** output channel. This monitor triggers when **T1 Read**, **T2 Read**, or **T3 Read** is > 0.4 °C from its set point.

Current SS#: The level of the CCN's current supersaturation. In **Auto SS** mode, the CCN determines the sequence of supersaturations for the session using a supersaturation table. All supersaturation tables start at level 0. Users can enter up to 256 different supersaturations per table, so the maximum level is 255.

Current SS%: The CCN's current supersaturation. Note that if the instrument is changing supersaturations, **Current SS%** will differ from **Current SS#.**

Delta T Set (C): The temperature differential used to calculate values for T1 Set, T2 Set, T3 Set, Inlet Set, Nafion Set, and OPC Set. **Delta T Set (C)** is equal to **T3 Set** – **T1 Set**.

DMA: A differential mobility analyzer. DMAs are traditional devices for sizing aerosol particles.

Dry Start Up: An option that can be selected during the first ten seconds of the CCN. **Dry Start Up** should only be selected when the unit has been totally dried out, such as after shipping.

Dry Shut Down: An option that can be selected during the first ten seconds of the CCN. **Dry Shut Down** should only be selected when the unit needs to be totally dried out prior to shipping.

Inlet Set (C): The set point temperature at the CCN inlet manifold.

Köhler Curve: A mathematical function representing the cloud-droplet formation process. Köhler curves are used to calibrate the CCN and determine the relationship between temperature gradient and supersaturation.

Laminar Flow: A flow in which the separate layers of air or fluid flow in parallel rather than mixing together. The CCN uses a laminar flow element.

Laser Current (mA): The electrical current flowing through the instrument's laser diode. A sudden change in current could reflect a problem with the instrument. A reading of 60 – 120 mA indicates the instrument is functioning properly. A high laser current can indicate the laser is nearing the end of its life. A sustained high Laser Current will generate an **Alarm Code.**

Nafion Set (C): The set temperature of the Nafion humidifier. When this temperature differs substantially from its set point for a sustained period, the CCN computer generates an **Alarm Code.**

Number Conc. / CCN Number Conc. (#/cm^3): The particle number concentration in sized particles per cubic centimeter of air. This is calculated as follows:

Number Conc = [(Sum of qualifying Bin Counts) + (ADC Overflow)] / Sample Flow ● 60

The 60 is a unit conversion factor, since **Bin Counts** and **ADC Overflow** are given in particles per second while **Sample flow** is in cm^3/min. The CCN's **Number Conc.** includes oversized particles but does not include particles in bins smaller than the **Bin Setting.** When **Number Conc.** falls below its threshold for a sustained period, the CCN computer generates an **Alarm Code.**

OPC: An optical particle counter. The OPC component of the CCN counts and bins activated aerosol particles in the sample air after they have grown to detectible size.

OPC Set (C): The set point temperature of the optical particle counter. When **OPC Temp (C)** differs substantially from this set point for a sustained period, the CCN computer generates an **Alarm Code.**

PADS: See Particle Analysis and Display System.

Particle Analysis and Display System (PADS): Optional DMT software that can be purchased with the CCN. Like the CCN's standard software, PADS is written in LabVIEW. PADS provides data analysis and reporting features for many DMT instruments simultaneously. It is useful if CCN data are being analyzed in conjunction with data from other instruments.

PID: A proportional-integrative-derivative control system. PID systems have three parameters that are used to determine a system's corrective response to errors. (See http://en.wikipedia.org/wiki/PID_controller for more information.) On the CCN, a PID algorithm is used to modify the CCN's proportional valve flow control loop. Users can

modify the three PID parameters from the PID section of the DMT Service tab. See section 12.4.2.1 for details.

Proportional Valve (V): The voltage the computer sends to the proportional valve to keep the CCN's air flow constant.

Sample air: The air that the CCN samples for aerosol particles. The sample air is confined to a small volume at the center of the CCN column. It is surrounded by sheath air, with the sheath:sample volume ratio set at approximately 10:1.

Sample Flow (Vccm): The volumetric sample flow rate. Typically the ratio of sample flow to sheath flow should be about 1:10, since the volume of sheath air should be about ten times more than that of the sample air. If the observed ratio diverges significantly from the set-point ratio for a prolonged period, the CCN computer generates an **Alarm Code**.

Sample Temp (C): An output channel that indicates the temperature of the sample air. When **Sample Temp (C)** exceeds its range for a sustained period, the CCN computer generates an **Alarm Code**.

Sheath air: The air that surrounds the sample air in the CCN column. The sheath air acts as a buffer to confine the sample.

Sheath Flow (Vccm): The volumetric flow rate of the sheath air. Typically the ratio of sheath flow to sample flow should be about 10:1, since the volume of sheath air should be about ten times more than that of the sample air. If the observed ratio diverges significantly from the set-point ratio for a prolonged period, the CCN computer generates an **Alarm Code**.

SS setting: An output data channel that stores the instrument's current supersaturation. A higher **SS setting** means that more particles will be detected.

SS Table: A supersaturation table, or a table that determines the progression of supersaturations settings the instrument will use in a sampling session. Users can select among existing SS tables from the **SS Tab**, and they can create or modify available SS tables using the **CCN SS Config Editor.exe** program.

Supersaturation: The state at which air contains more water vapor than thermodynamically allowed. The CCN counter uses supersaturation to grow aerosol particles to detectible size.

T Inlet (C): The temperature of the CCN's inlet manifold. When **T Inlet (C)** differs substantially from its set point for a sustained period, the CCN computer generates an **Alarm Code**.

T Nafion (C): The observed temperature at the Nafion humidifier. When **Nafion Temp (C)** differs substantially from its set point for a sustained period, the CCN computer generates an **Alarm Code**.

T OPC (C): The observed temperature of the CCN's optical particle counter. When **OPC Temp (C)** differs substantially from its set point for a sustained period, the CCN computer generates an **Alarm Code**.

T1 Read (C): The temperature in the CCN's top control zone.
T2 Read (C): The temperature in the CCN's middle control zone.
T3 Read (C): The temperature in the CCN's bottom control zone.

T1 Set (C): The set point temperature in the CCN's top control zone.
T2 Set (C): The set point temperature in the CCN's middle control zone.
T3 Set (C): The set point temperature in the CCN's bottom control zone.

TEC Relay: A control button on the **Temps** tab that switches the instrument's 28 VDC power buss on and off.

Temp Gradient: A CCN channel that stores the temperature gradient along the CCN's wetted walls, i.e. **T3 Read (C)** – **T1 Read (C)**. The gradient is the controlling factor that determines the instrument's supersaturation.

Temp Stable?: A Boolean output channel indicating when **T1**, **T2**, or **T3 Reads** differs by > 0.4 °C from its set point. A value of 1 indicates all three channels are close to their set points. If **Temp Stable?** is 0 for a sustained period, the CCN computer generates an **Alarm Code**. Note that **Temp Stable?** indicates temperature stability but does not necessarily indicate data stability, which also depends on other factors.

Temperature Gradient / Thermal Gradient: The temperature gradient between T1 (the top of the CCN column) and T3 (the bottom). See **Delta T (C)** for details.

Time: The time at which the computer writes the data from any given sampling instance to the output file.

Total Flow (Vccm): The sum of the **Sample Flow** and the **Sheath Flow.** When the **Total Flow** deviates from its set point for a prolonged period, the CCN computer generates an **Alarm Code.**

Vccm: Volume cubic centimeters / minute. Vccm is a unit of flow.

Watch dog: An indicator on the **Prog** tab of the CCN control program. The indicator alternates ON and OFF every second when the computer is cycling properly. The watch dog light on the instrument should blink at the same time as this indicator. If the indicator light is steady **OFF** or **ON**, reboot the computer.

Zero-Count Test: A CCN test performed by installing a filter that is known to be working well onto the CCN inlet, so that no aerosol particles can enter. The zero-count test should result in a particle reading of 5/sec or less.

Appendix B: Relationship between SS%, Particle Concentration, and Percentage of CCN Counted

Tests at DMT have shown that the aerosol count rate in the CCN varies with SS% and particle concentration. For concentrations at or below 6,000 particles/cc, all supersaturations have a 90% or higher aerosol count rate. For instance, all the supersaturation values plotted in Figure 51 have a 96% aerosol count rate at concentrations of 5,000 particles/cc. At higher particle concentrations, however, supersaturations below 0.2% show a decreased maximum count rate.

Note that observed and theoretical maximum concentrations differ considerably. On a theoretical level, the instrument can count 60,000 particles/cc at a sample flow rate of 50 Vccm with a maximum coincidence of 10%. This 60,000 particles/cc figure is based solely on the theoretical performance of the OPC, however; growth kinetics of particles in the CCN column will reduce the actual concentration at which the instrument can accurately detect particles.
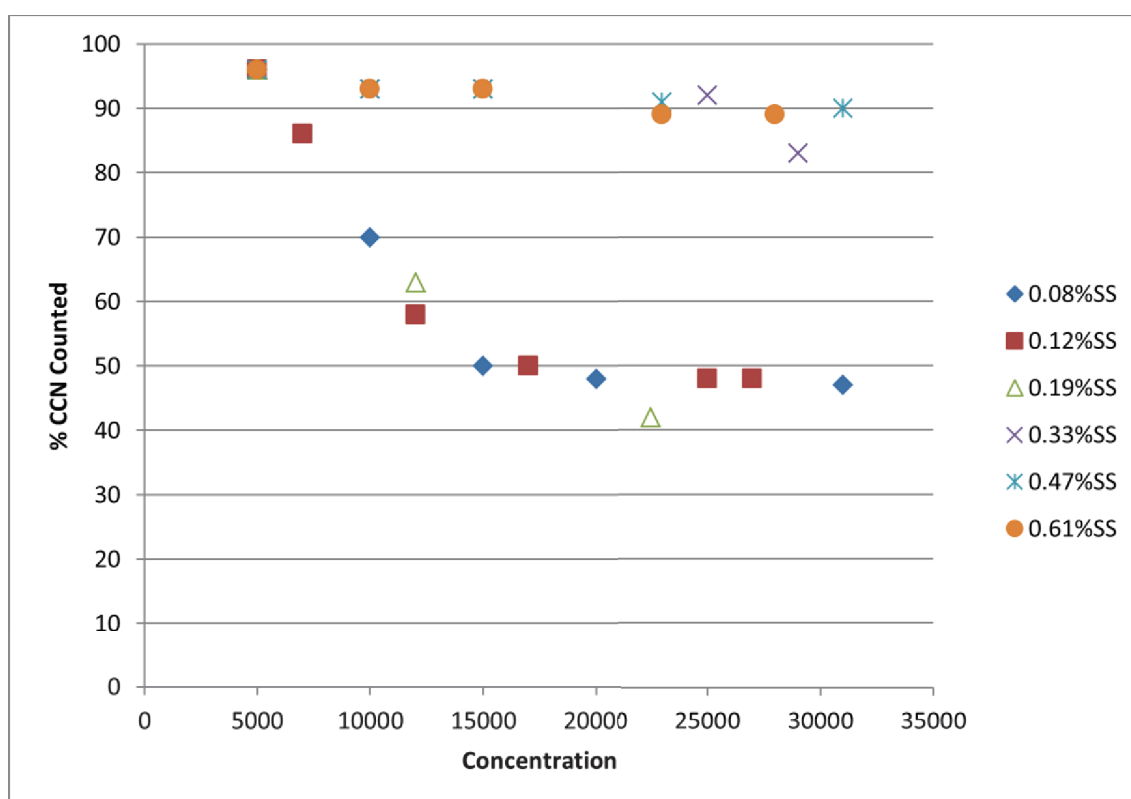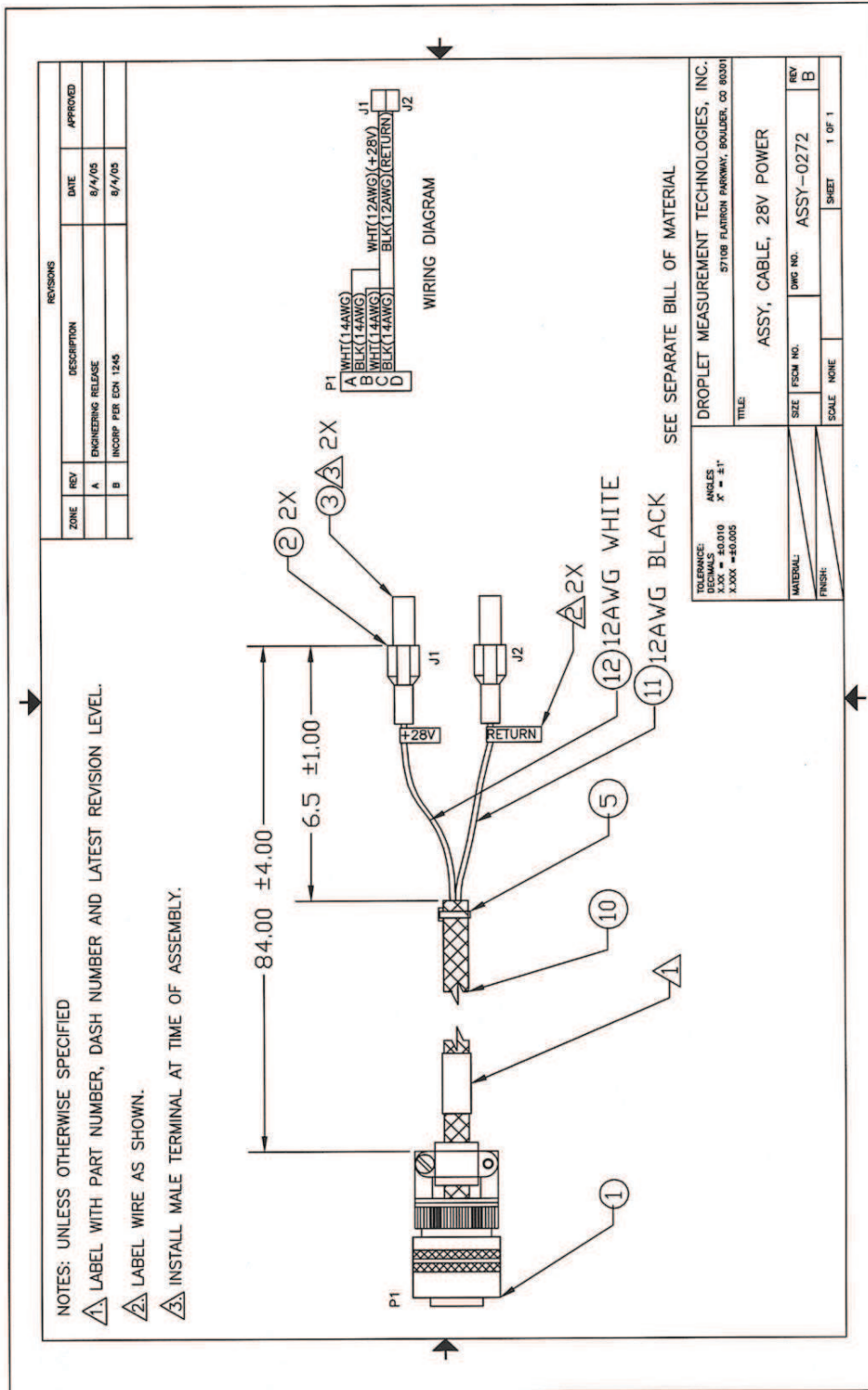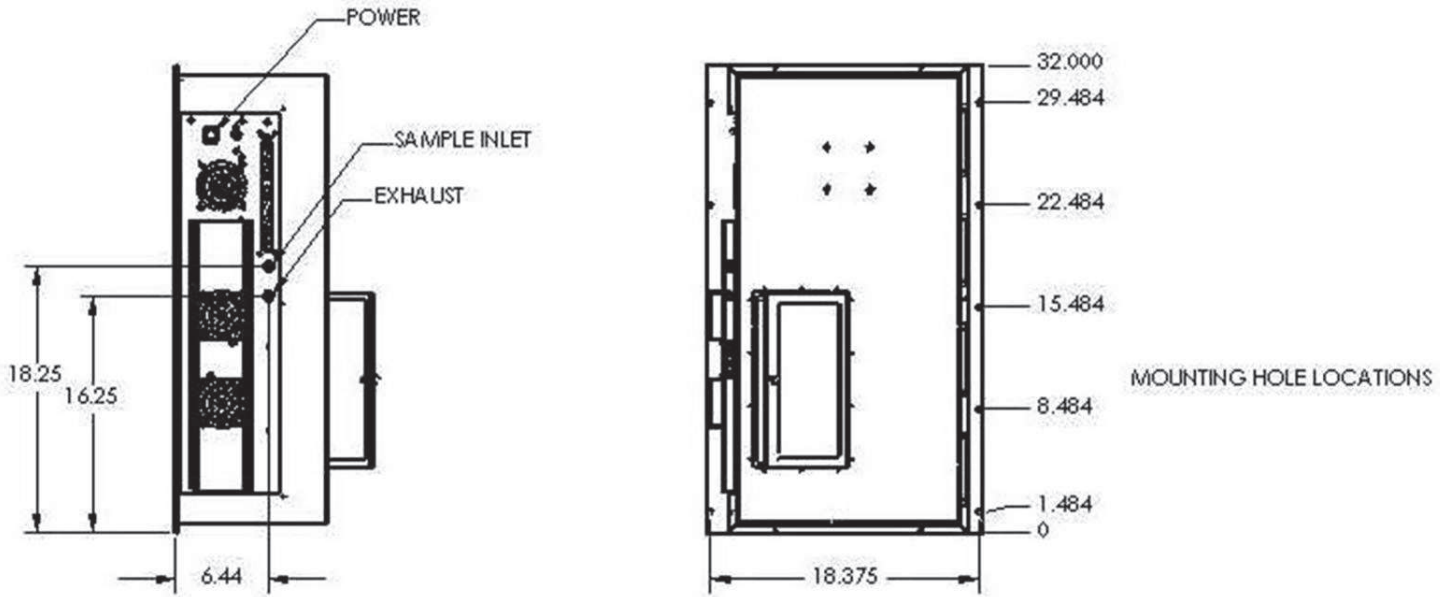

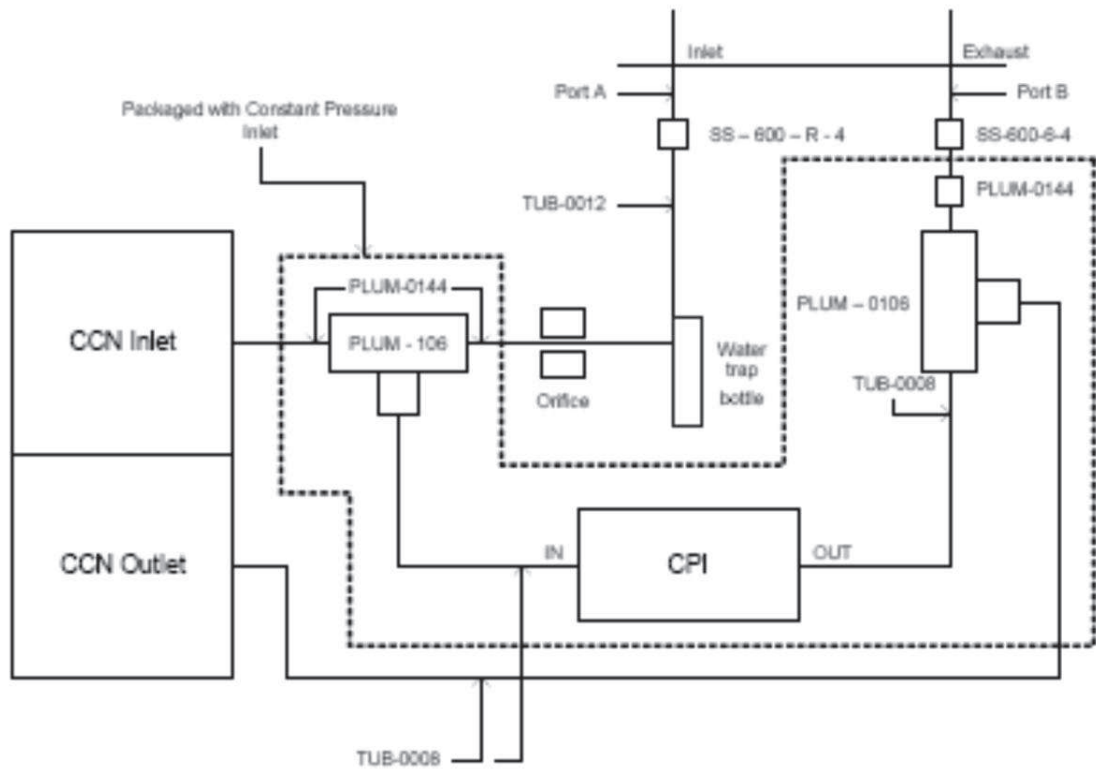*Figure 51: Percentage of CCN Counted vs. Particle Concentration for Different SS%*

Appendix C: Assy, Cable 28V Power

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Appendix D: CCN Mounting Hole Locations

POWER

SAMPLE INLET

EXHAUST

18.25

16.25

6.44

32.000
29.484

22.484

15.484

8.484

1.484
0

18.375

MOUNTING HOLE LOCATIONS

Appendix E: CCN Aircraft Inlet (for Constant Pressure Inlet)

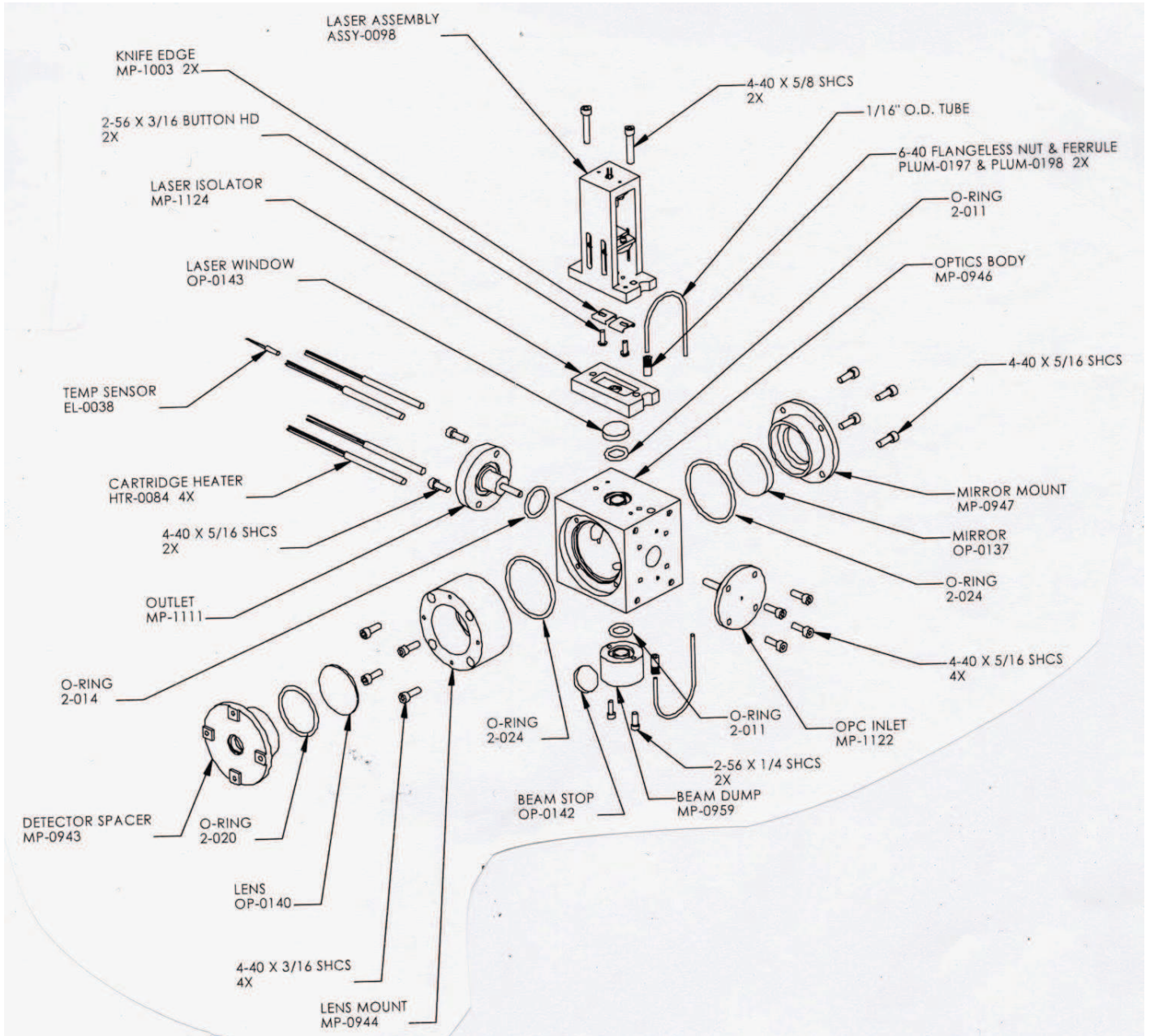# Appendix F: Exploded View of OPC

Figure 52: OPC Assembly, Exploded View

Appendix G: Sheath Flow Filter Testing and Replacement

Problem

Droplet Measurement Technologies (DMT) has recently become aware of a potential problem with CCN sheath flow filter. The symptoms are that the CCN instrument counts too many particles but will still zero count when a filter is installed on the inlet. These symptoms are noticed when doing an intercomparison between the CCN counter and another instrument. DMT researched changing to a different filter, but different pressure drops and physical sizes made this unrealistic.

Recommendations

DMT is recommending all CCN Sheath flow filters currently in service either be replaced by one tested by DMT (FL-0022, cost $20.00 each) or be removed and tested with a CN counter. The background counts when tested on a CN counter should be very close to zero (<.5 per ccm).

NOTE: if you use a different filter that has more of a pressure drop, you may not be able to get a flow ratio of 10.

If you do not have access to a CN counter, the following procedure can be used to test the sheath filter. A "bad" sheath filter will still zero count when a good filter is connected to the inlet. This is due to the sheath air being pre-filtered by the inlet filter. You must isolate the sheath flow filter.

1. Remove sheath line from manifold block.
2. Install ASSY-0122 plug (included in startup kit) into manifold as a plug.
3. Perform a leak check to ensure no leaks were induced.
4. Install DMT tested filter on inlet of CCN.
5. Run a scan that includes a 1% SS for at least 5 minutes
6. Counts should be less than 5 per update. If counts are higher, replace sheath filter with DMT tested filter (new filters from DMT will have a "tested" label on them).

Caution: The filters may test well initially and then start to pass particles at a later date. Thus we strongly recommend that the filters are replaced or the above test is performed every 3 months. All filters in starter and service kits should also be tested; new filters from DMT will have a "tested" label on them.

Please contact Rick Drgac at Droplet Measurement Technologies if you have any questions or concerns, or if you need to order replacement filters. Email CCN-Info@dropletmeasurement.com; Phone: 303-440-5576 EX. 123

Appendix H: International Shipping Certification

MEDINA PACKAGING SUPPLY, INC.
1190 South Lipan Street
Denver, Colorado 80223
(303) 722-7875 • Fax 722-6742
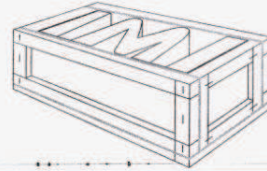
May 4, 2005

Patrick Kelly
Droplet Measurement Technologies Inc.
5710 Flatiron Parkway Unit B.
Boulder CO 80301

Dear Patrick Kelly:

SUBJECT: NON-MANUFACTURED WOOD PRODUCTS

This letter is to certify that all Non-Manufactured Wood Packing products containing coniferous wood used in the production of packaging material for Droplet Measurement Technologies (DMT) has been heat treated for 56 deg C for thirty minutes. Furthermore all of the wood products we supply DMT meet the current regulations stated in UN standard ISPM 15 required by the European Union countries as well as those of China and Australia.

Medina Packaging Supply Inc., has been and is continuously audited by Package Research Laboratory, of Rockaway New Jersey, which is a licensed and accredited provider chosen by the American Lumber Standards Committee (ALCS), to audit and enforce the regulations required by various countries. Our initial audit was on September 18, 2001. We received our official stamps from Packaging Research Laboratory on the same date. This stamp certifies that all Non-Manufactured Wood Packing contains HT or KD/HT lumber produced by an ALCS qualified lumber manufacturer or a secondary component manufacturer. You may check our current status with the ALCS by calling Packaging Research Laboratory at 973-627-4405.

Sincerely,

Dominic Medina

custom wood containers and pallets • foam converters • packaging materials

Appendix I: Revisions to Manual

Rev. Date	Rev. No.	Summary	Section
10/22/09	G-1	Revised Flow Calibration Procedure	8.2.2
		Updated DMT's address	Front matter
10/26/09	G-1	Expanded typical **Sample Flow (Vccm)** and **Sheath Flow (Vccm)** values; switched steps 3 & 4.	8.2.2
1/15/10	G-2	Updated pictures	Various
10/27/10	H	Modified Sheath Flow Filter Testing and Replacement Procedures	App. G
12/29/10	H-1	Modified theory of operation section	2.0
8/15/11	H-2	Updated instructions for checking unit functionality	3.3
9/1/11	H-3	Added descriptions of Inlet heater, Nafion heater, and OPC heater indicator lights	12.1.2
9/27/11	I	Modified Flow Calibration procedure	8.2
10/4/11	I-1	Inserted photos of Metering Valve Access Port	8.2
4/18/12	I-2	Clarified procedures for fixing stuck reeds	10.0