Standard Operating Procedure

for

Routine Operation of the
Rupprecht and Patashnick 8400S
Ambient Particulate Sulfate Monitor

DRAFT
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1. Scope and Applicability
This operating procedure applies to the operation of the Rupprecht and Patashnick 8400S Ambient Particulate Sulfate Monitor, with software version 0.535.

2. Summary of Method

2.1 Method Parameters
- Measured parameter: Sulfate in airborne particles below 2.5 µm.
- Time resolution: Typically 10-min, user selectable between 3 min and 20 min.
- Detection Limit: 1.0 µg/m³ for 10-min sample.
- Sample Flow: 1 L/min, with 5.5 L/min for precut
- Analytical Method: Particles are collected by humidification and impaction, and assayed in place by flash heating and UV fluorescence analysis of the evolved sulfur dioxide vapors.

2.2 Method Description
Ambient samples are pulled through a cyclone operated at 5.5 L/min to remove particles above 2.5 µm. From this, a 1 L/min portion of this flow is used for sulfate analysis. The 1 L/min sulfate sample flow passes through a carbon honeycomb denuder to remove potential gaseous interferences, and a Nafion humidifier to ensure that the particles are wet. Wetted, ambient particles are collected by impaction onto a platinum strip mounted in a collection and vaporization cell. Typical sample period is 8.5 mins. After sample collection the system switches from this collection mode to the analysis mode. During the analysis step the sample flow bypasses the collection cell, while maintaining flow through the sample line, denuder and humidifier. The collection and vaporization cell is flushed with air, most of which is introduced at the side of the cell (called cross flow), and a portion of which is introduced through the collection orifice (called orifice flow). The air flows through the cell and into a sulfur dioxide analyzer. The collection substrate is then flash heated by current from a battery until reaching an infrared cutoff. Typical heating times are 20-40 ms. Evolved sulfur oxides are carried in the airflow to the analyzer, where they are assayed by UV fluorescence. The analyzer output is integrated to yield the sulfate concentration. Additionally, the analyzer baseline is read prior to each analysis flash. At the end of the analysis period the system returns to sample collection.

The system may be setup to automatically conduct two types of audits: analyzer flow audits and analyzer span audits. Analyzer flow audits are done during the sample collection step, without interruption of the cycle. The analyzer flow audit value is used to set the cross flow during the analysis step. Span audits take the system off-line for one or two cycles. Span audits may be done automatically at a preset time of day, at a frequency of one to seven days, as selected by the operator. Additionally, the system is calibrated manually using aqueous standards applied directly to the collection substrate.
The system is based on the integrated collection and vaporization cell developed by Stolzenburg and Hering (2000).

3. Definitions
- Pulse Generator: the main component of the 8400S (large box)
- Pulse Analyzer: the SO₂ Analyzer component of the 8400S

4. Health and Safety Warnings
Gas cylinders (used for purge and calibration) must be properly secured, preferably with chain at top and bottom.

5. Cautions
- Do not turn on the Pulse Analyzer flow (i.e. connect to pump) without first connecting to the 25mm filter from the Pulse Generator.
- Test that air cylinder and calibration gas cylinder are installed without leaks following procedure below under Section 11.3.2.

6. Interferences
There can be positive interference from adsorption of sulfurous vapors not removed by the denuder. The extent of this interference is measured by the field blank described in Section 11.5.1.

7. Personnel Qualifications
The system requires a technically experienced operator who can understand the system, its operation and calibration.

8. Apparatus and Materials
- 8400S Pulse Generator
- 8400S Pulse Analyzer
- 8400S pump
- 5/16” OD aspirated sample line inside an insulated 3” ventilation line
- Ambient temperature probe with mounting clamp
- Dry air purge gas (grade 99.9% is sufficient), with CGA 590 regulator.
- 1 ppm SO₂ in CO₂-free air calibration gas with CGA 660 regulator
- 1/4” or 1/8” teflon line
- Distilled water
- Maintenance kit with:
  - Microliter syringe and aqueous calibration standards
  - In-line filter for blanks
  - Extra collection strips, washers and nuts
  - Spare denuder and analyzer filters
  - Software upload adapter
  - Forceps
  - Squirt bottle, watch glass, Q-tips, portable air
9. Site and Equipment Preparation

The sample line is 5/16” aluminum tubing housed inside a 3” aspirated duct, both of which should extend approximately 2 meters above the rooftop. There is an aluminum clamp to hold the tubing within the screened inlet hat. Make sure you have an inlet hat that is not painted.

Install the Pulse Generator and Pulse Analyzer per instructions in Appendix A: 8400N Quick Start Guide. No Quick Start Guide is available specifically for the 8400S. The 8400S installation is very similar to the 8400N installation with the following exceptions: there is no vacuum regulator connected to the 8400S Pulse Analyzer, the 8400S uses air as the carrier gas instead of nitrogen, and the 8400S uses platinum flash strips instead of nichrome.

The Pulse Analyzer can be placed either alongside or underneath the Pulse Generator provided it is within 24 inches of the outlet located at the left hand bottom of the main unit. If located underneath, it is best to construct a separate shelf so that the Pulse Analyzer can be removed easily without disturbing the Pulse Generator. Ensure that the analyzer filter is in place prior to starting the flow to the Pulse Analyzer. Insulate the indoor portion of the 3” aspirated duct with flexible insulation such as Reflectix or fiberglass.

The RS-232 port on the 8400N should be connected to the site data acquisition system with the supplied serial cable. See Section 14.1 for more details.

Prior to routine operation:

- Leak test cell and inlet per instructions in Appendix A: 8400N Quick Start Guide. Drift should be <0.01atm/1min
- Verify system and cycle parameters settings against the list in Table 1: System Parameters and Settings.
- Perform analyzer audit per instructions under Section 11.4.6.3.
- Startup system and check readings per Section 11.4.
- Run aqueous standards within first few days of operation per Section 11.5.3.
10. Instrument Calibration

The SO₂ monitor is automatically spanned every second day using a 1 ppm calibration gas from Scott-Marrin. The time of day is selected in the cycle setup window. The span is manually reset when it differs from the nominal concentration by ±10%. The complete system is calibrated with aqueous standards applied directly to the collection substrate every second week. Field blanks are measured every second week by placing a Teflon filter between the cyclone and the denuder. The aqueous standards and field blanks must be done manually, following the procedures described in Section 11.5.

11. Instrument Operation

11.1. General Operation

Turn on power to both the Pulse Generator and Pulse Analyzer. Confirm all system parameters are set as per Table 1: System Parameters and Settings. Pressing “RUN/STOP” will begin sampling and analysis. The 8400S is designed for automated operation and will continue sampling and analysis indefinitely barring further operator intervention or malfunction.

The site operator should check the instrument and complete the maintenance log sheets (see Appendix B) at least twice weekly as described in Section 11.

Pressing RUN/STOP again will halt sampling (with an option to abort immediately or finish the current ten minute cycle). Power can then be turned off to both the Pulse Generator and Pulse Analyzer.

See Appendix A: 8400N Quick Start Guide for details.

11.2. Schedule of Operational Tasks

11.2.1. Daily Checks

- Check Air and Cal cylinder pressures
- Refill water reservoir (grocery store distilled water OK)
- Check indicated sample flow rate during sample step
- Check flash time and flash strip
- Check manual rotameter flow indications and vacuum gauge readings
- Record analyzer audit data
- Run analyzer audit if not on auto-audit (2-3 times weekly)
- Check that 8400S Pulse Generator is running without error flags indicated

11.2.2. Semi-Monthly Tasks

- Replace air cylinder whenever low
- Measure field blank
- Clean cyclone
- Calibrate with aqueous standards

11.2.3. Monthly Tasks (Every 4-6 Weeks)

- Clean cell orifice
• Replace flash strip
• Replace makeup flow filter if makeup flow dropping
• Leak check system

11.3. Consumables

11.3.1. Consumable Items
The 8400S uses 99.9% pure dry air carrier gas. Normal consumption is 1 STP cubic foot per day. A 230 cu foot (size K or 1A) cylinder should last about 3 weeks and cost $30-$50.

11.3.2. Changing the Air Cylinder
When the air cylinder pressure drops below 300 psi, interrupt the running cycle by pressing “RUN/STOP”. Then press F2 to abort immediately. Or, if you have done this before and are confident that you can do the entire procedure within 5 minutes, wait for the beginning of a “SAMPLE” period. Make sure that the display does not read “SAMPLE/FLOW AUDIT”, but just “SAMPLE”. Then the air is not used and you can change the tank out before the next analysis without interrupting the cycle. The time you have before the end of the sample is indicated by the countdown in seconds.

Shut main tank valve, remove regulator, replace cylinder cap, and switch tanks with caps installed on cylinders (for safety). Strap new cylinder in place with chain. Install regulator on new cylinder and immediately check for leaks. Leak test as follows: open the tank valve and regulator outlet valve to pressurize the line, then close both valves. Watch that the indicated pressure on the tank (approx 2000 psi) does not drop over two minutes, and that the “purge” pressure gauge on the 8400S is also steady. Then reopen the tank valve and outlet valve, and adjust the regulator to deliver between 4 and 6 psi. If you have too much pressure, you will need to wait until the next analysis cycle to adjust the regulator properly. If you stopped the cycle, press “RUN/STOP” to resume normal operation.

11.4. Daily Checks

11.4.1. Frequency
These checks are straightforward and fast and should be done daily if an operator is already at the site. At a minimum, they should be done twice weekly.

Numbers in parentheses refer to log sheets.

11.4.2. Check the Air Cylinder (1)
Check the air cylinder pressure at least twice per week by recording the main pressure gauge on the cylinder regulator. The main gauge is on the right hand side of the two gauges and reads between 200 and 2000 psi. Note any excessive drops in pressure, as these indicate a leak. When the pressure drops below 1000 psi, make sure a substitute cylinder is available. When the pressure drops below 300 psi, change to a replacement cylinder per instructions above under Section 11.3.2. Changing the Air Cylinder.
11.4.3. Check Calibration Gas Cylinder (1)
Note the pressure on the SO\textsubscript{2} calibration gas cylinder, and check that the drop in pressure from the previous reading is not excessive. These cylinders are difficult to replace, so if a leak is detected you should close the main tank valve and change from automatic to manual analyzer audits.

11.4.4. Refill Water Reservoir (1)
Open the cap at top of the reservoir water bottle, replenish with distilled water of the quality available from the grocery or hardware store. Replace the cap loosely; do not tighten, but allow for air to penetrate head space. Check that there appears to be water in the lines to the humidifier. This should be OK unless the water bottle has been allowed to become dry. If lines are dry, loosen the 1/4” nut on the side of the upper tee of the humidifier and let the humidifier fill from the bottle.

11.4.5. Check and Record Orifice Flow Rotameter (1)
The orifice flow rotameter is the lower of the two rotameters located inside the Pulse Generator cabinet. The rotameter should read 0 during sample and 2-5 cc/min x100 during analysis (purge, baseline or read steps). Excess flow does not hurt the sample, but wastes nitrogen. Record the orifice flow during analysis and adjust to keep within range.

11.4.6. Check and Record Audit Data (2)
If the 8400S is set up to do automatic analyzer audits, then all that is needed is to record the data. With the system running, press “Data”, “Select Data”, “Audit Data” and record most recent values on Analyzer Audit Sheet. Analyzer audit data are not sent to the data system, so your manual record is very important.

11.4.6.1. If Zero has Drifted (2)
This is not critical as the system records the zero before each flash. But it is best to keep the zero within +5 ppb. The zero can be reset during the analysis step at the end of the air purge and before the baseline read. Simply watch the system and press the “CAL” button on the Pulse Analyzer, then the “ZERO” button twice at the proper moment.

11.4.6.2. If Span has Drifted (2)
Span is indicated by the “Steady State Check” value returned by the analyzer audit. If the steady state check differs from the span gas concentration by more than 10%, you will need to stop and reset the zero and span following instructions on the Analyzer Audit log sheet, Appendix B: Maintenance Log Sheets. Be sure to note time of day SO\textsubscript{2} analyzer span is reset. After resetting the span, immediately conduct and record a manual audit. If the system is not set for automatic analyzer audits (as is possible if a leak is suspected in the cal gas cylinder), then conduct a manual audit at least weekly.

11.4.6.3. To Conduct a Manual Analyzer Audit (2)
This is only necessary if you have just reset the span, or if the system is not setup for automatic analyzer audits. Press “RUN/STOP” and F1 to finish current sample. If necessary, open the main tank valve and regulator outlet valve on the calibration gas cylinder. The cal gas gauge on the 8400S should read 5 ± 2 psi. Press “Menu”, then
“Enter Service Mode”, then “Perform Analyzer Audit”. Press “Full Audit”. This starts the audit and will take 20 minutes. Record audit values on log sheet. At end of audit, press “Menu”, then “Exit Service Mode” to get back to the main screen and then “RUN/STOP” to resume normal operation. Close the calibration tank valve and cal gas regulator outlet valve if a leak is suspected.

11.4.7. Routine Checks, Pulse Analyzer (3)
Check for a steady green light next to “sample”. If light is not green, press “msg”, note message and press “clear” to reset. You will get a message upon any power failure.

11.4.8. Routine Checks, Pulse Generator (3)
Verify the following:

- Status light should be off. If blinking or on, check and note status codes in upper left hand corner. Correct and/or clear using “reset status” soft key.
- The purge and cal pressure gauges should both read between 4 and 6 psi.
- Display should show “RUN” mode, and is active
- Display should show “Water Reservoir OK”, and “Flash Strip OK”
- Check sample flow rate when “CURRENT STEP” reads “SAMPLE”. Should be between 0.9 and 1.1 L/min. If “CURRENT STEP” reads “PURGE”, “BASELINE”, “READ” or “WAIT” then the indicated flow is not the sample flow. Wait for system to enter step labeled “SAMPLE”, then read flow. If low, clean orifice, as described in Section 11.6.1.
- Specifically check that flash duration between 20-40 ms. From main screen press “data”. The flash duration is the last value listed. Press “escape” to return to main screen.
- Open the cover and check rotameter and manual vacuum gauge readings per log sheet (Appendix B). Makeup flow should read between 3 and 5 L/min, orifice flow should read 0 during sample and 2-5 cc/min x100 during analysis (purge, baseline or read steps). Front vacuum gauge should read between -15 and -17 in Hg. Back vacuum gauge should read between -20 and -30 in Hg. If any readings are out of range, record their value before changing. Then adjust and note value after adjustment.
- Close door and verify that system is on main screen and in “RUN” mode.

11.4.9. Check Cyclone after Recent Rain (3)
If it has just rained, dry the cyclone. Unscrew the bottom, dry and replace. If you are quick, note the time and check while the system running. Note if a lot of water is visible.

11.4.10. Note Corrective Actions Taken (3)
Note any corrective actions taken. Specifically note if cell orifice is cleaned, if flash strip is replaced, or semi-monthly tests are run.

11.4.11. Note If Semi-Monthly Checks Run (4)
Note if the Semi-Monthly Check were completed, and fill out the Semi-Monthly Checks log sheet (see Section 11.5).
11.5. Semi-Monthly Tasks

11.5.1. Measure Field Blank (5)
Press “RUN/STOP” and F1 to finish current sample. Connect disc cartridge filter in line, just above the black tubing above denuder. Use clear tubing to connect to sample line. Go to “Cycle Setup”, and adjust “Base Start Time” to “immed”. Press “Esc” to return to Main Screen and push “RUN/STOP” to run for two cycles. Reenter Cycle Setup and adjust “Base Start Time” back to “00:10”. Remove filter, reconnect sample line, press “RUN/STOP” to resume normal operation.

11.5.2. Clean Cyclone (6)
Unscrew the bottom of the cyclone, clean with water and Q-tip and reinstall. If you are quick, you need not stop system for this cleaning, but do note the time on the Semi-Monthly Checks log sheet (Appendix B).

11.5.3. Calibration with Aqueous Standards (7)
Press “RUN/STOP” and F2 to abort the current cycle. Retrieve the syringe, water in beaker and standard solution. Go to “Menu”—“Service Mode”—“Aqueous Standards”. Open the cell. Rinse the syringe in water, then fill to desired volume (see below) with standard. Ensure no drops cling to outside of syringe by touching to mouth of standards bottle. Apply standard to center of strip by emptying syringe and touching to strip.
Press “Edit” to enter the “Mass Deposit” value in nanograms on the Pulse Generator screen. Close the cell and press “Start” to analyze standard. Note: Software version 0.535 includes a two minute waiting time before beginning analysis. With earlier software versions, the operator must wait two minutes before pressing “Start”. Record the result on the “Aqueous Standards Log” log sheet (Appendix B).

Matrix of standards to run (300 ng/uL SO$_4^-$ with 400 ng/uL C [from oxalic acid]):

<table>
<thead>
<tr>
<th>No</th>
<th>Vol(µL)</th>
<th>ng sulfate</th>
<th>expected level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.2</td>
<td>60 ng</td>
<td>300-400 ppb*s</td>
</tr>
<tr>
<td>2</td>
<td>0.4</td>
<td>120 ng</td>
<td>600-800 ppb*s</td>
</tr>
<tr>
<td>2</td>
<td>0.6</td>
<td>180 ng</td>
<td>900-1200 ppb*s</td>
</tr>
<tr>
<td>2</td>
<td>0.8</td>
<td>240 ng</td>
<td>1200-1600 ppb*s</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>water blank</td>
<td></td>
</tr>
</tbody>
</table>

Run a third standard if either of the two standards is out of range.

Rinse syringe thoroughly with water, and put away. Press “RUN/STOP” to resume normal operation.

11.6. Monthly Tasks (Every 4-6 Weeks)

11.6.1 Clean Orifice (8)
Clean the orifice every 4-6 weeks and whenever the sample flow rate drops below 0.9 L/min. First check that the front vacuum gauge reads between 15 and 17 inches Hg. If it
is less than 15, readjust and check sample flow reading during the “sample” step. Do not use the reading during any other step. If sample flow is still low, then the orifice needs cleaning.

If the cycle is running stop it by pressing “RUN/STOP” and F2 to abort the cycle. Open the cell and unscrew the orifice using the yellow handled nut driver and large socket. Clean with distilled water using a squirt bottle. Dry with “portable air”, and reinstall. Assure that orifice is tight, so that O-ring provides a vacuum seal. Press “RUN/STOP” to resume normal operation. When in sample step, check the flow rate with a flow standard at the black tubing at the top of humidifier. Record reading from the flow standard and the flow indicated on the 8400S front panel. Reconnect the black tubing and close the Pulse Generator door.

11.6.2 Replace Flash Strip (9)
If the cycle is running stop it by pressing “RUN/STOP” and F2 to abort the run. Open the cell and unscrew the strip using the yellow handled nut driver and small socket. Remove the nuts, the washers and the strip. Place a new platinum strip on the posts. The strips are in a clear plastic cylindrical container. Put the washers and then the nuts back on the posts. Go to “Menu”—“Service”—“FlashIR Setup”. Press “Reset Flash Fault” if necessary and test flash once (press enter while the IR setting is highlighted). If the flash looked even and no sparks were seen close the cell, exit service mode and press “RUN/STOP” to resume normal operation

11.6.3 Check Make-Up Flow Filter (10)
This is OK as long as the makeup flow is between 3 and 5 L/min.

11.6.4 Check Analyzer Filter (10)
This need only be done every four months. Unscrew the filter holder mounted on the back of the Pulse Generator. Carefully remove the 25 mm membrane filter. Place a new 25 mm membrane filter (found in the accessories kit) between the black o-ring and the filter screen inside the holder. Be sure to place the black o-ring on top of the membrane filter before closing the filter holder. Screw the filter holder back together and tighten until leak tight.

11.6.5 Leak Check (11)
With system in “READY” mode, close the green valve above the cyclone and close the front vacuum valve (below front vacuum gauge). Let the system pump down for several minutes. Then close valve below back vacuum gauge. Watch cell pressure reading on front panel. Drift upward should be less than 0.01 atmospheres/min. If OK, slowly reopen valve above cyclone, and reopen both vacuum valves.

12. Preventative Maintenance and Repairs
Preventative maintenance issues have not been fully addressed at this time. Expected issues upon extended field use include the following:

- Replacing or recharging (by baking out adsorbed material) the carbon denuder.
- Replacing the Teflon analyzer filter (every four months).
• Cleaning or replacing the aluminum inlet line.
• Cleaning any corrosion on the battery terminals of the Pulse Generator.
• Cleaning or replacing the fan filter on the Pulse Generator.

13. Troubleshooting

13.1. Status Codes
The 8400S responds to a variety of conditions and malfunctions with status code messages. Current status codes can be viewed by pressing “Status Codes” from the main screen. Every data record contains a representation of these status codes in a hexadecimal number called the OP code. See below for a list of OP codes, status codes and their description.

<table>
<thead>
<tr>
<th>OP Code</th>
<th>Status Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000000</td>
<td>Ok</td>
<td>No status conditions</td>
</tr>
<tr>
<td>00000001</td>
<td>Y</td>
<td>System Reset</td>
</tr>
<tr>
<td>00000002</td>
<td>Z</td>
<td>Power Failure</td>
</tr>
<tr>
<td>00000004</td>
<td>H1</td>
<td>A/D Failure</td>
</tr>
<tr>
<td>00000008</td>
<td>S1</td>
<td>Ambient Temp Out Of Range</td>
</tr>
<tr>
<td>00000010</td>
<td>S2</td>
<td>Ambient Pres Out Of Range</td>
</tr>
<tr>
<td>00000020</td>
<td>S3</td>
<td>Cell Comp Temp Out Of Range</td>
</tr>
<tr>
<td>00000040</td>
<td>E</td>
<td>Electronics Temp Out Of Range</td>
</tr>
<tr>
<td>00000080</td>
<td>W</td>
<td>Check H2O Reservoir</td>
</tr>
<tr>
<td>00000100</td>
<td>X</td>
<td>Flash Failure</td>
</tr>
<tr>
<td>00000200</td>
<td>FS</td>
<td>Sample Flow Out Of Range</td>
</tr>
<tr>
<td>00000400</td>
<td>FC</td>
<td>Cross Flow Sensor Fail</td>
</tr>
<tr>
<td>00000800</td>
<td>C1</td>
<td>Cross Flow Control Fail</td>
</tr>
<tr>
<td>00001000</td>
<td>P1</td>
<td>Abs Pressure Out Of Range</td>
</tr>
<tr>
<td>00002000</td>
<td>C2</td>
<td>Abs Pressure Control Fail</td>
</tr>
<tr>
<td>00004000</td>
<td>P2</td>
<td>Sample Pressure Out Of Range</td>
</tr>
<tr>
<td>00008000</td>
<td>D</td>
<td>Cell dp Out Of Range</td>
</tr>
<tr>
<td>00010000</td>
<td>R</td>
<td>Cycle Aborted</td>
</tr>
<tr>
<td>00020000</td>
<td>A1</td>
<td>Analyzer Warning</td>
</tr>
<tr>
<td>00040000</td>
<td>A2</td>
<td>Analyzer Communication Failure</td>
</tr>
<tr>
<td>00100000</td>
<td>A4</td>
<td>Analyzer Data Capture Checksum</td>
</tr>
<tr>
<td>00200000</td>
<td>A5</td>
<td>Analyzer Data Capture Incomplete</td>
</tr>
<tr>
<td>00400000</td>
<td>A6</td>
<td>Analyzer Data Capture Timeout</td>
</tr>
<tr>
<td>00800000</td>
<td>U</td>
<td>Amb Temp Sensor Not Used</td>
</tr>
</tbody>
</table>

This hexadecimal system for OP codes is used so that combinations of status codes can easily be identified. For example: the OP code for Flash Failure, Sample Flow Out Of Range, and Cycle Aborted would be reported as “00001300” (00000100 + 00000200 + 00001000). Cross Flow Sensor Fail and Cross Flow Control Fail would be reported as “00000C00” (00000400 + 00000800).
Below are listed common status codes and their remedies.

13.1.1. Ambient Temp Out of Range
Possible failed ambient temperature probe. Ensure that the probe is properly connected to the Pulse Generator, and that the probe itself is not wet and is in good condition.

13.1.2. Check H₂O Reservoir
Add water to H₂O Reservoir water bottle. If the bottle appears full, check that the humidifier line is full of water and contains no large bubbles. If the humidifier line appears normal, the conditioned humidity sensor may need to be removed and dried.

13.1.3. Flash Failure
Replace the flash strip if it is visibly broken (see Section 11.6.2). Also check for burrs on the aluminum posts on which the strip rests. Any burrs or pitting may be removed by sanding with emery paper. If the strip does not appear broken, reset the flash fault in “Menu”—“Service Mode”—“Flash/IR Setup” and run a test flash while observing the strip. Repeated flash faults may indicate a battery problem or other electronic problem.

13.1.4. Sample Flow Out of Range
Clean the sample orifice. See Section 11.6.1.

13.1.5. Cross Flow Control Fail
This is most likely due to a problem with the air tank. Ensure there is sufficient pressure remaining in the tank. See Section 11.3.2.

13.1.6. Analyzer Warning
Note warning messages on Pulse Analyzer screen (press “MSG”). Clear messages by pressing “CLR”.

14. Data Acquisition, Calculations, and Data Reduction

14.1. Data Acquisition
There are three types of data, “Cycle”, “Audit” and “Standards”. For software version 0.532 or later, and with the communications protocol set to “CycleDat”, the “Cycle” data will download automatically via the RS-232 port to the site data acquisition system. For the prior version, commands were needed. Both are described in Table 2: Output Format and Expected Values for 8400S Cycle Data. Audit and Standards data should be downloaded manually. Cycle data can also be downloaded manually as described in Appendix A: 8400N Quick Start Guide. The data is comma delimited. The order of parameters, their names and their units are given in Table 2.

14.2. Data Reduction
Data are adjusted to account for the following:

- Average aqueous standard calibrations
- Variations in analyzer audit span
• Field blank readings
• Independent flow measurements
• Temperature and pressure correction to sample flow when no ambient temperature sensor installed

Log books and site summaries will be reviewed. Invalid and suspect data will be flagged as such.

15. Data Management and Records Management

The data set consists of the “Cycle Data” which is sent directly to the site data system, plus the analyzer audit, aqueous standards and field blank data, which are recorded by the operator on the log sheets. There are four log sheets:

• Daily Checks
• Analyzer Audit Data
• Semi-Monthly Checks
• Aqueous Standards Log

The “cycle” data from the 8400S should be reviewed daily to ensure that the system parameters are within an acceptable range, as listed in Table 2: Output Format and Expected Values for 8400S Cycle Data. This can be done most easily by personnel who receive the data remotely.

Note if there are sudden changes to “flash duration” or “Panal”, and that data values trend smoothly.

16. References

Table 1: System Parameters and Settings

<table>
<thead>
<tr>
<th>Menu Item</th>
<th>Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cycle Setup</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample Time</td>
<td>495</td>
<td><em>these parameters determine timing of cycle steps</em></td>
</tr>
<tr>
<td>Purge Time</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Baseline Read</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Read 1 time</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Read 2 time</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Base Start Time</td>
<td>0:10</td>
<td><em>will start even 10-min past hour</em></td>
</tr>
<tr>
<td>Minimum Cycle Length</td>
<td></td>
<td><em>calculated value</em></td>
</tr>
<tr>
<td>Desired Cycle Length</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>Number of Cycles</td>
<td>0</td>
<td><em>runs continuously</em></td>
</tr>
<tr>
<td>Perform Flow Audit</td>
<td>24</td>
<td><em>note: flow audit does not stop sample</em></td>
</tr>
<tr>
<td>Start Analyzer Audit</td>
<td>01:00</td>
<td><em>time of day for automatic analyzer audit with cal gas</em></td>
</tr>
<tr>
<td>Perform Analyzer Audit</td>
<td>0</td>
<td><em>runs automatic analyzer audit every second day</em></td>
</tr>
<tr>
<td><strong>Audit Setup</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steady State Check</td>
<td>450</td>
<td><em>these parameters determine timing of audit steps</em></td>
</tr>
<tr>
<td>Read SO(_2) 1</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Flow Balance Check</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Read SO(_2) 2</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Line Purge</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>Read SO(_2) 3</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>SO(_2) Pulse Read</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td><strong>8400 Setup</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conv. Fact. Calc</td>
<td>AUTO</td>
<td><em>these are calibration and control factors for sulfate analysis</em></td>
</tr>
<tr>
<td>Conv. Fact.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anal Cross Flow</td>
<td>85%</td>
<td></td>
</tr>
<tr>
<td>% Theor. Conv.</td>
<td>40%</td>
<td><em>depends on aqueous standards results</em></td>
</tr>
<tr>
<td><strong>System Setup</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>RS-232 Setup</strong></td>
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<td></td>
</tr>
<tr>
<td>Protocol</td>
<td>CycleDat</td>
<td><em>for automatic download of cycle data to computer</em></td>
</tr>
<tr>
<td>Baudrate</td>
<td>19200</td>
<td></td>
</tr>
<tr>
<td>Com para 1</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Com para 2</td>
<td>75048</td>
<td></td>
</tr>
<tr>
<td>Com para 3</td>
<td>13010</td>
<td></td>
</tr>
<tr>
<td>Com para 4</td>
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Table 2: Output Format and Expected Values for 8400S Cycle Data

Command Sequence to Retrieve Data every 10 minutes

With CycleDat Protocol available on Software version 0.532 or later, cycle data will be dumped automatically.

Data record is comma delimited. All except Date, Time, and OP fields are decimal numbers. OP field is hexadecimal.

Order of Variables Sent, Units and Expected Values

<table>
<thead>
<tr>
<th>Name (Data Sys.)</th>
<th>Name (8400S)</th>
<th>Units</th>
<th>Acceptable</th>
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<tbody>
<tr>
<td>Date</td>
<td>Record Date</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Record Time</td>
<td>(PST)</td>
<td></td>
</tr>
<tr>
<td>Tamb</td>
<td>Amb Temp</td>
<td>(C)</td>
<td>Tamb±10</td>
</tr>
<tr>
<td>Pamb</td>
<td>Amb Pres</td>
<td>(atm)</td>
<td></td>
</tr>
<tr>
<td>RHamb</td>
<td>Amb % RH</td>
<td>(%)</td>
<td>70-100</td>
</tr>
<tr>
<td>RHcond</td>
<td>Cond % RH</td>
<td>(%)</td>
<td></td>
</tr>
<tr>
<td>Tbox</td>
<td>Cell Comp T</td>
<td>(C)</td>
<td>Tamb±10</td>
</tr>
<tr>
<td>Qsmp</td>
<td>Sample Flow</td>
<td>(L/m)</td>
<td>0.9-1.1</td>
</tr>
<tr>
<td>Qxflo</td>
<td>Cross Flow</td>
<td>(L/m)</td>
<td>80±5% of Qanal</td>
</tr>
<tr>
<td>Qanal</td>
<td>Analyzer Flow</td>
<td>(L/m)</td>
<td>1.2-1.6</td>
</tr>
<tr>
<td>Psmpl</td>
<td>Ave Samp Pres</td>
<td>(atm)</td>
<td>0.35-0.5</td>
</tr>
<tr>
<td>dPanal</td>
<td>Cell dp</td>
<td>(inH2O)</td>
<td>-5 to -15, change&lt;±1</td>
</tr>
<tr>
<td>Not used</td>
<td>Not used</td>
<td>dummy value</td>
<td></td>
</tr>
<tr>
<td>tsmp *</td>
<td>Sample Time</td>
<td>(s)</td>
<td>set value, usu. 495</td>
</tr>
<tr>
<td>tread1</td>
<td>Read 1 Time</td>
<td>(s)</td>
<td>40</td>
</tr>
<tr>
<td>SO2amb</td>
<td>Average SO2</td>
<td>(ppb)</td>
<td>0-300</td>
</tr>
<tr>
<td>BslinArea</td>
<td>Baseline Area</td>
<td>(ppb*s)</td>
<td>&lt;100</td>
</tr>
<tr>
<td>FlsArea</td>
<td>Pulse 1 Area</td>
<td>(ppb*s)</td>
<td></td>
</tr>
<tr>
<td>ThConvFact *</td>
<td>Conv Fac</td>
<td>(ppb*s/ng)</td>
<td>10-20</td>
</tr>
<tr>
<td>CalFact **</td>
<td>Theor Conv %</td>
<td>(%)</td>
<td>60-80</td>
</tr>
<tr>
<td>dtFls</td>
<td>Flash Dur</td>
<td>(ms)</td>
<td>10-12</td>
</tr>
<tr>
<td>SO4</td>
<td>Sulfate Conc</td>
<td>(ng/L)</td>
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</tr>
<tr>
<td>OP</td>
<td>none</td>
<td>none</td>
<td>000000</td>
</tr>
</tbody>
</table>
Appendix A: 8400N Quick Start Guide
Appendix B: Maintenance Log Sheets