Standard Operating Procedure

for

Routine Operation of the
Rupprecht and Patashnick 8400N
Ambient Particulate Nitrate Monitor

DRAFT
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# Table of Contents

1. Scope and Applicability ................................................................................................ 4  
2. Summary of Method ..................................................................................................... 4  
   2.1 Method Parameters ................................................................................................. 4  
   2.2 Method Description ................................................................................................. 4  
   2.3 Data Quality Objectives ......................................................................................... 5  
3. Definitions ...................................................................................................................... 5  
4. Health and Safety Warnings ........................................................................................ 5  
5. Cautions ......................................................................................................................... 5  
6. Interferences .................................................................................................................. 5  
7. Personnel Qualifications .............................................................................................. 5  
8. Apparatus and Materials ............................................................................................. 6  
9. Site and Equipment Preparation ................................................................................. 6  
10. Instrument Calibration ................................................................................................. 7  
11. Instrument Operation ................................................................................................. 7  
   11.1. General Operation ............................................................................................... 7  
   11.2. Schedule of Operational Tasks ........................................................................... 7  
      11.2.1. Daily Checks ............................................................................................... 7  
      11.2.2. Semi-Monthly Tasks ................................................................................... 7  
      11.2.3. Monthly Tasks (Every 4-6 Weeks) ................................................................. 8  
   11.3. Consumables ......................................................................................................... 8  
      11.3.1. Consumable Items ........................................................................................ 8  
      11.3.2. Changing the N₂ Cylinder .......................................................................... 8  
11.4. Daily Checks ......................................................................................................... 8  
   11.4.1. Frequency ........................................................................................................ 8  
   11.4.2. Check the N₂ Cylinder (1) .............................................................................. 8  
   11.4.3. Check Calibration Gas Cylinder (1) ................................................................. 9  
   11.4.4. Refill Water Reservoir (1) ............................................................................... 9  
   11.4.5. Check NOₓ R-Cell Pressure (1) ....................................................................... 9  
   11.4.6. Check and Record Orifice Flow Rotameter (1) ............................................... 9  
   11.4.7. Check and Record Audit Data (2) ................................................................... 9  
      11.4.7.1. If Zero has Drifted (2) .............................................................................. 9  
      11.4.7.2. If Span has Drifted (2) ............................................................................. 9  
      11.4.7.3. To Conduct a Manual Analyzer Audit (2) ............................................. 10  
   11.4.8. Routine Checks, Pulse Analyzer (3) ............................................................... 10  
   11.4.9. Routine Checks, Pulse Generator (3) .............................................................. 10  
   11.4.10. Check Cyclone after Recent Rain (3) ......................................................... 11  
   11.4.11. Note Corrective Actions Taken (3) ............................................................. 11  
   11.4.12. Note If Semi-Monthly Checks Run (4) ...................................................... 11  
11.5. Semi-Monthly Tasks ............................................................................................. 11
11.5.1. Measure Field Blank (5) ................................................................. 11
11.5.2. Clean Cyclone (6) ...................................................................... 11
11.5.3. Calibration with Aqueous Standards (7) ................................. 11
11.6. Monthly Tasks (Every 4-6 Weeks) .............................................. 12
   11.6.1 Clean Orifice (8) ..................................................................... 12
   11.6.2 Replace Flash Strip (9) .............................................................. 12
   11.6.3 Check Make-Up Flow Filter (10) ............................................. 12
   11.6.4 Change Analyzer Filter (10) .................................................... 12
   11.6.5 Leak Check (11) ...................................................................... 13

12. Preventative Maintenance and Repairs ........................................ 13
13. Troubleshooting .............................................................................. 13
   13.1. Status Codes ........................................................................... 13
      13.1.1. Ambient Temp Out of Range ............................................... 14
      13.1.2. Check H2O Reservoir ......................................................... 14
      13.1.3. Flash Failure ................................................................. 14
      13.1.4. Sample Flow Out of Range ............................................. 14
      13.1.5. Cross Flow Control Fail .................................................. 14
      13.1.6. Analyzer Warning .......................................................... 14
14. Data Acquisition, Calculations, and Data Reduction ...................... 14
   14.1. Data Acquisition ..................................................................... 14
   14.2. Data Reduction ....................................................................... 15
15. Data Management and Records Management ............................... 15
16. References ..................................................................................... 15

Table 1: System Parameters and Settings .......................................... 16
Table 2: Output Format and Expected Values for 8400N Cycle Data .... 17
Appendix A: Quick Start Guide
Appendix B: Maintenance Log Sheets
1. Scope and Applicability
This operating procedure applies to the operation of the Rupprecht and Patashnick 8400N Ambient Particulate Nitrate Monitor, with software version 0.535.

2. Summary of Method

2.1 Method Parameters
- Measured parameter: Nitrate in airborne particles below 2.5 µm.
- Time resolution: Typically 10-min, user selectable between 3 min and 20 min.
- Detection Limit: 0.5 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 chemiluminescent analysis of the evolved nitrogen oxide 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 nitrate analysis. The 1 L/min nitrate 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 nichrome 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 nitrogen gas, 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 nitrogen flows through the cell and into a nitrogen oxide analyzer. The collection substrate is then flash heated by current from a battery until reaching an infrared cutoff. Typical heating times are 70-90 ms. Evolved nitrogen oxides are carried in the nitrogen flow to the analyzer, where they are reduced to NO by a molybdenum converter, and assayed by chemiluminescence. The analyzer output is integrated to yield the nitrate 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 cyclone precut, denuder, humidifier and collection-analysis cell are housed in a box, which is ventilated with outside air to try to maintain sampling temperatures close to ambient. The system outputs nitrate concentration and system operating parameters via a serial communications line at the end of each cycle.

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).

2.3 Data Quality Objectives
Data quality objectives were set at the outset of the study based on prior experience with the prototype system constructed by Aerosol Dynamics Inc., as reported by Stolzenburg and Hering (2000). These are:

- **Accuracy:** Daily average of 10 minute nitrate concentrations from the 8400N to agree within 25% of denuded nylon filter values from the sequential sampler at the same site.
- **Precision:** At least ±10% (= 1 sigma) as determined by replicate standards.
- **Lower Quantifiable Limit:** At least 10 ng, or 1µg/m³ for a 10 min sample.
- **Completeness:** At least 85% data completeness during designated intensive.

Quality assurance checks include (1) analysis of nitrate standards applied directly to the particle collection strip and (2) collection and analysis of filtered air samples to determine the dynamic blank and check for positive interferences. These are done at least monthly. Additionally, the NOₓ analyzer span is checked automatically every second day.

3. Definitions
- **Pulse Generator:** the main component of the 8400N (large box)
- **Pulse Analyzer:** the NOₓ Analyzer component of the 8400N

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 N₂ 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 nitrogenous 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

- 8400N Pulse Generator
- 8400N Pulse Analyzer
- 8400N pump
- 5/16” OD aspirated sample line inside an insulated 3” ventilation line
- Ambient temperature probe with mounting clamp
- N₂ purge gas (grade 99.99% is sufficient), with CGA 580 regulator.
- 5 ppm NO in N₂ 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: Quick Start Guide. 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 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 11.4.7.3.
- 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 NO\textsubscript{x} monitor is automatically spanned every second day using a 5 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. Approximately 30 minutes are required for the ozone generator in the Pulse Analyzer to begin operating. Confirm all system parameters are set as per Table 1: System Parameters and Settings. Pressing “RUN/STOP” will begin sampling and analysis. The 8400N 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: Quick Start Guide for details.

11.2. Schedule of Operational Tasks

11.2.1. Daily Checks
- Check N\textsubscript{2} and Cal cylinder pressures
- Refill water reservoir (grocery store distilled water OK)
- Check “R-Cell” pressure on NO\textsubscript{x} analyzer
- 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 8400N Pulse Generator is running without error flags indicated

11.2.2. Semi-Monthly Tasks
- Replace N\textsubscript{2} 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 8400N uses either industrial or Grade 4.8 nitrogen 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. “Ultra-pure” N\textsubscript{2} can be used, but is generally more expensive.

11.3.2. Changing the N\textsubscript{2} Cylinder
When the N\textsubscript{2} cylinder pressure drops below 300 psi, interrupt the running cycle by pressing “RUN/STOP”. Then press the soft key under “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 it does not say “SAMPLE/FLOW AUDIT”, but just “SAMPLE”. Then the N\textsubscript{2} 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 8400N 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 straight forward 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 N\textsubscript{2} Cylinder (1)
Check the N\textsubscript{2} 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 N₂ Cylinder.

11.4.3. Check Calibration Gas Cylinder (1)
Note the pressure on the NO calibration gas cylinder, and check that the drop in pressure
from the previous reading is not excessive. These cylinders require 4-6 weeks lead time
to acquire, 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 NOₓ R-Cell Pressure (1)
To check the R-Cell pressure, look for the value in the middle of Pulse Analyzer display.
If not displayed, press “test” to scroll through parameter list. If not between 4.7 and 5.3
in. Hg, then adjust the regulator at the back of analyzer. The data system records the R-
Cell value.

11.4.6. 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.

11.4.7. Check and Record Audit Data (2)
If the 8400N 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.

11.4.7.1. 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 N₂
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.

11.4.7.2. 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 NOₓ 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.

11.4.7.3. 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 8400N 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 10 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.

11.4.8. 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. On a cold start up, the ozone generator may not turn on for the first 30 minutes.

11.4.9. 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 50-90 ms. From main screen press “data”. The flash duration is the last value listed. Press “ESC” 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.
11.4.10. 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.

11.4.11. 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.

11.4.12. 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/µL NO₃ from NaNO₃):

<table>
<thead>
<tr>
<th>No</th>
<th>Vol(µL)</th>
<th>ng nitrate</th>
<th>expected level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.2</td>
<td>60 ng</td>
<td>1200-1400 ppb*s</td>
</tr>
<tr>
<td>2</td>
<td>0.4</td>
<td>120 ng</td>
<td>2400-2800 ppb*s</td>
</tr>
<tr>
<td>2</td>
<td>0.6</td>
<td>180 ng</td>
<td>3600-4200 ppb*s</td>
</tr>
</tbody>
</table>
2 0.8 240 ng 4800-5600 ppb*s
2 0.5 water blank

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 run. 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 8400N 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 nichrome 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 Change 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 8400N 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>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>
</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 N2 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 8400N Cycle Data. Audit and Standards data should be downloaded manually. Cycle data can also be downloaded manually as described in Appendix A: 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
- Field blank readings
- Variations in analyzer audit span
- Variations in the R-Cell pressure
- 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 8400N 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 8400N 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>525</td>
<td><em>these parameters determine timing of cycle steps</em></td>
</tr>
<tr>
<td>Purge Time</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Baseline Read</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Read 1 time</td>
<td>20</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>2</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>220</td>
<td><em>these parameters determine timing of audit steps</em></td>
</tr>
<tr>
<td>Read NOx 1</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Flow Balance Check</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Read NOx 2</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Line Purge</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Read NOx 3</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>NOx 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 nitrate analysis</em></td>
</tr>
<tr>
<td>Conv. Fact.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anal Cross Flow</td>
<td>85%</td>
<td><em>depends on aqueous standards results</em></td>
</tr>
<tr>
<td>% Theor. Conv.</td>
<td>85.00%</td>
<td></td>
</tr>
<tr>
<td><strong>System Setup</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RS-232 Setup</strong></td>
<td></td>
<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>
<td>0</td>
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</table>
Table 2: Output Format and Expected Values for 8400N 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 (8400N)</th>
<th>Units</th>
<th>Acceptable</th>
</tr>
</thead>
<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></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></td>
</tr>
<tr>
<td>RHcond</td>
<td>Cond % RH</td>
<td>(%)</td>
<td>70-100</td>
</tr>
<tr>
<td>Tamb</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>0.7-1.0</td>
</tr>
<tr>
<td>Psmmp</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>Prcell</td>
<td>RCell Pres</td>
<td>(in Hg)</td>
<td>4.6-5.3</td>
</tr>
<tr>
<td>tsmp</td>
<td>Sample Time</td>
<td>(s)</td>
<td>set value, usu. 525</td>
</tr>
<tr>
<td>tred1</td>
<td>Read 1 Time</td>
<td>(s)</td>
<td>20</td>
</tr>
<tr>
<td>NOxamb</td>
<td>Average NOx</td>
<td>(ppb)</td>
<td>0-300</td>
</tr>
<tr>
<td>BslnArea</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>CalFact</td>
<td>Theor Conv %</td>
<td>(%)</td>
<td>75-90</td>
</tr>
<tr>
<td>dtFls</td>
<td>Flash Dur</td>
<td>(ms)</td>
<td>40-80</td>
</tr>
<tr>
<td>NO3</td>
<td>Nitrate Conc</td>
<td>(ng/L)</td>
<td>0-100</td>
</tr>
<tr>
<td>OP</td>
<td>none</td>
<td>none</td>
<td>000000</td>
</tr>
</tbody>
</table>
Appendix A: Quick Start Guide
Appendix B: Maintenance Log Sheets