# UCD IMPROVE Technical Information #226A

# Site Maintenance for Field Technicians

***Interagency Monitoring of Protected Visual Environments***
***Air Quality Research Center***
***University of California, Davis***

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## DOCUMENT HISTORY

| Date Modified | Initials | Section/s Modified | Brief Description of Modifications |
|---|---|---|---|
| 04/22/21 | SRS | All | Separated TI: A-H doc into individual TIs |
| 5/17/21 | IVP | 10,11, TOC | Filled in missing sections, fixed TOC |
| 6/14/22 | IVP | 9 | Removed notes on valve rotations and coupler fixes, as all sites have been upgraded at this point. |
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# 1. PURPOSE AND APPLICABILITY

This technical information (TI) document details the procedures the field technicians must follow for routine maintenance of equipment in the IMPROVE sampling network. Prior to 2013, routine site maintenance occurred on a yearly basis. Starting in January 2013, sites will receive biennial maintenance, with half of the network receiving maintenance one year and the other half the next year. Routine maintenance is divided into "loops," with an average of ten sites visited on each loop. Maintenance is solely the responsibility of the Air Quality Research Center's field operations team, comprised of the field manager and field technicians.

# 2. SUMMARY OF THE METHOD

Prior to routine maintenance, the field technician will review and summarize all of the information collected at each site during the previous year(s) in order to characterize how well each site is functioning. The data recorded during weekly visits to the IMPROVE samplers by the operators, as well as any problems detected during quality assurance procedures, will be incorporated into the site summary. This reference will be used to determine whether extra maintenance or troubleshooting is required at each site. The Air Quality Research Center (AQRC) will establish and announce a rough maintenance schedule for the year.

Routine site maintenance will be performed by AQRC field technicians. During the site visits the cyclones, stacks, and inlets are cleaned; the electronics are checked; the pumps are flagged for replacement or repaired as needed; the sampler flow rates are checked; and calibration equations are verified. Operator training and review sessions as well as any sampler upgrades are also performed at this time.

# 3. DEFINITIONS

- Cassette: a plastic holder that contains a filter substrate or dummy.
- Dummy: a 25 micrometers (mm) or 37 mm piece of material used in cassettes that are not sampled.
- Cartridge: consists of a cartridge plate and 3-4 cassettes inserted in the cartridge plate.
- $PM_{2.5}$: Particulate matter, aerodynamic diameter of 2.5 mm or less.
- $PM_{10}$: Particulate matter, aerodynamic diameter of 10 mm or less.
- 1A module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with Teflon® as the filter medium and runs at 23 liters per minute.
- 2B module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with nylon as the filter medium and runs at 23 liters per minute.

- 3C module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with quartz as the filter medium and runs at 23 liters per minute.
- 4D module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{10}$ with Teflon® as the filter medium and runs at 16.9 liters per minute.
- Cyclone: IMPROVE particle size separator based on aerodynamic equivalency diameter of 2.5 mm.
- Denuder: Set of concentric aluminum tubes used to remove nitric acid from air stream.
- Ebox: Electronic box which houses pressure transducers and manifold drive relays.
- Rbox: Relay box which houses relays that turn on pumps.
- lpm: liters per minute.
- Stack: Inlet tube for module.
- Inlet: Cap over $PM_{2.5}$ stack with insect screen.
- Magnehelic: Device that measures differential pressure used for flow checking modules.
- Sierra inlet: EPA Louvered $PM_{10}$ Inlet.

# 4. HEALTH AND SAFETY WARNINGS

Be aware that various stinging insects, venomous creatures, and large mammals (such as bears) can be found at many of the IMPROVE sites. Be cautious when stepping in tall grass surrounding a site or when opening pump boxes.

Maintenance requires cleaning of the stack inlets, which typically requires accessing the roof of a structure. Safety ratings are assigned to classify fall risk at each site. These ratings range from “None,” “Low,” “Medium,” to “High.” The field manager and technician will meet to discuss the fall safety plan determined for accessing and cleaning the inlets and stacks.

Inclement weather is often an issue at many IMPROVE sites. If severe weather is impending, wait it out in the vehicle or reschedule the site visit.

Always carry a first aid kit. Report any injuries to the field manager immediately.

Refer to TI 226G for more information.

# 5. CAUTIONS

Many access roads to IMPROVE sites are locked after regular business hours. Be sure to communicate with any necessary staff how long the visit is expected to take to avoid being locked in the area.

Some IMPROVE sites are remote and require hiking to the site or driving off-road. Be sure to have detailed directions on how to get to a site that requires walking or off-road driving.

Many IMPROVE sites do not have cellular reception. Take this into consideration when planning site visits.

Wasps and rodents sometimes make nests in the inlets and the sampler enclosure. Check for this carefully, as this can cause issues during sampling and other health concerns. Report any infestations in the sampler to the field manager immediately.

There are several urban IMPROVE sites and care should be taken to lock vehicles and secure work and personal equipment while at the site.

# 6. INTERFERENCES

Occasionally, due to weather conditions or the way a site is housed, the 4D module stack at a site may rub against the funnel. This situation results in the formation of a black powder, referred to as "anodizing dust," that collects and falls down onto the filters. During site maintenance, check to make sure there is no sign of anodizing dust on any of the 4D module filters at the site before and during maintenance. If any anodizing dust is present on the filters, flag the site as a candidate for a stack-stabilizing tripod, take detailed pictures of the roof where the tripod will sit, and inform the field manager. If any anodizing dust is found in the funnel, locate the cause and flag any equipment that needs replacing.

# 7. PERSONNEL DUTIES

The field manager will:

- Oversee and maintain records of site and sampler operation
- Organize and schedule maintenance loops
- Review flow rate checks and flow rate adjustments
- Oversee the training of field technicians both at the AQRC and in the field
- Respond to any issues or concerns brought up by field technicians during maintenance

The site operator will:

- Note deviations from normal operations and inform AQRC personnel
- Attend site operator training and review sessions during site maintenance
- Replace equipment when requested by field operations
- Maintain a clean site

The field technician will:

- Perform routine site maintenance

- Perform site operator training and review sessions
- Maintain records on equipment repair and modification
- Report any issues or concerns in the field to the field manager

# 8. EQUIPMENT AND SUPPLIES

The equipment list for site maintenance trips will vary depending on the number of sites that will be visited and whether any new sites will be installed during the trip. Because of this and due to the extensive amount of supplies needed, equipment lists will not be reported within this TI. They can be located in Attachment 1, "Maintenance Packing Lists" of *UCD SOP #226: Site Maintenance.*

# 9. PROCEDURAL STEPS

Field technicians perform routine site maintenance, generally in the spring or summer. This visit to the site is an opportunity to flag non-vital sampler components for replacement, verify calibration equations, replace or update obsolete equipment, thoroughly clean each sampling module, and test the vacuum systems. It also allows trained personnel to inspect the site to ensure compliance with EPA sampling regulations and provides an excellent opportunity for operator training.

## 9.1 Preparation for Site Maintenance Loop

Preparation for site maintenance involves contacting each site, scheduling visit dates and times, and creating a site flow check and maintenance kit. The field manager is responsible for scheduling maintenance trips and overseeing the training and supplying of the field technicians, both prior to leaving the AQRC and while in the field. The process to prepare for site maintenance is described below.

1) The field technician notifies the site operator of the impending visit two to four weeks prior to the scheduled date. The following topics are covered during operator notification:
    - The exact date and time of scheduled maintenance at the site.
    - Scheduling of operator training sessions or review. The operator should agree to meet for at least twenty minutes so that any changes to the site can be explained.
    - Details of site access, including keys, combinations, etc.
    - Current problems with the sampler, power, site, etc.
    - Past performance/collection rate of the sampler (if requested by the operator or if the collection rate is low).
2) The field technician prepares the following documents:
    - Site access sheets.
    - Site information.

- Site data.
- Sample log sheets for each site.
- Maintenance checklist (one for each site; tasks should be checked off on the checklist as they are performed).
- Labels (for controller and electronics boxes).
- Notes generated during maintenance preparation meeting with field manager.
- History of all equipment replaced since last maintenance. Also, include any out of the ordinary troubleshooting that has occurred at the site that will provide insight on any other problems that may be encountered during the visit.
- Maintenance loop schedule. Check with the field manager to see if any sites have time restrictions.

3) The field technician must prepare the flow check devices and flow adjustment cartridges. First, the field technician must select two complete flow check devices (one as primary and the other as backup). The field technician must also prepare two sets of cartridges: one set for the flow rate check (with old lot nylon filters) and the other set for flow adjustment (new lot nylon filters). Teflon® and quartz filters are typically very stable without significant changes from lot to lot, so the Teflon® and quartz filters can be loaded from the current open box of filters in the lab. Teflon® filters from the new lot are used for both 1A and 4D cartridges. Quartz filters are used for 3C cartridges. Nylon filters, however, vary in resistance significantly between each other. Many 2B filters of both the old lot and the new lot must be tested and the one with average resistance in each lot must be selected and loaded in the cartridges. The field technician must also bring extra filters, as each filter should not be used for more than three sites. Use the following equation to determine the number of additional filters to bring:

   (# of sites) ÷ 3 = (# of filters to prepare)

4) The field technician checks the calibration of the two flow check devices with the BIOS Definer 220. If the flow rates are not within 2% of the previous device calibration, the flow checking device is recalibrated.

5) The field technician assembles a tool kit and organizes a comprehensive parts kit. Parts and tools required for basic electrical and carpentry tasks should be included. At this time, the maintenance loop documents should be reviewed to determine any extra work or suspected problems for which the technician must be prepared.

6) The field technician prepares clean, coated denuders to replace the used denuders in the 2B modules at each site. For instructions on how to clean and coat each denuder, please see TI 226D.

7) The field technician ships the maintenance gear before departing on the

maintenance trip if applicable.

## 9.2 Operator Training and/or Review

Once at the site, the field technician should meet with the operator and discuss the following:

- Introduce any new hardware/software that will be installed. Talk about any changes the operator will see and leave behind an explanation letter, sample change SOP, site contact info update form, and site report.
- Ask about any concerns or pending problems at the site. Make sure that all of the problems are addressed before leaving the site. If a particular problem cannot be resolved, leave a note or call the operator and explain what the plan is to resolve it in the near future. Call the lab for assistance or equipment if needed.
- Explain the range of temperature values that the operators should expect.
- Show the operator where the AQRC lab number is located on each log sheet and on the controller door instructions.
- Stress the importance of reporting if the time on the controller drifts more than five minutes ahead or behind actual time. Also remind them that all IMPROVE network controllers should run on standard time, and that the operators should not adjust the controller to match DST. Controllers that are connected to an internet device should sync their time automatically, and should not need to be adjusted.
- Stress the importance of writing comments in the comment section of the log sheets for minor issues. These comments are vital in helping the AQRC lab determine when equipment has failed, been requested, and been replaced.
- In addition to writing comments, stress the importance of also calling the lab, especially if equipment seems to be malfunctioning or when equipment is replaced.

If there is a new operator for the site who has not received training, make sure to set aside extra time to train the operator on sample change procedures. Site operator training involves review of the materials covered in *UCD SOP #201: Sampler Maintenance by Site Operators*. The site operator must be trained to perform the following tasks:

- Recording of the final readings for exposed filter cassettes
- Removal of exposed filter cassettes
- Installation of clean filter cassettes
- Recording of initial readings for the clean filter cassettes
- SD card installation
- Shipping/mailing procedures for the return of exposed filter cassettes and log sheets
- Air Quality Research Center phone numbers
- 4 letter site name code
- Basic troubleshooting procedures

- Overview of the site flow rate check procedure, as operators are occasionally required to perform audits due to significant changes in flow, equipment, replacements, etc.
- Replace some of the basic components, including the controller, electronics boxes (Eboxes), and pumps
- Ability to disengage the manifold motors in case they stop working between maintenance visits

## 9.3 Site Maintenance

### 9.3.1 Pre-Maintenance Inspection at Site

Prior to maintenance of the sampler, inspect the site for any general repairs needed. Any repair or changes to the sampler or site should be noted. The following is a review of the suggested pre-maintenance procedures:

1) Determine the location of the breaker for power to the sampler.
2) Check the integrity of the sampler stand, noting any parts that require repair or replacement. Required repairs must be reported to the host agency as soon as possible.
3) Note the condition of the sampler modules (e.g. are they rusted?)
4) Visually inspect the sample cassettes. Note and correct any errors involving the sample change protocol.

Take final readings on any samples that are complete and record them on the appropriate log sheet. If the blue box and log sheet are not available, make sure to record the information in the flow check/flow adjustment spreadsheet and transmit it to the sample-handling laboratory upon returning from maintenance.

If the controller is running upon arrival, the field technician needs to record the elapsed time of the running samples. Record the final PRES/ORI and FLOW/CYC values for the sample currently running and then take new initial readings for the sampler after the conversion and flow calibration. With this particular type of conversion, the calibration equations will be changed significantly and thus PRES/ORI and FLOW/CYC values for each section of data (before and after maintenance) are needed. Record these values on the log sheet.

Write them down in the flow check/flow adjustment spreadsheet if the log sheet is unavailable, and transfer the values onto the log sheet when it returns from the field.

Write a note in the comment section of the log sheet (if available) mentioning the visit. For example, “Site maintenance performed on 9/5/2017 by JSG. ET stopped at 800.”

### 9.3.2 Flow Rate Check

1) Remove the sampling cartridges from the modules, replace their red caps, and place them in Ziploc bags in their blue box or another clean area.

2) Disconnect the temperature probe from the 3C module and place the tip of the probe in the shade. Place the NIST traceable digital thermometer in the shade next to the 3C (or whichever applicable) module's temperature probe and allow it to reach equilibrium (approximately five to ten minutes). Record the current temperature (°C) from the controller home screen and the temperature (°C) from external thermometer, and fill in the flow check portion of the flow check/flow adjustment spreadsheet.
3) Record the VAC reading and zero flows for all the modules. VAC is checked with pump on, all solenoids closed, and zero flows can be measured with a solenoid open and pump off, both from the Calibration menu option.
4) Perform the flow check. Make sure the magnehelic dial is perfectly zeroed before starting. The hoses attached to the dial must be completely straight through the length of the protective springs; otherwise, the dial will shift. Sites with a fifth module formerly referred to the fifth module as an X module. These modules are now referred to as either 5A, 5B, 5C, or 5D to designate what type of filter media is used, and what particle size is collected. Remember that fifth position modules (X modules) do not have their own special cartridge. Use the same cartridge as the module that the fifth module represents (1A, 2B, 3C, or 4D). See TI 226B for step-by-step instructions on how to perform the flow check.
5) Review the flow check results. Compare the nominal values to the previous year's values. The errors generated through the flow check should be under 5%. If large errors occur, remember to review the problems noted pre-maintenance. Electronic box, controller replacements, or previous flow adjustments may account for large errors. Call the lab if phone reception is available so that a lab staff member can confirm whether they have seen these large errors in the data from blue boxes. If the data from blue boxes is different from the results of the flow check, a recent problem may have occurred with the module. Record all original flow check values for all four positions in the flow check spreadsheet. Select solenoid 1 on the controller and then try to wiggle the valve without actually turning it. If the magnehelic values change, note all these new values in the spreadsheet. If in doubt, call the lab for help.
6) Perform pre-leak check of all sampling modules. Make sure to first equilibrate the vacuum gauge. Use the plug and extension bar from the flow check probe to check the vacuum reading from each pump and module to ensure that the readings from each pump and its corresponding module are similar. If a difference between pump and module is greater than 2.0" Hg, a leak in the vacuum system was pre-existing. Fixing the leak is not necessary at this step, but locating the leak is very important in the next step. Leaks may arise from a bad alignment on the cyclone between the cyclone block and funnel, from loose valves, torn O-rings, or a cyclone that needs shimming.

### 9.3.3 Sampler Cleaning and Maintenance

#### *9.3.3.1 Clean Cyclones*

1) If you bring pre-cleaned cyclones with you for maintenance, you may skip the cleaning procedure. This can be useful in situations were poor site conditions make it difficult to clean the cyclones.
2) Remove the cyclones in the 1A, 2B, and 3C modules. Move the cyclones to an area where they can be cleaned comfortably and where there is low risk of dropping any tools or parts into dirt, water, etc.
3) As each cyclone is disassembled and reassembled, check each O-ring. If any O-ring is damaged or missing, replace the part or replace the O-ring with a vacuum-greased BUNA O-ring and report it in the site notes. When working with cyclone assemblies, use caution when using metal tools as they can damage the anodized surface. All internal surfaces of the cyclone assembly should be cleaned with alcohol and laboratory wipes.
4) Clean the 4D module funnel. Note that this requires removing the lid.

#### *9.3.3.2 Clean the Stacks, Inlets, Tees, and Stack Bottom Plugs*

1) Remove the stack bottom plugs, checking the O-rings and replacing the entire plug if they are damaged. Clean the Tees with alcohol and laboratory wipes.
2) If you bring pre-cleaned inlet with you for maintenance, you may skip the cleaning procedure. This can be useful in situations where poor site conditions make it difficult to clean the inlets. This method is recommended for sites with poor roof access, as having pre-cleaned inlets will save time on the roof and improve safety.
3) Remove and clean the inlet caps from the top of the stacks. Check and replace the O-rings if necessary. Use laboratory wipes and alcohol to clean the screen and remove dust and any spider webs. Wasps and other stinging or biting insects sometimes build nests in the inlets, so use caution when removing them and notify the field manager if any wasp nests are found.
4) For the Sierra inlet, which is located on the 4D stack:
    - Unscrew the water trap bottle, either plastic or glass, from the metal cover.
    - Empty the bottle and wipe out any sediments or materials that have collected inside it or on the metal cover. Check for cracks or chips. If the cup is damaged in any way, replace it immediately. Inspect the water trap bottle gasket for damage or excessive wear.

- Reinstall the water trap bottle.
- Unscrew the four Phillips head screws on the underside of the louvered flaps of the inlet and remove the top plate. Clean the cone attached to the top plate and the inlet funnel with alcohol and a lint-free laboratory wipe.
- Clean the exit tube for the inlet funnel with a cotton-tipped applicator and alcohol.
- Reassemble the inlet. If any of the screws appear to be stripped, replace them. They are 8-32 x ½" Phillips head screws. Use anti-seize when replacing any screws and/or standoffs.
- Hold the top of the inlet with one hand, grasp the pipe to the water trap bottle with the other hand, and unscrew the inlet top from the body at the seam located 7½" above the base of the inlet.
- Clean the impaction surface thoroughly with lint-free cloths and alcohol.
- Clean all interior surfaces with lint-free clothes or cotton-tipped applicators and alcohol.
- Reassemble the inlet head.
- Check the O-rings inside the stack sleeve, replacing them if necessary. They are ethylene propylene O-rings size 200-026 and are easily removed using a knife blade.
- Coat the O-rings in the stack sleeve and exit funnel with vacuum grease.

5) Remove the denuder from the 2B module by raising the stack, then removing the denuder detent O-ring. The denuder will now drop out of the Tee, or it can be pulled out of the top of the module if the stack is removed.
6) Clean the inlet stacks using a stack brush. Clean each stack at least twice.
7) Use alcohol and a clean rag or laboratory wipes to clean the inlet Tee. Inspect and replace any damaged O-rings.
*8)* Reinstall the inlet caps

*9.3.3.3 Clean the Interior of the Module and Check All Hoses, Wires, and Connectors*

1) Brush out the bottom of the modules to eliminate fugitive dust and insects. Be sure the vents are clear of debris.
2) Remove the needle valve stems carefully using a ¾" wrench. Clean the

inside of the valves with a cotton-tipped applicator and then reinstall them.

3) Check for cracked or aged hoses on the cyclone. Clip any damaged ends or, if the tubing is showing signs of wear, replace it with new tubing.

4) Use wire ties and anchors to keep wires out of the way of the site operator.

*9.3.3.4 Pump Maintenance and Equipment Replacement*

1) Listen to each pump to determine whether any of them are making unusual noises. Record the rebuild dates for all the pumps. Determine whether pumps need to be rebuilt. If you have a spare pump with you replace these pumps.

2) Replace any version II 4D funnels with version I funnels. These version II funnels are now rare.

3) Replace any grommets on module cases that have weathered and cracked.

4) Replace any broken or cracked manifold motor couplers.

5) Replace the used denuder with a clean, coated denuder. Make sure to record the inventory number of the new denuder in the site notes.

*9.3.3.5 Inspect the Sampler Stand or Structure and the Pump House/Area*

Look for deterioration of the stand or structure and the pump house or area, recording any issues in the site maintenance notes. The modules should be securely attached to the mounting structure, and the stacks should be firmly seated. The pumps should be in an area that has enough airflow for effective cooling, and the area should be free from pest infestation. Inform the field manager if there are any issues that need to be addressed immediately.

9.3.4 Post-Leak Check All Modules

Return all equipment to its proper location and perform a leak-check of all the modules.

Make sure to first equilibrate the vacuum gauge. Use the plug and extension bar from the flow check probe to check the vacuum reading from each pump and module to ensure that the readings from each pump and its corresponding module are similar. Pump and module differences cannot be greater than 2.0” Hg. If a difference is greater than 2.0” Hg, investigate to determine what is causing the leak. Leaks may arise from a bad alignment on the cyclone between the cyclone block and funnel. Adjust the play in the two mating pieces. Leaks may also arise because of a loose valve, torn O-rings, or a cyclone that needs realignment/shimming. Replacing the cyclone with a spare can often fix alignment issues because of differing machining tolerances. Refer to TI 226E for step-by-

step instructions.

9.3.5 Record Zero Flows

The zero flows for all primary modules should be 14.7 psi at sea level for the PRES/ORI value and ~0.0 in $H_2O$ for the FLOW/CYC value, depending on the individual sensor. X module values will match the primary module during flow adjustment. Please see TI226C for step-by-step instructions on how to perform the procedure.

**Note:** zero values are no longer manually adjusted.

9.3.6 Module Flow Rate Adjustment

Verify or adjust the flow rate on the modules. Note that the lot number of the nylon filter cartridges are tracked for the 2B module (as well as the X module, if applicable). For step-by- step instructions on how to prepare for flow adjustment, please see TI 226C.

1) From the Home Screen of the controller, press the **Menu** button, then **Advanced Menu** button, enter **9051**, press the **More** button, then **Flow Adjustment**. Starting with the 1A module (or applicable first configured module), open solenoid 1 by pressing **S1: Off** so that it reads "**S1: On**" on the appropriate module. Press "**Pump: Off"** so that it reads, "**Pump: On"**. The flow rate should be adjusted only on a clean filter in solenoid position 1 with the pump running.
2) Set the flow rate to the "Set Flow" value given in cell D23 on the A, B, C, D, or X worksheet. This is the temperature corrected flow rate in liters per minute (lpm) for module 1A. It should be 23 ± 1 lpm unless the temperature is more than 40 °C or lower than 0 °C. Check the "Device Nominal (23lpm)" value on the Site and Device Data section of the Site and Device Data sheet (cell C12). The number should be three significant digits. Once the flow rate is set to the temperature corrected value, the value read on the Magnehelic should be close to the Device Nominal. The value read on the Magnehelic will be entered into cell E20. Check the "Q Mag" box (cell B26). The value in this cell should be around 23.0 lpm. This is the actual flow being measured and will be different from the temperature corrected flow rate unless the temperature is exactly 20 °C. Turn the valve of the module until the flow rate displayed on the controller matches the temperature corrected flow rate. Record the Magnehelic, Pressure/ORI and Flow/CYC values.
3) Cycle through the other three positions, recording the magnehelic reading and the Pressure/ORI and Flow/CYC values for each.
4) If the $R^2$ value is reasonable, i.e. between "1.000 -0.98" (cells H29 and J29), check the "ORI Error" (cells E26 to E29) and "CYC Error" (cells F26 to F29), generated by comparing the calculated flow rates from the Pressure/ORI and Flow/CYC to the flow calculated from the measured

Magnehelic values (cells B26 to B29). For PM2.5 modules the ORI flow is not expected to be reliable and is displayed for informational purposes only. For $PM_{10}$ modules, ORI flow is the only flow rate reported and is important. If the flow values differ significantly (> 5%) recheck the Magnehelic, Pressure/ORI, and Flow/CYC values. If the errors are less than 5%, the values are acceptable. You must change equipment until the errors are below 5%. Some possible explanations are new electronics boxes and/or electronic drift in transducers. If you cannot determine the cause, please call the field manager for assistance. It may help to switch electronic boxes and try to calibrate again to see if the source of the problem is the particular electronic box. If the flow calculation error is between 5% and 10% you may waive the issue if you cannot fix it as that error is still within the flow measurement guidelines set by the EPA.

5) Move on to the 2B module. Repeat the steps listed above, making sure the controller displayed flow rate value on the screen matches the value in cell D23. This will be around 23.0 liters per minute. Record all of the values and compare them to the universal constant values. Then, proceed with module 3C in the same manner.

6) Module 4D is slightly different. The probe must be modified in order to fit properly. For step-by-step instructions on how to modify the probe, please see TI 226C. Also, the "Set Flow" value will be much different than the previous three modules. Find this flow value in cell D23 on worksheet "D". Make sure that it has a flow rate of around 16.9 lpm. Finally, only Pressure/ORI values are taken during 4D module calibrations, as the Flow/CYC sensor is not used in the 4D mod. All other procedures, such as comparing values to the previous year's values, still apply.

7) Record the new temperature values from the keypad display. Also make sure the "Vacuum/MxORI" and "Zero Flow" values were recorded during calibration. Currently the "Zero Flow" values will be roughly 14.7 psi at sea level for the Pres/ORI, and 0.00 for the Flow/CYC. Zero Flow values can be measured by taking the Pres/ORI and Flow/CYC sensors with the pump off and solenoid open, accessed from the Flow Adjustment menu option.

8) Record the time of flow adjustment in the flow check/flow adjustment spreadsheet.

9.3.7 Post Flow Adjustment Procedures and Checks

1) Update the date and time on the controller if necessary. Do this by pressing **Menu** from the home screen, then selecting **Settings**. Ensure that the GMT is set correctly by selecting **Time Zone** from the same menu.

2) Verify that all of the site configuration parameters are correct. From the Home Screen, go to **Menu**, then **Advanced Menu** and enter code **1123**. The Site Config menu option will be the first option. There are several

parameters to adjust within the Advanced Menu. Some of them are as follows:

- Site: The four-letter site name followed by a number.
- "UC Code": This is a four-digit number that is used as the site's inventory number. In most cases, it should match the last four digits under the barcode in the interior of the 1A module case.
- SD Card: This will configure whether the controller asks for a new memory card every week (bag) or every three weeks (box).
- Edit Schedule: Each site will be either "2-3-2" or a "3-2-2." If the blue box has a yellow sticker with the site code printed on it, the site is a "2-3-2." If the blue box has a green sticker with the site code printed on it, it is a "3-2-2." The IMPROVE calendar lists which week bag should be used on each Tuesday according to blue box schedule.
- Server Settings: Enable or disable remote backup of flow data.

3) Verify that the advanced site configuration parameters are correct. From the Home screen go to **Menu**, then **Advanced Menu** and enter code **9051**. The Maintenance Menu will come up and some of the options are as follows:
    - Unlock Controller: This can be used in special cases to unlock the controller to sample the following week without performing the filter readings procedure.
    - Elapsed Times: This can be used to edit the amount of the time the controller reports sampling for. This feature is used by maintenance technicians to correct the elapsed sample times due to interruptions resulting from maintenance.
    - Edit Constants: This can be used to edit the calibration constants. After 2018, this should no longer be necessary, and operator should never use this menu option.
    - Config Modules: This screen will display one module per page and lists whether the module is online, what module type it is (1A, 2B, 3C, or 4D) and gives the option to edit the calibration constants.
4) Update operator initials if needed. Do this by pressing **Menu** from the Home Screen, then **Settings**, and **Operator Initials**.
5) Install the current sampling set of cartridges and run through Final/Initial readings by pressing **Filter Readings** from the Home Screen. Correct initial readings for any samples that have not yet run.
6) Fill out or update the site data sheet and note any equipment changes.
7) Leave any pertinent documents for operators either inside the controller or

in the blue box if the documents cannot be given directly to the operator.

8) Make sure all equipment inventory numbers have been recorded. Most equipment labels are barcoded to make it easy to record numbers into the field laptop. If any equipment is missing an inventory label, the technician should come prepared with new labels. These include inventory numbers for:
    - Pumps
    - Controller/ Controller Configuration
    - Network device/ Network Configuration
    - Modules
    - Electronic boxes
    - Relay boxes
    - Denuder (note this is engraved and is not barcoded)
    - Ruby Orifice (note this is engraved and is not barcoded)
9) Record breaker amperage and quantity.
10) Label all equipment with colored tape to make it easy for the operator to troubleshoot.
11) Tape 1A, 2B, and 3C Tee plugs to the Tees and add 1A, 2B, 3C, and 4D stack labels to the stacks. Use the appropriate color of tape (red for 1A, yellow for 2B, green for 3C, blue for 4D, or orange for 5X modules) for each module.
12) Take pictures of the following:
    - Eight inward views while standing approximately 30 yards away from the site; take pictures of the site looking N, NE, E, SE, S, SW, W, and NW
    - Four outward views while standing with back against the site and looking towards N, E, S, W
    - All of the modules
    - Pumps and relay boxes
    - Source of power for controller and relay boxes (e.g., A/C outlets, power strip)
    - Breaker, from a distance and up close
    - Roof
    - Stacks (include inlets)
    - Sampler Overview
    - Photos detailing any site hazards if applicable

13) Call lab for any necessary equipment.

# 10. DATA AND RECORDS MANAGEMENT

All equipment inventory records collected during site maintenance are maintained on a SQL server running on the UC Davis AQRC network. Technicians employ the use custom .Net software tools to assist the updating of records.

Notes about site visits, including accessibility of the site, recommended hotel accommodations, and detailed directions are stored in Microsoft word documents on the shared network drive.

Photos are also saved in the shared drive.

All data on network drives and SQL servers are periodically backed up and are stored indefinitely.

# 11. QUALITY ASSURANCE AND QUALITY CONTROL

The field maintenance team visiting the site on any given year is responsible for verifying that all the equipment is in good working order from the last maintenance visit to the present. This means any issue encountered must be documented and reported to the data validation group. Any change and/or issue could affect the sample. To prevent unreported issues from a previous maintenance, the lead technician visiting on any given year should be different from the previous maintenance.

## 11.1 Cleaning and Inspection of Components

During site maintenance, field technicians thoroughly clean components with alcohol and laboratory wipes to reduce or eliminate any possible contaminants. Field technicians also inspect components for spider webs and other signs of pest infestation present in the modules and in the inlets. 4D modules are scrutinized to ensure that no anodizing dust is present due to the stack rubbing against the funnel or against the roof. If signs of anodizing dust are found, the field manager is notified immediately. If the issue causing the anodizing dust cannot be fixed during maintenance, the site is flagged for any equipment necessary to resolve the problem.

## 11.2 Equipment Replacement

Because of the potential for equipment failure, the field maintenance crew no longer rebuilds or repairs pumps in the field. Instead, field technicians examine flow data for the sites that they will be visiting prior to departing on the maintenance trip and determine what equipment may need replacing in the field. Field technicians bring enough spare

equipment to meet any needs that can be identified through both the flow data and through speaking with the site operators before the visit.

If a piece of equipment is showing signs of impending failure at the site, field technicians will either change it out with the spare equipment they brought with them, or the equipment is flagged for replacement. This reduces risk of equipment failure due to less than optimal working conditions.

### 11.3 Documenting the Site with Photographs

Prior to departing the site, field technicians photograph all of the equipment. This documents that the site was left in the same or better condition than it was found and that the sampler has been completely reassembled after maintenance. Photographs of the modules are taken to show that the stacks have been lowered back into the Tees for the PM2.5 modules and that the PM10 module stack has been lowered back into the funnel. Photographs are also taken of the roof to document that the inlets were placed back on top of the stacks and that the stacks were properly seated.

In addition to documenting the complete reassembly of the site, the photographs are useful for assisting AQRC staff with troubleshooting over the phone with operators, as the photographs allow the field technician to view the site configuration remotely.

### 11.4 Data Monitoring

The flow data returning from the site shortly after maintenance is scrutinized to ensure that the final flow rate check was performed properly and that the resulting flow data are valid, as well as to confirm that any replaced equipment is working appropriately. Action is taken immediately if any equipment appears to be malfunctioning or if any of the flow data differs significantly from what was expected.

## 12. REFERENCES

UCD SOP #226: Attachment 1, “Maintenance Packing Lists”

UCD SOP #226: Attachment 2, “Maintenance Checklist”

*UCD SOP #201: Sampler Maintenance by Site Operators*

TI 226B, “Audit”

TI 226C, “Calibration”

TI 226D, “Denuders”

TI 226E, “Leak Check”