UCD IMPROVE SOP #226 Technical Instruction

TI 226A: Site Maintenance for Field Technicians
TI 226B: Flow Check
TI 226C: Calibration
TI 226D: Denuders
TI 226E: Leak Check
TI 226F: Controller Repair
TI226G: Field Safety Plan
TI226H: Calibration of Flow Check Devices

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TI 226A: Site Maintenance for Field Technicians

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1. PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) 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 biannual 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 being visited on each loop. Maintenance is solely the responsibility of the Air Quality Group's field operations team, comprised of the field manager and field technicians.

2. SUMMARY OF THE METHOD

Prior to routine maintenance, the field technician shall 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, shall be incorporated into the site summary. This reference will be used to determine whether extra maintenance or troubleshooting is required at each site. As of January 2017, Air Quality Group will establish and announce a rough schedule of maintenance schedule for the year.

Routine site maintenance shall be performed by Air Quality Group field technicians. For those sites receiving maintenance in a given year, during the site visit, the cyclones, stacks, and inlets are cleaned, the electronics are checked, the pumps are flagged for replacement or repair as needed, the samplers are audited, and new calibration equations are recorded. 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 25mm or 37mm 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 micrometers or less.
- PM_{10}: Particulate matter, aerodynamic diameter of 10 micrometers or less.
- "A" 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.
- "B" 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.
- "C" 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.
- "D" 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.

- Double-C site: refers to sites that have two quartz filters loaded per cassette instead of the typical single C filter.
- Cyclone: IMPROVE particle size separator based on aerodynamic equivalency diameter of 2.5 micrometers.
- 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
- EPROM: Erasable Programmable Read Only Memory which holds IMPROVE software.
- 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". Fall safety plans are assigned for each classification of fall risk, and sites with a "High" risk assignment have site-specific fall safety plans. 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 sometimes make nests in the inlets. Check for this carefully, as this can cause issues during sampling. Report any infestations in the inlets to the field manager immediately.

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

6. INTERFERENCES

Sometimes, 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 shall:

- Oversee and maintain records on site and sampler operation
- Organize and schedule maintenance loops
- Review flow rate audits and calibration equations
- Oversee the training of field technicians both at the Air Quality Group and in the field
- Respond to any issues or concerns brought up by field technicians during maintenance

The site operator shall:

- Note deviations from normal operations and inform Air Quality Group 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 shall:

- 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 SOP but can be located in Attachment 1 of SOP 226, "Maintenance Packing Lists."

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.

The following sections describe the site maintenance procedure:

9.1 Preparation for Site Maintenance Loop

9.2 Operator Training and/or Review

9.3 Site Maintenance

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 Air Quality Group 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 calibration 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 calibration (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 lot are used for both "1A" and "4D" cartridges. Quartz filters are used for "3C" cartridges. Nylon filters, however, vary in resistance fairly significantly between each other. Thus, 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 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.

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. If the operator is interested, show them the "1" hot key so that they can see the actual temperature in degrees Celsius.
- Show the operator where the AQG lab number is located on each log sheet and on the controller door instructions.
- Stress the importance of updating the time on the controller if it drifts more than five minutes ahead or behind actual time. It is critical that if they adjust the date at all, they must perform filter readings after the adjustment. Otherwise, they may potentially lock out the controller. 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.
- Stress the important of writing comments in the comment section of the log sheets. These comments help the AQG lab determine when equipment has failed, been requested, and been replaced. This is very important.
- 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 time to train the operator on sample change procedures. Site operator training involves review of the materials covered in 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
- Memory card installation
- Shipping/mailing procedures for the return of exposed filter cassettes and log sheets.
- Air Quality Group phone numbers
- 4 letter site name code
- Changing the date/time on the controller

- 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.
3) Note the condition of the sampler modules; 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/calibration spreadsheet and transmit it to the sample-handling laboratory upon returning from maintenance.

If the controller is running upon arrival, the field technician only needs to record the elapsed time of the running samples unless the site is being converted from one type of electronic box to another (version I to version II or vice versa). If the site is being converted, record the final ORI and CYC values for the sample currently running and then take new initial readings for the sampler after the conversion and calibration. With this particular type of conversion, the calibration equations will be changed significantly and thus ORI and 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 audit/calibration 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 certified digital thermometer in the shade next to the "3C" module's temperature probe and allow it to reach equilibrium (approximately five to ten minutes). Record the current temperature millivolts (mV) from the controller keypad and the temperature in degrees Celsius from external thermometer, and fill in the flow check portion of the flow check/calibration spreadsheet.

3) Record the Max Orifice reading and zero flows for all the modules. Max Orifice is hot key "2" from the main menu and zero flows can be accessed through "9051" advanced menu.

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 audit should be under 5%. If large errors occur, remember to review the problems noted pre-maintenance. Electronic box or controller replacements may account for large errors. Call the lab if phone reception is available so that a lab staff 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 keypad 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.

9.3.3 Sampler Cleaning and Maintenance

9.3.3.1 Clean Cyclones

1) 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.

2) 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 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 Kimwipes™, or another sterile, dust-free cloth.

3) 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 Kimwipes™.
2) Remove and clean the inlet caps from the top of the stacks. Check and replace the O- rings if necessary. Use Kimwipes™ and alcohol to clean the screen and remove dust and any spider webs. Wasps and other stinging insects sometimes build nests in the inlets, so use caution when removing them and notify the field manager if any wasp nests are found.
3) 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.
    - 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 cloth, such as a Kimwipe™.
    - 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.
4) 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.
5) Clean the inlet stacks using a stack brush. Clean each stack at least twice.

6) Use alcohol and a clean rag or Kimwipe™ to clean the inlet Tee. Inspect and replace any damaged O-rings.

7) 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) As of 2016, all needle valves network-wide are facing outward. If this is not the case, jam nut on valve body is loosened, valve is clocked 90°, and upper CPC and coupler are reoriented to face right, pointing towards the cyclone. Valves are cleaned after being reconfigured.
4) 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.
5) 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 any unusual noises. Record the rebuild dates for all the pumps. Flag any aging pumps (2+ years old) for replacement.
2) Replace any version II "D" 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) As of 2017, if motor coupler disk is fixed to motor coupler hub, remove nut and screw and free the motor coupler disk, allowing for easier replacement.
6) 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 having 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.

9.3.3.6 Inspect the Controller

1) Check the CPU battery voltage. Ensure that the value is adjusted according to the calibration on the Volt-meter. If it is less than 2.98V, replace the battery. If the battery is soldered on, note the voltage and report it to the field manager.

Replace the CPU if there is a spare available.

2) Check the CPU voltage regulator. The "+" test point is "U3" next to the regulator. If the value is not 5.00±0.05V, replace the CPU. Make sure to adjust the value according to the calibration on the Volt-meter. Remember to put a zip tie around the new CPU if it is a ribboned model.
3) Install any new software, if necessary.
4) Record the CPU serial number if it is not an AMD chip. The serial number is on the underside of the CPU. Either use a mirror and flashlight or remove the CPU in order to see the number.
5) If the motherboard is a V3, record the serial number. If the motherboard is not V3, then replace it.
6) Install a new grounding harness to those controllers that do not have one. Remember to correct the polarity of the grounding harness.
7) Upgrade the DC power harness to the new type with double wires to the supplies.
8) Add controller information to the front plate. Remove any old labels or cover them if possible.
9) Evaluate and troubleshoot any apparent controller issues, and request a new controller if necessary. Refer to TI 226F for further information on troubleshooting controllers.

9.3.4 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 audit 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 shimming. Refer to TI 226E for step-by-step instructions.

9.3.5 Set Zero Flows

Set the zero flows for all primary modules to be 10 for the ORI value and 5 for the CYC value. "X" module values will be changed to match the primary module during calibration. Please see TI226C for step-by-step instructions on how to perform the procedure.

9.3.6 Module Calibration

Calibrate the modules. Note that the calibration cartridges loaded with new lot filters are to be used for the "1A," "2B," and "3D" modules (as well as the "X" module, if applicable). For step-by- step instructions on how to prepare for calibration, please see TI 226C.

1) Set the flow rate to 23 liters per minute (lpm) for module "1A." Check the "QSITE"

value in the "Device Constants" section of the flow check/calibration sheet (cell B9). The number should be two significant digits. Type this number in the "CALIBMAG" box (cell H25). Check the "QA" box (cell K25). The value in this cell should be 23.0 lpm. If the value is less than this, add "0.01" to the value in cell H25 until the liters per minute is at least 23. It is better to be over

23.0 lpm than to be under. Now, turn the valve of the module until the magnehelic dial matches the number in cell H25. Record the ORI and CYC values.

2) Cycle through the other three positions, recording the magnehelic reading and the ORI and CYC values for each.

3) If the R^2 value is reasonable (close to "1.000"), compare the generated nominal values for

ORI and CYC to last year's values. If the values differ significantly (>5%), the cells on the flow check/calibration sheet with the new nominal values (cells E32 and E33) will change color. If the cells remain the same, the values are acceptable. Also compare the equation slope and intercept for both the ORI and CYC to last year's values. If they are not similar, please determine the cause of the difference in nominal values. Some possible explanations are new electronics boxes, a reconfiguration of the flow valve, 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.

4) Move on to the "2B" module. Repeat the steps listed above, making sure the calibration value in cell H25 creates a flow rate of at least 23.0 liters per minute in cell K25. Record all of the values and compare them to last year's values. Then, proceed with module "3C" in the same manner.

5) Module "4D" is slightly different. The probe has to be modified in order to fit properly. For step-by-step instructions on how to modify the probe, please see TI 226C. Also, the "QSITE" value will be much different than the previous three. Enter this new value into cell H25. Make sure that it produces a flow rate of at least 16.9lpm. Finally, only ORI values are taken during "4D" module calibrations, as the CYC is not used in the "4D" mod. All other procedures, such as comparing values to the previous year's values, still apply.

6) Record the new temperature values from the keypad display. Also make sure the "Max Orifice" and "Zero Flow" values were recorded during calibration. Currently the "Zero Flow" values are set to "10" for ORI and "5" for CYC for all modules. Run through the "Acquire Zero Flows" option to give the controller a reference point when diagnosing leaks and/or flows. To do this, go to the "9051" advanced menu and press "F2" for "Zero Flows."

7) Record the time of calibration in the flow check/calibration spreadsheet.

9.3.7 Post Calibration Procedures and Checks

1) Update the date and time on the controller display if necessary. Do this by

pressing "F2" while in the main menu. Ensure that the GMT is set correctly.

2) Verify that all of the site configuration parameters are correct. Go to the "1123" advanced menu and press "F2." The following menus will come up:
   - "Old 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.
   - Module Type: This screen should list the numbers "1 2 3 4 5" with the characters "A B C D _" under them, respectively. Note that if the site has an "X" module, the letter "X" should be under the number "5." The following screen will ask if the "X" module is a PM2.5 or a PM10. Select the appropriate value. If a site only has a "3C" module, only the letter "C" should be present under the number "3".
   - Time Average: This should be set to fifteen minutes.
   - Change Day: Tuesday should be selected.
   - Box Sequence: Each site will be either a "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."
   - Controller ID: This number should match the number listed on the interior left wall or door of the controller module.
3) Update operator initials if needed. Do this by pressing "F3" in the "1123" advanced menu.
4) Install the current sampling set of cartridges and run through Final/Initial readings by pressing "F1" in the main menu. Correct initial readings for any samples that have not yet run.
5) Restore all elapsed times. Use the "9051" advanced menu and press "F1."
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. These include inventory numbers for:
   - Pumps
   - Controller
   - Electronic boxes: both the electronic box inventory number and the inventory numbers of the parts inside, which should be listed on a paper taped to the outside of the electronic box.
   - Denuder
9) Make sure the pump rebuild dates have been recorded.
10) Record breaker amperage and quantity.

11) Label all equipment with colored tape to make it easy for the operator to troubleshoot.

12) 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, yellow, green, blue, or orange for "X" modules) for each module.

13) 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 (i.e., A/C outlets, power strip)
- Breaker, from a distance and up close
- Roof
- Stacks (include inlets)

14) Call lab for any necessary equipment.

10. REFERENCES

SOP 226, Attachment 1, "Maintenance Packing Lists"

SOP 226, Attachment 2, "Maintenance Checklist"

SOP 201, "Sampler Maintenance by Site Operators."

TI 226B, "Audit."

TI 226C, "Calibration."

TI 226D, "Denuders."

TI 226E, "Leak Check."

TI 226B: Flow Check

TABLE OF CONTENTS

1. PURPOSE AND APPLICABILITY

The purpose of this SOP is to describe the flow check procedures used during field maintenance for all IMPROVE network sites.

2. SUMMARY OF THE METHOD

The field technician performs a flow check of the modules during field maintenance to test current flow rates and equations in order to determine if there has been any drift since the last maintenance visit. Flow rate values for each module are checked and recorded.

3. CAUTIONS

Make sure that the magnehelic is set to zero when vertical and that the tubing for the device is straight and not kinked before beginning the flow check.

4. EQUIPMENT AND SUPPLIES

A black, hard-cased flow check kit should contain the following:

- Magnehelic and Probe
- One flow check cartridge for each module, four total
- One 5/32" hex key
- NIST-certified thermometer

The field technician should also have a prepared, site-specific flow check sheet.

5. PROCEDURES

5.1 Preparing the Modules and Controller for the Flow Check

1) Open the controller door and press the "Enter" button, which will bring up the main menu.
2) Remove the sampling cartridges from the modules. Make sure that final readings have already been taken.
3) Insert each flow check cartridge into its corresponding module.

5.2 Recording Temperature, Max Orifice, and Zero Values

1) In the flow check device case, there will be a NIST-certified thermometer. Please take the thermometer out of the case and place it in the shade next to the "3C" module. Turn the power switch to the "On" position and the unit switch to "°C." Disconnect the temperature probe from the "3C" module and place the tip of the probe next to the thermometer. Allow the thermometer to equilibrate for approximately five to ten minutes.
2) To take the temperature reading from the probe, press the "1" key. The millivolt reading will be on the left-hand side of the display. Record this value in cell A25. Then, record the value reported by the thermometer in cell B25.
3) To take Max Orifice (or MxORI) values, make sure the display is showing the main menu. Press "2." All the pumps should turn on. After running for a few seconds, MxORI values will appear for each module. Record the values for each module in cell E25 for each sheet.
4) To take zero values for the ORI and CYC of each module, go to the main menu and press "F3" for the advanced menu. Enter the code "9051" and then press "F2" for "Get Zero Flows." Note that if the system was sampling upon arrival, going to the advanced menu will halt sampling. The controller display will show the zero values for the "1A" module. Enter the values in cells F25 and G25 of the "1A" module sheet. Cycle through the modules by pressing "Enter" and record the values in the

appropriate sheets and cells. When finished with the last module, press "Enter" to return to the advanced menu. Press "Enter" again to return to the main menu.

5.3 Preparing the "A" Module and Magnehelic

1) Place the magnehelic on the inside of the module "1A" door. Note that it is important that the dial remains vertical while being read. The magnehelic has a magnet on the back, so it will stay attached. Make sure that the magnehelic reads "0." If not, adjustments can be made using the two knobs in the lower left corner of the device. First, loosen the outer knob, which is the smaller of the two. Then, turn the larger knob (which is between the two metal pieces) to adjust the pitch of the device until it reads "0."
2) Once the device reads zero, tighten the smaller knob down to the metal so that the outer metal piece is held in place by the two knobs.
3) Inside the "1A" module, locate the stack plug and the black plastic cap. Remove the cap by pushing down on it from the top, and remove the plug by pulling down on the brass fitting.
4) Place the probe into the Tee. Do this by pushing the probe (hose end down) through the bottom of the module and up into the Tee until the probe bottoms out.

Figure 1. Removing the Plastic Cap and Stack Plug

Figure 2. Inserting the Probe into the Tee

5.4 Begin the Flow Check

1) Return to the controller's display. From the main menu, select "F3" for the advanced menu. The display will ask for a password. Enter "1123." Do not press the "Enter" button after submitting the code.
2) Now, select "F1" for "Calibration" mode. The module "1A" pump will turn on.

5.5 Filling in the Flow Check Sheet

1) Check the magnehelic value. Enter the displayed number into cell H4 of the flow check sheet, making sure to place a decimal before the number. Note that each tick mark on the magnehelic represents 0.02" H_2O.
2) Look at the controller display. It will show two values for position 1, the Orifice (ORI) and the Cyclone (CYC). Enter these in cells I4 and J4, respectively. If either

of the values is unstable, note the full range of values in the comments section on the bottom left of the flow check sheet.

3) Once these values are recorded, press the "F4" button to move to the second position of the flow check cartridge, and record the magnehelic and ORI/CYC values in cells H5-J5. Repeat the previous steps 1 and 2 for each of the four positions, making sure to record the values in the appropriate cells.
4) Repeat steps 1-3 for modules "2B" and "3C."

5.6 Preparing Module "4D"

1) In order to flow check module "4D," first raise the stack to accommodate the flow check probe. There are two things that need to be loosened before the stack can be raised. First, loosen the locking collar on top of the module by turning it counterclockwise. Then, take the 5/32" hex key and loosen the four screws of the "4D" brace. Do not remove the screws.
2) Slide the stack up approximately four inches or until it is above the "4D" brace. After moving the stack, retighten the locking collar to temporarily secure the stack.

Figure 3. Module "4D"

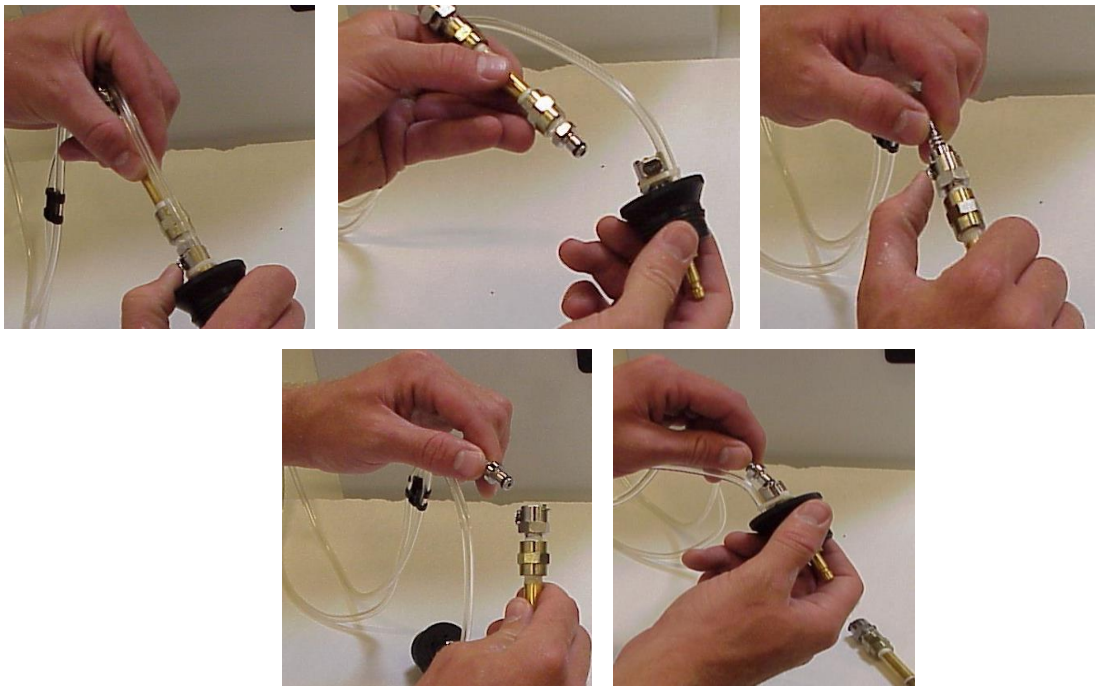
5.7 Preparing the Magnehelic Probe

In order for the probe to fit into the funnel of the "4D" module, it is necessary to make two modifications to the probe itself:

- First, locate the spring-loaded coupler, which is between the probe and the probe plug. Push this coupler's outer sleeve down (toward the hose). This will release the probe plug.
- Secondly, locate the 3-inch brass extender bar, which is attached via quick connects. To remove this extender bar, disengage the quick connects by pushing on the buttons and gently pulling the bar away. After removing the extender bar, attach the quick-connect fitting on the hose to the probe quick-connect.

Figure 4. Releasing the probe plug.

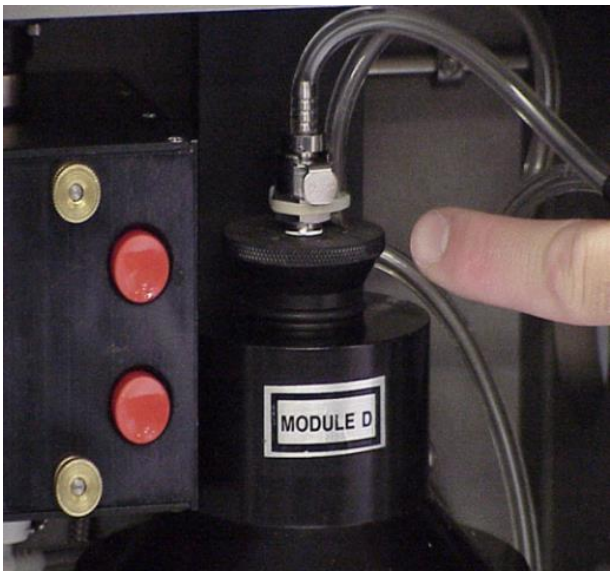
Figure 5. Modifying the probe.



5.8 Conducting the Flow Check on Module "4D"

1) Place the probe into the top of the funnel (where the stack was previously) and gently push down until it bottoms out.
2) With the flow check probe in the funnel of the "4D" module, the "4D" module flow check can now be completed. Repeat the steps in 5.4 for the "4D" module.

Figure 6. Placing the Probe in Module "4D"



5.9 Re-installing the "4D" Stack

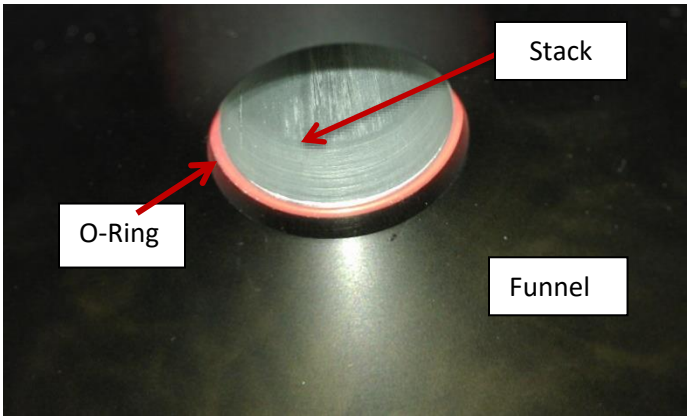
1) Remove the "4D" funnel's bottom lid. Using both hands with thumbs on the recessed channels of the funnel, pull downwards to separate the bottom lid from the rest of the

funnel (Figure 7). Sometimes it is necessary to use a soft mallet to gently tap the bottom lid to separate the two pieces.

Figure 7. Removing the Bottom Lid of Module "4D"

2) Gently lower the stack back to its original position, making sure that the stack is fully seated into the black funnel. It should rest on an orange O-ring as in Figure 8.
3) While the "4D" funnel's bottom lid is still removed, verify that the "4D" stack O-ring is securely in place and uniformly positioned between the silver stack and the retaining lip of the "4D" funnel.

Figure 8. "4D" O-Ring between Stack and Funnel



4) Tighten the sleeve collar by turning it clockwise and then tighten the four screws on the "4D" brace to secure the stack.
5) Replace the "4D" funnel's bottom lid.
6) If the modules are not being calibrated, perform the following steps:
    - Double-check that all black plastic caps and stack plugs are in their proper position for modules "1A," "2B," and "3C."

- Reassemble the magnehelic probe to its original configuration.
- Place all of the flow check components back into the flow check kit.
- Reload the modules with the exposed sampling cartridges. If a sample change needs to be performed, do it now. Record final readings for all modules, install clean sampling cartridges, and take initial readings.

5.10 "X" Modules

Some sites have a fifth module for collocated precision measurements, referred to as an "X" module or "5X". The "X" module is a duplicate of a "1A," "2B," "3C," or "4D" module. The "A," "B," "C," or "D" designation after the "5" determines what filter media and particle size is used for the "5X" module. If there is fifth "X" module present, determine what type of module it is and perform the flow check accordingly.

TI 226C Calibration

TABLE OF CONTENTS

1. PURPOSE AND APPLICABILITY

The purpose of this SOP is to describe the calibration procedures used during field maintenance for all IMPROVE network sites.

2. SUMMARY OF THE METHOD

The field technician performs a calibration of the modules after completing a flow check and general cleaning of the equipment. The calibration corrects current flow rates and equations in the event of any drift since the last maintenance visit due to equipment malfunction or new equipment installation.

3. CAUTIONS

Make sure that the magnehelic is set to zero (while the dial is vertical) and that the tubing for the device is straight before beginning the calibration.

4. EQUIPMENT AND SUPPLIES

A black, hard-cased audit kit should contain the following:

- Magnehelic and Probe
- One calibration cartridge for each module, four total
- One 5/32" hex key
- NIST-certified thermometer

The field technician should also have a prepared, site-specific flow check/calibration sheet.

5. PROCEDURES

5.1 Preparing the Modules and Controller for the Calibration

1) Open the controller door and press the "Enter" button, which will bring up the main menu.
2) Remove the sampling cartridges from the modules. Make sure that final readings have already been taken.
3) Insert each calibration cartridge into its corresponding module.

5.2 Recording Temperature, Max Orifice, and Zero Values

1) In the flow check device case, there will be a NIST-certified thermometer. Please take the thermometer out of the case and place it in the shade next to the "3C" module. Turn the power switch to the "On" position and the unit switch to "°C." Do not remove the tip cover from the thermometer, as this can cause the reading to become unstable. Disconnect the temperature probe from the "3C" module and place the tip of the probe next to the thermometer. Allow the thermometer to equilibrate for approximately ten minutes.
2) To take the temperature reading from the probe, press the "1" key. The millivolt reading will be on the left-hand side of the display. Record this value in cell A25. Then, record the value reported by the thermometer in cell B25.
3) To take Max Orifice (or MxORI) values, make sure the display is showing the main menu. Press "2." All the pumps should turn on. After running for a few seconds, MxORI values will appear for each module. Record the values for each module in cell E25 for each sheet.
4) To take zero values for the ORI and CYC of each module, go to the main menu and press "F3" for the advanced menu. Enter the code "9051"and then press "F2" for "Get Zero Flows." Note that if the system was sampling upon arrival, going to the advanced menu will halt sampling. The controller display will show the zero values for the "1A" module. Enter the values in cells F25 and G25 of the "1A"

module sheet. Cycle through the modules by pressing "Enter" and record the values in the appropriate sheets and cells. When finished with the last module, press "Enter" to return to the advanced menu. Press "Enter" again to return to the main menu.

5.3 Preparing the "1A" Module and Magnehelic

1) Place the magnehelic on the inside of the module "1A" door. Note that it is important that the dial remains vertical while being read. The magnehelic has a magnet on the back, so it will stay attached. Make sure that the magnehelic reads "0." If not, adjustments can be made using the two knobs in the lower left corner of the device. First, loosen the outer knob, which is the smaller of the two. Then, turn the larger knob (which is between the two metal pieces) to adjust the pitch of the device until it reads "0."
2) Once the device reads zero, tighten the smaller knob down to the metal so that the outer metal piece is held in place by the two knobs.
3) Inside the "1A" module, locate the stack plug and the black plastic cap. Remove the cap by pushing down on it from the top, and remove the plug by pulling down on the brass fitting.
4) Place the probe into the Tee. Do this by pushing the probe (hose end down) through the bottom of the module and up into the Tee until the probe bottoms out.

Figure 1. Removing the Plastic Cap and Stack Plug.

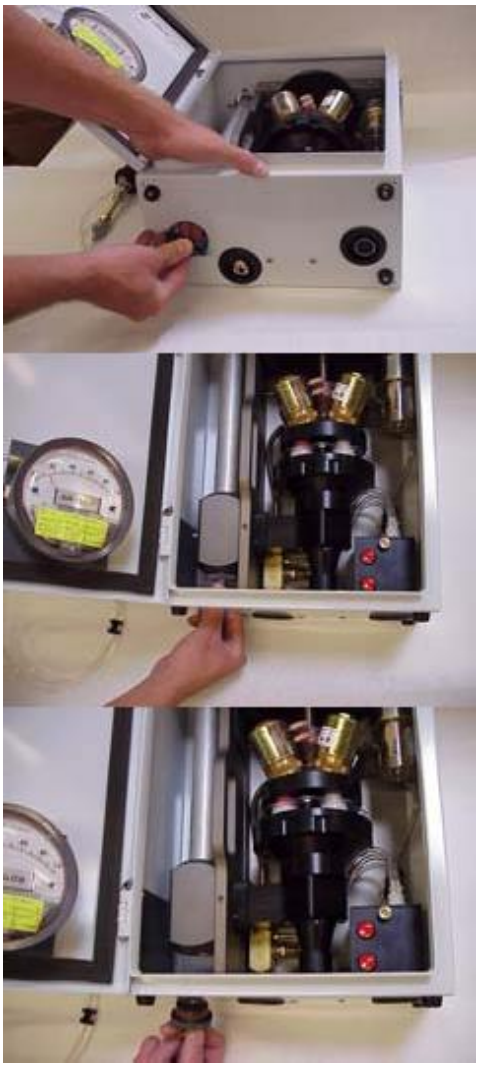


Figure 2. Inserting the Probe into the Tee.

5.4 Preparing Module "4D"

1) In order to calibrate module "4D," first raise the stack to accommodate the flow check probe. There are two things that need to be loosened before the stack can be raised. First, loosen the locking collar on top of the module by turning it counterclockwise. Then, take the 5/32" hex key and loosen the four screws of the "4D" brace. Do not remove the screws.
2) Slide the stack up approximately four inches or until it is above the "4D" brace. After moving the stack, retighten the locking collar to temporarily secure the stack.

Figure 3. Module "4D"

5.5 Setting Zero Flows and Beginning the Calibration

1) Return to the controller's display. From the main menu, select "F3" for the advanced menu. The display will ask for a password. Enter "9051." Do not press the "Enter" button after submitting the code.
2) Now select "F2" for "Get Zero Flows." A "CYC" value and an "ORI" value will show for Module "1A."
3) The two potentiometers (pots) on the side of the electronics box (Ebox) will need to be turned until the "CYC" and "ORI" values read 5.0 and 10.0 respectively. In order to gain access to these pots, the Ebox will need to be reconfigured. Disconnect the grey cable underneath the "1A" module by twisting it. Now loosen the two thumb screws on the electronics box next to the two red buttons. These screws do not come out; they just loosen. Once the screws are loose, pull the electronics box partially out of the white module case and reconnect the grey cable by routing it through the module door (not the bottom hole as before). Now the Ebox is free to move and the two pot holes are visible and accessible on the side of the box. Use the small flat screw driver from the audit kit case to adjust the pots so that the values on the screen read 5.0 and 10.0 for the CYC and ORI respectively. Please note that most adjustments will only require one full turn. These pots are delicate and should not be turned more than 3 full turns in either

direction. If the values on the keypad are not adjusting, make sure that the appropriate module is being worked on by checking the controller display to see what module is currently turned on. (Note, this repositioning of the Ebox will also help with access to the valve in step 1 of section 5.6)

4) Repeat step 2 for the "2B" and "3C" modules, pressing "Enter" to advance from one module to the next.

5) The "4D" module pots are easily accessible without having to move the Ebox. They can be accessed from the right of the box using the small pot screwdriver provided.

6) After setting zero flows, press "Enter" to get back to the advanced menu, and then press "Enter" once more to get back to the main menu.

7) From the main menu, press "F3" for advanced menu. This time enter the code "1123" and select "F1" for "Calibration" mode. The module "1A" pump will turn on.

5.6 Filling in the Calibration Sheet

1) The display will show two values (ORI and CYC). The magnehelic will indicate a value as well. Look at the number in cell B9 ("QSITE"). If there is no number listed, enter the device constants (which are located on the flow check device case) and a number should be generated. Enter the number displayed in cell B9 into cell H25, and then check the value displayed in K25, which is the liters per minute (lpm) that will be generated with that particular magnehelic value. The number in cell K25 should be at least 23.0. If the number is below this, adjust the number in H25 by adding 0.01. Once the flow rate value in K25 is acceptable, the magnehelic needs to be adjusted to reflect that flow rate for position #1. To achieve this flow rate, manipulate the value located at the bottom center of the module (use the black knob on the needle valve, left of the cyclone, facing outward from the module) until the magnehelic value matches that of the value in H25.

2) Look at the controller display. It will show two values for position #1, the Orifice (ORI) and the Cyclone (CYC). Enter these in cells I25 and J25, respectively. If either of the values is unstable, note the full range of values in the comments section on the bottom left of the calibration sheet.

3) Once these values are recorded, press the "F4" button to move to the second position of the calibration cartridge, and record the magnehelic and ORI/CYC values in cells H26-J26. Repeat the previous steps for positions #3 and #4, recording the values in the appropriate cells.

4) Repeat steps 1-3 for all four positions for modules "2B" and "3C" with one exception; the magnehelic value in H25 that produces the appropriate flow rate will already be filled in. All that is needed for position #1 for both the "2B" and "3C" cartridges is to adjust the magnehelic (by turning the valve behind the cyclone) to the value in H25 and then record the ORI and CYC.

5.7 Preparing the Magnehelic Probe

In order for the probe to fit into the funnel of the "4D" module, it is necessary to make two modifications to the probe itself:

- First, locate the spring-loaded coupler, which is between the probe and the probe plug. Push this coupler's outer sleeve down (toward the hose). This will release the probe plug.
- Secondly, locate the 3-inch brass extender bar, which is attached via quick connects. To remove this extender bar, disengage the quick connects by pushing on the buttons and gently pulling the bar away. After removing the extender bar, attach the quick-connect fitting on the hose to the probe quick-connect.

Figure 4. Releasing the probe plug.

Figure 5. Modifying the probe.

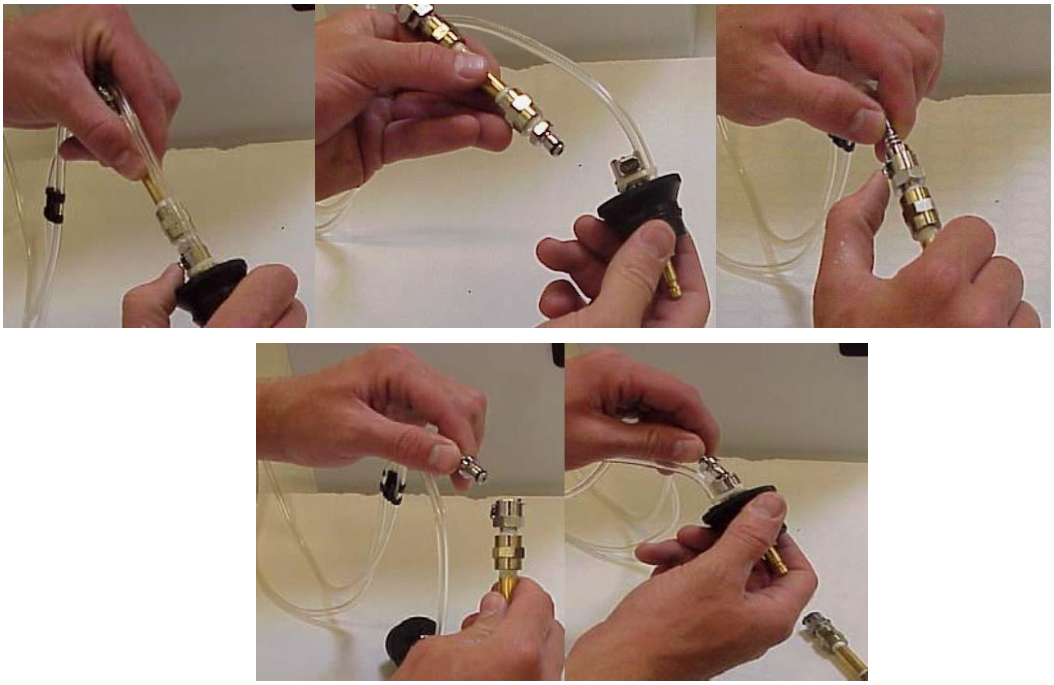
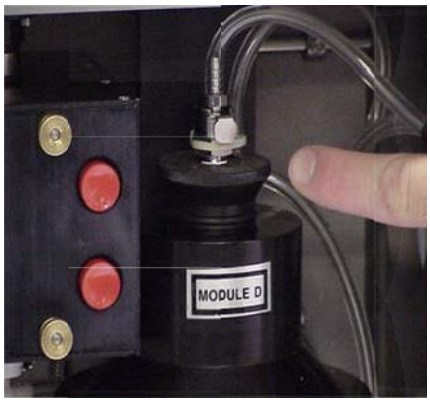


Figure 6. Placing the Probe in Module “4D”

Figure 6. Placing the Probe in Module "4D" (con.)



5.8 Calibrating Module "4D"

1) Place the probe into the top of the funnel (where the stack was previously) and gently push down until it bottoms out.
2) With the audit probe in the funnel of the "4D" module, the "4D" module calibration can now be completed. Repeat the steps in 5.4 for the "4D" module with a couple of exceptions. The number listed in cell B9 ("QSITE") will be different than the one used for the previous modules. This is because "4D" modules run at a different flow rate. When entering the value in cell H25, the flow rate in K25 should be 16.9 liters per minute. If it is below that, add 0.01 to the value in H25 until the value is at least 16.9. It is better to be a little over than under. Also, the "4D" module does not have a functioning CYC, so only the magnehelic and orifice values need to be recorded for each position.

5.9 Re-installing the "D" Stack

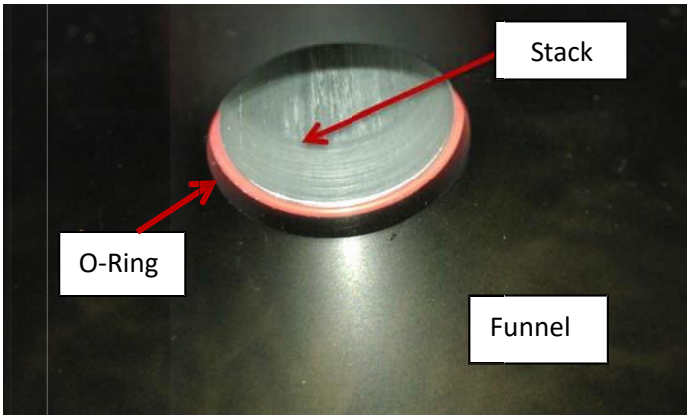
1) Remove the "4D" funnel's bottom lid. Using both hands with thumbs on the recessed channels of the funnel, pull downwards to separate the bottom lid from the rest of the funnel (Figure 7). Sometimes it is necessary to use a soft mallet to gently tap the bottom lid to separate the two pieces.

Figure 7. Removing the Bottom Lid of Module "4D"

2) Gently lower the stack back to its original position, making sure that the stack is fully seated into the black funnel. It should rest on an orange O-ring as shown in Figure 8.

3) While the "4D" funnel's bottom lid is still removed, verify that the "4D" stack O-ring is securely in place and uniformly positioned between the silver stack and the retaining lip of the "4D" funnel.

Figure 8. "4D" O-Ring Between Stack and Funnel



4) Tighten the sleeve collar by turning it clockwise and then tighten the four screws on the "4D" brace to secure the stack.

5) Replace the "4D" funnel's bottom lid.

6) Perform the following steps once calibration is complete:

- Double-check that all black plastic caps and stack plugs are in their proper position for modules "1A," "2B," and "3C."
- Reassemble the magnehelic probe to its original configuration.
- Place all of the calibration components back into the audit kit.
- Reload the modules with the exposed sampling cartridges. If a sample change needs to be performed, do it now. Record final readings for all modules, install clean sampling cartridges, and take initial readings.

5.10 "X" Modules

Some sites have a fifth module for collocated precision measurements, called an "X" or "5X" Module. The "X" is a duplicate of an "A", B", "C", or "D" module. If there is an "X" module present, determine what type of module it is and perform the calibration accordingly.

TI 226D Denuders

TABLE OF CONTENTS

1. PURPOSE AND APPLICABILITY

The purpose of this standard operating procedure (SOP) is to describe the function of the denuders used in “B” modules and to detail how they are cleaned and coated for reuse after returning from the field.

2. SUMMARY OF THE METHOD

Denuders are used in “B” modules to remove nitric acid vapor from the air before it binds to the nylon filter. All denuders are assigned an inventory number for record-keeping. Denuders stay in “B” modules for approximately one to two years and are switched out with a fresh one during field maintenance. The “dirty” denuders are brought back to the Air Quality Group shop, where they are cleaned and coated. The denuders are then ready to be sent out to another site.

3. DEFINITIONS

Denuder: a series of concentric aluminum tubes that is placed within the “B” module stack at sampling sites. The denuder serves to remove nitric acid vapor from the air stream before it binds to the nylon filter. The goal is to collect nitrate particles (which affect visibility) and not nitric acid (which does not).

4. HEALTH AND SAFETY

Always be cautious when handling chemicals. Wear gloves and safety goggles when preparing the solutions to clean and coat the denuders.

5. PERSONNEL QUALIFICATIONS

Field technicians and trained shop assistants are responsible for cleaning and coating denuders in preparation for them to be sent out into the field.

6. EQUIPMENT AND SUPPLIES

Supplies for Cleaning Denuders

- Household grade ammonia
- Alconox glass cleaner
- Balance
- 1L graduated cylinder
- 2L Flask
- Ultrasonic bath
- Deionized water
- Denuder drying bucket-rack
- Paper
- “Dirty” denuder bin
- “Clean” denuder bin
- Safety glasses and gloves

Supplies for Coating Denuders

- 1L graduated cylinder
- Balance
- 2L flask
- 1L plastic bottle
- Deionized water
- Glycerol
- Sodium carbonate (Na2CO3)
- Paper
- “Coated” denuder bin

Miscellaneous Supplies

- Computer
- Engraver

All of the necessary supplies can be found in the IMPROVE shop. The chemical materials are found with the cart of supplies, kept in the chem lab.

If any of the solution ingredients have run out, chemical supplies can be obtained in the Chem 149 storeroom. See the field manager or shop supervisor for the billing number, which is required for making purchases. Make sure to obtain a receipt for billing purposes. Sign and date the receipt and then submit it to the shop supervisor or field manager.

7. PROCEDURE

7.1 Assigning an Inventory Number

All denuders must be assigned an inventory number. The inventory number should be etched on either the top or bottom end of the denuder. If a denuder does not have an inventory number, go into the denuder inventory file, find the next available sequential ID number, and assign it to the denuder. This inventory file can be found in U:\IMPROVE_Field\Shop and Operator Resources\Equipment Inventory. All denuder inventory numbers are in the format "D####." Use the engraver to inscribe the next sequential number onto the end of the denuder.

7.2 Updating the Inventory

A denuder is classified as being in one of four states: dirty, coated, scrapped, currently installed at a field site. If a denuder has just returned from the field, it is considered "dirty" and should be classified as such. To inventory a denuder, first pull up the denuder inventory on the shop computer. Sort according to denuder ID and find the line that corresponds to the last known location of the denuder. Insert a new line into the spreadsheet. Fill out the columns for the denuder ID, the site in which it was last installed, and the date it arrived in the shop. Change the Status "dirty" in the "Status" column. Clear the "Date Coated," "Site Sent To," "Date Sent" columns.

7.3 Cleaning the Denuders

All "dirty" and brand new denuders must be cleaned before being coated. "Dirty" denuders can be found in a designated bin.

7.3.1 Preparing and Using the Ultrasonic Bath

The ultrasonic bath is on the denuder cart, which is located directly outside of the AQG shop, near the sink. Fill the bath with seven liters of deionized water. If unsure of where to locate the deionized water, ask shop personnel for assistance. Then, put on gloves and safety goggles. Take the graduated cylinder and add 10 mL of household grade ammonia. Pour the ammonia into the bath. Take a two liter flask and fill it with one liter of deionized water. Next, take a piece of paper and make it into a cup. Put the cup on the balance in the shop. Tare the balance, and then scoop 80g of Alconox glass cleaner into the cup. Pour the glass cleaner into the flask and stir until it dissolves. Add the solution to the bath.

Place up to eight denuders in the bath and run the bath for 30 minutes. If additional

denuders need to be washed, the bath may be reused an additional three times for 32 denuders. If more than 32 denuders need to be cleaned, a new bath must be made. Discard all bath solution in the sink when the bath is complete.

7.3.2 Rinsing the Denuders

After the denuder bath is complete, remove the denuders promptly and rinse them thoroughly with the deionized water hose for several minutes. This can be done using the deionized water source outside AQG shop. Allow as much water as possible to drain from the denuders, and then place them in the denuder drying bucket-rack. Allow them to dry overnight. Once the denuders are dry, place them in the "cleaned" denuder bucket. They are now ready to be coated.

7.4 Coating the Denuders

After being cleaned, denuders need to be completely immersed in a sodium carbonate (Na2CO3) solution. The coating solution enhances the ability of the denuder to remove nitric acid from the air stream.

7.4.1 Preparing the Solution

First, put on gloves and safety goggles. Locate the 2L flask, which is the vessel that the solution will be mixed in. Find the graduated cylinder and fill it with 100mL of deionized water. Then, measure out 30 mL of glycerol into the graduated cylinder, on top of the water. Pour the solution into the flask. Measure out another 900mL of deionized water into the graduated cylinder and add it to the solution.

Next, prepare to weigh the sodium carbonate. Use an empty weighing dish and place it on the balance. Tare the balance and then measure out 71g of sodium carbonate. Add it to the flask and agitate the solution until all of the sodium carbonate is dissolved. The solution is now prepared and should be placed into a 1L plastic bottle for storage.

7.4.2 Coating the Denuders

Obtain the graduated cylinder. Add 860mL of the sodium carbonate solution to the graduated cylinder. This level will ensure that the solution will not spill over once the denuder is placed into the cylinder. Take a clean denuder and submerge it into the solution. Pull the denuder out, turn it over, and submerge the other side. Remove the denuder from the solution and allow it to dry in the bucket-rack. Repeat this procedure for up to ten denuders. After ten denuders have been coated, the solution must be discarded. Take the solution to the sink and dilute it with hot water before pouring it down the drain. Allow the denuders to dry overnight and then place them in the "coated" denuder bin.

7.4.3 Updating the Inventory

Once the denuders are coated, their statuses must be updated in the inventory. Open the Access inventory file and change the appropriate lines with the "Dirty" status in the "Status" column. Change the status to "Coated." Fill in the date in the "Date Coated" column.

TI 226E Leak Check

TABLE OF CONTENTS

1. PURPOSE AND APPLICABILITY

The purpose of this SOP is to describe the procedure used to check the modules at IMPROVE sites for any vacuum leaks.

2. SUMMARY OF THE METHOD

Vacuum readings are taken from each pump and its corresponding module to ensure that the readings from each pump and module pair are similar to each other. Pump and module differences should not be greater than 2.0” Hg. If differences are too large, troubleshooting procedures are performed to determine where the leak is coming from.

3. CAUTIONS

After zeroing the vacuum gauge, make sure to close the switch on the gauge. If the tab is left open, glycerin will leak out.

4. EQUIPMENT AND SUPPLIES

Vacuum kit including the following:

- Adapter
- Probe
- Coupler
- Manifold plug
- Vacuum grease
- Vacuum gauge

Maintenance spare parts kit including the following:

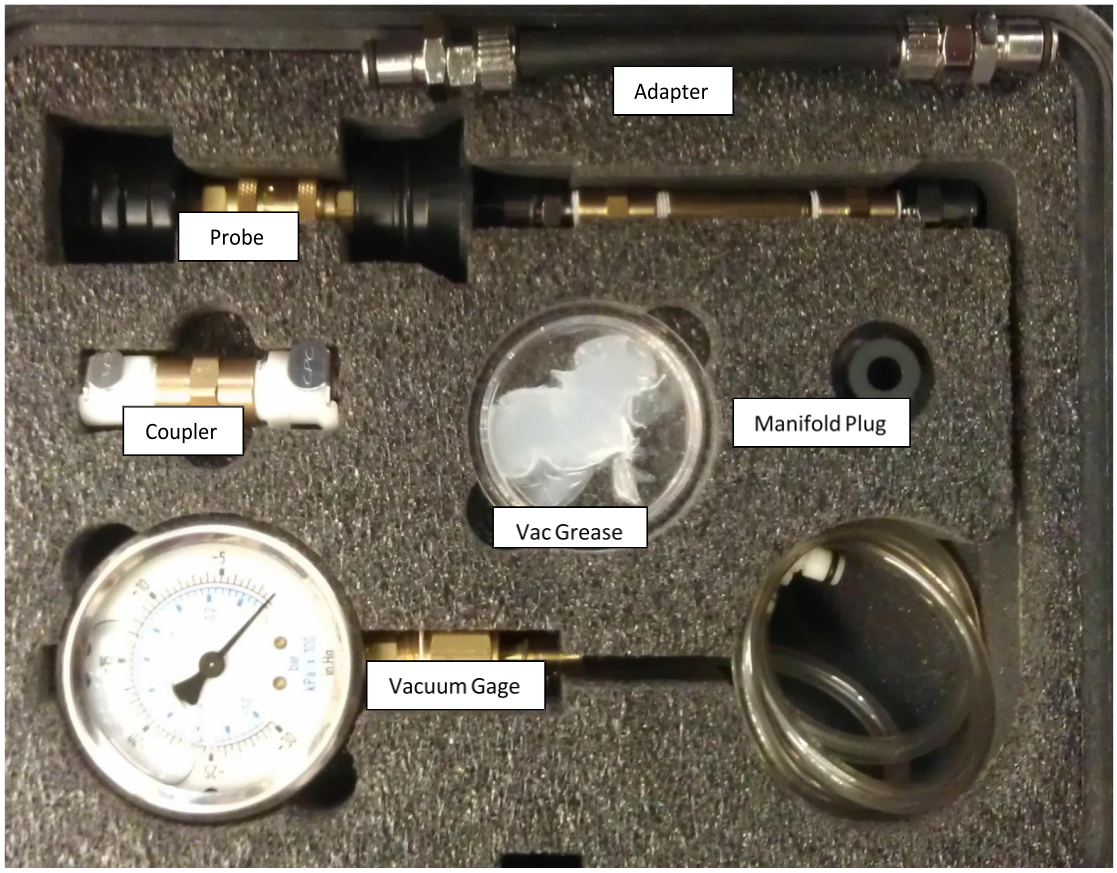
- Spare O-rings
- Cyclone
- Manifold
- Braided hose
- Valve

5. PROCEDURE

5.1 Leak Check at the Pump Hose

1) Take the vacuum gauge out of the vacuum kit. Zero the gauge by briefly lifting the yellow tab at the top to the “Open” position. After a few seconds, return the tab to the “closed” position to ensure that glycerin does not leak from the gauge.
2) Detach the pump hose from underneath the module and attach it to the large opening of the coupler. Attach the white plastic end of the vacuum gauge to the smaller end of the coupler.
3) On the keypad of the controller, press “Enter” once to get to the main menu.
4) On the main menu screen, press “2” (not F2). This will activate all the pumps one by one.
5) The needle on the pressure gauge will rise once the pump it is connected to is activated. Record this value in cell A28 of the audit/calibration sheet or under “Pump Reading” on the Leak Check form, whichever is being used.
6) Press “Enter” to stop the pumps and exit out of the menu.
7) Disconnect the vacuum gauge, coupler, and pump hose. Restore the original configuration of the system.

Figure 1. Vacuum Kit



5.2 Leak Check at the Module

1) Open the module that needs to be leak checked and make sure that it has a complete filter cartridge. Remove the black plastic cap from the bottom of the module. Then, remove the plug from the Tee, which is the rectangular part of the module located right above the black cap.
2) Insert the white, CPC end of the gauge into the end of the probe.
3) Fully insert the probe into the Tee. If the probe does not go into the Tee easily, try applying a very small amount of vacuum grease on the circumference of the top end of the probe. It is important to get the probe fully inserted into the Tee, as the reading on the vacuum gauge will not be accurate otherwise.
4) From "Auto Mode" on the keypad to the controller, press "Enter" to get to the main menu, and then press "F3" for the advanced menu. The display will ask for a code. Press the numbers "1123." Do not press "Enter" after keying in the code.
5) Press "F1" for "Calibration."
6) Use "F3" or "F4" to cycle through to the module being tested. For this particular procedure, it does not matter what position is running.
7) The needle on the vacuum gauge should rise. Record the value in cell B28 of the flow check/calibration sheet or under "Module Reading" on the Leak Check form, whichever document is being used.

8) The difference between the pump and module readings should be less than two inches. If the difference is two or less, the leak check test is complete. If the difference is greater than two, continue to the next section.

5.3 Leak Check at the Manifold

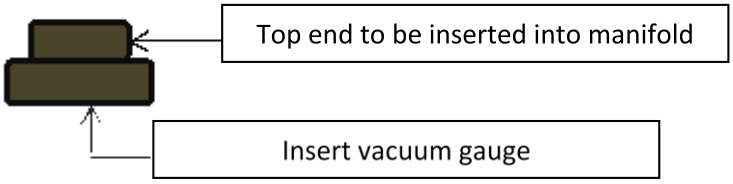
If the difference between the module and the pump is greater than two inches, this means that there may be a leak in one of five different places:

- Manifold
- Braided hose
- Valve
- Cyclone
- Cartridge

To narrow it down, perform the following test at the manifold:

1) Insert the end of the vacuum gauge (the white plastic barbed fitting) into the large circular end of the manifold plug (pictured below):

Figure 2. Manifold Plug



2) Use the instructions listed in section 5.2 to go into “Calibration” mode. Use “F3” and “F4” to advance to the appropriate module being tested. Stay on position #1 for the module.
3) There are four holes on the underside of the manifold that normally encompass the tops of the filter cassettes. Insert the top end (smaller end) of the manifold plug into the bottom of the first hole, where the first filter cassette would normal sit.
4) The needle on the vacuum gauge should rise. Record this reading in the comments section of the flow check/calibration sheet or under “Manifold Reading’ on the Leak Check form, whichever is being used.
5) If the difference between the manifold and pump readings is less than two inches, the problem likely resides in the cyclone or the cartridge. Check to see if the cyclone is seated properly and that the connection between the cyclone and the Tee is straight. Check the cartridge to ensure that it is seated properly and that all of the cassettes have O-rings in the appropriate places. Remedy any issues and note the findings in the comments section on the flow check/calibration sheet or on the Leak Check form.
6) If the difference between the manifold and pump readings is more than two inches, a leak likely exists in the manifold, the braided hose, or the valve. To narrow it down even further, continue to the next section.

5.4 Leak Check at the Valve

To determine whether or not there is a leak in the valve, compare the vacuum from the top of the valve to the pump by performing the following procedure:

1) Find a short piece of pump hose (if included in the maintenance kit) or borrow a full pump hose from an alternate pump at the site.
2) Put the vacuum gauge in one end of the pump hose. Disconnect the braided hose from the valve and then connect the pump hose to the valve.
3) Use the instructions in section 5.2 to go into "Calibration' mode, and then use "F3" and "F4" to get to position #1 of the appropriate module.
4) The needle on the vacuum gauge should rise. Record the value in the comments section of the flow check/calibration sheet or on the Leak Check form.
5) If the difference between the valve and pump readings is greater than 2" Hg, there is a leak from the valve. Replace the valve with a spare or remove and check fittings for integrity.
6) If the difference between the valve and pump readings is less than 2" Hg, the leak is likely coming from either the braided hose or the manifold. Replace them both with spare parts or determine faulty component and service it.

TI 226F Controller Repair

TABLE OF CONTENTS

1. PURPOSE AND APPLICABILITY

The purpose of this SOP is to describe the procedures used to diagnose, repair, and ship version II controllers that are used at every site in the IMPROVE network. Controllers are diagnosed and repaired in the Air Quality Group shop, which is located in Jungerman Hall on the University of California, Davis campus.

2. SUMMARY OF THE METHOD

When an IMPROVE controller fails in the field, it is shipped to the AQG shop. At the shop, it is inventoried and a note is logged regarding the symptoms the controller had in the field. Field technicians or student shop assistants test the controller components in order to recreate and diagnose the problem(s). Once the problem has been determined, the controller is repaired and then tested again to confirm that it is fully functional. It is then ready to be shipped out to the next site in need of a controller.

3. CAUTIONS

Both of the controller power supplies need to be grounded to earth ground before the controller is worked on. If they are not, do not touch any part of the power supplies while the controller is uncovered and powered up in order to avoid an electrical shock.

4. PERSONNEL QUALIFICATIONS

Student shop assistants and field technicians work in the Air Quality Group's shop under the supervision of the field manager and shop manager. Each new student shop assistant and field technician receives one-on-one training on how to completely disassemble controllers. Each new employee also observes an experienced employee diagnose and repair a few controllers before he or she attempts one on their own. An experienced employee oversees the new employee for the first few controllers he or she repairs in order to correct any mistakes and to answer any questions.

5. EQUIPMENT AND SUPPLIES

The equipment and supplies for each controller repair vary significantly depending on what issues the controller has. Thus, the necessary equipment and supplies will be described in each section.

6. PROCEDURES

6.1 Diagnosis of Controller Problems

An IMPROVE controller can be thought of as sprinkler timer with a compact flashcard attached.

A timer module opens and closes solenoids and relays and records the data from the pressure sensors to the flashcard. While this seems like a simple system, a myriad of problems can and do occur with these units. In the best case scenario, the problem can be recreated on the spot and isolated to one component, which is then replaced or reworked so that the controller can go back into service. Unfortunately, however, the process is typically not so straightforward.

6.1.1 Receiving, Inventorying, and Documenting a Controller

Controllers must be checked in when they are received from the field. Locate the UPS shipping label on the box that the controller came in and note the sender's site code (five characters) and JIRA issue tracking number. Use this data to locate the issue reported through JIRA, the online issue tracking database used by AQG.

Open up the box and remove the controller. Note any damage to the controller that may have occurred during shipping. Discard the box by breaking it down and dispose of it in the cardboard recycling bin, which is located outside at the southwest corner of Jungerman Hall If the foam inserts in the box are intact, place them with the other shipping supplies. If they cannot be reused, throw them away.

Each controller has an assigned inventory number in order to keep track of where it has been and what problems it has had in the past. Inventory numbers are five characters long. Each inventory number begins with the letter "C" and is followed by four digits. The first digit signifies the version of the equipment and the next three digits are a sequential count of controllers. Inventory numbers can be found on the inside of the controller door or on the inside of the case on the left side. Locate the inventory number for the controller and open the Microsoft Access controller inventory sheet located in U:\IMPROVE_Field\Shop and Operator Resources\Equipment Inventory. Find the most recent entry for the controller. If it is not already present, add a new line to the inventory and fill in the cells for "CNTRLR_ID," "Site_Received_From," "Date_Received" (use today's date if the actual date received is unknown). For "Site_Received_From," find the site listed in the "Site_Sent_To" field of the previous entry for the controller. The site in that cell should match the site code that was listed on the shipping label. If there is a discrepancy, notify a supervisor. Clear the "Status" cell of the previous entry, and for the "Status" cell of the new entry, change it to "Needs Repair." Keep the controller inventory open, as the "Problem_At_Site" cell still needs to be filled in.

The simplest way to determine why the controller was removed from the field is to check the JIRA issue number in the online issue tracking database, JIRA. Either type the four letter site code or unique JIRA issue number, the four letter site code followed by a number, (SITE-99 for example) that was pulled from the controller box shipping label. A new page should load, which should display all of the recorded problems for the site.

Close to the top (where the most recent entries are located), there should be both an equipment request issuetype entry indicating when a replacement controller was sent to the site, as well as a parent entry the subtask belongs to, detailing the problem that prompted the equipment replacement. Summarize the problems associated with the controller in a few words in the "Problem_At_Site" field of the controller inventory sheet. The Microsoft Access inventory database auto-saves all data entered, and allows simultaneous use by multiple users.

Next, advance the JIRA equipment request through its workflow. This means advancing the issue from "Pending Equipment Return" to "Completed" by clicking "Equipment Checked In". This will prompt the user to enter "Checked In By," "Check In Date," "Return Inventory," and "Comments" if applicable. JIRA workflow is shown in Appendix 7.2.1.

Edit the technician name, controller inventory number, and problem as appropriate. Leave the repair status as “Needs Repair.”

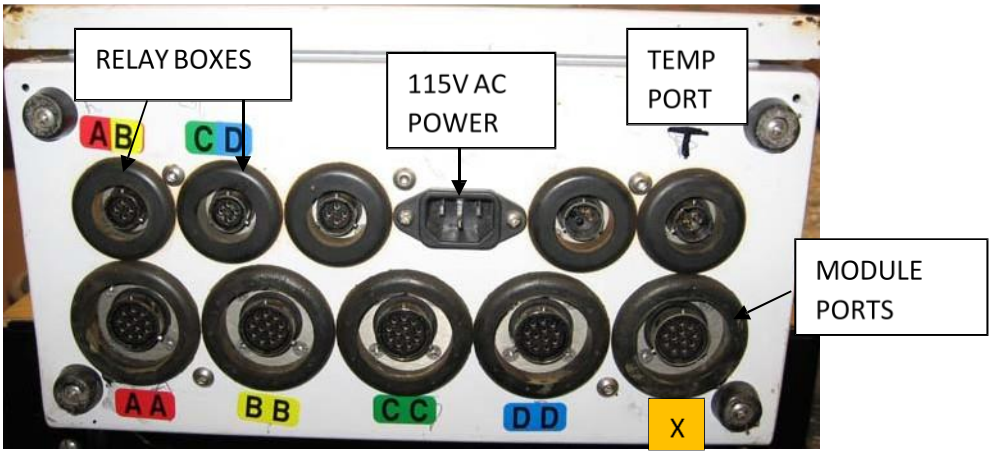
Now that the controller has been checked in, the next step is to test the controller in order to diagnose the exact cause of the problem and to check for any additional problems not detailed in the JIRA issue. Sometimes the diagnosis is time sensitive because if the controller being checked in works fine, typically that means a different component will need to be sent to fix the problem in the field. If this is the case, the controller should be tested upon receiving.

To proceed with diagnosis, continue on to the next section. If the controller is only being checked in, place it in the of the “To Be Repaired” shelves in the AQG shop.

6.1.2 Controller Set-Up

Set up the controller, five modules, three relay boxes, five pumps, and a temperature probe along with all of the corresponding cables. Make sure that all components are properly installed in order to accurately model a working sampling unit. The controller should have five module cables, which should be plugged into the “1A” (Red), “2B” (Yellow), “3C” (Green), “4D” (Blue), and “5X” (Orange) ports, respectively. Relay box cables should be plugged into the “1A/2B” port (Red/Yellow), the “3C/4D” port (Green/Blue), and the “5X” port (Orange) (see Figure 1). A temperature probe should be plugged into the temperature probe port. Do not plug in the controller’s power cord yet. Note that when testing the “5X” port, the controller must first be configured for an “5X” module (see section 6.4.2.1 for details).

Figure 1. Port Layout



Each module should be fully operational and attached to a vacuum pump via a pump hose. The five pumps should be plugged into the AC outlets of the relay boxes. Make sure that each pump is plugged into the correct relay box, as the pump and relay box should both correspond to the same module. The relay box power cords should be plugged into 115 Volt AC outlets.

Remove the faceplate from the controller by unscrewing four or five screws: two at the top corners, two on the flashcard receptacle, and, on occasion, a fifth one on the bottom right where the previous version memory card reader was located. Before removing the cover plate, make sure to disconnect the display. The inside of the controller should now

be exposed.

Warning: Before touching any of the boards, make sure to dissipate any static electricity by touching the steel controller case.

Plug the display back into the controller and, if the memory card reader has a data ribbon, place the flashcard receptacle to one side so that it is out of the way and will not come into electrical contact with anything.

Now, plug the power cord into the bottom of the controller.

6.1.3 Check MOVs

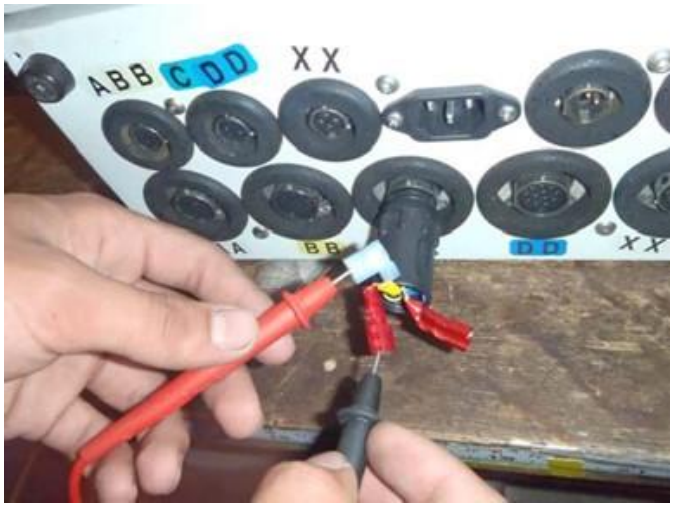
Metal Oxide Varistors (MOVs) help regulate the voltages supplied to the controller. A multi- meter and a variable DC power supply are needed to test the MOVs. The MOVs are wired in parallel with the DC Output of each power supply. As the power output exceeds the threshold for the MOV, it goes into "shunt mode," which means that its resistance should drop exponentially. The voltage thresholds for the 12 and 24 volt MOVs are 24V and 38V, respectively. Please note that the MOV response is not a step function; it is exponential, which means that the resistance will start to drop as the threshold is approached. In order to test an MOV, fully disconnect it from the controller's power supply and connect it to a DC variable power supply that can exceed the threshold for the MOV. As the input voltage increases and approaches the threshold, the resistance across the MOV leads should start to drop. Please note that MOVs get hot as they go into "shunt mode," and they cannot stay in this mode indefinitely. Testing should be done quickly and with caution. If the MOV does not go into "shunt mode," it needs to be replaced.

6.1.4 Check 12- and 24-Volt Sources

Use a multi-meter to test the voltage of both the 12V and 24V sources. Set the multi-meter to test for DC voltage. Force the controller to run as if it were a standard IMPROVE particle sampling day. Do this by changing the date to a standard sampling date and running filter readings in order to unlock the controller. The largest load is placed on each of the power supplies when the sampler is running. Testing the power supplies while not under load may provide a false representation of their performance.

Next, connect the testing widget to any of the module ports on the controller. Probe the two terminals that are marked with a red band for the 12V and then probe the other terminals marked with a yellow band for the 24V. Note that the 12V source should always be located on the left. There should also be a label on the large black cylinder in the volt source. The voltage should read at or above 11.5V for the 12V source and at or above 23.0V for the 24V source. If the voltage is too low for a supply, refer to sections 6.2.2 and 6.2.3 for instructions on repairing volt sources.

Figure 2. Checking 12V and 24V Sources.



6.1.5 Check Solenoids

Install a calibration cartridge into each module. From the controller's main menu, press the "F3" key to enter the "Advanced Menu." Enter "1123" when prompted for the access code.

Then, press "F1" for the calibration menu. The "1A" module position 1 solenoid will turn on. To move to the next solenoid, press "F4".

Turn on each solenoid, one at a time, for each of the four positions. Make sure only the corresponding solenoid turns on by looking for reasonable orifice (ORI) and cyclone (CYC) values. Note that all solenoids are wired in parallel, meaning that all position #1 solenoids will open when signaling any position #1 solenoid, but only one module's pump will turn on. Verify this by the "stereo click" that is audible when all four solenoids open and close. The ORI values should increase while the CYC values should decrease as each subsequent position of the calibration cartridge is cycled through. This also checks the CYC and ORI values for proper levels. See Table 1 for an example of flow readings for both Version I and II electronic boxes at sea level. These are typical values under standard conditions with a PM2.5 module set at 23 liters per minute (lpm) and electronic zeroes set at ORI = 10 and CYC = 5. The values do not need to match exactly, but they should be similar. The ascending ORI and descending CYC trend must occur for the results to be considered acceptable.

Physically check that only the proper solenoid opens for each position by raising the manifold and blocking the airflow with ungloved fingers for each channel underneath the manifold. Suction should be felt only on the open solenoid. Another method is to use a screwdriver to check if the top of an open solenoid becomes magnetic. However, if only the second method is used, it is possible to miss "sticky" solenoids, which are solenoids that do not fully close. Therefore, this second method should only be used in addition to the first and never by itself.

Repeat this procedure for the "2B," "3C," "4D," and "5X" modules.

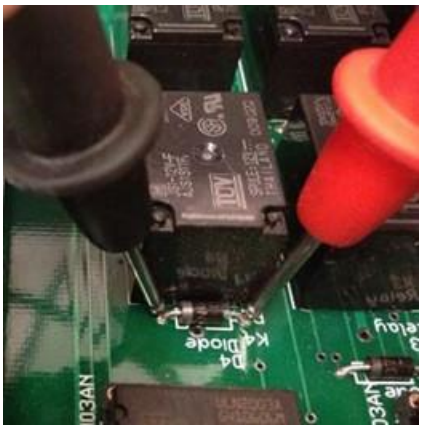
NOTE: The "4D" module does not have a working CYC, so all of the positions on the "4D" module will give a CYC reading of 5.0mV (in some cases, it may be 10.0).

Check the solenoid relay diodes (D1-D8) on the motherboard with the multi-meter. They are located above the mechanical relays on the left side of the motherboard (see Figure 14). Set the multi-meter to test for diodes. Touch the ends of the diode with the leads of the multi-meter (see Figure 3). The values should read 0.245±0.01. If the multi-meter does not pick up a reading, reverse the leads of the multi-meter and re-test. If the diode still does not generate a reading, refer to section 6.2.5 for repairs. Table 1 shows an example of transducer readings that might be recorded if a calibration filter cartridge is installed.

Table 1. Sample Flow Readings.

	Version I EBOX		Version II EBOX	
	ORI	CYC	ORI	CYC
Position 1	12.9	32.7	12.9	17.4
Position 2	15.4	26.1	15.4	14.3
Position 3	23.3	19.2	23.3	10.5
Position 4	27.3	16.2	27.3	8.5
Solenoid closed	40.9	5.0	40.9	5.0

Figure 3. Solenoid Diodes.



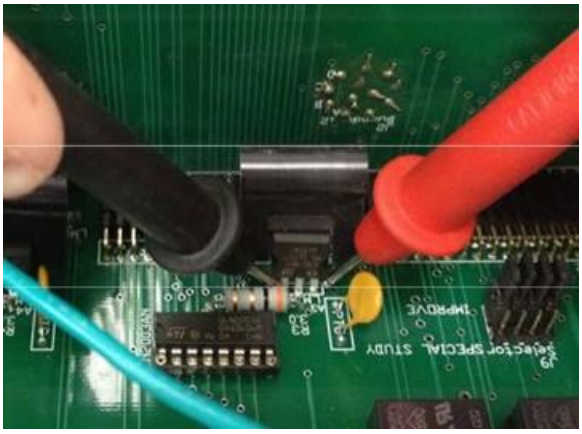
6.1.6 Check Manifold Motors

Test the “1A” module for working motor drives by pressing the red buttons on the electronic box to raise and lower the motor that controls the manifold. Repeat for every module. If repairs are needed, see section 6.2.6.

6.1.7 Check Voltage Regulators

A faulty voltage regulator will overdrive the manifold motor and crush the cartridge, or it will not drive the motor at all. To locate the voltage regulators, see Figure 14. The regulators correspond to the "1A," "2B," "3C," "4D," and "5X" module ports, from left to right. Test the resistance of the voltage regulators with a voltmeter by touching the two outside prongs of the voltage regulators with the leads (see Figure 4). The multi-meter should read ~3.14Ω, but any resistance is acceptable. Make sure that the pins at the base are intact and that the heat sinks are attached when finished. If a voltage regulator is faulty, see section 6.2.7 for instructions on how to replace it with a new voltage regulator.

Figure 4. Checking Voltage Regulator.



6.1.8 Check Flashcard

Insert a compact flashcard into the flashcard receptacle. Go to the controller's main menu and press "9." The display should read, "Testing memory card," followed by, "Memory card OK."

If there is a possibility that the flashcard reader is faulty, run the controller with the averaging time set to one-minute intervals. Collect a week's worth of data. Finally, check the flashcard data to confirm continuous recording. If the flashcard reader is faulty, please refer to section 6.2.8.

6.1.9 Check CPU Battery

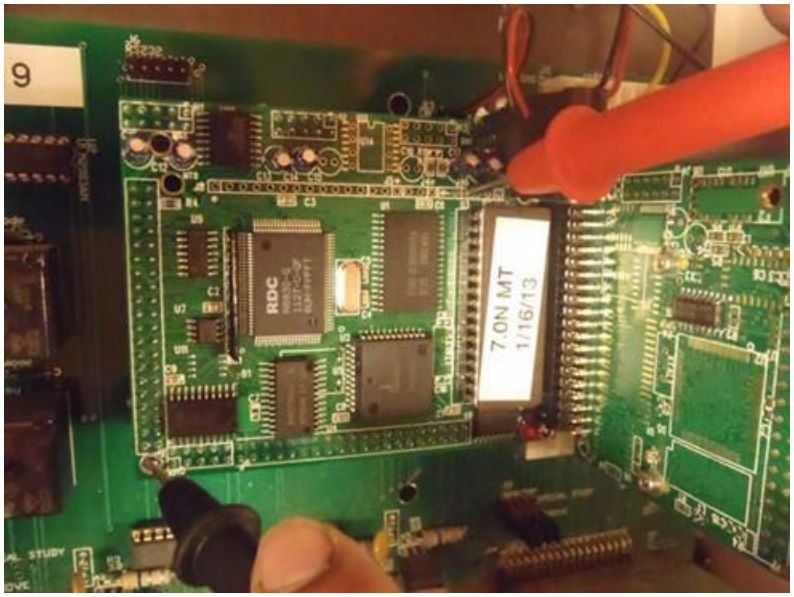
Use the multi-meter to check the battery voltage when the controller is unplugged. Set the multi-meter to read DC voltage. Place the red lead on the top of the battery and the black lead on one of the corner CPU main grounds (see Figure 5). The battery voltage should be ≥3.00V. Make sure the version II battery clip is installed. If repairs are needed, see section 6.2.9.

Figure 5. CPU Battery (with Version II Clip).

6.1.10 CPU Voltage Regulator Check

The CPU voltage regulator is located in the upper right corner of the CPU and provides a 5.0V supply. Use a multi-meter to check the CPU voltage regulator when the controller is plugged in. Set the multi-meter to read DC voltage. Place the black lead on the ground trace, which is located on the bottom left corner of the CPU, and place the red lead on the U3 terminal near the voltage regulator (see Figure 6). The voltage regulator's output voltage should be between 4.98 and 5.02V. If the voltage is outside of that range, the CPU voltage regulator must be replaced. Refer to section 6.2.7 for more information.

Figure 6. Checking CPU Voltage Regulator



6.1.11 Check Temperature

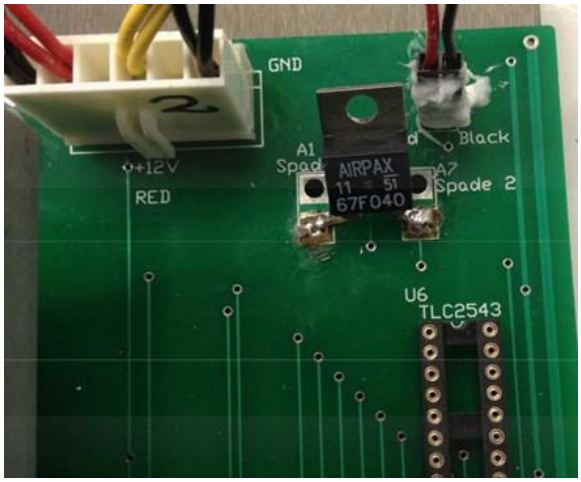
First, plug a working temperature probe into the bottom of the controller (see Figure 1). Go to the controller's main menu and press "1." Next, check for a reasonably stable ambient temperature reading. The temperature reading will fluctuate, but it should not vary by more than ±1 ˚C. Compare the readings to that of a NIST certified thermometer. The readings should be within 2 ˚C. Heat up the tip of the temperature probe by placing a fingertip on it to see if the temperature reading changes accordingly. The temperature value should increase a small amount (depending on the ambient temperature). Then, release the probe and verify that the temperature reading slowly begins to fall.

If the temperature readings are out of normal range, test the CPU voltage regulator (see section 6.1.10). For more information, refer to section 6.2.10.

6.1.12 Check Cooling Fan

The cooling fan temperature sensors are located on the upper right side of the motherboard (see Figure 7). Heat up the thermostat with a heat gun. The fan should turn on. Check to make sure that the black and red wires from the fan are attached at the J12 connector if the fan fails to turn on (see Figure 7). If additional troubleshooting is necessary, please refer to section 6.2.11.

Figure 7. Testing Fan Circuitry.



6.1.13 Check Display

Check to see if the controller display turns on. Navigate through the sample change and site configuration menus to check for responsiveness from the display buttons. Check to see if the modular jack is securely attached to the connecting board. Check the four magnets on the back of the display and verify the integrity of the spiral cord. For more information, refer to section 6.2.12.

6.2 Controller Repair

6.2.1 Replacing MOV Units

Release the faulty MOV unit by unscrewing the two set screws that are holding it in place. Replace it with a new MOV and secure it by re-tightening the screws (see Figure 8).

Figure 8. Replacing MOV

6.2.2 Repairing/Replacing the 12V Source

Unplug the controller. Then, check to see if the fuse located at the top center of the power supply has blown. If it has, replace it. Next, examine the wiring harness to ensure that a connector has not slipped loose. If the problem has still not been resolved, the power supply is dead and needs to be replaced. First, remove the two wiring connectors from the

power supply. The easiest way to remove these is to grab the Molex connector with needle nose pliers and pull straight back. If the old version standoffs are still present, pinch the plastic tabs in on all four corners and then pull straight back to release the 12-volt source. If the new version standoffs are present, unscrew them and make sure not to lose the spacers. Replace with a new 12-volt source and re-attach all of the wiring. If the old version white plastic standoffs are present, they must be upgraded. Refer to section 6.2.13 for further instructions on upgrading standoffs.

6.2.3 Repairing/Replacing the 24V Source

Unplug the controller. Check to see if the fuse located at the top center of the power supply has blown. If it has, replace it. Next, examine the wiring harness to ensure that a connector has not slipped loose. If the problem has still not been resolved, the power supply is dead and needs to be replaced. Remove the two wiring connectors from the power supply. The easiest way to remove these is to grab the Molex connector with needle nose pliers and pull straight back. If the old version standoffs are still present, pinch the plastic tabs in on all four corners and pull straight back to release the 24-volt source. If the new version standoffs are present, unscrew them and make sure not to lose the spacers. Replace with a new 24-volt source and re- attach all of the wiring. If the old version white plastic standoffs are present, they must be upgraded. See section 6.2.13 for further instructions on upgrading standoffs.

6.2.4 Board Removal

The following techniques detail the proper way to remove and reinstall the electrical boards of the controller. Extreme care must be taken with these components.

6.2.4.1 CPU Removal

First, disconnect the power harness (one red and one black wire) from the CPU. Next, cut the hold-down zip tie (if present). Now, firmly grip the CPU (see Figure 14) and slowly pull straight up. It may require a fair amount of force to remove the CPU. Make sure all of the spacers stay on the motherboard. To install a CPU, follow these same instructions in reverse. During installation, make sure not to misalign the spacers.

6.2.4.2 Compact Flashcard Reader Removal

First, remove the CPU. If working with a “ribboned” compact flashcard reader, unplug the white compact flashcard harness header and pull it out of the motherboard. Remove the two Phillips screws that secure the metal bracket holding the ferrite core to the backing plate of the controller. Next, remove the compact flash harness, ferrite core, and support bracket. If working with a “ribbonless” flashcard reader, remove the two lock nuts securing the flashcard reader to the aluminum “L” bracket, which is bolted onto the CPU. Next, remove the two socket head screws securing the aluminum “L” bracket to the CPU. Finally, remove the aluminum “L” bracket and unplug the flashcard reader from the CPU.

6.2.4.3 Motherboard Removal

First, remove the CPU and compact flashcard reader (see section 6.2.4.2). To disconnect the white plastic Molex (power connector) at the top right of the board, pull up a half of an inch or so, and then rotate it towards the 24-volt supply to unhook the wiring harness.

Next, remove the cooling fan harness. If the old version clip style standoffs are still present, disconnect each of them by pushing the small white tab towards the center of the standoff and lifting up. Only lift high enough that the board is clear of the standoff. If the new version standoffs (screws) are present, unscrew and remove them. Next, remove the motherboard by slowly pulling up (towards the power supplies) on the board while holding it clear of the standoffs. It may require significant force to remove the motherboard, so be careful not to damage the board when it finally dislodges. To install, follow these instructions in reverse.

6.2.4.4 Bottom Board Removal

First, remove the CPU, compact flashcard reader, and motherboard. Unscrew the five button head hex screws on the bottom of the controller enclosure to release the bottom plate. The bottom board can now be rotated up (towards the power supplies) and removed. There are five spacers that correspond to the five screws that were just removed. Collect the spacers and set them aside. Next, unscrew the connecting board from the bottom plate (four screws per port, 40 screws overall). Replace any rubber grommets in the case that have deteriorated. Reattach a working connecting board to the bottom plate. Do not over-tighten the screws, as the plastic will strip very easily. When reattaching the bottom plate, make sure that there are spacers on each hex screw. The bottom board is extremely sensitive and hard to line up; work with extra care in reassembling this part of the controller. The best method to reassemble the bottom board is to hang the controller on the wall and then position the spacers over the holes. Line up the bottom board and insert the screws from below, starting at the rear.

6.2.5 Repairing Solenoids

Replace the solenoid drivers (U1 or U2) located on the motherboard with solenoid driver IC's ULN2003. If the problem persists, unsolder the relay diodes (D1-D8) and re-solder a replacement. If the solenoid continues to be faulty, unsolder the relay (K1-K8). Replace it with a NAIS SPST relay. For unresponsive ORI and CYC values, replace the CPU.

6.2.6 Repairing Manifold Motors

Double-check the 24V source and the appropriate voltage regulator. Replace either if necessary. If the problem persists, replace the motherboard, connecting board, and/or CPU.

6.2.7 Replacing Voltage Regulators (Including the CPU Voltage Regulator)

Remove the motherboard from the controller. Unsolder the faulty voltage regulator from the motherboard. Re-solder a new voltage regulator onto the board. Note that if the CPU voltage regulator is replaced, the new one must be labeled with the appropriate output voltage. The controller inventory must be updated to reflect the new value.

6.2.8 Replacing the Flashcard Reader

The flashcard reader cannot be repaired. If a unit is faulty, it must be replaced. Please see section 6.2.4.2 for proper removal and installation of the flashcard reader. Note that the "ribboned" readers are being phased out and are no longer being installed. Only install "ribbonless" flashcard readers. If the flashcard writing problems persist, replace the CPU.

6.2.9 Repairing/Replacing the CPU Battery

If the battery is attached with a version I clip (no black plastic), it needs to be removed and replaced with a version II clip (black plastic). To replace the battery clip, remove the CPU from the controller and the standoffs from the CPU. Unsolder the two sides of the clip from the bottom of the CPU. Get a new battery clip, remove the three small plastic nubs on the bottom side, and bend the two metal tabs out slightly (splay them out to about 10 degrees each). Now the clip should be able to mount onto the CPU. Solder it in from the bottom side of the CPU, making sure to get good contact.

If the battery voltage is below 3.00V, replace the battery with a new one. If the date on the CPU keeps resetting, it is an indication that either the CPU battery is dead or that the solder joints are bad.

6.2.10 Repairing Temperature

If the temperature reading is out of range, first replace the CPU to see if the CPU is faulty. If the problem persists, desolder and replace the temperature circuitry on the motherboard. If the issue is not resolved, test the temperature probe or the continuity on the bottom board.

6.2.11 Repairing Cooling Fan

Dysfunctional cooling fans could be due to the fan itself, the onboard thermostat, or the Darlington array (U2). The thermostat comes in two varieties: one is a round plug-in cylinder, and the other is a solder-in IC (see Figure 9). Before testing the thermostat, check for a loose or backward connection in the wiring from the motherboard to the fan.

If the fan is not turning on, first wire another fan to the J12 jack. This will determine whether it is the fan or the circuitry that is bad. If the fan is faulty, unscrew the fan from the inside wall of the controller. Detach wiring from the motherboard. Installation procedures are the reverse of removal.

If the second fan does not turn on as well, test the thermostat and make sure that its leads close when heat is applied (see Figure 10). If the thermostat is functioning properly, replace the U2 IC (Darlington array).

If the fan is continually running, check the thermostat and make sure that its contacts are open when the unit is cooled (see Figure 11).

Figure 9. Cylinder Style Thermostat (Above), IC Style Thermostat (Below).

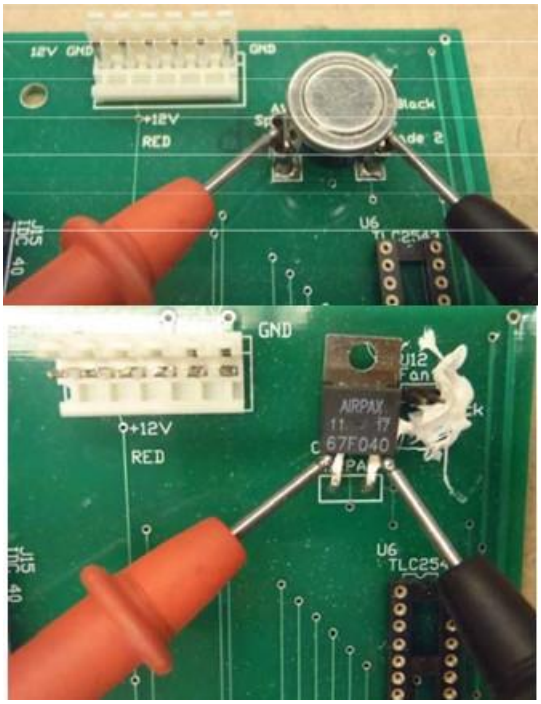


Figure 10. Thermostat Being Heated with Heat Gun.

Figure 11. Thermostat Being Cooled with a Vortex Tube

6.2.12 Repairing Display

First, confirm whether it is the display or the controller that is faulty by testing the controller with another display unit. If the controller is bad, first inspect the modular (mod) tab. If it is damaged or loose, it will need to be replaced. To replace the mod tab, first remove the bottom board from the controller. Next, remove the 40 screws that attach the bottom plate to the individual ports (four per port). Desolder and replace the mod tab, and then reassemble by following the above steps in reverse.

If the mod tab is intact, check leads on the controller boards for corrosion and continuity. If the problem persists, replace the connecting board.

6.2.13 Standoffs

Originally, plastic standoffs held the power supplies and the motherboard to the metal backing plate of the controller. However, they were prone to failure and are now being replaced with stainless steel captive nuts and screws.

6.2.13.1 Updating Standoffs

If the old standoffs are still present in the controller, replace them with stainless steel 6-32 captive nuts and matching screws. To do this, remove all of the boards and the power supplies from the case. There are two nuts at the bottom of the case and two metal standoffs at the top of the case (see Figure 12). There are screws that attach to these on the backside of the case. Remove these four Allen head button screws and lift up the backing plate. With the plate out of the module, remove the 10 old-style standoffs – four for each power supply and two for the motherboard.

Next, the backing plate must be re-drilled for the #6 captive nuts. This can be accomplished using the 3mm drill on the drill press. Make sure to only re-drill the 10 holes for the standoffs and not any other holes on the backing plate. Now the captive nuts can be pressed into the holes. To do this, position the nut over the hole and use an arbor press to secure them. The backing plate can now be reinstalled into the controller. ¼" plastic standoffs and ½" stainless steel screws are used to secure the power supplies (holes #1-8). 3/8" plastic standoffs and ¾" stainless steel screws are used to secure the motherboard (holes #9 and 10). From this point, the reassembly procedure is the reverse of removal.

Figure 12. Controller Backing Plate

6.2.14 "Controller Information" Sheet

After repairing the controller, note what repairs were made on a "Controller Information" sheet. Keep the sheet with the controller so that it can be used to update the Controller Inventory file.

6.2.15 Troubleshooting Problems

The table below displays the most common issues with controllers and how to troubleshoot them.

Table 2. Troubleshooting Issues

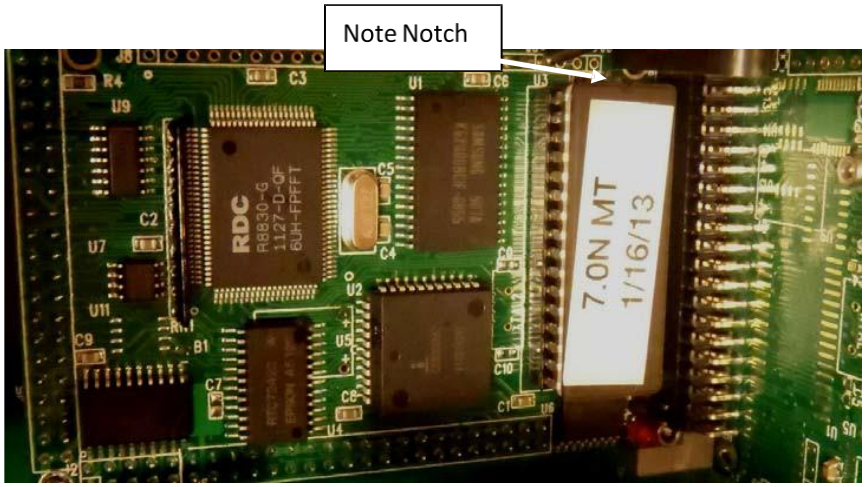
Frequently Occurring Symptoms	Solution
Flashing CPU LED	Test 12V source
No power at all	Test 12V and/or 24V source
Display is blank	Replace CPU, Test key pad or 12V source
Controller does not recognize the flashcard	Replace compact flashcard reader, and or CPU
Bad CYC readings	Replace CPU
Bad Max ORI readings	Replace CPU
Solenoids do not open	Test 24V source and or U1
Motor drives do not work	Test 24V, U3, motherboard, and or connecting board
Pumps do not turn on	Test motherboard, U3, or connecting board
Bad temperature readings	Replace CPU, and or test motherboard
Display freezes during FIN/INT	Run through site configuration
Continuous negative ETs	Bad SRAM, replace CPU

6.3 Preparing Controllers

6.3.1 Installing an EPROM

Check to make sure that the most updated program version EPROM (Electronic Programmable Read Only Memory) is installed. Do this by looking on the label of the EPROM or by pressing the "7" key when the display is at the main menu. If the EPROM is not the latest version, it needs to be replaced. Carefully remove the EPROM from the CPU using an EPROM pulling tool. Try not to damage the prongs on the EPROM as EPROMs are reused. Replace the EPROM with the most current version. Make sure that the EPROM prongs are not bent during installation. Also, the notch on the EPROM should be pointing upwards (see Figure 13).

Figure 13. Properly Installed EPROM



6.3.2 Final Testing

Set up the controller, five modules, three relay boxes, five pumps, and a temperature probe along with all of the corresponding cables as outlined in section 6.1.2. Run through the Filter Readings sequence one time to ensure that everything is working properly.

6.3.3 Reassembling the Controller

Disconnect the display from the modular jack. Move the MOV unit to the left side of the case to ensure that it remains on the outside of the faceplate once the faceplate is installed. Position the faceplate so that the flashcard reader aligns properly with its slot. Set the bottom of the faceplate into the three plastic spacers along the bottom connector board. The faceplate is set inside these spacers so that it aligns properly. Two screws at the top fasten a protective plate that covers the top portion of the controller and secures the faceplate. If this top cover plate is not aligned correctly with the faceplate, the screws will not go in properly. Attach the MOV unit onto the top cover plate with the top left screw. The back of the MOV unit has screws that should sit inside pre-drilled holes in the cover plate. Next, attach the flashcard reader with the last two screws. Finally, reattach the display.

6.4 Controller Configuration

The following steps describe the specific information required to configure a controller for the site it is being shipped to.

6.4.1 Site Information Collection

Access the site information file through a shortcut on the desktop or located in the Site Info section of the Microsoft Access equipment inventory and the Contact info section of the contact info Microsoft Access database.

Record the following information for later use:

- Site INV #
- Initials of Primary, Secondary, and Backup Operators. Note the Contact's initials as well if there is no backup operator.

- Time Zone (Do NOT use Daylight Savings Time). Use the “State” column and http://www.timetemperature.com to determine the time zone.
- Week Cycle (3-2’-2 or 2-3-2’)
- 5X site? If so, check what type: “1A,” “2B,” “3C” (all PM2.5), “4D” (PM10)

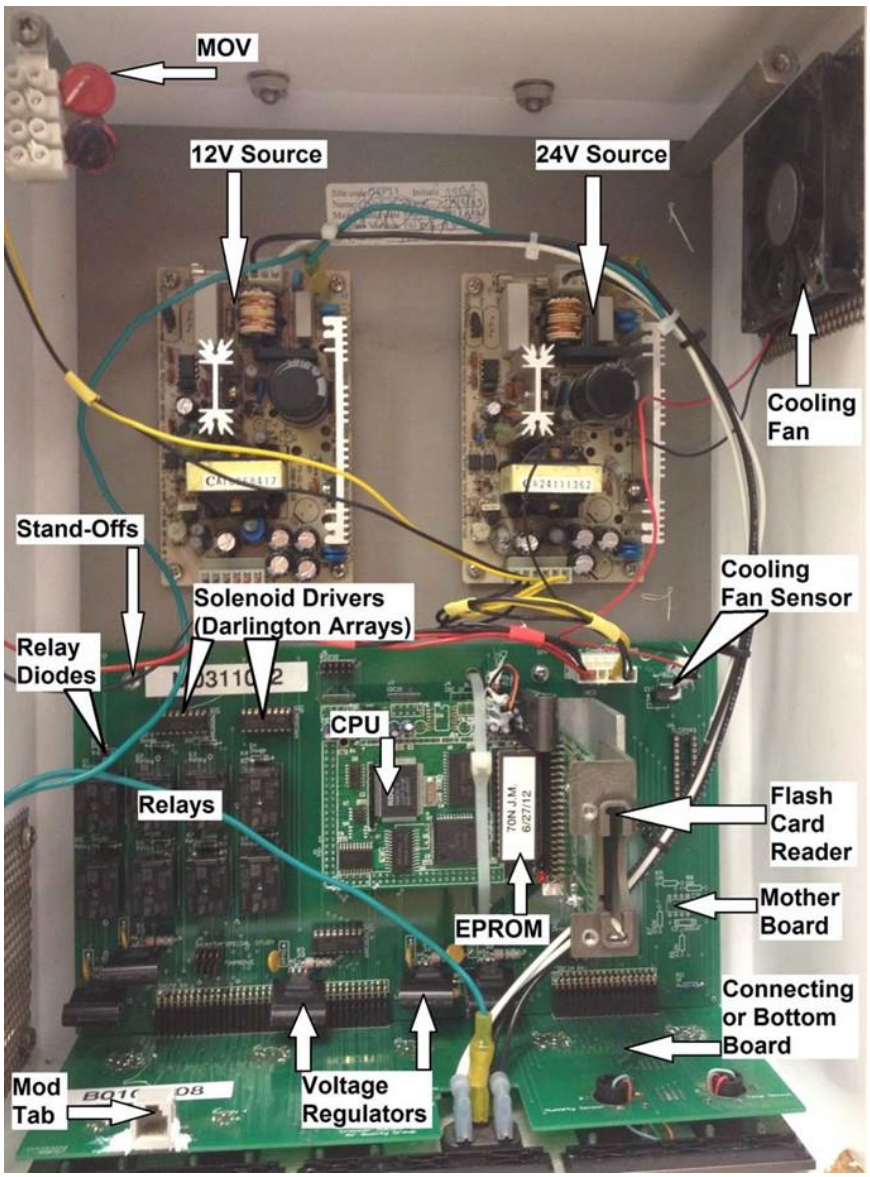
6.4.2 Controller Configuration and Testing

6.4.2.1 Site Information

Reboot the controller with a flashcard installed. Verify that the card is good by pressing “9” at the main menu. The controller should re-check the flashcard upon reset.

From the main menu, go to the advanced menu by pressing “F3” and entering the code: “1123.”

Figure 14. Inside of the Controller.



Select “Operator Initials” by pressing “F3.” Input each set of initials in the following order: primary (1), secondary (2), and backup/contact initials (3). When finished, press “Enter” to save the settings and return to the advanced menu.

Pressing “Enter” twice takes the user back to the main menu. If this is done accidentally, go back to the advanced menu by pressing “F3” and entering the code again (“1123”).

Select “Site Config” (“F2”) and input the “site inventory” number (referred to as Old UCCODE on the “Site Config” screen). Adjust port 5 if the site has an “5X” module, and select the particle size (2.5 for 1A, 2B, 3C; 10 for 4D). The “CFLSH AVG” (min) should be set to 15 minutes. The change day should be left on “TUES” unless otherwise instructed. Next, select the appropriate “BLUE BOX” sequence. Finally, enter the “CNTRLR ID#,” which is the identification number found on the interior of the controller’s white steel case. Once the last parameter is set, the controller display will briefly flash an abridged summary of the parameters and will then return to the advanced menu.

6.4.2.2 Temperature Calibration and Testing

Starting from the main menu, press “1” to access the temperature screen. Use the shop thermometer to verify the correct temperature value. It should read within +/- 2 degrees C. The controller should display a voltage of around 1200mV. If this is not the case, reboot the controller. If the problem persists, label the controller with a description of the problem and put it back in the “To be repaired” area. Ship an alternate controller.

Return to the temperature screen and test that the probe is working properly by squeezing it gently between two fingers. The temperature should increase rapidly. After releasing the probe, the temperature should slowly decrease. Once satisfied that the probe is working properly, press “Enter” to go back to the main menu.

6.4.2.3 Date and Time

From the main menu, press “F2” to access the date and time configuration screen.

The first screen that will be displayed shows the GMT offset. Select the proper offset for that specific site, taking into account its time zone. Once the GMT offset is correct, press “Enter” to advance to the date and time. If the date shows largely inaccurate numbers (ex. 547/43/1513), scroll down to correct the format, which should be displayed as MM/DD/YY.

Next, correct the time, which should be in an AM/PM format. Note that IMPROVE sites run on Standard Time only. After the date and time are correct, exit out of the menu by pressing “Enter” and then return to the date/time menu to confirm that both values reset properly.

6.4.2.4 Port Testing

Plug in all relay boxes and module cables into their respective ports. Access the advanced menu by pressing “F3” and entering the code: “1123.”

Go into the “Calibration” menu by pressing “F1.” Check that the controller is communicating with the Electronic Box (EBOX) by pressing the red buttons on the

EBOX.

Cycle through each filter by pressing “F4.” While proceeding through positions, make sure the solenoids click open with each position. If the EBOX is producing 40/40 values, try retesting the controller with a different memory card. Make sure that standard values are produced for all filter positions and for all ports.

6.4.2.5 Finals/Initials

Before the controller can be shipped, run through final and initial readings one final time to make sure that no problems occur with the new controller configuration and to verify that the controller is unlocked and ready for sampling. From the main menu, access “Filter Readings” by pressing “F1.” Select “Yes” to begin final readings. The pumps should turn on. Because the ports have already been tested to confirm that they are working properly, the actual readings do not need to be examined. At the next screen, select “Yes” and cycle through all of the initial readings.

6.5 Controller Shipping

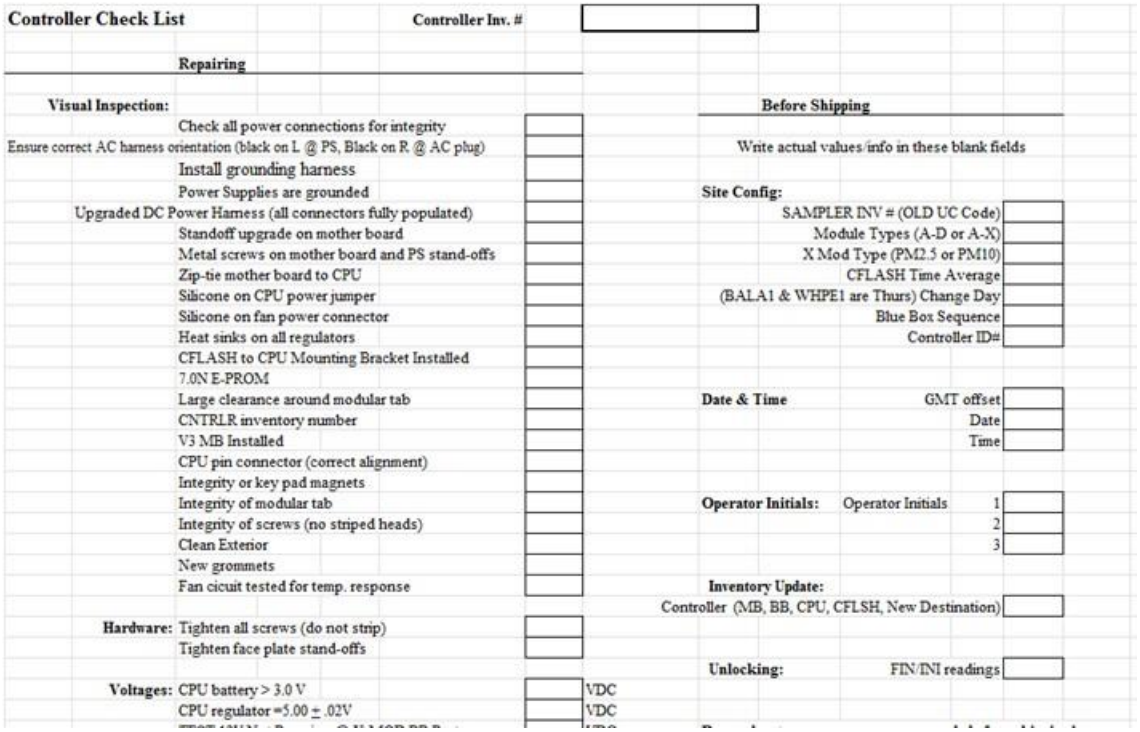
6.5.1 Controller Preparation

1) Obtain a repaired controller with a completed “Controller Information” sheet. Fill out the shipping portion on the sheet (see Figure 15).
2) Fill out the “Controller Checklist” form for final inspection before shipping

Figure 15. “Shipping” Portion of “Controller Information” Sheet

	Shipping	Final Configuration	
Date Ready For Shipping:		MB:	
	Shipped By:	BB:	
Completed By:		CFLASH:	
	Destination Site:	CPU:	
Run Through Checklist:		EPROM:	
	Shipping Date	Batt Volt:	Ground H?
		Volt Reg:	

Figure 16. Controller Checklist.



Controller Check List — **Controller Inv. #**

Repairing

Visual Inspection:
- Check all power connections for integrity
- Ensure correct AC harness orientation (black on L @ PS, Black on R @ AC plug)
- Install grounding harness
- Power Supplies are grounded
- Upgraded DC Power Harness (all connectors fully populated)
- Standoff upgrade on mother board
- Metal screws on mother board and PS stand-offs
- Zip-tie mother board to CPU
- Silicone on CPU power jumper
- Silicone on fan power connector
- Heat sinks on all regulators
- CFLASH to CPU Mounting Bracket Installed
- 7.0N E-PROM
- Large clearance around modular tab
- CNTRLR inventory number
- V3 MB Installed
- CPU pin connector (correct alignment)
- Integrity or key pad magnets
- Integrity of modular tab
- Integrity of screws (no striped heads)
- Clean Exterior
- New grommets
- Fan cicuit tested for temp. response

Hardware:
- Tighten all screws (do not strip)
- Tighten face plate stand-offs

Voltages:
- CPU battery > 3.0 V — VDC
- CPU regulator =5.00 ± .02V — VDC

Before Shipping

Write actual values/info in these blank fields

Site Config:
- SAMPLER INV # (OLD UC Code)
- Module Types (A-D or A-X)
- X Mod Type (PM2.5 or PM10)
- CFLASH Time Average
- (BALA1 & WHPE1 are Thurs) Change Day
- Blue Box Sequence
- Controller ID#

Date & Time
- GMT offset
- Date
- Time

Operator Initials: Operator Initials 1, 2, 3

Inventory Update:
- Controller (MB, BB, CPU, CFLSH, New Destination)

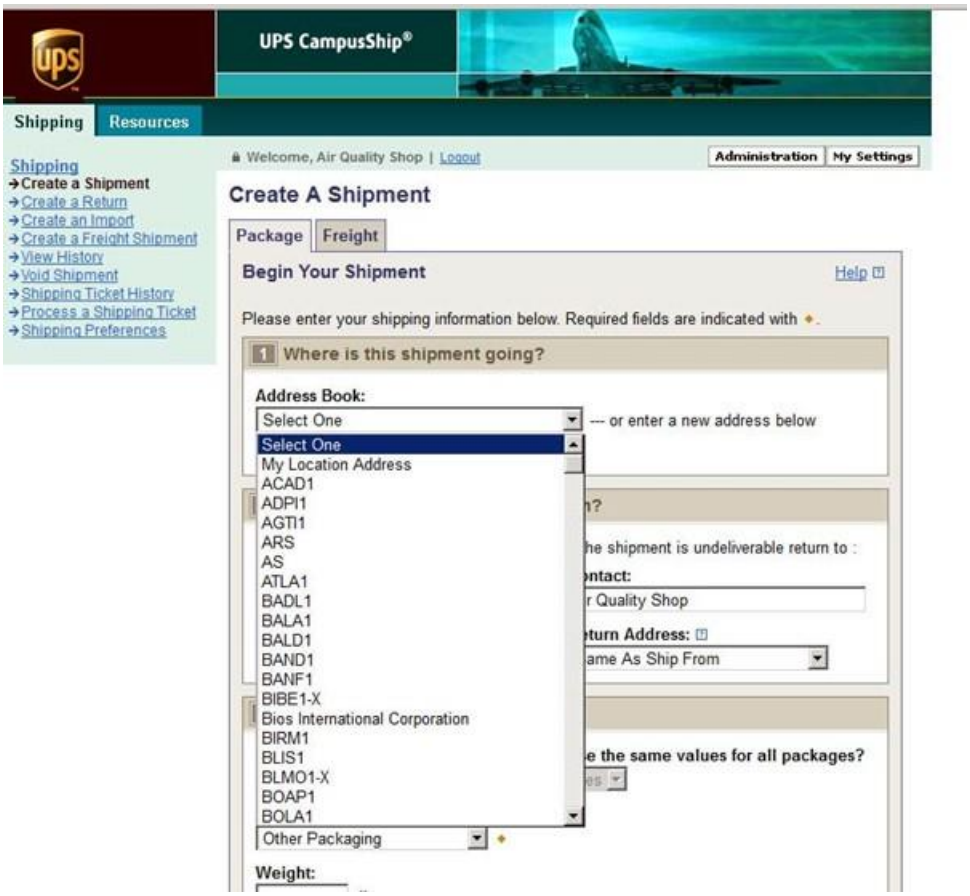
Unlocking: FIN/INI readings

6.5.2 Creating the Shipping Label

6.5.2.1 Create Shipment

1) Go to the UPS website and log in using the AQG shop account.
2) Click on the “Create a Shipment” option on the left-hand side and select the shipping site under the address book drop-down menu.

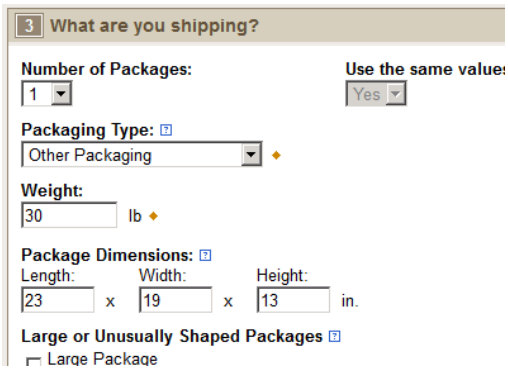
Figure 17. "Create a Shipment" on the UPS Website.



6.5.2.2 Packaging Type

Select "Other Packaging" under the "Packaging Type" drop-down menu and enter the appropriate weight and dimensions of the controller box (see Figure 18).

Figure 18. Shipment details.



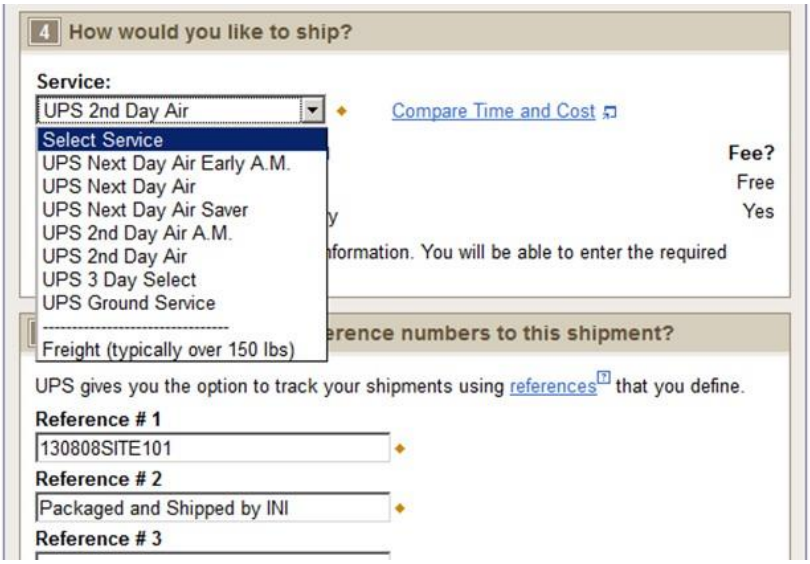
6.5.2.3 Shipping Service

Select the appropriate shipping service and fill out "Reference" lines 1 and 2 in the following format:

Reference #1: JIRA issue number

Reference #2: Packaged and Shipped by XX (<= user initials)

Figure 19. "Select Service" and "References" on the UPS Website



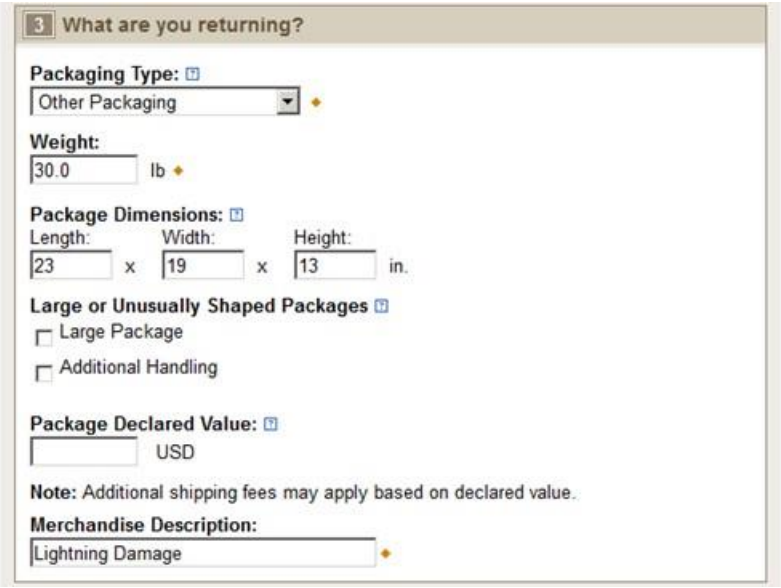
Once complete, review the shipment on the next page and select "Ship Now."

6.5.3 Creating the Return Label Select "Create a Return Shipment"

Figure 20. "Create a Return Shipment" on the UPS Website

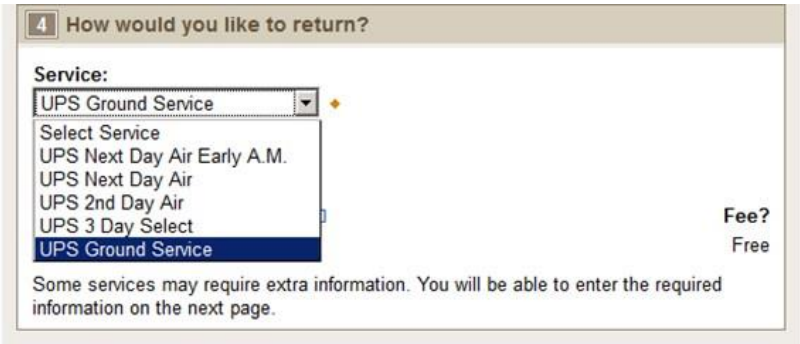
Under "Merchandise Description," enter a short description of the problem that the controller at the site has.

Figure 21. Return Shipment Details



Select “Ground Service” for the return shipment and print the return shipping label.

Figure 22. Return Shipment Service.



6.5.4 Packaging the Controller

Place the controller in a shipping box (same size as for shipping modules) with special module protection foam inserts. Also place the return label with the field letter instructions on how to replace and install a new controller in the box. Tape up controller box and leave the box in the shipping bay for UPS pickup.

Note: UPS pickup times are daily at around 4 pm.

6.5.5 Update the Inventory File and the Problems File

6.5.5.1 Controller Inventory File

Go to the equipment inventory file located in “U:\IMPROVE_Field\Shop and Operator Resources\Equipment Inventory” and open the “IMPROVE Inv” Microsoft Access Database. Update the controller information for the controller being shipped using the “Controller Information” sheet, making sure to account for any equipment changes during repairs. Also fill in the “Site_Sent_To” and “Date_Sent” columns.

6.5.5.2 JIRA Update

Edit the Equipment Request issue on the JIRA site issue tracking website. The issue should be advanced through the workflow from either, “Open” or, “In Progress” to, “Pending Equipment Install” by selecting the, “Equipment Shipped” button. The information necessary to fill out the form that comes up is date shipped, shipper’s initials, inventory number, relevant UPS tracking numbers, and any applicable comments.

7. APPENDIX

7.1 Temperature Probe Construction/Repair

7.1.1 Equipment/Supplies

The following pieces of equipment are necessary for building and/or repairing temperature probes:

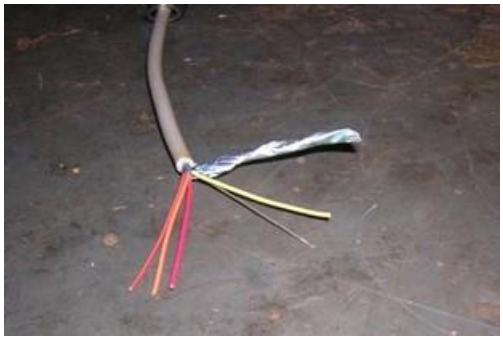
- Solder
- Soldering iron
- Small Allen wrench
- Wire cutters/strippers
- Crimpers
- Pin removal tool

7.1.2 Stripping Wires

First, check to see if the new wire is damaged. Next, choose any side to start with and strip the gray casing off about an inch from the end. Be careful not to cut through the encased wires.

If foil is still on the wires, remove it before continuing. There will be five wires remaining: one orange, one brown, one red, one yellow, and one bare. Cut off the yellow wire and the bare wire. Next, strip the orange, brown, and red wires about halfway. Twist the ends of the wires so that each of them is intact. Before continuing, ensure that the Tee plug and bottom plastic cap are on the wire because it will be difficult to fit them on later.

Figure 23. Exposed Wiring.

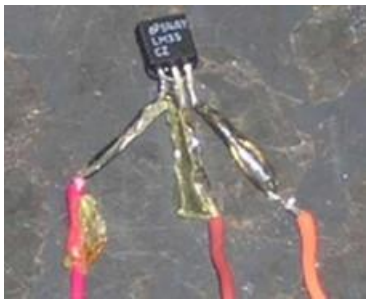


7.1.3 Soldering the Thermistor

The next step will be to solder the temperature chip to the three wires that have been exposed (red, brown, and orange). The order in which they are soldered is very important

as mixing wires can fry electrical components in the controller. With the flat part of the temperature chip facing 6 o'clock, solder the red wire to the left prong, the brown wire to the middle prong, and the orange wire to the right prong. All exposed wires must now be coated with liquid electrical tape, which can be found in the cabinet. None of the wires can touch each other. After one or two coats (depending on coverage), press all the wires together and put on a final coat of electrical tape to keep the wires compact. There shouldn't be so much tape that the end is bulbous, but there should be enough to separate and protect all of the wires. All of the exposed wires, including yellow and bare wires cut earlier, should be covered.

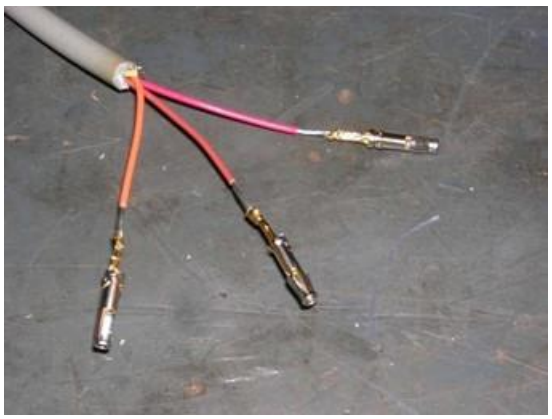
Figure 24. Wires in Order from Left to Right: Red, Brown, Orange.



7.1.4 Crimping on Pins

To start the connector side of the temperature probe, strip off about one inch of the gray wire casing. Again, cut off the yellow and bare wires and strip the red, brown, and orange wires. For the next step, use the wire crimpers. Hold the largest part of the pin's tail in place using the 2.3mm crimpers and carefully insert the exposed part of the red wire into the pin. Crimp them together. Finish off by crimping the protrusions from the pin with the 1.6mm crimper. Repeat with the other two wires.

Figure 25. Wires with Pin Attached.



7.1.5 Assembling Plug

For the next part, insert the pins attached to the wire into the connector that attaches to the controller. Before doing this, all extra parts that go with the same connector should already be attached (the bottom attachment, two washers, and a spacer as shown in Figure 26.

Figure 26. Order of Connector Pieces.

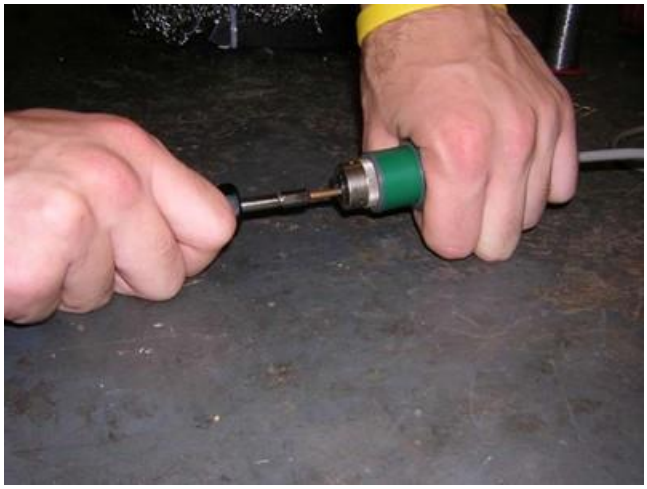
Look carefully at the bottom of the connector and note that there are four letters present: “A,” “B,” “C,” and “D.” Only “A”, “B,” and “D” are used. The red pin should be inserted into the “1A” slot, brown into the “2B” slot, and orange into the “4D” slot. Once again, it is important that the order is correct so as to not cross wires. All three pins are inserted at once, so try to align the pins into a triangle (in the right order) and then slide them into their correct slots. Use an Allen wrench or other thin object to push the pins all of the way through. A little force may be required to get the pins to the proper depth. The end of the pin should be nearly flush to the end of the connector (see Figure 27). Finish off by pushing all of the parts of the connector together and screwing it together. Finally, screw the clamp onto the base of the connector.

Figure 27. End of the Female Plug.

7.1.6 Repairing Temperature Probes

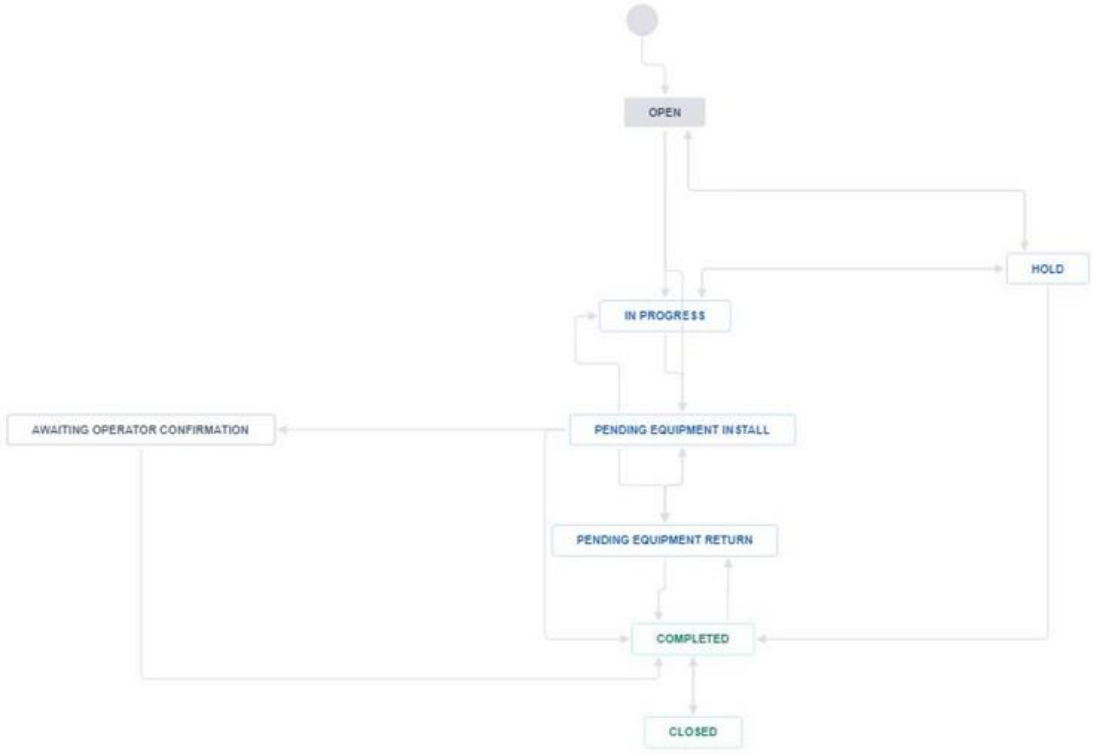
The procedure for repairing a temperature probe follows the same procedure as creating one from scratch, with the exception that the previously used parts of the wire have to be removed. If there is a noticeably broken or corroded part, remove and replace only that part. The temperature chip is just cut off and thrown away, followed by the procedures listed in section 7.1.2. To remove the pins from the connector, unscrew the bottom and use the pin removal tool to disconnect the pins from the connector. Simply cut off the pins and continue with the gray wire as described in section 7.1.4.

Figure 28. Removing the Connector Pins.



7.1.7 JIRA Workflow

JIRA is the in-house issue tracking online software used by the Air Quality Group at UC Davis. This software has the capability to simultaneously track different issues from all sites in the sampling network, in a user-friendly, highly organized and searchable way. Each issue has a parent issue based on data received from the field, whether it is an email, phone call, or logsheet comment from the operator, or a review of the flashcard data received. Each issue can have many different requests for equipment to fix the issue. These equipment requests are sub-tasks associated with the parent issue. Shown below in Figure 29 is the workflow that an equipment request sub-task can go through as the equipment request is processed.



TI 226G Field Safety Plan

TABLE OF CONTENTS

1. PURPOSE AND APPLICABILITY

The purpose of this Field Safety Plan is to describe the procedures, equipment, training, and documentation needed to ensure the safety of field maintenance crews during site maintenance visits.

2. SUMMARY

UC Davis field technicians visit each IMPROVE monitoring site at least once every two years. This document describes the steps to be taken to ensure their safety both at the site and during travel to and from the site. Also addressed is the safety of visitors who might accompany them to the site. Training and documentation required to enhance safety are also described in this Technical Information (TI) Document.

3. CAUTIONS

All UC Davis employees making site visits will be required to read this document and to complete the prescribed training and documentation before embarking on a site visit trip.

4. EQUIPMENT AND SUPPLIES

The following safety-related equipment should be available for the site maintenance crew:

- Ladder or other safe roof access
- Safety harness and lanyard to wear while working on the roof
- Other necessary fall protection equipment per fall safety plan
- First aid kit
- SPOT GPS
- Personal protective equipment for power tools (safety glasses, gloves)
- Cell phone
- Closed-toed shoes
- Drinking water
- Insect repellant and mesh hood
- List of nearest emergency room for each site

5. FIELD SAFETY PROCEDURES

5.1 Travel

1) To prevent fatigue field crews should avoid working more than 12 hours on any given day, including on-site time, travel time, and lunchtime. An exception is made for air travel days. The limit for these exceptions is 16 hours and if it must be exceeded, the traveler must make an effort to limit the drive from the airport to the hotel to one hour.
2) Drivers should not drive more than two hours before taking a break or switching driving with their trip partner.
3) Texting while driving is not allowed under any circumstances. Not only is it generally unsafe, it is also expressly forbidden by our Federal contract. Drivers will pull over if they need to send or receive a text message.
4) Making or receiving phone calls without a hands-free set while driving is not allowed under any circumstances. Drivers will pull over if they need to use their cell phones.
5) Be sure to rent an off-road vehicle (from National/Enterprise whenever possible, otherwise first obtain prior approval from Risk Management at 530-752-2629) if you need to visit sites requiring off-road access. Drive the off-road vehicle in a safe, responsible manner. Do not travel to off-road sites in a standard passenger vehicle.
6) Do not offer rides to non-UC Davis employees such as friends or hitchhikers. Site operators or other local IMPROVE employees may ride to and from the sites with the UC Davis field crew.

5.2 On-Site Maintenance Work

1) Electrical Safety – No damaged or frayed electrical equipment should be used. Electrical equipment should not be used around water nor during adverse weather conditions such as thunderstorms.
2) Using Tools – Apply the safety precautions associated with any tools that are used. Do not use tools that are broken or that may otherwise be unsafe. Wear appropriate personal protective equipment for each type of tool.
3) Working on the Roof – Caution should always be exercised when working on the roof of a shelter. Access the roof only with a ladder or other safe device. Do not climb on unsafe equipment such as chairs or stacked concrete blocks. If there is no safe roof access then do not perform the roof-related tasks such as servicing the stacks.

   Wear a harness if the roof seems to be especially high or steep. Refer to the site-specific fall safety plan if it has been deemed a "high" risk site. Secure the harness to something stable such as a railing or post that has been engineered for either fall arrest or work positioning, depending on the level of risk.
4) Footwear – Closed-toed footwear should always be worn when working on-site. Wearing sandals or other open-toed footwear is not allowed.
5) Weather Restrictions – Do not work during weather conditions that may be unsafe. During thunderstorms, in particular, stay indoors until conditions become safe.

5.3 Safety for Site Operators and Other Guests

1) Inform all non-UC Davis personnel that safety is a priority during maintenance visits and that they must follow all safety instructions given by the UC Davis staff.
2) The roof restrictions are the same for non-UC Davis personnel as they are for UC Davis staff. Namely, the roof must be accessed only by a ladder or other safe route, and a safety harness must be worn if the roof seems especially high or steep.
3) Non-UC Davis personnel are to use tools only at the direction of UC Davis staff. Personal protective equipment must be worn if required for the type of tool.

5.4 General Safety

1) Know the location of the nearest emergency room. When planning the trip obtain this information from the local operator at each site and compile a list including all of the sites on the trip.
2) Carry a first aid kit.
3) Carry a SPOT GPS so you can report your exact location for evacuation or roadside assistance in case of an emergency. Travelers should send a SPOT "We are OK" update when they arrive at the site and a second update when they leave the site.
4) If in a foreign country, know the location and contact information for the nearest U.S. Consulate.

5.5 Environmental Safety

1) Be aware of the effects of heat. Drink plenty of water throughout the day to remain

hydrated.

2) Pace yourself when working at high altitude. Stop and take a break if you feel dizzy or short of breath.

3) Be prepared for insects, especially flying insects. Carry insect repellent and a mesh hood to use when insects are bothersome.

4) Be alert for snakes and spiders. Do not step or place your hands and feet where you cannot see.

5) Be alert for bears or other large animals. Make plenty of noise as you approach any secluded location so the animals will not be surprised by your arrival. Most animals will flee if they can sense that you are coming.

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

5.6 Training

1) All UC Davis field staff are required to undertake field maintenance training prior to going on a maintenance trip. SOP 226 (Site Maintenance) and its associated TI documents form the basis for this training. The training is conducted and supervised by experienced members of the UC Davis field staff.

2) First Aid, CPR, and Wilderness training are strongly recommended for field staff. This training is offered on campus through UC Davis Campus Recreation and Unions. Information on classes and schedules can be obtained through the UC Davis Outdoor Adventures website:

http://cru.ucdavis.edu/outdooradventures

5.7 Documentation

1) Field staff supervisors should maintain a list of the location of the nearest emergency room to each site. This list should be updated as needed based on information obtained from the site operators during the trip planning stage.

2) Travelers should prepare a trip plan for each trip, to be filed with their supervisor prior to departure. The plan should include:

    a. Where you will be each day (sites visited and planned hotel)
    b. The location of the nearest emergency room each day
    c. Cell phone numbers for each traveler
    d. Emergency contact information for each traveler

    Guidance on preparing a trip plan can be found on the UC Davis Safety Services website:

    http://safetyservices.ucdavis.edu/ps/rm/rmr/fieldOperationalPlanner

    Click on the active link titled “Access the FSTOP System” to log in and receive personal trip planning guidance.

3) Prior to each trip, each traveler should register for UC traveler insurance coverage

and should print out the insurance card. Details and registration information can be found on the UC Risk Services website:

http://www.ucop.edu/risk-services/loss-prevention-control/travel-assistance/index.html

4) Travelers should obtain the rental car contract and keep it in the rental car at all times.

TI 226H: Calibration of Flow Check Devices using Positive Displacement Flow Meter

TABLE OF CONTENTS

1. PURPOSE AND APPLICABILITY

This technical instruction document describes the procedures for calibrating the flow check devices necessary for performing flow rate measurements on an IMPROVE aerosol samplers. The calibration of the flow check device is done by Air Quality Group personnel prior to and subsequent to flow rate measurements at an IMPROVE sampling site. Each flow check device is labeled so that its calibration can be tracked through time. All calibrations are stored on the computer network and in the field specialist's flow check device files. The most current calibration equation for each flow check device is written on a sticker which is pasted on the flow check device gauge following the calibration procedure.

2. RESPONSIBILITIES

2.1 Field Specialist

The field specialist shall:

- Train field technicians in the use of flow check device calibration equipment.
- Approve and file the flow check device calibration equation.
- Maintain an accurate database of flow check device calibrations.

2.2 Field Technician

The field technician shall:

- Perform the calibration of the flow check device.
- Submit the derived calibration equation to the field specialist for approval.

3. REQUIRED EQUIPMENT AND MATERIALS

The equipment required to calibrate a flow check device includes the following:

a. Definer 220, Mesa Labs, http://drycal.mesalabs.com/definer-series/, accuracy 1%.
   - 3/8" I.D. hose, 2'
   - ¼ NPT brass nipple for 3/8" I.D. hose
   - Stack inlet plug for top of IMPROVE PM2.5 module tee inlet
   - 3/8" O.D. stainless steel tube, 2"
   - IMPROVE PM2.5 module tee plug tapped for ¼ NPT fitting

b. 1 flow check device (orifice meter) and calibration form.

c. 1 leak checked IMPROVE PM2.5 module.

d. 1 IMPROVE controller.

e. 1 IMPROVE rocker piston pump with corresponding vacuum line.

f. 1 IMPROVE pump relay box

g. 1 leak checked calibration filter cartridge

4. METHODS

This technical note covers the methods for calibrating orifice meters using a Definer 220 as a standard. Section 4.1 covers the theory describing the behavior of orifice meters, while section 4.2 describes the procedures used to calibrate orifice meters against a Definer 220.

4.1 Orifice Meter Theory

An orifice meter consists of a restriction in the air path and a device to measure the pressure drop across the restriction. Orifice meters in the IMPROVE network use magnehelics to measure the pressure drop. The flow check devices consists of a magnehelic, tubing, and a probe that fits into the base of the inlet tee of the PM2.5 (fine) sampling modules and at the base of the inlet stack in the PM10 (coarse) module. For the fine modules, the probe blocks the normal flow through the inlet, forcing all air entering the system to pass through the probe orifice. The probe and magnehelic, hereafter called the flow check device, are calibrated at Davis using a Definer 220.

The flow rate through an orifice meter, Q, depends on the pressure drop across the restriction, δP, and the square root of the density of the air:

$$Q = Q_1 (\delta P)^{\beta} \sqrt{\frac{P_\circ}{P}} \sqrt{\frac{T+273}{293}} \qquad \text{(TI226-1)}$$

Where P is atmospheric pressure, T is temperature in °C, and Q_1, β, and P_° are constants. For laminar flow, β =0.5. We express Equation TI226-1 in parameterized form using the magnehelic reading, M, for the pressure drop:

$$Q = 10^{a}\, M^{b} \sqrt{\frac{P(sea\ level)}{P(site)}} \sqrt{\frac{T+273}{293}} \qquad \text{(TI226-2)}$$

We have arbitrarily defined all pressures relative to the standard pressure at sea level and all temperatures relative to 20°C. Thus, the parameters, a and b, are always calculated relative to 20°C and Davis. The value of b should be similar to that of β, around 0.5. The advantage in expressing the parameters relative to sea level is that all modules should have parameters with similar values independent of the site elevation.

Because of the difficulties in measuring the ambient pressure at each sample change, we have chosen to use an average pressure based on the elevation of the site. The pressure- elevation function is discussed in SOP201-3.

The reference flow rate is provided by a Definer 220 located in the sampler laboratory at UCD. Taking the logs of Equation TI226-2, the flow rate equation for the flow check device is

$$\log(Q) = a_{\circ} + log \sqrt{\left(\frac{29.92}{P}\right)\left(\frac{T+273}{293}\right)} + b_{\circ} * \log(M_{\circ}) \qquad \text{(TI226-3)}$$

The log of the meter reading, Mo, is regressed against the log of the flow rate for a set of four flow rates covering the normal range of the device. The constants relative to the nominal sea level pressure (29.92” Hg) and 20 °C are calculated using

$$a_c = intercept - log \sqrt{\left(\frac{29.92}{P}\right)\left(\frac{T+273}{293}\right)} \qquad b_{\circ} = slope \qquad \text{(TI226-4)}$$

4.2 Calibration of an Orifice Meter Using a Definer 220

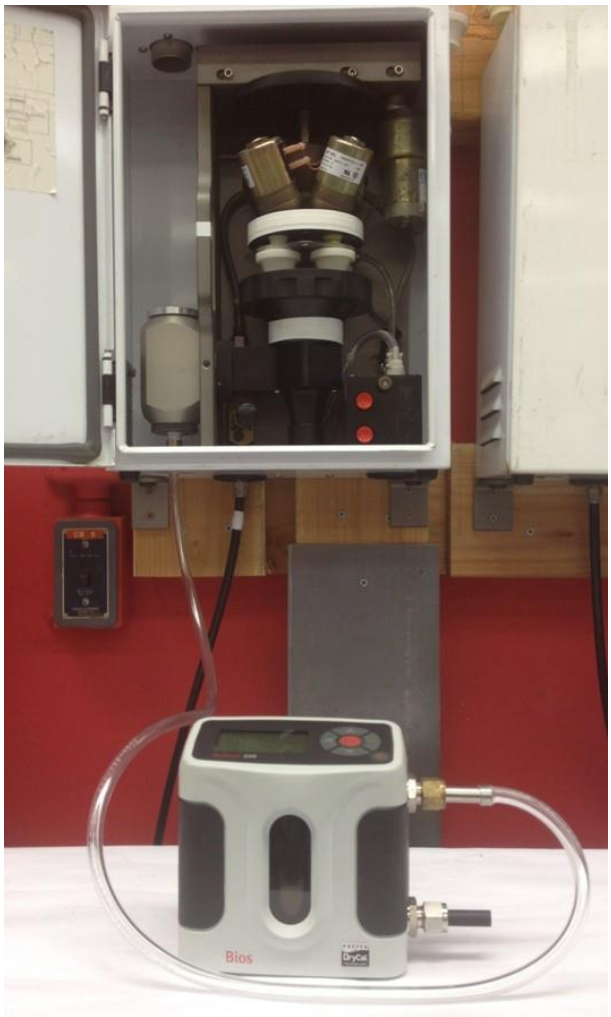
The flow check device, or orifice meter, is used as the standard against which each module in the field is calibrated. The flow check device is calibrated against a primary flow device, a Definer 220, at the Air Quality Group Lab both prior to and following calibration at a site. The calibration equation for the orifice meter is printed on a sticker on the magnehelic side, along with the date of calibration and name of the technician responsible for the equation. A flow restricting device and a filter cartridge with 4 filters with distinct pressure drops, is used to change the flow rate to develop the equation. Finally, a spreadsheet for doing logs and linear regressions is required.

1. Install the calibration cartridge shown in Figure 1. in the module. This cartridge is set up with four cassettes that produce a range of flow rates.

Figure 1. Calibration Cartridge.

2. Insert Definer 220 probe at bottom of tee and tee plug on top of tee as shown in Figure 2. Ensure that both probe and plug are inserted fully.

Figure 2. Calibration System with Definer 220



3. At the controller access the main menu and press F-3 for “Advanced Menu”.
4. From the “Advanced Menu” press F-1 for “Calibration”. This will turn on the pump and open solenoid one on module A.
5. Turn on the Definer 220 by pressing the red power button in the bottom of the right corner for 2 seconds.
6. When the Definer has been turned on press the red “Enter” button while “Measure” is selected as in Figure 3.

Figure 3. Setting up the Definer 220

7. Select “Burst” mode and take flow reading for filter position 1 of the calibration cartridge. Ensure that the Definer is set to the standard temperature of 20°C for determining SLPM. This is indicated by “Std. Temp:20” shown on the definer screen during readings as shown in Figure 4.

Figure 4. Operating the Definer 220

8. Record the average flow rate for each filter position in cell B7 of the calibration spreadsheet shown in Figure 5.

Figure 5. Flow Check Device Calibration Spreadsheet

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Device:	F-6											
2	Year:	2015											
3													
4	Calib. Date:		Calib. By:										
5	ΔP_{mag}	Q_{bios} Savg	Q_{eqn}	% Error from prev. calib	LOG ΔP_{mag}	LOG Q_{bios}	R^2	a	b	23 lpm	16.9 lpm	Temp	BP
6	"H_2O	lpm	lpm							STP	STP	°C	"Hg
7			#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!		
8			#NUM!	#NUM!	#NUM!	#NUM!	Comments:						
9			#NUM!	#NUM!	#NUM!	#NUM!							
10			#NUM!	#NUM!	#NUM!	#NUM!							

9. Repeat steps 7 and 8 for the remaining filter positions.
10. Remove the Definer plug and tee inlet plug from the module.
11. Insert the flow check device probe into the bottom end of the inlet tee. Ensure that the probe is fully inserted. Attach the magnehelic gauge on a vertical metallic surface as shown in Figure 6. The back end of the gauge base is magnetic.

Figure 6. Calibration System with Magnehelic Flow Meter.

12. Press F-3 on the controller key pad to return to filter position one for module 1A.
13. Record the magnehelic reading for each filter position on cells A7-10 of the calibration spreadsheet.
14. Record the calibration date, technician name, ambient temperature, and pressure on the spreadsheet.

15. The spreadsheet will generate values for R2, intercept, slope, nominal magnehelic value for a flow rate of 23 LPM, and 16.9 LPM at standard temperature and pressure.
16. If the r2 is not better than 0.990, the calibration is invalid. Repeat the orifice meter calibration procedure, beginning with step 2.
17. If the r2 is better than 0.990, write out the equation, the date, technician initials, temperature, and r2 value on a 3 7/16" x 9/16" file folder label, and paste it to the side of the orifice meter magnehelic.
18. Save the calibration spreadsheet.
19. Share the results of calibration spreadsheet with the field manager for approval.