UCD IMPROVE Technical Information #226D

Denuders

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

July 15, 2022
Version 2.5

Prepared By: DocuSigned by: 46441F2308F14C2... Date: 9/26/2022

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DOCUMENT HISTORY

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05/10/21	SRS	All	Separated TI: A-H doc into individual TIs
5/17/21	IVP	5,6	Added missing sections
07/15/22	SRS	All	Annual formatting, no procedural changes

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1. PURPOSE AND APPLICABILITY

The purpose of this technical information (TI) is to describe the function of the denuders used in 2B 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 2B 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 Research Center 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 2B 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 WARNINGS

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

5. CAUTIONS

When coated, denuders easily attract dust, dirt and oils. Take care to only handle denuders with clean hands, and be cautious not to set them down on unclean surfaces.

6. INTERFERENCES

It is important to leave the denuders to dry at an angle to properly drain excess solution. If excess solution does not drain properly, the coating will not be even and can clog the air paths. This leads to lowering the surface area and therefore the effectiveness of the denuder.

7. 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.

8. EQUIPMENT AND SUPPLIES

Supplies for Cleaning Denuders:

- Household grade ammonia
- 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.

9. PROCEDURAL STEPS

9.1 Assigning an Inventory Number

All denuders must be assigned an inventory number. The inventory number should be etched on either the top or the 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 the U:\ Drive. All denuder inventory numbers are in the format "D####." Use the engraver to inscribe the next sequential number onto the end of the denuder.

9.2 Updating the Inventory

A denuder is classified as being in one of four states: dirty, coated, scrapped, or 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 to "dirty" in the "Status" column. Clear the "Date Coated", "Site Sent To", and "Date Sent" columns.

9.3 Cleaning the Denuders

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

9.3.1 Preparing and Using the Ultrasonic Bath

The ultrasonic bath is on the denuder cart, which is located directly outside of the AQRC 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 80 g of 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.

9.3.2 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 AQRC 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.

9.4 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.

9.4.1 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 100 mL 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 900 mL 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.

9.4.2 Coating the Denuders

Obtain the graduated cylinder. Add 860 mL 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.

9.4.3 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.

UCD IMPROVE Technical Information #226E

Leak Check

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

July 15, 2022
Version 2.5

Prepared By: DocuSigned by: 46441F2308F14C2... Date: 9/26/2022

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5/17/21	IVP	4,5,6,7,10,11	Added missing sections
07/15/22	SRS	All	Annual formatting, no procedural changes

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1. PURPOSE AND APPLICABILITY

The purpose of this technical information (TI) 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. DEFINITIONS

- Hg: mercury
- TI: technical information

4. HEALTH AND SAFETY WARNINGS

At some sites, modules are not mounted at an ergonomic height for taking measurements. Make sure you have solid footing on proper step stool before taking any sampler measurements.

5. 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.

The Vacuum in the sampler can cause filter tearing if suddenly released by suddenly removing the leak probe. You should always remove the small vacuum gauge plug first before pulling out the full problem.

6. INTERFERENCES

Not applicable.

7. PERSONNEL QUALIFICATIONS

Leak checks should be performed by trained field technicians who have experience with the procedure and have a good understanding of the fundamentals of sampler operation. In extraordinary circumstances, a local operator might be asked to perform this check with the remote assistance of a field technician, while closely following printed instructions and/or and instructional video.

8. EQUIPMENT AND SUPPLIES

Supplies for the vacuum kit:

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

Supplies for the maintenance spare parts kit:

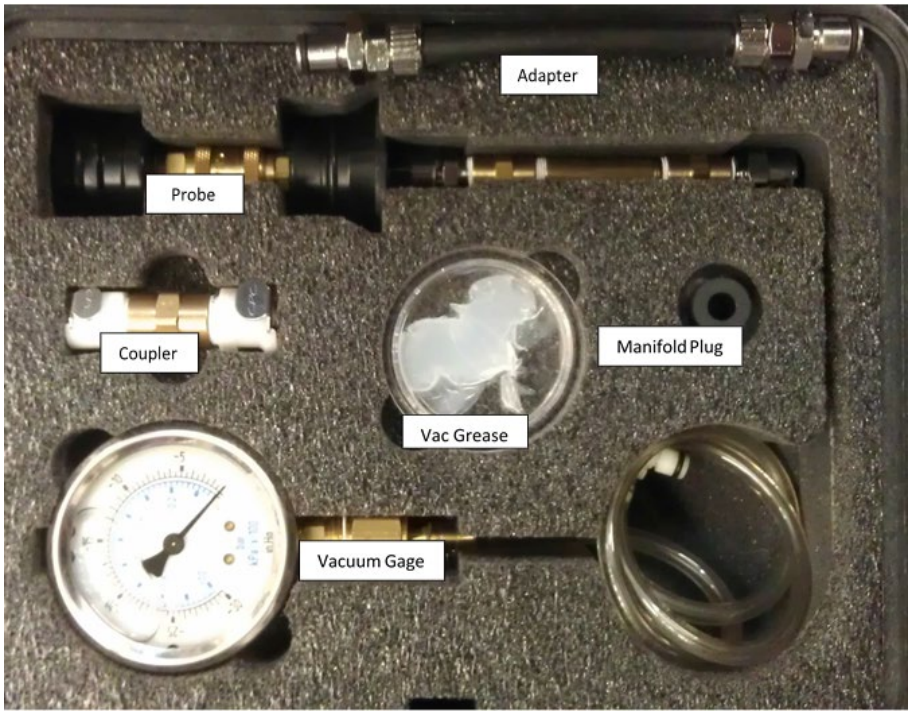
- Spare O-rings
- Cyclone
- Manifold
- Braided hose
- Valve

9. PROCEDURAL STEPS

9.1 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) From the Home Screen of the controller, press the **Menu** button, then **Advanced Menu** button, enter **9051**, press the **More** button, then **Flow Adjustment**.
4) Press the **Pump: Off** button to turn on the pump.
5) The needle on the pressure gauge will rise once the pump it is connected to is activated. Record this value in cell B20 of the flow check/calibration sheet or under “Pump (“Hg)” on the Leak Check form, whichever is being used. If the pump has trouble starting under vacuum, disconnect the coupler and reattach once the pump has started.
6) Press **Pump: On** to turn off the pump.
7) Disconnect the vacuum gauge, coupler, and pump hose. Restore the original configuration of the system.

Figure 1. Vacuum kit.



9.2 Leak Check at the Module

1) Open the module that needs to be leak checked and confirm 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 Flow Adjustment mode press **S2: Off** to turn on the second solenoid. The solenoid used is not important, but at least one solenoid should be open to measure the vacuum pressure through the module.

5) Use > or < to cycle through to the module being tested. For this particular procedure, it does not matter what position is running.

6) The needle on the vacuum gauge should rise. Record the value in cell B21 of the module specific flow check/flow adjustment sheet or under “Mod (“Hg)” on the Leak Check form, whichever document is being used.

7) The difference between the pump and module readings should be less than two inches mercury (“Hg). 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.

9.3 Leak Check at the Manifold

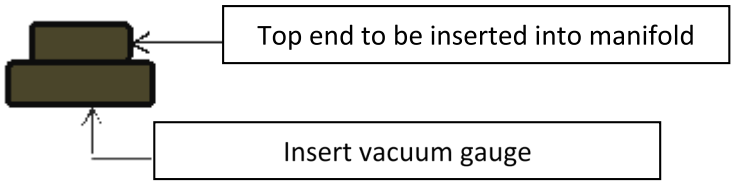
If the difference between the module and the pump is greater than two inches, this means that there may be a leak in one of five areas:

- 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 (Figure 2):
2. Use the instructions listed in section 9.2 to go into **Flow Adjustment** mode. Use **>** and **<** 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/flow adjustment 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.

Figure 2. Manifold plug.



9.4 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 9.2 to go into **Flow Adjustment** mode, open solenoid 1 by pressing **S1: Off** so that it reads "S1: On" on 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.

10. DATA AND RECORDS MANAGEMENT

The results of the leak check are stored on the same excel sheet as the flow check procedure. These files are to be stored indefinitely on the shared network drive.

11. QUALITY ASSURANCE AND QUALITY CONTROL

Excessive leaks can cause improper flow measurements and faulty sampling. If a leak is detected it should be fixed right away by replacing equipment until the leak falls below an empirical 2" Hg. After the leak is fixed the flow rate should be measured again. If the flow now falls outside of the 10% requirement, it should be reported to the data validation group for proper flagging.

12. REFERENCES

Not applicable.

UCD IMPROVE Technical Information #226F

Controller Repair

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

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1. PURPOSE AND APPLICABILITY

The purpose of this technical information (TI) is to describe an overview of the procedures used to diagnose, repair, and ship controllers that are used at every site in the IMPROVE network. Detailed guides of repair procedures are now held within in-house documents. Controllers are diagnosed and repaired at the Air Quality Research Center shop, which is located off-campus of University of CA, Davis at the Drew Avenue location.

2. SUMMARY OF THE METHOD

When an IMPROVE controller fails in the field, it is shipped to the Air Quality Research Center (AQRC) 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. DEFINITIONS

- AQRC: Air Quality Research Center of UC Davis
- IMPROVE: Interagency Monitoring Program of Visual Environments
- JIRA: an online database used to track issues and manage programs
- TI: technical information document, a subset of a SOP (standard operating procedure)

4. HEALTH AND SAFETY WARNINGS

The controller circuitry must be unplugged before any work is performed; the electrical contacts behind the protective panels operate at Line voltages.

When first testing a repaired controller, It should be done using a GFI rated outlet and the technician should not touch any part the of the metal body of the controller. It is possible to mistake the wiring on reassembly and cause the shell of the controller to become energized. This will cause a ground fault that should be cleared by the GFI receptacle.

Solder fumes can be dangerous. Always solder under a well-ventilated exhaust hood

5. CAUTIONS

Ground your body, ideally with an anti-static wrist when handling printed circuit boards. Static discharge can harm the sensitive parts of the electronics.

6. INTERFERENCES

Not applicable.

7. PERSONNEL QUALIFICATIONS

Student shop assistants and field technicians work in the AQRC 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 assemble/disassemble controllers. Each new employee also observes an experienced employee diagnose and repair 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.

8. 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.

9. PROCEDURAL STEPS

9.1 Diagnosis of Controller Problems

The goal on an IMPROVE controller is to trigger sampling start and stop based on an internal calendar then continuously log pressure readings to an sd card and an online server.

A timer module opens and closes solenoids and relays and records the data from the pressure sensors to the memory card. 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.

9.1.1 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 AQRC.

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 the Drew Avenue building. 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 of 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 entry for the controller. Follow the workflow dictated by the inventory application. If there is a discrepancy, notify a supervisor. 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 issue type 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 the comment field of the inventory application. 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 section 9.4.7.

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. Often the diagnosis is time sensitive. For example, if the checked in controller 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.

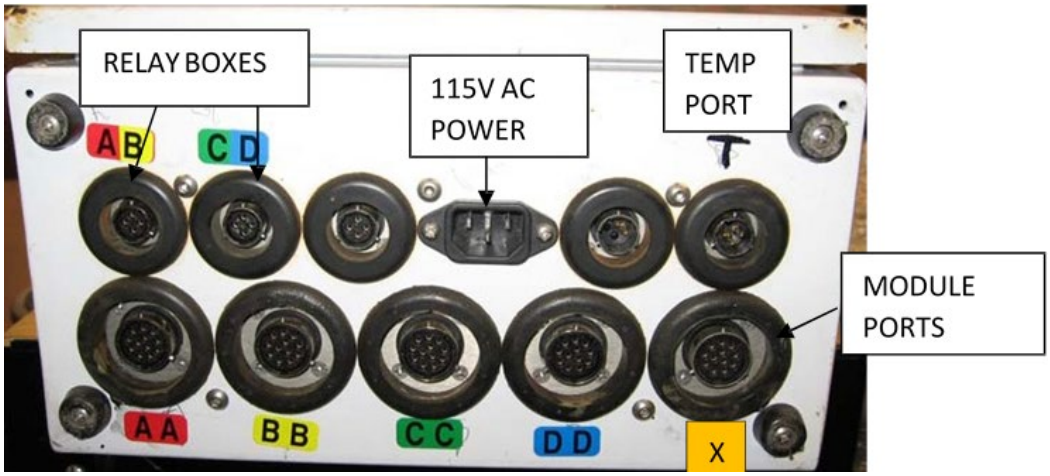
To proceed with diagnosis, continue on to the next section. If the controller is only being checked in, place it on the "To Be Repaired" shelves in the AQRC shop.

9.1.2 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 a 5X module.

Figure 1. Port layout.



Each module should be 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.

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

9.2 Controller Configuration

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

In the V4 controller, the site configuration information is stored in a repository within the controller. To access and configure this repository, press the **Menu** button from the Home Screen, then **Advanced Menu**, and enter code **1123**. Press **Site Config**, then press the **pencil icon** next to row labeled "Site". Use the **<** and **>** arrows to move the cursor position. Use the ^ and **v** to change the character. Enter the four-letter site name with number. Press **Save**, then use the **Back arrow** to navigate back to the Advanced Menu. Press the **Update Cfg File** button, and then press the **Replace config.ini** button.

The controller must now restart for settings to take effect. Press the **Back arrow**, then press **More**, press **More** again, then press **Shutdown**, **Restart**, and then **Yes**. When controller reboots, all the site configuration parameters should be correct.

9.3 Controller Shipping

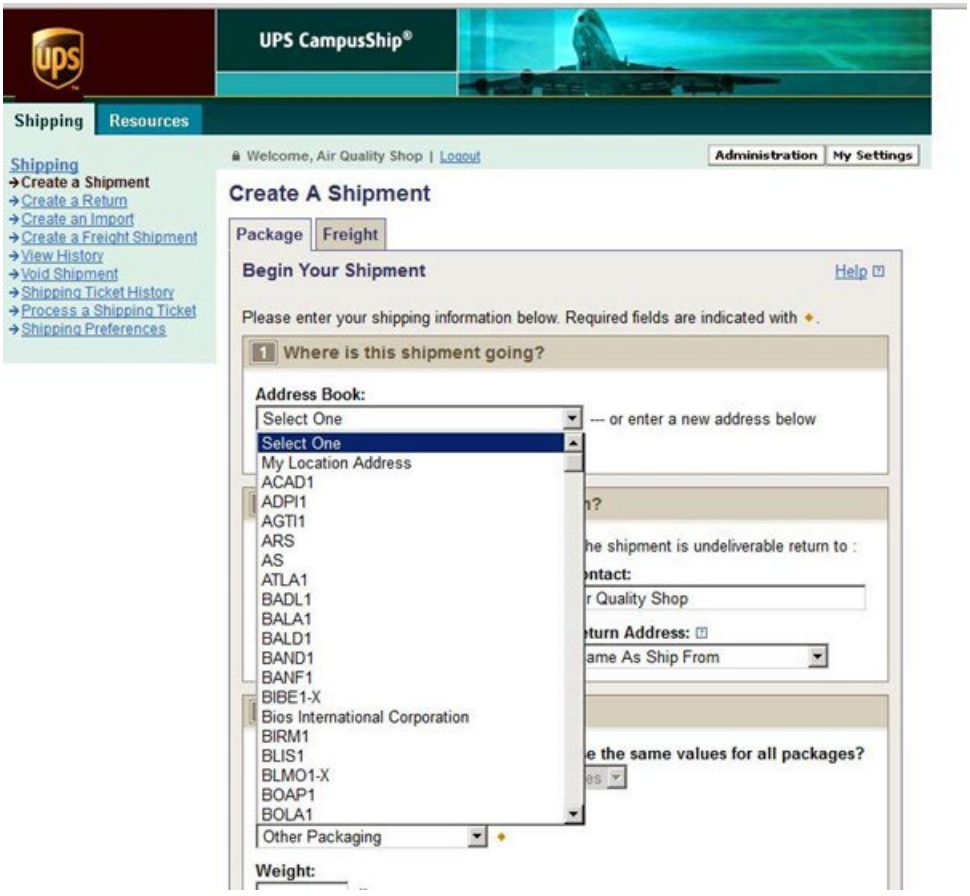
Controller Preparation:

1. Obtain a repaired controller on the ready shelf
2. Use the controller's interface to set site name to the destination
3. Click the update config button to load auto load site specific configurations
4. Set GMT offset to the time zone at the destination
   Navigate and click "Prep For Shipping" button.

9.3.1 Creating the Shipping Label

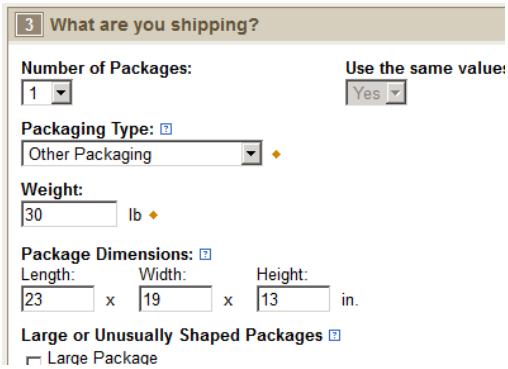
1. Go to the UPS website and log in using the AQRC shop account.
2. Click on the **Create a Shipment** option on the left-hand side and select the shipping site under the address book drop-down menu.

Figure 2. "Create a Shipment" on the UPS website.



Select **Other Packaging** under the "Packaging Type" drop-down menu and enter the appropriate weight and dimensions of the controller box (see Figure 3).

Figure 3. Shipment details.

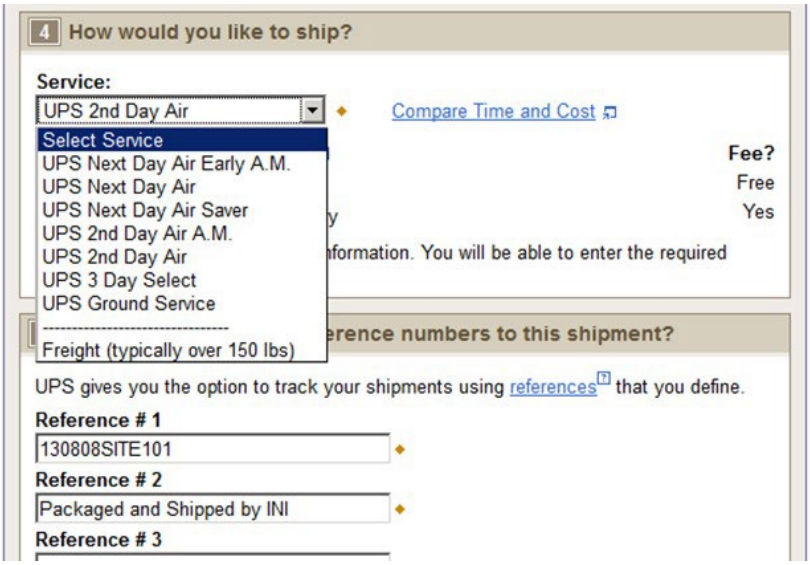


Select the appropriate shipping service and fill out “Reference” lines 1 and 2 in the following format:

Reference #1: JIRA issue number (No dash between site name and issue number)

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

Figure 4. “Select Service” and “References” on the UPS website.



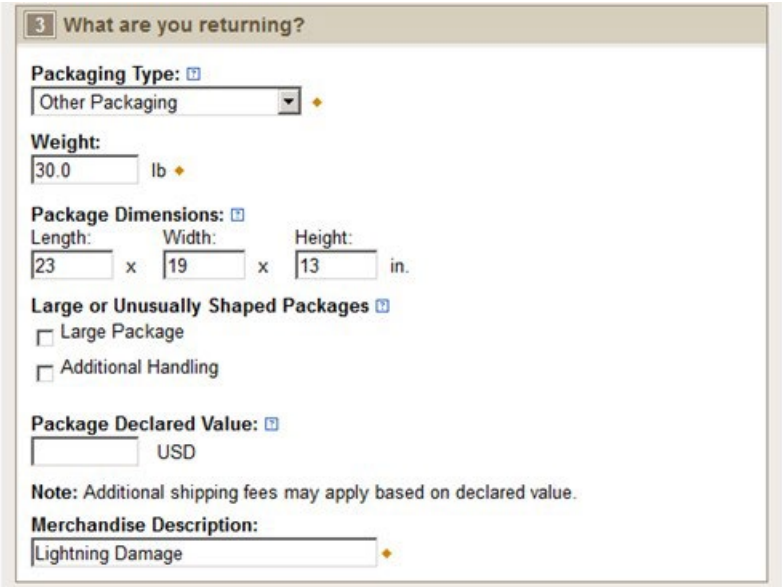
Once complete, review the shipment on the next page and select **Ship Now**.

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

Figure 5. "Create a Return Shipment" on the UPS website.

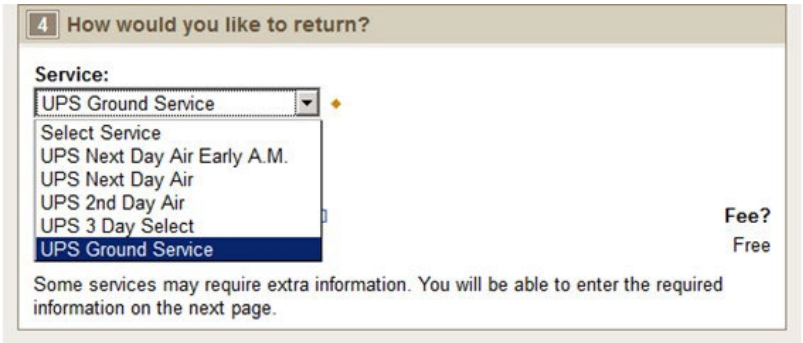
Under "Merchandise Description," enter a short description of the problem that the controller at the site has.

Figure 6. Return shipment details.



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

Figure 7. Return shipment service.



9.3.3 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.

9.3.4 Update the Inventory Data Base and JIRA

Go to the equipment inventory database located in "U:\IMPROVE_Field\Shop and Operator Resources\Equipment Inventory" and open the inventory application titled, "Field_Inventory_App.exe". Update the controller information for the controller being shipped using the **Ship Equipment** button, making sure to account for any equipment changes during repairs.

Edit the Equipment Request issue on the online issue-tracking JIRA software. 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.

9.4 Temperature Probe Construction/Repair

9.4.1 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

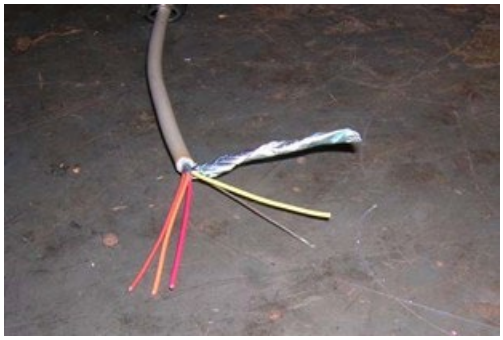
9.4.2 Stripping Wires

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 8. Exposed wiring.



9.4.3 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 damage electrical components in the controller. With the flat face of the temperature chip facing 6 o'clock, solder the red wire to the left prong (1), the brown wire to the middle prong (2), and the orange wire to the right prong (3). 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 should not 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.

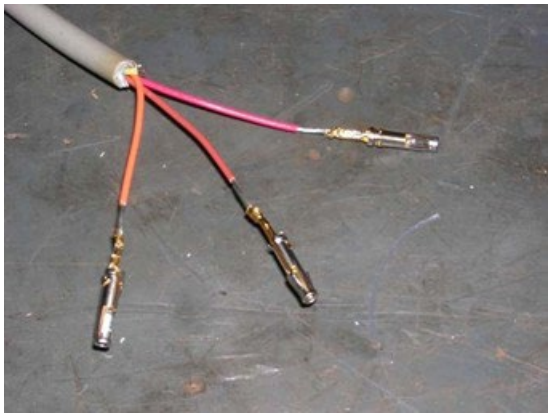
Figure 9. Wires in order from left to right: red, brown, orange.

9.4.4 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 2.3 mm 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 1.6 mm crimper. Repeat with the other two wires.

Figure 10. Wires with pin attached.



9.4.5 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 11).

Figure 11. 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 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 13). 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 12. End of the female plug.

9.4.6 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 9.4.2. 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 9.4.4.

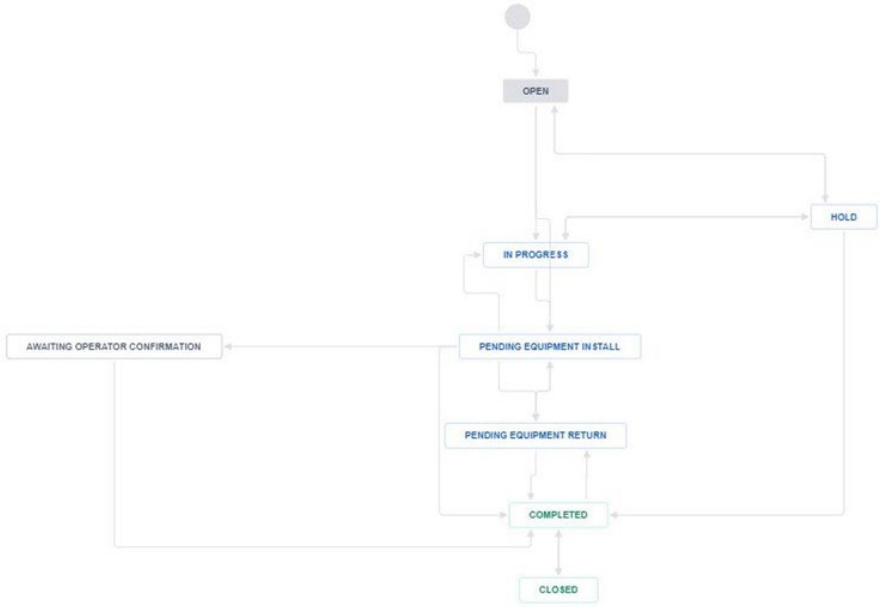
Figure 13. Removing the connector pins.

9.4.7 JIRA Workflow

JIRA is the online issue-tracking software used by the Air Quality Research Center at UC Davis. This software has the capability to 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 memory card 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 14 is the workflow that an equipment request sub-task can go through as the equipment request is processed.

Figure 14. Equipment request workflow.



10. DATA AND RECORDS MANAGEMENT

Equipment Ticket tracking is accomplished using the commercial cloud software package “JIRA” by Atlassian. This ticketing system will store all relevant information about the nature of the problem at the site.

Equipment inventory is stored on a Microsoft SQL server instance running on a local network server. Some custom-made .NET software tools facilitate the updating of records. The status of the equipment is also kept in the SQL server. It is up to the technician to verify all equipment changes are properly reflected in the database.

11. QUALITY ASSURANCE AND QUALITY CONTROL

The controller is a complicated system of hardware and software; diagnosing intermittent problems can prove difficult. Any problems exhibited by a controller in the field must be recreated in the shop conditions before it is sent out again. If the issue is not replicable under these conditions, the equipment must be long-term tested for proper operation for at least a week before being marked as ready to go into the field again.

12. REFERENCES

Not applicable.

UCD IMPROVE Technical Information #226G

Field Safety Plan

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

July 15, 2022
Version 2.5

Prepared By: DocuSigned by: 46441F2308F14C2... Date: 9/26/2022

Reviewed By: DocuSigned by: Yongjing Zhao 342B5E57044E4A9... Date: 9/26/2022

Approved By: DocuSigned by: Marcus Langston 0A10CECE79B0452... Date: 9/26/2022

UCDAVIS
AIR QUALITY RESEARCH CENTER

DOCUMENT HISTORY

Date Modified	Initials	Section/s Modified	Brief Description of Modifications
05/14/21	SRS	All	Separated TI: A-H doc into individual TIs
5/17/21	IVP	3,4,5,6,10,11	Added missing sections
07/15/22	SRS	All	Annual formatting, no procedural changes

TABLE OF CONTENTS

1. PURPOSE AND APPLICABILITY

The purpose of this technical information (TI) is to describe the procedures, equipment, training, and documentation needed to ensure the safety of field maintenance crews during site maintenance visits.

2. SUMMARY OF THE METHOD

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 TI.

3. DEFINITIONS

- SPOT GPS: An emergency satellite text messaging and SOS beacon device
- UC Davis LMS: An online job training resource used by the university
- AQRC: Air Quality Research Center of UC Davis
- IMPROVE: Interagency Monitoring Program of Visual Environments
- UC Davis: University of California, Davis

4. HEALTH AND SAFETY WARNINGS

The nature of field work implies unpredictable dangers from working in remote environments. This document will outline the systematic procedures of our group follows to prevent serious injury and illness. However, additional care should be practiced by the traveler to assess specific dangers associated with the location being visited.

5. 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.

6. INTERFERENCES

Not applicable.

7. PERSONNEL QUALIFICATIONS

All UC Davis field staff are required to undertake field maintenance training prior to going on a maintenance trip. *UCD IMPROVE 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.

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: https://campusrecreation.ucdavis.edu/outdoor-adventures

8. EQUIPMENT AND SUPPLIES

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

- Ladder or alternative 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

9. PROCEDURAL STEPS

9.1 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 attempt to limit the drive between the airport and 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.
7. Always use the university travel website to register each trip to be signed up for travel insurance.

9.2 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.
    a. 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.
    b. 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.

9.3 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, only a ladder or other safe route must access the roof, 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.

9.4 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.

9.5 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 the vehicle and to secure work and personal equipment while at the site.

10. DATA AND RECORDS MANAGEMENT

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:

https://safetyservices.ucdavis.edu/units/ehs/research/field/planning

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:

   https://www.ucop.edu/risk-services-travel/index.html

4. Travelers should obtain the rental car contract and keep it in the rental car at all times.
5. Online training courses are recorded using the UC Davis Learning Management System (lms.ucdavis.edu). Supervisors are required to make sure all relevant safety courses are assigned to employees and the employees maintain a record of completion of all the courses.

11. QUALITY ASSURANCE AND QUALITY CONTROL

Not applicable.

12. REFERENCES

1. *UCD IMPROVE SOP #226: Site Maintenance*
2. campusrecreation.ucdavis.edu/outdoor-adventures
3. lms.ucdavis.edu
4. safetyservices.ucdavis.edu/units/ehs/research/field/planning
5. ucop.edu/risk-services-travel/index.html

UCD IMPROVE Technical Information #226H

Calibration of Flow Check Devices Using Positive Displacement Flow Meter

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

July 15, 2022
Version 2.5

Prepared By: DocuSigned by: 46441F2308F14C2... Date: 9/26/2022

Reviewed By: DocuSigned by: Yongjing Zhao 342B5E57044E4A9... Date: 9/26/2022

Approved By: DocuSigned by: Marcus Langston 0A10CFCF79B0452... Date: 9/26/2022

UCDAVIS
AIR QUALITY RESEARCH CENTER

DOCUMENT HISTORY

Date Modified	Initials	Section/s Modified	Brief Description of Modifications
05/14/21	SRS	All	Separated TI: A-H doc into individual TIs
5/17/21	IVP	2,3,4,5,10,11	Added missing sections
6/14/22	IVP	5	Added caution on calibration stability

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LIST OF FIGURES

1. PURPOSE AND APPLICABILITY

This technical information (TI) document describes the procedures for calibrating the flow check devices necessary for performing flow rate measurements on IMPROVE aerosol samplers. The calibration of the flow check device is done by Air Quality Research Center (AQRC) 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. SUMMARY OF THE METHOD

The primary flow measurement standard device the Field Technicians use to measure flow is too expensive and fragile to be taken into the field. To get around this we calibrate a number of transfer standards in the form of an arbitrary flow restriction and a pressure measurement device. These transfer standards called "Magnehelic Probes" are then used in the filed with the aid of a spreadsheet and calibration constants to measure flow rate. This TI explains probe calibration methods.

3. DEFINITIONS

- AQRC: Air Quality Research Center of UC Davis
- IMPROVE: Interagency Monitoring Program of Visual Environments
- $PM_{2.5}$: Particulate matter, aerodynamic diameter of 2.5 mm or less.
- PM_{10}: Particulate matter, aerodynamic diameter of 10 mm or less.
- TI: Technical Information
- Magnehelic Probe: the custom flow restriction and pressure measurement device we use as a transfer standard for flow measurements in the field

4. HEALTH AND SAFETY WARNINGS

Person protection equipment should be used/worn in accordance to university and lab safety policy.

5. CAUTIONS

Leaks in the sampler used to audit and calibrate the probe will change the measurement. Perform a leak check on the sampler before auditing or calibrating.

Historically transfer standard calibrations remain very stable or drift slowly over time. If the calibration constants change significantly from the last calibration look for pressure gauge damage, leaky hoses, hose kinks or other device defects. If calibration is found not to be stable after subsequent calibrations, consider retiring the device.

6. INTERFERENCES

Temperature is assumed to be 20 °C when calculating the field correction factors used after calibration. Make sure the room temperate is whiting 2 degrees of standard value prior to calibrating.

7. PERSONNEL QUALIFICATIONS

7.1 Field Specialist

The field specialist will:

- 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.

7.2 Field Technician

The field technician will:

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

8. EQUIPMENT AND SUPPLIES

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

- Definer 220, Mesa Labs (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 $PM_{2.5}$ module tee inlet
  - 3/8” O.D. stainless steel tube, 2”
  - IMPROVE $PM_{2.5}$ module tee plug tapped for ¼ NPT fitting
- 1 flow check device (orifice meter) and calibration form
- 1 leak checked IMPROVE $PM_{2.5}$ module
- 1 IMPROVE controller
- 1 IMPROVE rocker piston pump with corresponding vacuum line
- 1 IMPROVE pump relay box
- 1 leak checked calibration filter cartridge

9. PROCEDURAL STEPS

This technical note covers the methods for calibrating orifice meters using a Definer 220 as a standard. Section 9.1 covers the theory describing the behavior of orifice meters, while section 9.2 describes the procedures used to calibrate orifice meters against a Definer 220.

9.1 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 Magnehelic to measure the pressure drop. The flow check devices consist of a magnehelic, tubing, and a probe that fits into the base of the inlet tee of the $PM_{2.5}$ (fine) sampling modules and at the base of the inlet stack in the PM_{10} (coarse) module. For the five modules, the probe blocks the normal flow through the inlet, forcing all air entering the system to pass through the probe orifice. The flow check device probe is a machined piece with slight variations between the holes drilled and geometry. The results in the need to calibrate each device probe. The digital magnehelics all agree within 1% and no individual calibration is needed for each. The digital magnehelics are, therefore, interchangeable. The probe and magnehelic, hereafter called the flow check device, are calibrated at the Air Quality Research Center (AQRC) at UC Davis (UCD) 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 ℃, 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 ℃. Thus, the parameters a and b are always calculated relative to 20 ℃ and UCD. 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 *UCD IMPROVE SOP #201: Sampler Maintenance* in sections 9.3.3 and 9.4.2.

The reference flow rate is provided by a Definer 220 located in the sampler laboratory at AQRC. 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

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

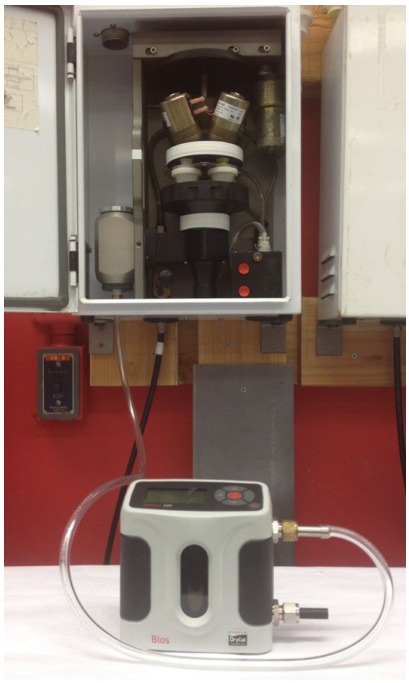
9.2 Calibration of an Orifice Meter Using a Definer 220

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 probe is calibrated against a primary flow device — a Definer 220 — at AQRC both prior to and following calibration at a site. The calibration equation for the flow check device probe is printed on a sticker within 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 twelve filters with distinct pressure drops is used to change the flow rate to develop the equation. Finally, a spreadsheet to complete 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.
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 1. Calibration Cartridge.

Figure 2. Calibration system with Definer 220.



3. At the controller press **Menu** from the Home Screen, then **Advanced Menu**, then enter code **9051**.
4. From the Advanced Menu press **Calibration**. Turn on the pump and open solenoid one on module 1A.
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.
7. Select **Burst** mode and take flow reading for filter position 1 of the calibration

cartridge. Ensure that the Definer is set to measure volumetric flowrate

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

Figure 3. Setting up the Definer 220.

Figure 4. Operating the Definer 220.

Figure 5. Flow check device calibration spreadsheet.

	F-07 PROB												
	Calib. Dat	1/22/2020	Calib. By:	FJ									
	ΔP_{DIGMAG} "H_2O	Q ALICAL lpm	Q_{DIGMAG} lpm	%Diff	LOG DiG_{MAG}	LOG ALICAL	R^2	a	b	23 lpm STP	16.9 lpm STP	Temp °C	BP "Hg
SET1	0.61	23.89	23.89	-0.01%	-0.215	1.378	1.000	1.502	0.575	0.570	0.334	21.9	766.00
	0.58	23.27	23.25	-0.09%	-0.236	1.367							
	0.47	20.61	20.61	-0.01%	-0.327	1.314							
	0.37	18.01	18.02	0.06%	-0.428	1.256							
SET2	0.62	24.12	24.14	0.06%	-0.208	1.382							
	0.59	23.35	23.37	0.06%	-0.232	1.368							
	0.53	22.16	22.13	-0.16%	-0.273	1.346							
	0.36	17.60	17.60	0.00%	-0.446	1.246							
SET3	0.63	24.30	24.34	0.15%	-0.201	1.386							
	0.59	23.50	23.48	-0.09%	-0.228	1.371	Comments:		Average (ABS) of difference between AliCal VS Digital MAG				
	0.49	21.03	21.03	0.01%	-0.312	1.323			0.01%				
	0.39	18.54	18.54	0.01%	-0.407	1.268							

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. Record the magnehelic reading for each filter position on cells B7-B18 of the calibration spreadsheet.
13. Record the calibration date, technician name, ambient temperature, and pressure on the spreadsheet.
14. 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.
15. If the r2 is not better than 0.990, the calibration is invalid. Repeat the orifice meter calibration procedure, beginning with step 2.
16. 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 attach it to the side of meter magnehelic.
17. Save the calibration spreadsheet.
18. Share the results of calibration spreadsheet with the field or shop manager for approval.

10. DATA AND RECORDS MANAGEMENT

All calibration data is stored on a spreadsheet specific to each individual magnehelic probe on the network drive. It is the responsibility of the field technicians to immediately maintain a written record for all calibrations/audits performed on a device.

11. QUALITY ASSURANCE AND QUALITY CONTROL

The magnehelic probes are audited against the primary standard before and after every in-field use. If the calibration drifts more than 2% flow, then the probe is recalibrated and all flow checks performed by said probe are reviewed for accuracy.

The primary standard is sent to the manufacturer every year for recertification.

12. REFERENCES

UCD IMPROVE SOP #201: Sampler Maintenance