UCD IMPROVE Technical Instruction #226C

Flow Adjustments

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

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DOCUMENT HISTORY

Date Modified	Initials	Section/s Modified	Brief Description of Modifications
05/04/21	SRS	All	Separated TI: A-H doc into individual TIs.
5/17/21	IVP	6,7,10,11	Added missing sections

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LIST OF FIGURES

1. PURPOSE AND APPLICABILITY

The purpose of this Technical Instruction (TI) 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 flow adjustment of the modules after completing a flow check and general cleaning of the equipment. The flow adjustment 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. DEFINITIONS

- Cassette: a plastic holder that contains a filter substrate or dummy.
- Dummy: a 25 mm or 37 mm piece of material used in cassettes that are not sampled.
- Cartridge: consists of a cartridge plate and 3-4 cassettes inserted in the cartridge plate.
- $PM_{2.5}$: Particulate matter, aerodynamic diameter of 2.5 micrometers or less.
- PM_{10}: Particulate matter, aerodynamic diameter of 10 micrometers or less.
- 1A module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with Teflon® as the filter medium and runs at 23 liters per minute.
- 2B module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with nylon as the filter medium and runs at 23 liters per minute.
- 3C module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with quartz as the filter medium and runs at 23 liters per minute.
- 4D module: one of four channels routinely run at every site in the IMPROVE network. Measures PM_{10} with Teflon® as the filter medium and runs at 16.9 liters per minute.
- 5X module: a duplicate of 1A or 2B or 3C or 4D module installed at selected site for quality assurance purpose.
- 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
- Stack: inlet tube for module
- Inlet: cap over $PM_{2.5}$ stack with insect screen
- Magnehelic: device that measures differential pressure in mercury (Hg), used for flow checking modules.
- Sierra inlet: EPA Louvered PM_{10} Inlet
- EPA: Environmental Protection Agency

4. HEALTH AND SAFETY WARNINGS

Not applicable.

5. CAUTIONS

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

6. INTERFERENCES

The magnehelic probe device relies on an accurate measurement of atmospheric pressure on one leg of the pressure tube. On windy days the wind will cause pressure fluctuations on the open end and lead to an inaccurate flow measurement. Using the wind damper device shown in Figure 2 prevents measurements from the effect.

7. PERSONNEL QUALIFICATIONS

Flow adjustments 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 technicians closely following printed instructions and/or and instructional video.

8. EQUIPMENT AND SUPPLIES

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

- Magnehelic and Probe
- One flow adjustment 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/ flow adjustment sheet.

9. PROCEDURAL STEPS

9.1 Preparing the Modules and Controller for the Flow Adjustment

1) Open the controller door and press the **Home** 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 adjustment cartridge into its corresponding module.

9.2 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 ten minutes.
2) To take the temperature reading from the probe, record the temperature from the upper right corner of Home Screen. Record this value in cell C18 of the "Site and Device Data" sheet. Then, record the value reported by the thermometer in cell C17.
3) To take Vac/Max Orifice (or MxORI) values, access the Flow Adjustment Mode, as described previously, or use the Vacuum Test option from the Equipment Tests menu. All the pumps should turn on in Vacuum Test mode. If in Flow Adjustment mode, turn on the pump, and make sure all solenoids are off. After running for a few seconds, MxORI values will appear for each module. Record the values for each module in cell D20 for each module-specific sheet.
4) To take zero values for the Flow/CYC and Pres/ORI of each module, access the Flow Adjustment Mode, open a single solenoid and make sure the pump is off. Note that if the system was sampling upon arrival, the pump will be running and will need to be turned off by pressing **Pump: On** so that it will read "Pump: Off". The controller display will show the zero values for the 1A module. Enter the values in cells D21 and D22 of the 1A module sheet. Cycle through the modules by pressing > and record the values in the appropriate sheets and cells, making sure that no pumps are running during the measurement. When finished with the last module, press the **Home** button to exit the Flow Adjustment Menu.

9.3 Preparing the 1A Module and Magnehelic

1) Place the magnehelic on the inside of the module 1A door. Note that the magnehelic is digital so orientation doesn't matter. Make sure the magnehelic reads "0.000" when on. If not, hold the "Zero" button on the magnehelic until it reads zero. The magnehelic has a magnet on the back, so it will stay attached to the door. If it is windy out, it is necessary to try to shelter the ambient pressure hose from the wind, without plugging it. This is best accomplished by attaching the ambient hose end to the PVC dampener included in the kit (Figure 2).

2) 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.

3) 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.

4) On a windy day, the magnehelic reading may fluctuate. Remedy this by attaching the ambient hose end to the PVC dampener included in the kit (Figure 2) as mentioned above.

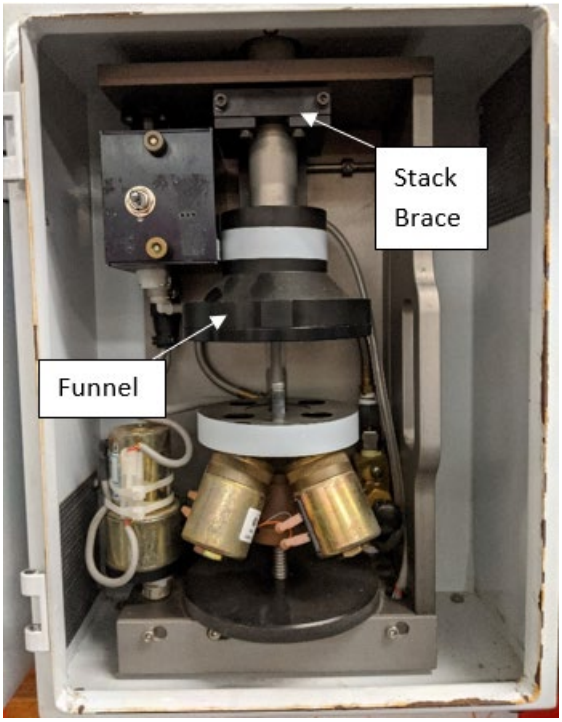
Figure 1. Removing the plastic cap and stack plug and inserting the probe into the tee.

Figure 2. Attaching the PVC dampener.

9.4 Preparing Module 4D

1) In order to flow adjust 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.



9.5 Beginning the Flow Adjustment

1) Return to the controller's display. From the Home Screen, press the **Menu** button, then **Advanced Menu**, enter code **9051**, press **Submit** press the **More** button, and press **Flow Adjustment**.
2) Note that zero flows are no longer set for each module. The zero flow measurements are actual pressure measurements and reflect environmental conditions. The Flow/CYC sensor should be very close to zero (± 0.02) and the Pres/ORI sensor will be around 14.7 psi at sea level and reducing linearly with elevation.
3) The flow adjustment cartridge has a filter in its first position, and physical restrictions of increasing resistance in each consecutive position. Open the first solenoid by pressing **S1: Off** so that it reads "S1: On". Turn on the pump by pressing **Pump: Off** so that it reads "Pump: On".

9.6 Filling in the Flow Adjustment Sheet

1) The display will show two values (CYC and ORI). The magnehelic will indicate a value as well. Look at the number in cell D23 ("Set Flow"). If there is no number listed, enter the device constants into cells C10 and C11 of the "Site and Device Data" sheet (which are located on the flow check device case) and a number should be generated. The number in cell D23 will be around 23.0 LPM, depending on temperature. This will be the value that you will adjust the flow rate to, as displayed

by the controller screen. To achieve this flow rate, manipulate the valve 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 controller displayed flow rate value (to the right of the CYC pressure reading measured in " H_2O matches that of the value in D23. Record the value reported by the magnehelic for that position in cell E20.

2) Look at the controller display. It will show two values for position #1, the Cyclone (CYC) and the Orifice (ORI). Enter these in cells F20 and G20, 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 **S2: Off** and **S1: On** button to move to the second position of the calibration cartridge and close the first solenoid. The buttons should read "S1: Off" and "S2: On". Record the magnehelic and CYC/ORI values in cells F21 and G21. 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.

9.7 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.

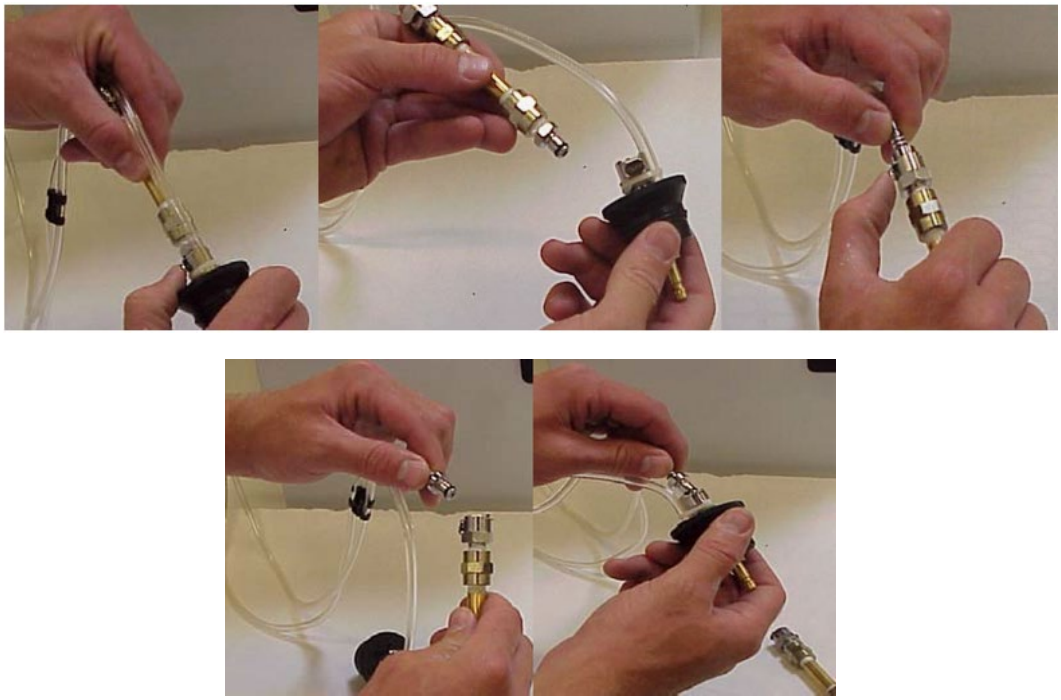
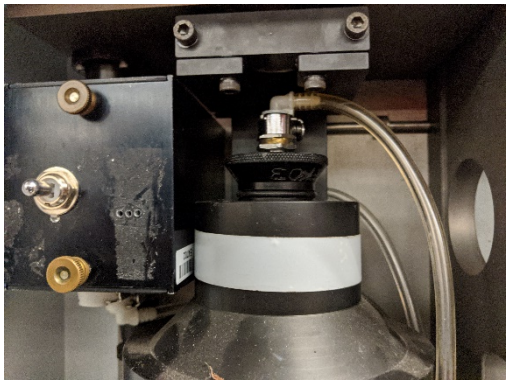


Figure 6. Placing the probe in Module 4D.



9.8 Flow Adjusting 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 adjustment probe in the funnel of the 4D module, the 4D module flow adjustment can now be completed. Repeat the steps in 5.4 for the 4D module with a couple of exceptions. The number listed in cell D23 ("Set Flow") will be different than the one used for the previous modules. This is because 4D modules run at a different flow rate. The value in cell D23 should be around 16.9 LPM. The 4D module does not have a functioning CYC, so only the magnehelic and orifice values need to be recorded for each position.

9.9 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.
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

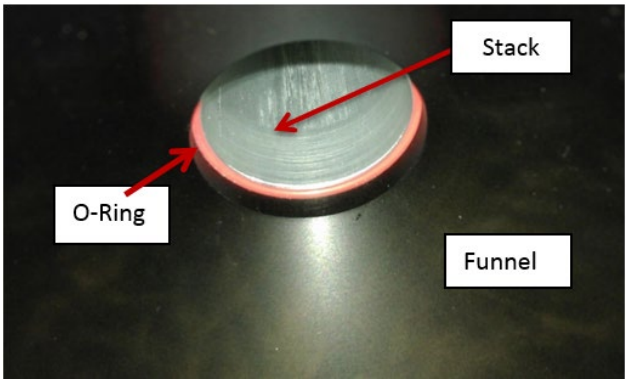
lip of the 4D funnel.

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 flow adjustment is complete:
    - Double-check that all black plastic caps and stack tee 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 adjustment 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 exposed (final) readings for all modules, install clean sampling cartridges, and take clean (initial) readings.

Figure 7. Removing the bottom lid of Module 4D.

Figure 8. 4D O-Ring between stack and funnel.



9.10 5X 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 flow adjustment accordingly.

10. DATA AND RECORDS MANAGEMENT

Data recorded from the flow check is stored on am excel spreadsheet. When technician returns from maintenance, he is responsible for storing this spreadsheet on the network drive in a folder of all flow checks performed at this site.

11. QUALITY ASSURANCE AND QUALITY CONTROL

Flow accuracy displayed on the controller is important for the proper function of the sampler. This accuracy is checked periodically by external EPA audits, and by the next visiting field technicians.

12. REFERENCES

Not Applicable