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UCD IMPROVE Technical Instruction #226B

Flow Check

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

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DOCUMENT HISTORY

Date Modified	Initials	Section/s Modified	Brief Description of Modifications
04/26/21	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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1. PURPOSE AND APPLICABILITY

The purpose of this TI 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. DEFINITIONS

- Cartridge: consists of a cartridge plate and 3-4 cassettes inserted in the cartridge plate.
- $PM_{2.5}$: Particulate matter, aerodynamic diameter of 2.5 mm or less.
- PM_{10}: Particulate matter, aerodynamic diameter of 10 mm or less.
- 1A module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with Teflon® as the filter medium and runs at 23 liters per minute.
- 2B module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with nylon as the filter medium and runs at 23 liters per minute.
- 3C module: one of four channels routinely run at every site in the IMPROVE network. Measures $PM_{2.5}$ with quartz as the filter medium and runs at 23 liters per minute.
- 4D module: one of four channels routinely run at every site in the IMPROVE network. Measures PM_{10} with Teflon® as the filter medium and runs at 16.9 liters per minute.
- Stack: Inlet tube for module.
- Inlet: Cap over $PM_{2.5}$ stack with insect screen.
- Magnehelic Probe: Custom device that measures differential pressure across an arbitrary restriction created for the purpose of flow measurements.
- NIST: National Institute of Standards and Technology
- Sierra inlet: EPA Louvered PM_{10} Inlet.

4. HEALTH AND SAFETY WARNINGS

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

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

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

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

Refer to TI 226G for more information.

5. CAUTIONS

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.

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 3 prevents measurements from the effect.

7. PERSONNEL QUALIFICATIONS

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

8. EQUIPMENT AND SUPPLIES

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

- Magnehelic and probe
- One flow check cartridge for each module being checked, four maximum
- One 5/32" hex key
- NIST-certified thermometer

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

9. PROCEDURES

9.1 Preparing the Modules and Controller for the Flow Check

1) Open the controller door and press the **Home** button if the display is not on main screen, 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.
4) Access pump and solenoid control through the Flow Adjustment option of the Maintenance Menu. From the Home Screen, Press Menu, Advanced Menu, enter code 9051, press Submit, press More and Flow Adjustment will be the second menu option.

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 five to ten minutes.
2) To take the temperature reading from the probe, look at the temperature displayed in the upper right corner of the Home Screen. Record this value in cell C16 of the sheet titled "Site and Device Data". Then, record the value reported by the thermometer in cell C15.
3) To take Vac/Max Orifice (or MxORI) values, enter the Flow Adjustment Mode. For each module turn on its pump and no solenoids. Record the values for each module in cell B8 for each module specific sheet.
4) To take zero values for the Pres/ORI and Flow/CYC of each module, go to the Flow Adjustment menu option. Note that if the system was sampling upon arrival, the pump must be stopped before measuring zero flows. With the pump off and at least one solenoid open, the controller display will show the zero values for the 1A module. Enter the CYC Zero and ORI zero values in cells B9 and B10, respectively, of the 1A module sheet. Navigate through each module by pressing the > button and record the values in the appropriate sheets and cells. 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 it is digital so orientation doesn't matter. The magnehelic has a magnet on the back, so it will stay attached. Make sure that the magnehelic reads "0.000," when turned on. If not, hold the "Zero" button to reset the value to zero.
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. To keep the reading stable, use the PVC cylinder included in the Flow Check Kit. If no PVC cylinder is included, wrap the open end of the Tygon tubing with a piece of laboratory wipe, making sure not to block or restrict any of the holes on the probe or pressure hoses.

Figure 1. Removing the plastic cap and stack plug.

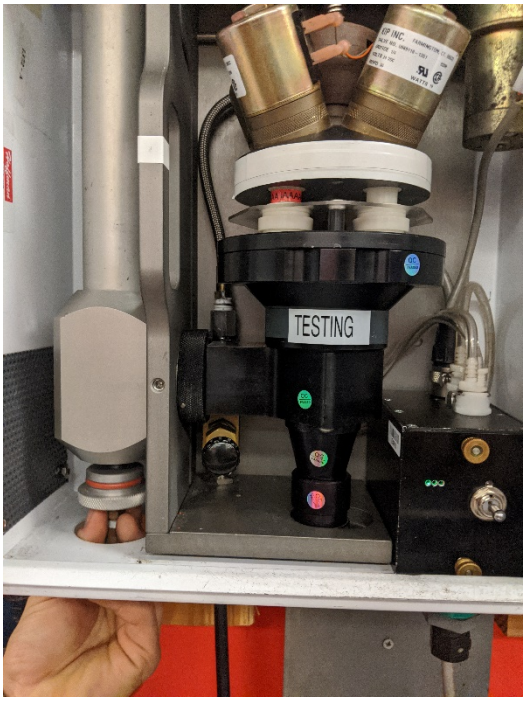


Figure 2. Inserting the probe into the tee.

Figure 3. Attaching the PVC dampener.

9.4 Begin the Flow Check

1) Return to the controller's display. From the Advanced Menu enter **9051** and press **Submit**. Press **More** and then **Flow Adjustment**.
2) The module 1A sensor data will be displayed. Turn on solenoid 1 by pressing **S1: Off**. Turn the pump on by pressing **Pump: Off**. The magnehelic pressure gauge will move from the 0" H2O position to a value greater than 0.

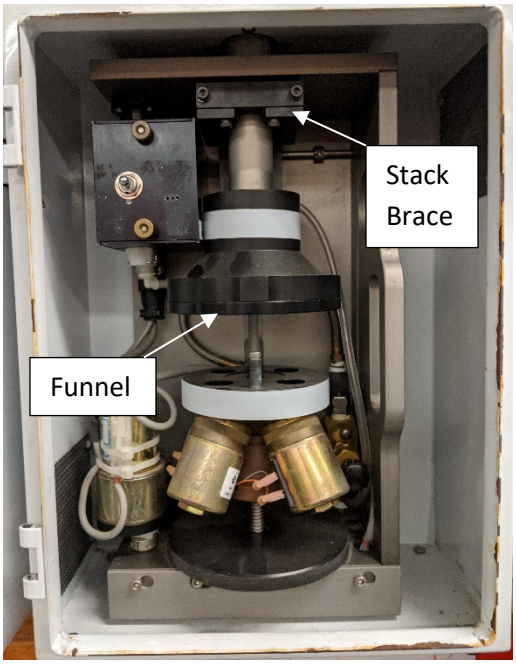
9.5 Filling in the Flow Check Sheet

1) Check the magnehelic value. Enter the displayed number into cell C8 of the flow check sheet, making sure to place a decimal before the number.
2) Look at the controller display. It will show two values for position 1, the Flow/Cyclone (CYC) and the Pres/Orifice (ORI) sensor values. Enter these in cells D8 and E8, 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 **S1: On** button and then the **S2: Off** button to move to the second position of the flow check cartridge. The buttons should now read "S1: Off" and "S2: On." Record the magnehelic and CYC/ORI values in cells D9-E9. Repeat the previous steps 1 and 2 for each of the four positions, making sure the correct solenoid is open and record the values in the appropriate cells.
4) Repeat steps 1-3 for modules 2B and 3C.

9.6 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 4. Module 4D.



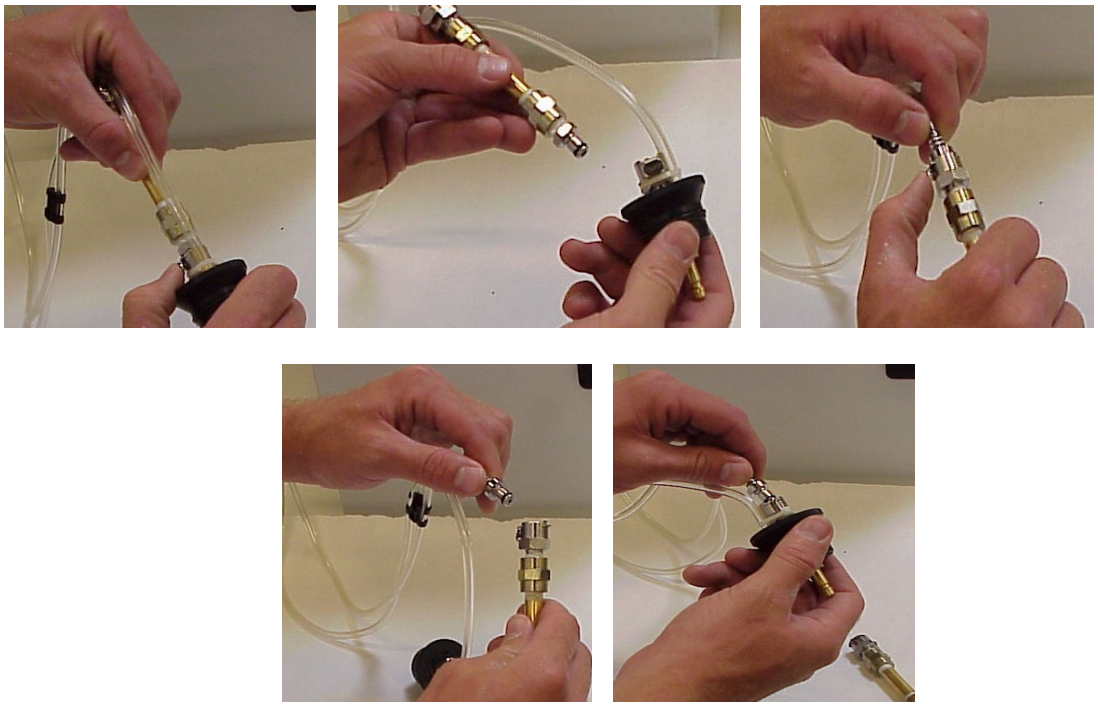
9.7 Preparing the Magnehelic Probe

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.
- Second, 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 5. Releasing the probe plug.

Figure 6. Modifying the probe.



9.8 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 section 5.4 for the 4D module.

Figure 7. Inserting the flow check probe into the 4D Module.

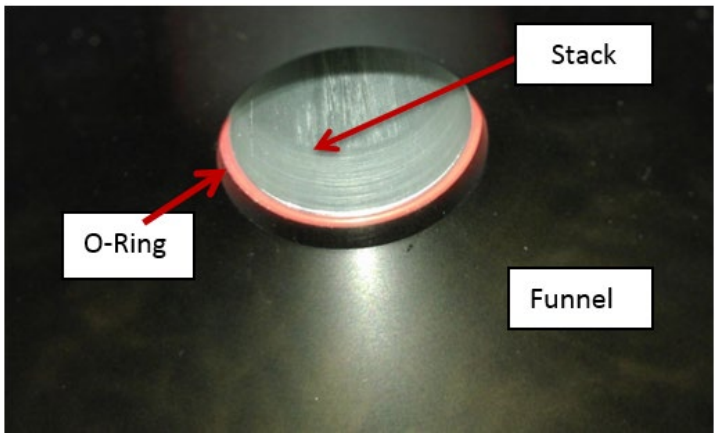
9.9 Re-installing the 4D Stack

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 8). Sometimes it is necessary to use a soft mallet to gently tap the bottom lid to separate the two pieces.

Figure 8. Removing the bottom lid of 4D Module funnel.

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 (or black) O-ring as in Figure 9.
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 9. 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 flow adjusted, 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.

9.10 5X 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.

10. DATA AND RECORDS MANAGEMENT

Data recorded from the flow check is stored on am excel spreadsheet. When technicians return from maintenance, they are 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

If the flow measurement is outside 10% of nominal values, the discrepancy must be reported to the data validation group for proper flagging. In these circumstances the technician should do their best to explain the reason for the discrepancy as the reason will help narrow down when the sampler failure was likely to occur in the preceding 2-year period leading up to site maintenance. Technicians carry a backup Magnehelic device for these situations. Verify any out of specification measurements with the backup device by creating a copy of the flow check excel spreadsheet labeled accordingly. When returning back from maintenance both, primary and backup Magnehelic device are audited for accuracy and will inform the technician on what data is valid.

12. REFERENCES

Not Applicable