

6.0 Performance Audit Procedures for PM_{2.5} Speciation Samplers – IMPROVE

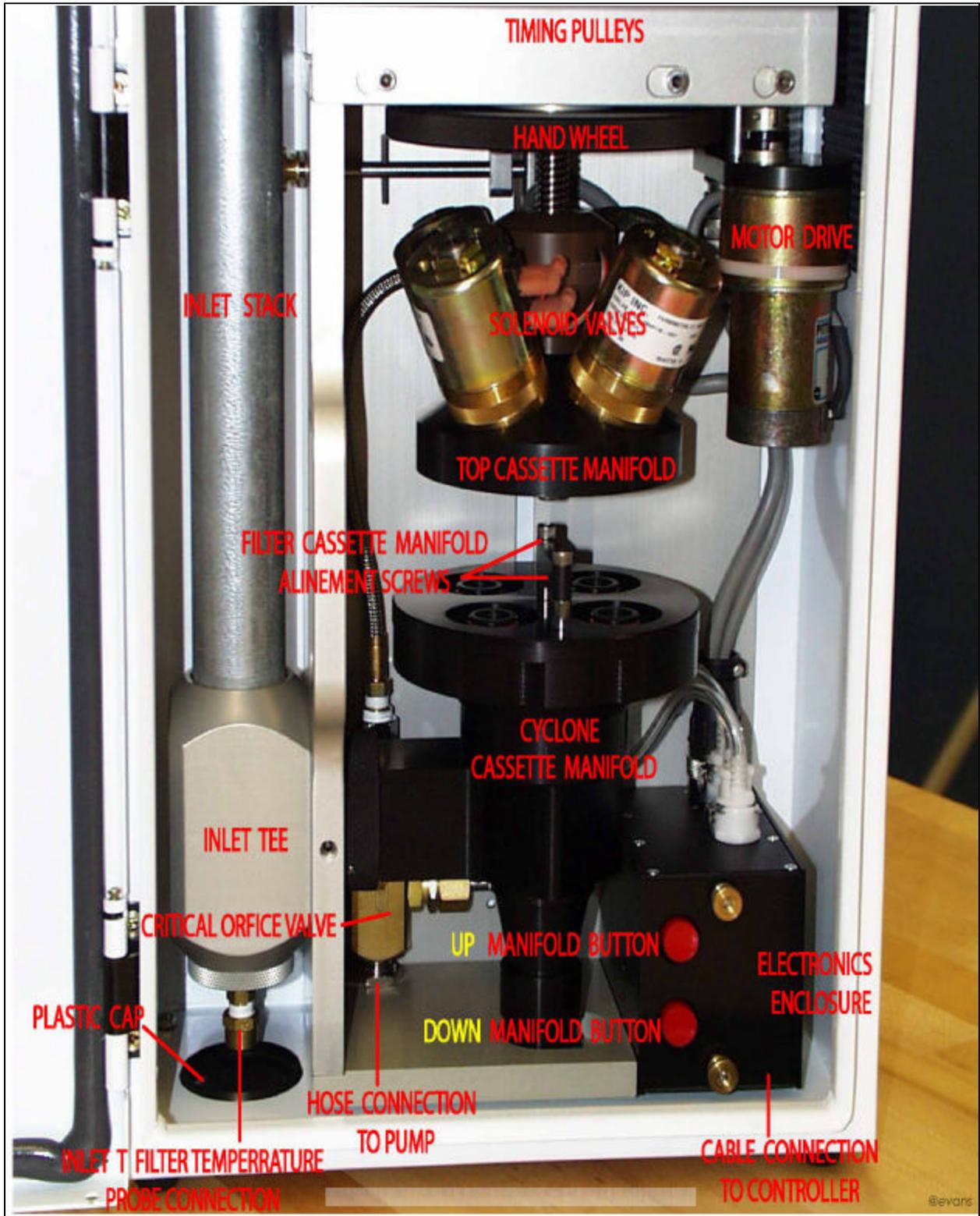


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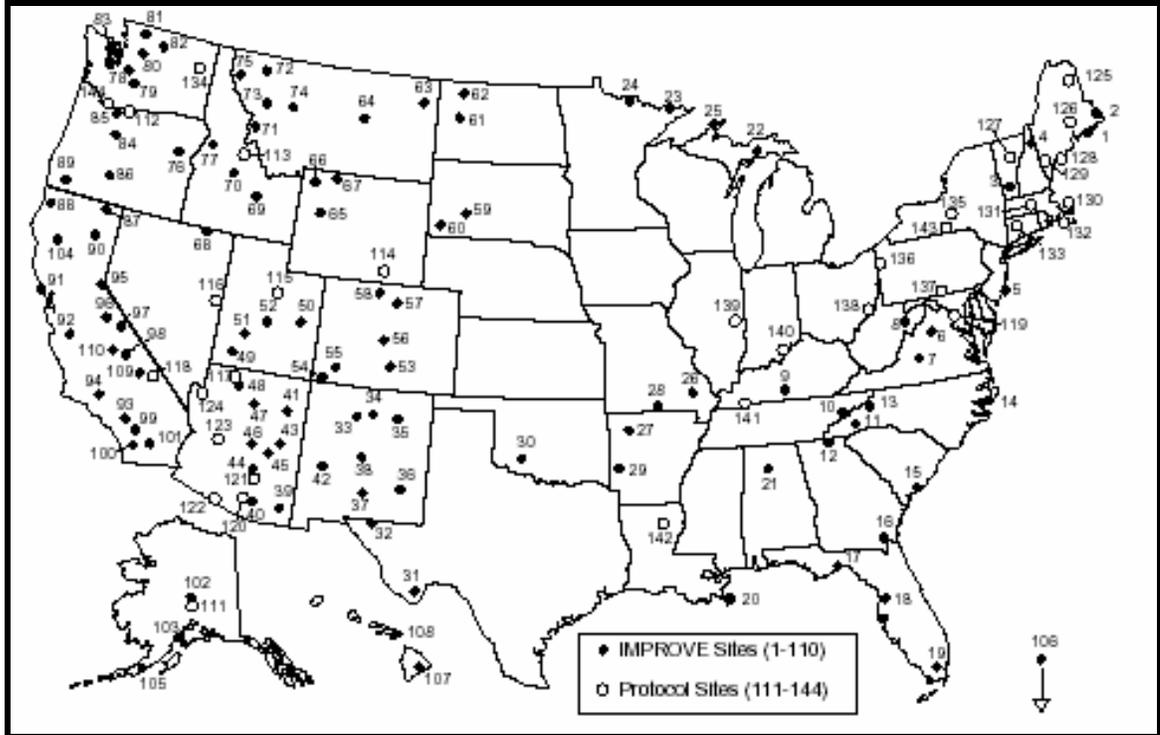
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6.1 Background

The IMPROVE visibility program (Interagency Monitoring of Protected Visual Environments) is a cooperative measurement effort designed to establish current background aerosol concentrations in mandatory Class I areas, identify chemical species and emission sources responsible for existing man-made visibility impairment, document long-term trends, and to provide regional haze monitoring when obtainable at mandatory Class I areas. The following figure (Figure 6-1) provides a map of the current IMPROVE site locations.

Figure 6 -1: IMPROVE aerosol sites in early 2001.



The IMPROVE sampling frequency is 1-day-in-3 protocol (sampling for one 24-hour period, every third day). On-site operators will change samples once a week, and send them to Crocker Nuclear Laboratory for analysis of major aerosol components and trace metals. Validated concentrations will be available to all parties and to the public via electronic transmission and printed data reports.

6.2 IMPROVE Sampler Description

The IMPROVE sampler has been designed to collect and measure airborne particles affecting visibility. Two types of particulate matter are collected: $PM_{2.5}$ and PM_{10} . There are four sampling modules excluding the controller module - Module A, Module B, Module C, and Module D. Table 6-1 lists the analytical measurements for each module. Modules are mounted from left to right, in alphabetical order. Filter cartridges in modules A and D (cassettes 1 and 2 only) may be either masked (masking the cassettes allows more concentrated material buildup on the filter through the reduction in surface area) or unmasked. Masking filters is dependent on location (rural vs. urban). Rural locations have less buildup resulting in less-sensitive results. This results in increased sensitivity and thus data results.

Table 1: Analytical measurements for each module.

Module	Size Region	Filter	Analytical Measurement
A	PM _{2.5} particles	Teflon	mass, optical absorption, elemental (H, Na-Pb)
B	PM _{2.5} particles	nylon with denuder	nitrate, sulfate, chloride
C	PM _{2.5} particles	quartz	organic and elemental carbon
D	PM ₁₀ particles	Teflon	PM ₁₀ mass

6.3 Audit Procedure

Prior to conducting an audit, ensure that the site location to be audited is not scheduled as a sample run day. Performing an audit on a sample collection date could potentially interfere with data results.

Note: Sampling dates can be determined from Table 5 of the Version II IMPROVE Sampler Operating Procedures Manual. For convenience, the table listed above has been included in Attachment 6-1.

If the air sampler is to be interrupted, manually note the following parameters: date and time that the air sampler was interrupted, or any damage done to sampling filters. This information must be included in the Quality Assurance Audit Report prepared by the auditor or auditing agency. This information is also recorded in the Control Module memory which is downloaded and sent with the samples so when the samples are analyzed the 'flags' can be addressed.

Prior to the site visit, obtain the flow rate correlation factors (coefficients), site altitude, and site operator information from the pre-established contacts (see Attachment 6-1). Additional items may be needed such as red caps (necessary to plug sample cassettes upon removal of sampling cartridges from sampling unit), and type of cartridge located in the sampling station (masked/unmasked) will need to be known. If cassettes are masked, the auditor must provide a masked audit cartridge for the appropriate module. Record this information on the IMPROVE Performance Audit Worksheet.

Calibration instrument checks need to be conducted prior to field activities. These checks will include calibration date verifications, battery voltage (must be within 10%), sensor checks (temperature probe), and ensuring all necessary ancillary equipment (including spare batteries) is with instrument. If the instrument is out of calibration, do NOT use and return to vendor for re-calibration.

6.3.1 Additional Information Acquired On-Site Prior to Audit Commencement

The following information must be obtained and documented on the IMPROVE Audit Worksheet prior to commencement of the sample audit: sampler location, audit date, auditor(s) name, auditor(s) affiliation, collocation, operator name, operator affiliation, sampler calibration date, sampler calibration due date, site altitude, NIST traceable reference standard serial number and calibration date, and site code.

Module cassette type for Modules A and C must also be known prior to site visit so that the proper cassette is used during calibration. For example, Module A uses masked or unmasked cassettes, and Module C uses single or double filtered cassettes.

6.3.2 Temperature Check

Upon arrival at the site, unpack the TriCAL and turn it on by pressing the on/off switch located at the side of the instrument (Figure 6-2). The LCD will display a menu that prompts the user to insert venturi #1, #2, or #3. The appropriate venturi to be used is determined by the flow rate of the air sampler being audited. Once the flow venturi (flow venturi #1: 6-30 LPM) has been inserted in the TriCAL, the TriCAL will perform a self-calibration test of the venturi (Figure 6-3 and 6-4).

Figure 6 -2: TriCAL calibration instrument.



Figure 6 -3: Inserting venturi into TriCAL.

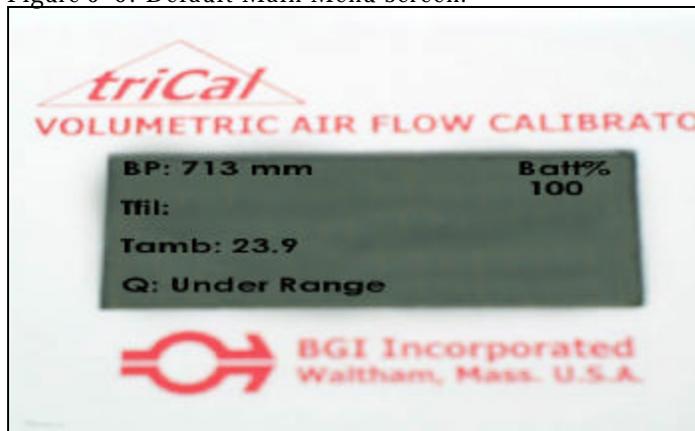


Figures 6 -4: Venturi self-calibration screen.



Once the venturi has been calibrated, the TriCAL will default to the Main Menu screen displaying barometric pressure, battery capacity, temperature, and flowrate (Figure 6-5).

Figure 6 -5: Default Main Menu screen.



Attach the ambient temperature probe to the TriCAL (Figure 6-6). A value for the T_{fil} will then be displayed which is the temperature reading of the probe. T_{amb} is the displayed reading of the internal temperature sensor of the TriCAL.

Figure 6 -6: Inserting temperature probe.

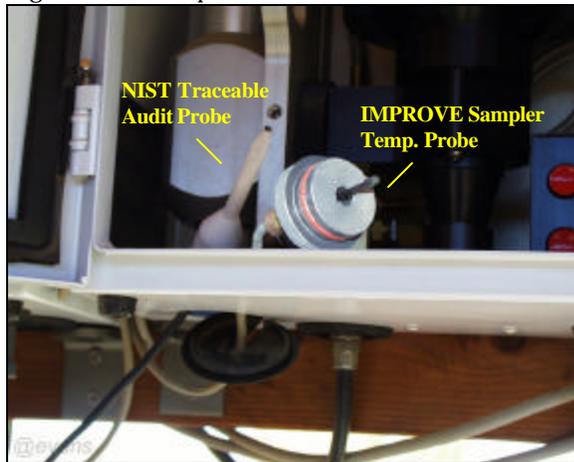


A single thermocouple probe is used to determine ambient temperature in the IMPROVE sampler. It is *normally* installed in the bottom of the inlet tee of Module C (see Figure 6-7) – it may also be found in the inlet tee of Module B. Open the module containing the temperature probe (it can be found by tracing the temperature probe wire from the controller module), and carefully remove the probe plug and set it inside the module, away from direct sunlight (exposing the probe to ambient conditions). Place the reference temperature probe (TriCAL) alongside the sampler temperature probe and allow both temperatures to equilibrate (see Figure 6-8). If it is windy, it might be a good idea to place probes into the module for reading. This will minimize interference from wind.

Figure 6 -7: Temperature Probe in Module C.



Figure 6 -8: Temperature Probes.



From the beginning menu, on the terminal keypad in the IMPROVE controller Module, press *Enter* key twice to enter the *Main Menu*. Press *1* (**not FI**) to display the filter and ambient temperatures. Temperature values must be recorded, from the displays on both the IMPROVE sampler and the TriCAL reference probe, in the Performance Audit Worksheet after the audit has been completed. Temperature is recorded after the audit to ensure that temperatures have had ample time to equilibrate to ambient temperatures.

6.3.3 Clock Check

From the Main Menu screen, of the IMPROVE Controller Module, record the sampler clock time and the NIST audit clock time on the Performance Audit Worksheet. The NIST time is obtained through the use of a portable atomic watch.

Press the *Enter* key twice to return to the *Beginning Menu*.

6.3.4 Flow and Leak Checks

Attach the tygon tubing to the TriCAL venturi hose adapter. Next, attach the hose adapter to the venturi. (Figures 6-9 and 6-10) (**Note: The correct venturi hose adapter is determined by the size of the venturi that was inserted into the TriCAL, in section 6.3.2.**)

Figure 6 -9: Attaching tubing to venturi hose adapter.



Figure 6 -10: Attaching venturi hose adapter to the venturi.



Leak and flow checks for Modules A, B, and C are conducted in a similar manner to one another. The differences will be discussed during the audit procedure.

MODULE A

Open the module door and press the (**Up**) Manifold red button (located in the lower right hand corner of the module enclosure) to raise the Top Cassette Manifold. When raising the cassette manifold, the sample cartridge will automatically pop loose. Remove the sample cartridge and place aside (inside the module with the filter side facing the module enclosure – this minimizes filter exposure to the ambient air and unnecessary loading) during the audit procedure. (Figure 6-11)

Figure 6 -11: Sample filter cassette placement, and **Up** & **Down** Manifold buttons.



Install the audit filter cartridge **of the same type** (cartridges are distinguished by a colored dot and are identified on the inside of the Module door). Ensure that the caps are removed from the audit filter cartridge prior to inserting into sampler. Align the cartridge with the alignment pins located on the cassette manifold. Press the lower red button until the manifold is down and locked in place. (Figures 6-12 – 6-16)

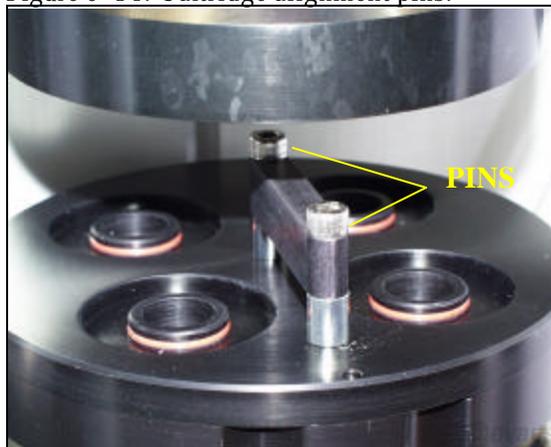
Figure 6 -12: Filter cartridge identification procedure.



Figure 6 -13: Audit cassette caps.



Figure 6 -14: Cartridge alignment pins.



Figures 6-15 & 6-16: Filter cartridge placement.



Next, loosen the inlet compression sleeve (on top of the module box), and then lift the inlet stack from the inlet tee exposing the inside of the inlet tee. (Figure 6-17 – 6-19). Retighten the compression sleeve (with the raised inlet stack) so that the stack is high enough above the tee to allow access to the tee inlet port.

Figures 6-17 & 6-18: Loosening compression sleeve and raising the inlet stack.



On the Control Module keypad press the *Enter* key twice to enter the *Main Menu*. The press *F3* to enter the *Advanced Menu*. The screen will prompt the user for a user-authorization code. Press the *1* key twice, the *2* key once, the *3* key once, and then the *Enter* key. This results in the following code: *1123* being entered on the Control Module. All Control Modules use the same code.

Press the *F1* and *Enter* keys to enter the *Calibration Menu*. At this menu press the *Enter* key again to start the pump for Module A, cartridge cassette No. 1). There are 4 filter cassettes per cartridge. 'Module A, F1' will then be displayed on the Controller module digital display. This translates to Module A, filter cassette 1 is now sampling.

Note: To select a specific sampler module (A,B,C, or D) or filter cassette (1- 4), use the F3 and F4 keys. These steps are necessary for auditing the other modules. Dependent on site, Module cartridge may contain either masked or unmasked filters (section 6.3.1). This information is necessary so that the correct filter cassette is used during the audit. The cassettes are arranged in order as follows:

Cassette1: unmasked

Cassette 2: masked

Cassette3: unmasked

Cassette 4: masked

Remove the black plastic filler cap (located just below the inlet-T of the Module A enclosure). (Figure 6-19) Place the plastic filler cap on top of the inlet tee port to block any air passage, then allow the system to stabilize (Figure 6-20).

Figure 6 -19: Black Filler Cap

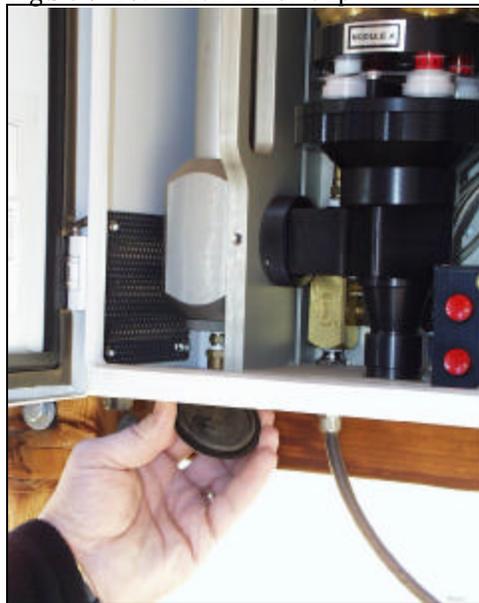


Figure 6 -20: Filler Cap placement on inlet-T



Figure 6 -21: Inlet-T Leak Check



Record the vacuum reading from the Control Module screen onto the Leak Test portion of the Performance Audit Worksheet. Carefully, slowly remove the cap from the inlet tee. If this cap is removed too quickly the vacuum seal will cause the cassette filter to be expelled from its cassette and will be lodged in the upper cassette manifold.

The next procedure in the audit process is the Flow Test. There are two sizes of adapters that are used in this procedure the smaller adapter is used in module D. (Figures 6-22 – 6-23) With the correct flow adapter selected attach the hose from the TriCAL Venturi Hose Adapter to the flow Audit Adaptor, inserting the flow adapter into the inlet tee ensuring that there is a complete seal. Allow the system to stabilize. (Figure 6-24 – 6-27). On the Performance Audit Worksheet record the Magnehelic and Vacuum readings, from the control module display, in the row marked *Readings (Raw)*. Also record the reference std., (TriCAL) flow meter reading.

Figures 6-22 & 6-23: Flow audit adapters.



Figures 6-24 & 6-25: Attaching hose to flow audit adapter and inserting the adapter into inlet-T.



Figure 6-26 & 6-27: Flow audit adapter in inlet tee and flow audit device.



Note: On the module with the temperature probe (Modules B or C), it is necessary to place the temperature plug (Figure 6-28) in the bottom of the inlet tee before conducting the leak and flow tests. After the tests, remove the temperature plug and reinsert the temperature probe to its original position making sure that it is completely sealed in place.

Figure 6 -28: Temperature plug (Module B or C).



Once the flow test is complete, press the *Enter* key twice to return to the *Beginning Menu*. This will automatically stop the sampler pump.

Remove the flow adaptor and return the inlet stack to its original position by loosening the compression sleeve, and **pushing the stack down until it is properly seated**, and retightening the sleeve (see Figures 6-17 and 6-18). Use caution when seating the stack to ensure that the O-ring is not damaged in this process.

Using the red **Up & Down** Manifold buttons (Figure 611), remove the audit filter cartridge and reinsert the original sample filter cartridge, ensuring that it is properly seated, completely closed and ready for the next sample run prior to moving to the next module.

MODULES B and C

Perform the steps outlined above for MODULE A. In the *Calibration Menu* use the *F3* and *F4* keys to toggle to the appropriate module. The selected module will appear in the upper left hand corner of the Control Module's display.

Note that Module B's inlet stack contains a carbonate-coated, glass annular denuder that slides freely inside the inlet stack. The denuder structure is very fragile and must be protected from any impact - handle carefully.

Also note that dependent on site, Module C cartridge may contain either single or double filters (section 6.3.1). This information is necessary so that the correct filter cassette is used during the audit. The cassettes are arranged in order as follows:

- Cassette1: single filter**
- Cassette 2: double filter**
- Cassette3: single filter**
- Cassette 4: double filter**

When conducting leak and flow tests, the denuder must be slid up into the inlet stack and held in place while placing either the black filler cap or the flow adapter onto the inlet tee. The denuder will then be gently lowered onto the filler cap and/or flow adapter. (Figures 6-29 – 6-32)

After the audit has been completed for the module containing the denuder, ensure that the denuder is properly positioned and aligned in the inlet tee, with the alignment indicator facing to the front and center of the inlet tee and inserted past the O-ring. Then lower the inlet stack over the denuder and seat it into the inlet tee O-ring ensuring there are no leaks (Figure 6-33).

Figures 6 -29 and 6-30: Inlet tee and denuder.

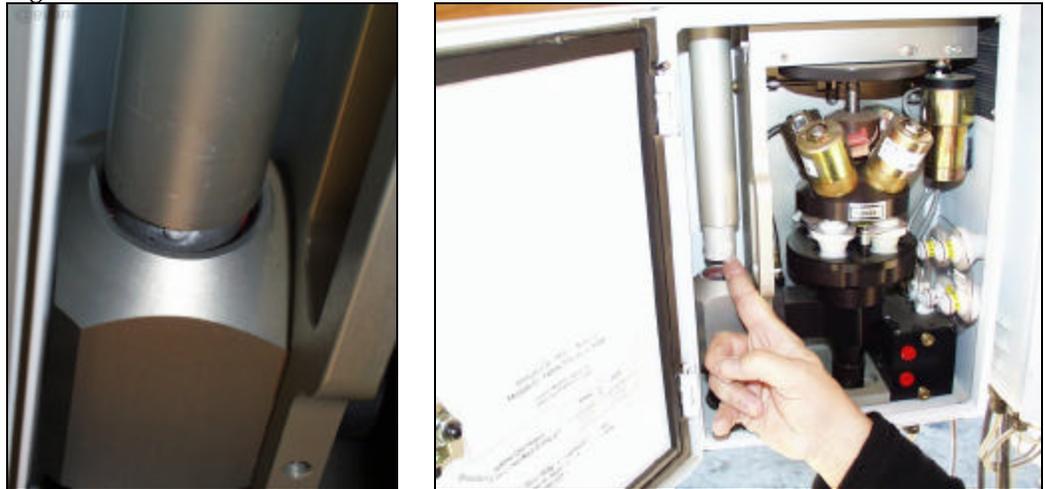


Figure 6 -31 and 6-32: Hose assembly flow and leak checks.



Figure 6 -33: Proper seating of denuder.



MODULE D

In Module D (PM₁₀ sampler) the sampled ambient air does not go through an inlet tee assembly, but comes in straight to the cassette manifold via the inlet stack. As a result, only a vacuum flow reading is used to measure the airflow. Switch the sample filter cartridge with the same type of audit cartridge. The bottom red button raises the manifold and the top button lowers it - this manifold is installed upside down; therefore, the raise and lower functions are reversed from Modules A, B, and C.

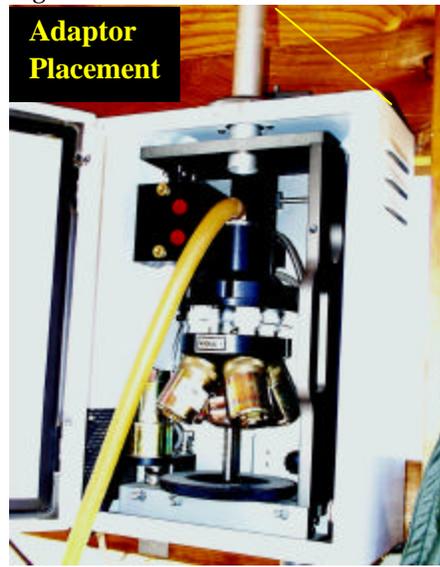
(Figure 6-34)

Figure 6 -34: Module D.



Loosen the compression sleeve (on top of the module box) and raise the inlet stack off of the cassette manifold high enough to accommodate the flow audit adaptor placement into the inlet of the cassette manifold (Figure 6-35) and the black plastic cap.

Figure 6 -35: Module D flow audit adaptor placement.



Follow the procedures outlined in the Module A section to select Module D and start the sampling process, place the black plastic cap on top of the inlet of the cassette manifold, allow the system to stabilize then record the vacuum reading on the Leak Test portion of the Performance Audit Worksheet for Module D.

Slowly remove the black plastic cap and insert the correct flow audit adaptor for the reference standard flow meter (this module requires a different sized adaptor than Modules A, B, and C). After the flow has stabilized, record the vacuum reading for the module in the row marked *Readings (RAW)* on the worksheet. Also record the reference standard flow rate reading (TriCAL).

Return the sampler to its original state. Restore the sampler controller module back to the main menu. Ensure that audit filter cassettes are capped prior to packaging. This completes the audit procedures for the IMPROVE air sampler.

Attachment 6-1 – Table 5 of the Version II IMPROVE Sampler Operating Procedures Manual.

Appendix II. Dates of Sample Collection for Every Third Day

The dates of sample collection for every third day are listed in Table 5.

Table 5. Dates of sample collection for every third day.
 Dates where the sample collection is on a Tuesday are underlined.

2000			2001			2002			2003			2004		
5/1	5/3	5/3	5/1	5/1	5/1	5/2	5/2	5/2	5/3	5/3	5/3	5/1	5/3	5/3
<u>5/4</u>	5/6	5/6	5/4	5/4	<u>5/4</u>	5/5	5/5	5/5	5/6	<u>5/6</u>	5/6	5/4	5/6	5/6
5/7	<u>5/9</u>	5/9	5/7	5/7	5/7	<u>5/8</u>	5/8	5/8	5/9	<u>5/9</u>	5/9	5/7	5/9	5/9
5/10	5/12	<u>5/12</u>	5/10	5/10	5/10	5/11	5/11	5/11	5/12	5/12	5/12	5/10	5/12	5/12
5/13	5/15	5/15	5/13	5/13	5/13	5/14	<u>5/14</u>	5/14	5/15	5/15	5/15	<u>5/13</u>	5/15	5/15
5/16	5/18	5/18	<u>5/16</u>	5/16	5/16	5/17	5/17	<u>5/17</u>	5/18	5/18	5/18	5/16	<u>5/18</u>	5/18
5/19	5/21	5/21	5/19	5/19	5/19	5/20	5/20	5/20	<u>5/21</u>	5/21	5/21	5/19	5/21	<u>5/21</u>
5/22	5/24	5/24	5/22	<u>5/22</u>	5/22	5/23	5/23	5/23	5/24	5/24	5/24	5/22	5/24	5/24
<u>5/25</u>	5/27	5/27	5/25	5/25	<u>5/25</u>	5/26	5/26	5/26	5/27	<u>5/27</u>	5/27	5/25	5/27	5/27
5/28	<u>5/30</u>	5/30	5/28	5/28	5/28	<u>5/29</u>	5/29	5/29	5/30	5/30	<u>5/30</u>	5/28	5/30	5/30
5/31	6/2	<u>5/31</u>	5/31	5/31	5/31	6/1	6/1	5/31	6/2	6/2	5/31	5/31	6/2	5/31
6/3	6/5	5/31	6/3	6/3	5/31	6/4	6/4	5/31	6/5	6/5	5/31	6/3	6/5	5/31
6/6	6/8	5/31	6/6	6/6	5/31	6/7	6/7	5/31	6/8	6/8	5/31	6/6	6/8	5/31
6/9	6/11	5/31	6/9	6/9	5/31	6/10	6/10	5/31	6/11	6/11	5/31	6/9	6/11	5/31
6/12	6/14	5/31	6/12	6/12	5/31	6/13	6/13	5/31	6/14	6/14	5/31	6/12	6/14	5/31
<u>6/15</u>	6/17	5/31	6/15	6/15	<u>6/15</u>	6/16	6/16	5/31	6/17	<u>6/17</u>	5/31	6/15	6/17	5/31
6/18	<u>6/20</u>	5/31	6/18	6/18	5/31	6/19	6/19	5/31	6/20	6/20	5/31	6/18	6/20	5/31
6/21	6/23	<u>6/23</u>	6/21	6/21	5/31	6/22	6/22	5/31	6/23	6/23	5/31	6/21	6/23	5/31
6/24	6/26	5/31	6/24	6/24	5/31	6/25	<u>6/25</u>	5/31	6/26	6/26	5/31	<u>6/24</u>	6/26	5/31
6/27	6/29	5/31	<u>6/27</u>	6/27	5/31	6/28	6/28	<u>6/28</u>	6/29	6/29	5/31	6/27	<u>6/29</u>	5/31
7/1	7/2	5/31	7/2	7/2	5/31	7/3	7/3	5/31	7/4	7/4	5/31	7/2	7/2	5/31
7/5	7/5	5/31	7/5	<u>7/5</u>	5/31	7/6	7/6	5/31	7/7	7/7	5/31	7/5	7/5	5/31
<u>7/7</u>	7/8	5/31	7/8	7/8	<u>7/8</u>	7/9	7/9	5/31	7/10	7/10	5/31	7/7	7/8	5/31
7/10	<u>7/11</u>	5/31	7/11	7/11	5/31	<u>7/10</u>	7/10	5/31	7/11	7/11	<u>7/11</u>	7/10	7/11	5/31
7/13	7/14	<u>7/14</u>	7/14	7/14	5/31	7/15	7/15	5/31	7/16	7/16	5/31	7/13	7/14	5/31
7/16	7/17	5/31	7/17	7/17	5/31	7/18	7/18	5/31	7/19	7/19	5/31	7/16	7/17	5/31
7/19	7/20	5/31	<u>7/20</u>	7/20	5/31	7/21	7/21	5/31	7/22	7/22	5/31	7/19	<u>7/20</u>	5/31
7/22	7/23	5/31	7/23	7/23	5/31	7/24	7/24	5/31	7/25	7/25	5/31	7/22	7/23	5/31
7/25	7/26	5/31	7/26	<u>7/26</u>	5/31	7/27	7/27	5/31	7/28	7/28	5/31	7/25	7/26	5/31
<u>7/28</u>	7/29	5/31	7/29	7/29	<u>7/29</u>	7/30	7/30	5/31	7/31	7/31	5/31	7/28	7/29	5/31
7/31	<u>8/1</u>	5/31	8/1	8/1	5/31	<u>8/2</u>	8/2	5/31	8/3	8/3	5/31	7/31	8/1	5/31
8/3	8/4	<u>8/4</u>	8/4	8/4	5/31	8/5	8/5	5/31	8/6	8/6	5/31	8/3	8/4	5/31
8/6	8/7	5/31	8/7	8/7	5/31	8/8	8/8	5/31	8/9	8/9	5/31	8/6	8/7	5/31
8/9	8/10	5/31	<u>8/10</u>	8/10	5/31	8/11	8/11	5/31	8/12	8/12	5/31	8/9	<u>8/10</u>	5/31
8/12	8/13	5/31	8/13	8/13	5/31	8/14	8/14	5/31	8/15	8/15	5/31	8/12	8/13	5/31
8/15	8/16	5/31	8/16	<u>8/16</u>	5/31	8/17	8/17	5/31	8/18	8/18	5/31	8/15	8/16	5/31
<u>8/18</u>	8/19	5/31	8/19	8/19	<u>8/19</u>	8/20	8/20	5/31	8/21	8/21	5/31	8/18	8/19	5/31
8/21	<u>8/22</u>	5/31	8/22	8/22	5/31	<u>8/23</u>	8/23	5/31	8/24	8/24	5/31	8/21	<u>8/22</u>	5/31
8/24	8/25	5/31	8/25	8/25	5/31	8/26	8/26	5/31	8/27	8/27	5/31	8/24	8/25	5/31
8/27	8/28	5/31	8/28	8/28	5/31	8/29	<u>8/29</u>	5/31	8/30	8/30	5/31	8/27	8/28	5/31
8/30	8/31	5/31	8/30	8/30	5/31	8/31	8/31	5/31	8/31	8/31	5/31	8/30	8/31	5/31