

# IMPROVE Standard Operating Procedure for Site Maintenance SOP 226

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## 1. PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) describes the procedures for routine maintenance of equipment in the IMPROVE sampling network. Prior to 2013, routine site maintenance occurred on a yearly basis; starting in January 2013, sites will receive biannual maintenance, with half of the network receiving maintenance one year and the other half the next year. Routine maintenance is divided into “loops,” with an average of ten sites being visited on each loop. Maintenance is solely the responsibility of the Air Quality Group’s field operations team, comprised of the field manager and field technicians.

## 2. SUMMARY OF THE METHOD

Prior to routine maintenance, the field technician shall review and summarize all of the information collected at each site during the previous year(s) in order to characterize how well each site is functioning. The data recorded during weekly visits to the IMPROVE samplers by the operators, as well as any problems detected during quality assurance procedures, shall be incorporated into the site summary. This reference will be used to determine whether extra maintenance or troubleshooting is required at each site.

Air Quality Group field technicians shall perform routine site maintenance. For those sites receiving maintenance in a given year, during the site visit, the cyclones, stacks, and inlets are cleaned, the electronics are checked, the pumps are flagged for replacement or repair as needed, the samplers are audited, and new calibration equations are recorded. Operator training and review sessions as well as any sampler upgrades are also performed at this time.

## 3. DEFINITIONS

- Cassette: a plastic holder that contains a filter substrate or “dummy.”
- “Dummy”: a 25mm or 37mm piece of material used in cassettes that are not sampled.
- Cartridge: consists of a cartridge plate and 3-4 cassettes inserted in the cartridge plate.
- PM<sub>2.5</sub>: Particulate matter, aerodynamic diameter of 2.5 micrometers or less.
- PM<sub>10</sub>: Particulate matter, aerodynamic diameter of 10 micrometers or less.
- “A” module: one of four channels routinely run at every site in the IMPROVE network. Measures PM<sub>2.5</sub> with Teflon® as the filter medium and runs at 23 liters per minute.
- “B” module: one of four channels routinely run at every site in the IMPROVE network. Measures PM<sub>2.5</sub> with nylon as the filter medium and runs at 23 liters per minute.
- “C” module: one of four channels routinely run at every site in the IMPROVE network. Measures PM<sub>2.5</sub> with quartz as the filter medium and runs at 23 liters per minute.
- “D” module: one of four channels routinely run at every site in the IMPROVE network. Measures PM<sub>10</sub> with Teflon® as the filter medium and runs at 16.9 liters per minute.
- Double-C site: refers to sites that have two quartz filters loaded per cassette instead of the typical single C filter.
- Cyclone: IMPROVE particle size separator based on aerodynamic equivalency diameter of 2.5 micrometers.
- Denuder: Set of concentric aluminum tubes used to remove nitric acid from air stream.
- Ebox: Electronic box which houses pressure transducers and manifold drive relays.
- Rbox: Relay box which houses relays that turn on pumps.

- LPM: liters per minute
- EPROM: Erasable Programmable Read Only Memory that holds IMPROVE software.
- Stack: Inlet tube for module
- Inlet: Cap over PM<sub>2.5</sub> stack with insect screen
- Magnehelic: Device that measures differential pressure used for auditing modules.
- Sierra inlet: EPA Louvered PM<sub>10</sub> 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. A ladder should be available at any given site. If a ladder is not available, do not go on the roof. Contact the field manager and an alternate plan will be determined for cleaning the inlets.

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.

#### **5. CAUTIONS**

Many access roads to IMPROVE sites are locked after regular business hours. Be sure to communicate with any necessary staff how long the visit is expected to take to avoid being locked in the area.

Some IMPROVE sites are remote and require hiking to the site or driving off-road. Be sure to have detailed directions on how to get to a site that requires walking or off-road driving.

Many IMPROVE sites do not have cellular reception. Take this into consideration when planning site visits.

Wasps sometimes make nests in the inlets. Check for this carefully, as this can cause issues during sampling. Report any infestations in the inlets to the field manager immediately.

#### **6. INTERFERENCES**

Sometimes, due to weather conditions or the way a site is housed, the "D" stack at a site may rub against the funnel. This situation results in the formation of a black powder, referred to as "anodizing dust," that collects and falls down onto the filters. During site maintenance, check to make sure there is no sign of anodizing dust on any of the "D" module filters at the site before and during maintenance. If any anodizing dust is present on the filters, flag the site as a candidate for a tripod, take detailed pictures of the roof where the tripod will sit, and inform the field manager. If any anodizing dust is found in the funnel, locate the cause and flag any equipment that needs replacing.

#### **7. PERSONNEL DUTIES**

The field manager shall:

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

The site operator shall:

- Note deviations from normal operations and inform Air Quality Group personnel
- Attend site operator training and review sessions during site maintenance
- Replace equipment when requested by field operations
- Maintain a clean site

The field technician shall:

- Perform routine site maintenance
- Perform site operator training and review sessions
- Maintain records on equipment repair and modification
- Report any issues or concerns in the field to the field manager

## **8. EQUIPMENT AND SUPPLIES**

The equipment list for site maintenance trips will vary depending on the number of sites that will be visited and whether any new sites will be installed during the trip. Because of this and due to the extensive amount of supplies needed, equipment lists will not be reported within this SOP but can be located in Attachment 1, "Maintenance Packing Lists."

## **9. PROCEDURAL STEPS**

Field technicians perform routine site maintenance, generally in the spring or summer. This visit to the site is an opportunity to flag non-vital sampler components for replacement, verify calibration equations, replace or update obsolete equipment, thoroughly clean each sampling module, and test the vacuum systems. It also allows trained personnel to inspect the site to ensure compliance with EPA sampling regulations and provides an excellent opportunity for operator training.

The following sections describe the site maintenance procedure:

- 9.1. Preparation for Site Maintenance Loop
- 9.2. Operator Training
- 9.3. Pre-Maintenance Procedures at the Site
- 9.4. Flow Rate Audit
- 9.5. Sampler Cleaning and Maintenance
- 9.6. Detailed Inspection of Components and Housing
- 9.7. Leak Check of the Sampling Modules
- 9.8. Module Calibrations
- 9.9. Post Calibration Check and Documentation

### *9.1. Preparation for Site Maintenance Loop*

Field technicians prepare for site maintenance by contacting each site, scheduling visit dates and times, and creating a site audit and maintenance kit. The field manager is responsible for organizing maintenance loops and overseeing the training and supplying of the field technicians both prior to leaving the Air Quality Group and while in the field. Refer to TI 226A for more information.

### *9.2. Operator Training*

Once at the site, field technicians should meet with the operator to explain any new software and to ask about any concerns or pending problems at the site. Field technicians should ensure that each of the reported problems is addressed before leaving. If a site operator is new, the field technician will review the materials covered in SOP 201, "Sampler Maintenance by Site Operators" with the operator to ensure that the operator understands how to perform sample changes at the site. The field technician should also show the operator how to replace some of the basic components in case equipment replacements are necessary before the next routine maintenance visit. For further details, see TI 226A.

### *9.3. Pre-Maintenance Procedures at the Site*

Prior to maintenance of the sampler, the field technician inspects the site for any general repairs needed. Any necessary repair or changes to the sampler or site should be noted. If a problem that affects flow rate or system vacuum is identified, the technician will have to perform two audits; one with the existing problem and a second once the problem is corrected.

The field technician prepares the sampler for maintenance by recording final readings and noting the elapsed times for each sample. The field technician visually inspects the sampling cassettes, noting and correcting any errors involving sample change protocol, and removes the sampling cassettes from the modules in preparation for the audit. For step-by-step instructions on these procedures, see TI 226A.

### *9.4. Flow Rate Audit*

The field technician performs an audit using a magnehelic dial and probe. The audit will serve to test current flow rates and equations to determine whether there has been any drift since the last maintenance visit. Further details on this procedure are located in TI 226B.

### *9.5. Sampler Cleaning and Maintenance*

The field technician thoroughly cleans the cyclones for the PM<sub>2.5</sub> modules ("A," "B," and "C") and the "D" module funnel with Kimwipes™ and alcohol. The stacks, inlets, Tees, and stack bottom plugs are cleaned as well. The interior of each module is brushed to eliminate fugitive dust. The valves are carefully removed and cleaned with cotton-tipped applicators and alcohol. The field technician checks for cracked or aged O-rings and hoses and makes repairs or replacements as needed. Refer to TI 226A for more information.

#### *9.6. Detailed Inspection of Components and Housing*

After cleaning, the field technician performs a detailed check of the site and the sampler. The field technician listens to each pump carefully to determine whether any of them are making unusual noises, and any pumps that need replacing are flagged. The stand/structure and the pump house/enclosure are examined for any signs of deterioration. The field technician confirms that the modules are securely attached to the mounting structure and that the stacks are stable and seated firmly. The field technician checks to confirm that the controller's CPU battery, voltage regulator, and power supplies maintain a proper output and that the latest version EPROM is installed. The technician also evaluates any issues with the controller and performs troubleshooting procedures to determine the cause. After the inspection is complete, the field technician prepares the modules for a leak test. More details on these procedures can be found in TI 226A and TI 226F.

#### *9.7. Leak Check of the Sampling Modules*

The field technician performs a leak check of the sampling modules using the plug and extension bar from the audit probe. The field technician checks the magnehelic reading from each pump and module to ensure that the readings from each pump and its corresponding module are similar. Pump and module differences cannot be greater than 2.0" Hg. If a difference is greater than 2.0" Hg, the field technician performs troubleshooting procedures to identify where the leak is located and corrects it. Step-by-step instructions for this procedure can be found in TI 226E.

#### *9.8. Module Calibrations*

The field technician sets the zero flows for all primary modules to be 10 for the orifice values and 5 for the cyclone values. The field technician then calibrates all of the PM<sub>2.5</sub> modules ("A," "B," and "C") to run at a rate of 23lpm, and the PM<sub>10</sub> module ("D") to run at a rate of 16.9lpm. Any "X" module is calibrated to match its corresponding primary module. The techniques used to set zero flows and calibrate the modules are explained in TI 226C.

#### *9.9. Post Calibration Check and Documentation*

After calibration is complete, the field technician updates the controller's date, time, and GMT offset (if necessary) and verifies that all of the site configuration parameters are correct. All of the equipment is then labeled with colored tape in order to make it easy for an operator to replace equipment or to troubleshoot. The sampling cartridges are returned to their corresponding modules and the field technician prepares the controller to resume its normal sampling schedule.

Various photographs are taken of the sampler components and the site itself, as well as the area surrounding the site. These photographs are taken to verify that the sampler and all of its components were left in the same condition as they were found, as well as to provide AQG staff with a way to view site configurations remotely when troubleshooting with an operator over the

phone. The photographs of the surrounding areas are used to ensure that there is no vegetation that is encroaching on the sampling cone or impeding access to the site.

Once all of these tasks are done, field maintenance is complete. For more information on these procedures, please see TI 226A.

## **10. DATA AND RECORDS MANAGEMENT**

Site audits and calibrations are initially stored in a shared drive after the field technician returns from the site maintenance trip. The field manager reviews the audit and calibration for each site. Once the values are approved, the field manager enters them into the SQL database via a web application called Improve Data Manager.

Site photographs and notes are stored in site-specific folders on a shared drive.

## **11. QUALITY ASSURANCE AND QUALITY CONTROL**

The field maintenance team focuses on several areas to limit sources of possible contamination, to prevent equipment failure during maintenance, and to ensure that site maintenance has been performed correctly. These areas include cleaning and inspection of components, equipment replacement, taking pictures of site equipment prior to departure, and closely monitoring the data from a site for several weeks after maintenance was performed.

### *11.1 Cleaning and Inspection of Components*

During site maintenance, field technicians thoroughly clean components with alcohol and Kimwipes™ (or an alternate lint-free cloth) to reduce or eliminate any possible contaminants. Field technicians also inspect components for spider webs and other signs of pest infestation present in the modules and in the inlets. “D” modules are scrutinized to ensure that no anodizing dust is present due to the stack rubbing against the funnel or against the roof. If signs of anodizing dust are found, the field manager is notified immediately. If the issue causing the anodizing dust cannot be fixed during maintenance, the site is flagged for any equipment necessary to resolve the problem.

### *11.2 Equipment Replacement*

Because of the potential for equipment failure, the field maintenance crew no longer rebuilds or repairs equipment in the field. Instead, field technicians examine flow data for the sites that they will be visiting prior to departing on the maintenance trip and determine what equipment may need replacing in the field. Field technicians bring enough spare equipment to meet any needs that can be identified through both the flow data and through speaking with the site operators before the visit.

If a piece of equipment is showing signs of impending failure at the site, field technicians will either change it out with the spare equipment they brought with them, or the equipment is flagged for replacement. This reduces risk of equipment failure due to less than optimal working conditions.



### *11.3 Documenting the Site with Photographs*

Prior to departing the site, field technicians photograph all of the equipment. This documents that the site was left in the same or better condition than it was found and that the sampler has been completely reassembled after maintenance. Photographs of the modules are taken to show that the stacks have been lowered back into the Tees for the PM<sub>2.5</sub> modules and that the PM<sub>10</sub> module stack has been lowered back into the funnel. Photographs are also taken of the roof to document that the inlets were placed back on top of the stacks and that the stacks were properly seated.

In addition to documenting the complete reassembly of the site, the photographs are useful for assisting AQG staff with troubleshooting over the phone with operators, as the photographs allow the field technician to view the site configuration remotely.

### *11.4 Data Monitoring*

The flow data returning from the site shortly after maintenance has occurred is particularly scrutinized to ensure that the calibration was performed properly and that the resulting values are valid, as well as to confirm that any replaced equipment is working appropriately. Action is taken immediately if any equipment appears to be malfunctioning or if any of the flow data differs significantly from what was expected.

## **12. REFERENCES/ATTACHMENTS**

Attachment 1, "Maintenance Packing Lists"  
Attachment 2, "Maintenance Checklist"  
SOP 201, "Sample Maintenance by Site Operators"  
TI 226A, "Site Maintenance for Field Technicians"  
TI 226B, "Audit"  
TI 226C, "Calibration"  
TI 226D, "Denuders"  
TI 226E, "Leak Check"  
TI 226F, "Controller Repair"

## Attachment 1: Maintenance Packing Lists

### Equipment Lists for Field Maintenance

Equipment and material quantities required for field maintenance vary depending on the number of sites being visited and whether a new site is being installed. Equipment lists for maintenance trips that include a site installation and routine maintenance trips with approximately ten sites are listed below. For trips with less or more sites than 10, adjust the spare parts and pump kit quantities only. All other lists should remain the same.

#### Routine Maintenance (approx. 10 sites)

##### *Backpack*

- Side cutters
- Colored tape (red, yellow, green, blue, and orange) – one roll each
- Plastic hammer
- Tape measure
- Hex key set
- Zip ties (small and large) – 30+ each
- O-Ring kit:
  - FEP O-rings:
    - 124 (qty. 4)
    - 130 (qty. 6)
    - 156 (qty. 4)
    - 218 (qty. 4)
    - 222 (qty. 4)
    - “D” stack O-ring (qty. 10)
  - EPBM O-rings:
    - 06 (qty. 10)
    - 08 (qty. 10)
    - 11 (qty. 40)
    - 26 (qty. 6)
    - 35 (qty. 6)
- Stack brush
- EPROM remover
- 5/8” socket set
- Phillips screwdrivers, including #1, 2-#2, and #3)
- Flathead screwdrivers, including #1, #2, and #3)
- Regular pliers
- Adjustable wrench
- Set of standard wrenches (includes 1/4”, 5/16”, 11/32”, 7/16”, 1/2”, 9/16”, 5/8”, 11/16”, 3/4”)
- Special 13/16” milled wrench
- Special 3/4” milled socket

- Valve removing bar
- Multi-meter
- Channel locks
- Wire stripper/crimper (1 each)
- Level
- Large vice grip
- DC Power Harness w/ spare MOVs (5 minimum)
- Solder/iron
- Laser
- Box cutter/blades
- Needle nose pliers
- Wire cutter
- Teflon tape
- Torque wrench
- Anti-seize
- Sierra standoffs & screws (6 sets)
- Nylon motor couplers (10 minimum)
- Loctite 290
- Brush
- Spare Screws for controller and modules (3 each)
- Soft grip round channel locks
- Pot screwdriver (small flat head driver)
- Door hinge pins (6)
- Pin extractors
- Inlet remover

#### *Laptop Case*

- Laptop (with battery)
- GPS (with site coordinates)
- Digital camera (with flashcard)
- Compass
- Excel calibration sheets
- DC/AC power converter
- Permanent markers (Sharpies)
- Memory card reader (Compact Flash & SD)

#### *Heavy Duty Tool Bag*

- Caulking gun and silicone caulk or tar for boots
- Work lights
- Extension cord
- Hacksaw
- Steel hammer
- Hole saw kit

- Whisk broom
- Steel square
- Electrical kit
- Screw kit
- Garbage bags (3)
- Module template (only if installing/relocating modules)
- Rain ponchos (2)
- Mosquito nets (2)
- Work gloves (2 pairs)
- Eye wear (2 pairs)
- Dust masks (2)
- Wood boring bit set
- Weather stripping (6 ft.)
- Respirator (1+)
- Bleach sprayer
- Electric air blower

*Pump Kit*

- Pump feet (20 minimum)
- Pump hose fittings (10)
- Muffler felts (40 minimum)
- Pump hose (25 feet)
- Protective hose wrap (6 ft.)

*Audit Kit*

- Audit devices (2)
- Calibration cassettes (2 sets, one with old lot filters and one with new lot filters)
- Vacuum gauge
- Vacuum coupler
- Vacuum grease
- Potentiometer (Pot) screwdriver
- Extra probe O-rings
- Controller keypad rubber bumper
- NIST certified temperature gauge

*Drill Kit*

- Drill
- Bit set
- Batteries and/or charger
- Driver extension

*Spare Parts*

- Electronics boxes (Versions I and II, 2 each)
- Flow valve (2)
- EPROMs (10)
- 12 and 24V sources (2 of each)
- Relay boxes (1 long and 1 short)
- Controller display and cord (2)
- Temperature probes (4)
- Motherboard (2)
- CPU and batteries (2)
- Faceplate plastic rails (12)
- Memory cards (3)
- Bottom board (2)
- GCBLs (regular and long, 2 of each)
- Stack boot set (2)
- Controller power cord (2)
- Cyclone (2)
- Motors (4)
- Mounting bracket sets (2)
- Denuders (one for each site)
- Valve quick connects (4)
- Valve panel nuts (4)
- Sierra glass/plastic jars (2)
- Motor timing belts (4 minimum)
- V4 PM<sub>2.5</sub> inlets (2 sets)
- Tygon tubing (2 ft.)
- Tee plugs and black caps (4 each)
- Controller
- Version I "D" funnels (2)
- Large grommets (40)
- "D" module brace (2)
- Large Kimwipes™ (2 large boxes)
- Tripp Lite ULTRABLOK Isobar surge protector (2)
- Manifold (2)
- Grounding harness (3)
- AC power harness (3)
- MB heat sinks (for thick and thin regs., 6 each)
- 12V MB to CPU jumper harness (3)
- CFLSH to CPU brackets and hardware (3 sets)
- Cassette ejection/alignment hardware (2 sets)
- Stack stickers (10 sets)
- 3-way short extension cord

*Site Documentation and Important Items*

- Controller labels
- 7.0N software update sheets
- EBOX inventory labels and inventory numbers
- Maintenance schedule
- Site access sheets
- Site information sheets
- Problems file printout
- Site data sheets
- Rental car and hotel information
- UPS tracking numbers
- Laminated sample log sheets for each site
- Laminated controller door instructions for each site
- "Standard time" stickers for each site
- "Insert flash cards" stickers for each site
- Maintenance checklist (one for each site)
- Pre-printed return labels (if possible)

*Items to Buy on the Road*

- Compressed air (use electric air blower if possible)
- Silicone tube
- Ethanol
- Packing tape

**Maintenance and Site Installation Equipment**

The equipment needed for a maintenance trip that includes a site installation (of 4 routine modules) is the same as the equipment listed above for a routine maintenance trip, along with the following:

*Controller Installation*

- Controller
- Power cord
- Mounting hardware
- Keypad
- Compact flashcards (2-3)

*"A" Module Installation*

- "A" module
- Inlet (PM<sub>2.5</sub>) & Stack
- Tee plug
- Mounting hardware
- 5' module cable
- Black plastic cap

- Boots

*“B” Module Installation*

- “B” module
- Inlet (PM<sub>2.5</sub>) & Stack
- Tee plug
- Mounting hardware
- 3' module cable
- Black plastic cap
- Boots
- Denuder
- Denuder detent (FEP O-ring)

*“C” Module Installation*

- “C” module
- Inlet (PM<sub>2.5</sub>) & Stack
- Temperature probe
- Mounting hardware
- 3' module cable
- Black plastic cap
- Boots

*“D” Module Installation*

- “D” module
- “D” module brace (if not already installed in the module)
- Boots
- Mounting hardware
- 5' module cable
- Sierra Inlet
- 2 Sierra glass jars
- PM<sub>10</sub> Stack

*Pump Installation Equipment*

- 4 Pump Hoses (lengths depend on specific installation)
- 2 Relay boxes (cable lengths depend on specific installation)
- 4 Pumps

## Attachment 2: Maintenance Checklist

### Maintenance 2013 Checklist

1. Talk with OPRTR
  - a. Ask about problems
  - b. Give business card if needed
  - c. Stress Time & Date updates, mark any change on LGSHT
  - d. Stress comment section
  - e. Stress calling (especially after replacing equipment or when something is out of the ordinary)
2. Final Readings
3. Audit
4. Clean ABC Cyclones
5. Service ABCD valves
  - a. Take notes on dirtiness
6. Tighten ABCD valves
7. Clean D funnel
8. Clean ABCD stacks
9. Clean ABC Ts
10. Clean ABC inlets – Upgrade to tall shells
11. Clean sierra inlet
12. Replace broken screws and standoffs on sierra inlet (Use anti-seize)
13. Replace denuder – label old one and record new ID #
14. Replace EPROM if necessary
15. Upgrade Motherboard to V3
16. Add Grounding Harness
17. Record CPU:
  - battery voltage (replace if <3.0)
  - Voltage Reg voltage (compensate for the meter)
  - Serial #s (Motherboard, Bottom Board, CPU, CFLSH reader)
18. Test 12/24 V power supplies under full load
19. Add CNTRLR info label
20. Site Configuration
21. Flag all Pumps older than 2003 for replacement
22. Check all pump hoses for O-ring condition
23. Check all pump hoses for friction wear points. Cut out bad sections and add protective covering to unavoidable vibration locations.
24. Replace ALL broken feet
25. Replace ALL muffler felts – unless pump has been serviced with in the past year.
26. Leak check (record values)
27. Check CNTRLR date & time
28. Calibration (compare new constants to old)
29. Initial readings
30. Acquire zeros
31. Set ETs if necessary
32. Fill out site data sheet
33. Record breaker Amperage & quantity
34. Leave SOPs and manual if they don't have one
35. Check OPRTR initials
- 36. Record all inventory numbers**
37. Record pump born on dates
38. Find North
39. Take pictures
  - a. Inward views (8 shots)
  - b. Outward views (4 shots)
  - c. MODs (showing taped/stickered Tees)
  - d. Pumps
  - e. Power
  - f. Breaker away & close
  - g. Roof
  - h. Stacks (inlets)
  - i. Controller (when leaving; in auto mode)
  - j. Sampler overview pics
40. Call lab for equipment replacement
41. **TAPE TEE PLUGS and place labels on all Stacks**
42. **Place D stack O-ring seat in D funnel**
43. Label all equipment with color tape or color DOTs.
44. Place Daylight Savings Sticker on Controller
- 45. Tape laminated sample log sheet somewhere on the samplers.**