IMPROVE
STANDARD OPERATING PROCEDURES

SOP 101
Procurement and Acceptance Testing

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1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) describes the process for procurement and acceptance testing of supplies used in the IMPROVE sampling network. Aerosol samplers are constructed by the Air Quality Group and tested prior to installation to ensure proper, and stable, functioning in the network. Filter support cassettes are constructed by machining Nuclepore brand filter holders. Aerosol collection filters are purchased from suppliers guaranteeing purity levels, and are acceptance tested by the Air Quality Group for precision and lack of contamination. Finally, laboratory supplies are purchased which are guaranteed by the supplier for the uses to which they are applied.

Procurement and acceptance testing procedures for aerosol collection filters are addressed in detail in TI 101A, for IMPROVE modules in TI 101B and TI 101C, and for filter cassettes and laboratory supplies in TI 101D.

2.0 RESPONSIBILITIES

2.1 Project Manager

The project manager shall:

- Quote IMPROVE aerosol sampler specifications and prices to interested parties.
- Determine applicability of IMPROVE aerosol samplers to the problem being studied.
- Obtain site information, contact person's name, phone number and shipping address.
- Initiate the new site in the IMPROVE database.
- Verify planned continuation of current sites.
- Review filter and sampler test data to determine whether acceptable.

2.2 Field Specialist

The field coordinator shall:

- Initiate purchase orders for filters and sampler construction parts.
- Oversee assembly and testing of sampler.
- Label all completed samplers with inventory identification numbers
- Maintain an accurate inventory of filters, samplers, and supplies.
- Verify proper functioning of sampler.
- Initiate and oversee acceptance testing of filters.
- Prepare an operations manual for the site operator.
- Oversee packaging and shipment of the sampler.

2.3 Research Technician

The research technician shall:

- Run acceptance tests on aerosol collection filters.
- Run acceptance tests on IMPROVE protocol aerosol collection samplers.
- Run acceptance tests, where applicable, on laboratory supplies.
- Construct IMPROVE protocol aerosol samplers.

3.0 REQUIRED EQUIPMENT AND MATERIALS

3.1 Filters and Filter Testing Supplies

The equipment required for filter acceptance testing are as follows:

- Annual supply of stretched teflon membrane filters having the same lot #.
- Nylasorb filter medium
- Filter cassettes
- Leak check device.
- Four side-by-side $PM_{2.5}$ IMPROVE protocol samplers.
- Facilities for gravimetric and absorption analysis of collected aerosol samples.

3.2 Aerosol Sampler Parts

A short list of equipment for constructing IMPROVE protocol aerosol samplers follows:

- Aluminum stack and inlet
- denuder
- IMPROVE $PM_{2.5}$ cyclone
- cyclone to stack adapter
- manifold with solenoids
- critical flow orifice
- magnehelic and pressure gauge
- elapsed timers
- switches
- clock controller
- fiberglass container with aluminum mounting sheets.
- 16.7 lpm or 18.9 lpm PM_{10} inlet with aluminum stack
- filter support funnel

3.3 Inventory of Supplies and Equipment

The equipment and supplies required for laboratory procedures include:

- Kimwipes
- sterile cotton tipped applicators
- forceps
- polonium anti-static strips
- Cahn microbalance
- certified calibration and tare weights
- temperature and humidity monitor
- data entry terminal
- microbalance calibration log book
- cassettes (Nuclepore) to hold 25 mm filters
- spare parts for cassettes
- filters
- logsheets
- leak check device
- HEPA vacuum

4.0 METHODS

4.1 Filter Procurement and Acceptance Testing .

Annual network filter requirements are estimated at the start of each financial year by the project manager. Estimates include filters for network site sampling, quality control and quality assurance, and planned special studies. Purchase orders for teflon and Nylasorb filters are generated by the project manager and forwarded to the supplies vendors. Filter testing is done upon receipt of the order, prior to accepting the new filter lots for network use. A complete description of procedures for filter procurement and testing is detailed in TI 101A, Filter Procurement and Acceptance Testing.

Quartz and SO2 filters are provided to the Air Quality Group by the subcontractors responsible for analyzing the associated data. The filters are included in the analysis costs charged to the network. All quality assurance testing of filters is done prior to shipment to the Air Quality Group according to the specifications listed in the subcontractor standard operating procedures.

4.2 Sampler Construction and Testing .

IMPROVE samplers are constructed at the University of California at Davis by Air Quality Group personnel. An identical sampler is available from Air Resource Specialists (ARS). The various configurations of the IMPROVE aerosol sampler were designed by the Air Quality Group. The design and plans are public domain. The blue prints for construction are available by request. Currently, the Air Quality Group and ARS are the only vendors for completed IMPROVE aerosol samplers.

When funding for an IMPROVE aerosol sampler arrives, the Field Specialist types purchase orders (PO's) for parts to construct samplers and forwards the PO's to the project manager for approval. When approved, the PO's are sent to the vendors and subcontractors used to supply the components for the aerosol sampler. The parts ordered from vendors are guaranteed to meet the required specifications by the manufacturer. Parts or components not available through the vendors are constructed by subcontracted machine shops or electricians, according to the aerosol sampler blue prints. Upon receipt, these parts are inspected by the field specialist to guarantee the specifications were met.

IMPROVE aerosol samplers are constructed and tested in the Crocker Nuclear Lab shop by technicians under the supervision of the Field Specialist. The construction process is described fully in TI 101B. The wiring diagrams are in TI 101C. Upon completion of the construction process, the sampler is set up on the work bench and thoroughly tested. Testing procedures include:

4.2.1 Electrical Systems Testing
4.2.2. Verification of the Integrity of the Vacuum System.

There are several type of modules in use.

- Satellite Sampling Module: These modules require a separate signal from a controller to start and stop sampling. There are two variations of the satellite module: $PM_{2.5}$ and PM_{10}. These are identical except the $PM_{2.5}$ module has a fine inlet and a cyclone, while the PM_{10} module has either a Sierra or Wedding PM_{10} inlet.
- Independent Controller Module (IC): These non-sampling modules control multiple satellite sampling modules. There are several versions with minor variations. One major variation is the addition of a lock-out circuit to prevent a second sample collected without an intervening sample change.
- Single Independent Module (SIM): This sampling module includes the clock controller in the sampling module. It cannot control satellite sampling modules.
- SIM-Controller (SC): This sampling module includes the clock controller in the sampling module, plus the relays to control satellite sampling modules. This module is now used in place of the independent controller module.

The various configurations of the controller modules are listed in Table 1.

Table 1 Controller Module Configurations.

code	pump relay voltage	multiple pump relay location	pump outlet location	thermostat and position	lock-out device
IC1	24V	external	box in pump house		no
IC1L	24V	external	box in pump house		yes
IC2	110V	internal	box on module		no
IC2L	110V	internal	box on module		yes
IC3	24V	internal	box on module		no
IC3L	24V	internal	box on module		yes
SIM1	24V	none	1 on module	under	no
SIM2	24V	none	1 on module	on	no
SIM2L	24V	none	1 on module	on	yes
SC1	24V	external	box on module	on	no
SC1L	24V	external	box on module	on	yes

IC Independent Controller non-sampling, controls satellite sampling modules
SIM Single Independent Module sampling, self-controlling only
SC SIM-Controller sampling, controls self and satellite sampling modules

thermostat and position: under: under the heater panel with relays
on: on the heater panel

4.2.1 Electrical Systems Testing

This procedure describes the process for verifying that the electrical systems (the clock controller, elapsed timers, solenoids, pumps, and switches) function properly, both individually and as a system. This testing is done as the final stage of sampler construction, and only after approval has been given by the field manager.

1. Plug or wire the sampler into power, (110V, 60 Hz). For SIM modules and controller module A's, verify the breaker switch on the heater support plate is in the off position prior to plugging in an extension cord to power.
2. For SIM modules and controller module A's, turn on the breaker switch on the heater panel. If any smoke or sparks are seen, turn it off and recheck the wiring.
3. When the sampler is connected to power, the clock controller will come on. Using a pen, press the "reset" button on the clock controller to ensure the system is clear.
4. Verify correct switching of the solenoids and elapsed timers using the clock controller.
    a. One at a time, turn on each Channel (1, 2, 3, 4) by using the top row of override buttons on the clock controller. Above the screen on the clock controller, each channel, 1 through 4, is listed with the options I or O, meaning on or off respectively. A small black rectangle will appear under the I on the display if the corresponding channel is on. If the channel is off, the rectangle will appear under the O, or not at all. Continued pressing of one of the top row override buttons will cycle through these options.
    b. Verify that the appropriate channel, the one switched on by the clock controller, comes on in all sampling modules.
        - Check the solenoid by placing your hand on the solenoid valves to verify its activity.
        - Verify the functioning of the elapsed timer by leaving the channel running for a minute and observing the timer moving.
        - Verify that 110V power is provided for the pump outlet(s) when a channel is turned on by using a voltmeter, or by plugging in a pump.
    c. Turn each channel off by pressing the channel override button on the top row of the clock controller. The black rectangle will appear under the O.
    d. If a solenoid or elapsed timer does not function, or there is no power to the pump outlets, disconnect the sampler from power (turn off the white breaker switch on a controller Module A, or remove the fuse for an IMPROVE controller module), and check for loose wires. Use a voltmeter to check for proper functioning of the clock (verify it sends a signal when the override buttons are used), and check the continuity of the circuits through the sampling modules.
    e. If the wrong solenoid or elapsed timer come on, the wiring is incorrect or the clock is damaged. Verify correct wiring, then check clock functioning using a voltmeter. If the clock controller is not switching properly, use a pen to press the reset button on the clock controller, then try again. If the problem persists, the clock may need to be replaced, but first contact the field manager.
5. Verify correct switching of the solenoids and elapsed timers using the module channel toggle switches.
    a. Set the sampler for manual override readings.

- For an IMPROVE controller module, turn the override timer in the controller module past 5 minutes and 110 V power is provided to the pump outlets by using a voltmeter, or plugging in a pump. Note that the power to the outlets will turn off when the timer reaches zero.
- For an IMPROVE Module A controller or a SIM module, turn the pump override switch on the face plate from "off " or "auto" to "on" or "manual". Verify that power is provided to the pump outlet(s) by using a volt meter.

b. Turn on each channel by using the toggle switches under the elapsed timers in each sampling module. Verify that the elapsed timer and solenoid for each channel in each module functions.
c. If a solenoid or elapsed timer does not function, or the pump does not come on, disconnect the sampler from power (turn off the white breaker switch on a Module A controller, or remove the fuse for an IMPROVE controller module), and check for loose wires. Verify circuit continuity using a volt meter. If the problem persists, call the field manager.
d. If the wrong solenoid or elapsed timer come on, the wiring is incorrect. Carefully check the wiring. If the problem persists, call the field manager.

6. Repeat the checks in sections 4.1.1 for each of the modules, eliminating all leaks prior to continuing.

4.2.2 Verification of the Integrity of the Vacuum System.

The procedures for validation of the vacuum system are as follows.

1. Plug in and turn on each pump. They should start instantly and be reasonably quiet.
   - If the pumps don't start, and the sampler vacuum gauges indicate more than 5" Hg, try flipping the toggle switches in the sampling modules to release the vacuum. The pumps cannot start under vacuum, so it must be released or bleed off before the pumps will start.
   - If the pump(s) don't start, verify there is power to the outlet using a volt meter. If there is a switch on the pump cord, verify it is turned on. If no response, replace the pump, or follow the pump maintenance procedures from SOP 201.
   - If noisy, verify nothing is caught in the fan. If still noisy, replace the pump, or follow the maintenance procedures from SOP 201 for pump maintenance.
2. Thread a calibrated pressure gauge, see SOP 176 for calibration procedures, onto the brass elbow connection on the pump, tightening it firmly with a 5/8" wrench. Record the pressure drop produced by the pump (generally about 28" Hg at sea level) on the top of the pump with a marker pen, using alcohol to remove any old readings.
3. Plug the pump(s) into the power outlets provided by the samplers. For an IMPROVE controller, the outlets are in the pump house. For a controller module A, the outlets are in the pump outlet box. For a SIM module, the outlet is the male recessed plug on the base of the sampler.
4. Connect the vacuum line hoses from the sampling modules to threaded brass elbow fittings on the pumps. Tighten to a snug fit with a 5/8" wrench. Do not over-tighten.

5. Install a calibration cassette in the module connected to solenoid #1 (the solenoid farthest to the left), and verify that all cyclone ports either have filters mounted on them, or are covered by port caps to prevent leaks.
6. Verify the manual override switch functions.
    - For an IMPROVE controller module, turn the 30 minute timer past 5 minutes. The pumps plugged into the pump outlets should start, in a staggered fashion, at 8 second intervals. NOTE: If the pumps won't start, and the sampler vacuum gauges indicate more than 5" Hg, try flipping the toggle switches in the sampling modules to release the vacuum. The pumps cannot start under vacuum, so it must be released or bleed off before the pumps will start.
      When the timer reaches 0 minutes, the pumps should turn off. If not, Use TI 101C to verify the wiring.
    - For a controller module A, turn the pump override switch on the faceplate of the module from "auto" to "manual" ("off" to "on"). Verify the breaker switch on the heater support plate is "on". The pumps should turn on, in a staggered fashion at 8 second intervals, when the pump override switch is turned to "manual". NOTE: If the pumps won't start, and the sampler vacuum gauges indicate more than 5" Hg, try flipping the toggle switches in the sampling modules to release the vacuum. The pumps cannot start under vacuum, so it must be released or bleed off before the pumps will start.
      When the switch is turned to "auto", the pumps should turn off. If not, return to TI 101C to verify the wiring for the module.
    - For a SIM module, turn the pump override switch on the faceplate of the module from "auto" to "manual" ("off" to "on"). Verify the breaker switch on the heater support plate is "on". The pump should turn on immediately when the pump override switch is turned to "manual". NOTE: If the pumps won't start, and the sampler vacuum gauges indicate more than 5" Hg, try flipping the toggle switches in the sampling modules to release the vacuum. The pumps cannot start under vacuum, so it must be released or bleed off before the pumps will start. When the pump override switch is turned to "auto", the pumps should turn off. If not, return to TI 101C to verify the wiring for the module.
7. With the pumps on, verify the vacuum reading in each sampling module are within 6% of the values, recorded on the top of each pump, from the calibrated vacuum gauge. If not:
    - There may be a leak in the system. All connections should be checked and tightened securely. If necessary, remove and replace the vacuum gauge.
    - The module vacuum gauge readings may be offset. Remove the gauge and install it directly on a pump with a known pressure drop. Turn on the pump and record the new pressure drop. If the pressure is still offset, correct the gauge by removing the vacuum gauge needle with pliers and re-installing it at the correct reading.
    - The vacuum gauge may be malfunctioning. Remove the gauge and install it directly on a pump with a known pressure drop. Turn on the pump and record the new pressure drop. If the reading is still highly anomalous, replace the gauge and label the old gauge as needing repair.

8. Block both ends of the stack side of the Tee connecting the stack to the cyclone. Use two stack bottom plugs. Open a solenoid using a toggle switch on the face plate. The vacuum reading on the small gauge should climb to the vacuum reading recorded in step 2. Tap the vacuum gauge in case the needle is sticking. Simultaneously, the sampler magnehelic gauge should decrease to less than 0.05" H_2O above Mag_O. Deviations from this behavior indicate leaks.
9. If leaks are found, check the following:
    a. Both of the stack plugs must be seated properly in the stack Tee to prevent air flow. Shift them around to see if it reduces the leak.
    b. Filters and port plugs must be securely mounted on the cyclone. Press and twist the filters and port covers. Poorly fitting port covers or bad or missing o-rings may be found in this manner.
    c. Hoses from the sampler magnehelic must be securely connected to both the cyclone and the back of the magnehelic. The hoses should be securely fitted on the brass nipples. If they fit loosely, the end may be stretched and should be cut off and re-seated. No cracks or splits should be present in the tubing.
    d. Hoses from the filters to the solenoids must be locked in place on the filter end, and threaded hand tight on the solenoid end. The plastic quick connect fitting should lock into place. The brass swagelock fitting should be threaded on hand tight, but not cross threaded. Damaged hoses or fittings must be replaced immediately.
    e. The vacuum tubing from the pump must be securely tightened at the pump and at the brass T in the sampler. The brass vacuum fittings should be tightened with a wrench. If the fittings are tight, but movement of the hose causes vacuum changes, the brass fittings on the hose, in the sampler, or on the pump are damaged and must be replaced.
10. Repeat the checks in sections 4.1.2 for each of the modules, eliminating all leaks prior to continuing.

4.3 Filter Cassette Procurement, Construction, and Acceptance Requirements.

Purchase orders (PO's) for filter cassettes are initiated by the Laboratory Manager or Project Manager as necessary to meet demand. The filter cassettes are modified 25mm Nuclepore brand filter holders. All filter cassettes are machined by Air Quality Group or shop personnel in the Crocker Nuclear Lab shop. Detailed descriptions of filter cassette construction follow in TI 101D.

4.4 Laboratory Supplies Procurement and Acceptance Requirements.

Purchase orders for laboratory supplies are generated as deemed necessary by the Laboratory Manager. Once approved by the Project Manager, the purchase orders are forwarded to the suppliers. All ordered materials are guaranteed for use by the supplier.