IMPROVE
STANDARD OPERATING PROCEDURES

SOP 151
Installation of Samplers

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SOP 151 Installation of Samplers.

TABLE OF CONTENTS

TABLE OF FIGURES

Technical References:
TI 151A Installation of Controller Module

1.0 PURPOSE AND APPLICABILITY

This standard operating procedure (SOP) describes the procedures for installing new aerosol sampling sites according to IMPROVE sampling network protocol.

The IMPROVE protocol aerosol monitoring program is designed to collect quantitative information on the composition and concentration of fine ($PM_{2.5}$) aerosol particles that reduce visibility. Aerosol data in the IMPROVE network are frequently collected in conjunction with other monitoring such as characterization of haze through photography, and the measurement of optical extinction with transmissometers and nephelometers. These data provide an effective means of correlating visibility with aerosol concentrations and compositions.

Aerosol and visibility data provide information to decision-makers and the public on the state of the Class 1 area, causes of visibility impairment, and trends in visibility of a region. Finally, elemental analysis of aerosol samples can identify tracers for emissions sources.

An IMPROVE aerosol sampling site generally has a controller and four sampling modules, though the number of sampling modules can vary from 1 to 4 depending on the sampling requirements at the site. The modules run in parallel; the controller sends the same signals to each module. The four standard sampling module types are A, B, C, and D. Module A collects fine particles (0 - 2.5 μm) on a stretched Teflon filter, and provides data on elemental composition of fine particles. Module B collects fine particles (0 - 2.5 μm) on a nylon filter, has a denuder before the nylon filter to remove acidic gases, and is used primarily for nitrate, though sulfate and chlorine data are also provided. Module C collects fine particles (0 - 2.5 μm) on a quartz fiber filter to measure organic and elemental carbon. Module D collects coarse particles (0 - 10 μm) on a stretched Teflon filter, and provides data on PM_{10} mass loading. At many sites, the Module D Teflon filter is followed by a quartz filter impregnated with K_2CO_3, used to collect SO_2 gas.

Each module is independent, with a separate inlet, sizing device, flow measurement system, critical orifice flow controller, and pump. Module A is the primary aerosol sampling module and is found at all sites. Modules B, C, and D are secondary aerosol sampling modules and are installed as needed. All modules are wired to a common controller clock which, for IMPROVE protocol sampling, is programmed to collect two twenty-four hour samples per week, on Wednesdays and Saturdays from midnight to midnight.

The design is simple and rugged to withstand ambient field conditions, and for ease of operation and maintenance.

The purpose of this standard operating procedure is to facilitate installation of IMPROVE aerosol samplers, to assure consistent, quality data, and to minimize data loss by installing aerosol monitoring systems according to design specifications and EPA requirements

2.0 RESPONSIBILITIES

2.1 Project Manager

The project manager shall:

- Approve final site configuration materials including photographic documentation, maps, installation location, and site configuration specifications.
- Verify funding and approval of the final site configuration and location by contacting the agency(s) or program(s) responsible for the funding of the site.
- Determine the appropriate mask size, the required filter surface area, to ensure optimal sensitivity during elemental analysis.
- Initiate the new site in the filter and analysis databases.

2.2 Field Specialist

The field specialist shall:

- Schedule the aerosol sampler installation
- Make suggestions on construction of the support structure for the aerosol sampler based on the site photos and descriptions returned with the siting document.
- As required, review the determined site preparation and installation requirements with the local contact.
- Maintain communications with the local contact during site preparation. Verify that all site preparation is completed prior to the installation.
- Schedule an operator training session for all identified operators and the primary local contact.

2.3 Field Technician

The field technician shall:

- Install the sampling modules at the site
- Clean and test the sampling modules

2.4 Lab Manager

The lab manager shall:

- Verify the addition of the new site in the aerosol samples and analysis databases.
- Create site specific filter and sampling date identification labels for the new site.
- Assemble cassettes, shipping boxes, and labels for shipping samples between Davis and the new site.
- Verify the address to which the samples will be shipped.
- Send out the filters to initiate sampling at the site, as scheduled by the project manager.

2.5 Local Contact

The local contact shall:

- Review the determined site preparation and installation requirements with the field specialist
- Identify and contact local land owners, primary contacts, and site operators regarding site installation and routine maintenance requirements.
- Finalize contracts with land owners for site installation and power usage.
- Perform any necessary site preparation prior to the installation (e.g. tree or brush removal, access road maintenance, electrical re-wiring to meet power requirements, aerosol sampler support structure construction, etc.)
- Maintain communications with the field specialist and local land owners to confirm scheduled installation requirements.
- Schedule operator training session with the field technicians and the field specialist
- Provide site access and installation assistance as needed.
- Verify site location and geographic reference specifications documented by the field specialist.

3.0 REQUIRED EQUIPMENT AND MATERIALS

The materials required to install an IMPROVE aerosol sampler depend on the type of installation; in an existing building, in a newly constructed sampler shed, or on an outdoors stand. Other factors include how many aerosol sampling modules are being installed; one, two, three, or four sampling modules fit within standard protocol.

Information for the local contact on preparing existing buildings for sampler installation, constructing new buildings to house aerosol samplers, or constructing an outdoors stand for aerosol samplers is included in Section 4.1 Site Preparation and Communication Procedures. However, as the local contact at each site will encounter different problems, no general listing of the equipment required to site preparation prior to sampler installation will be made.

3.1 Sampler Installation Equipment

The installation of the aerosol sampler(s) by field technicians shall occur only after all site preparations are completed, including ensuring adequate power supply, preparing access roads, sampler stand or support structure construction, etc. Standard equipment and materials required for installation of aerosol samplers includes:

- 1 aerosol sampler controller, either as a separate module (IMPROVE Controller Module), or as part of an air sampling module (IMPROVE Module A Controller).
- Module A ($PM_{2.5}$ sampler collecting samples for elemental analysis) plus up to 3 other aerosol sampling modules:

- Module B ($PM_{2.5}$ sampler collecting samples to analyze for nitrate, nitrite, sulfate and chloride ion)
- Module C ($PM_{2.5}$ sampler collecting samples to analyze for carbon)
- Module D (PM_{10} sampler)
- Module D/S (PM_{10} sampler to collect PM_{10} samples, and samples to analyze for SO_2 gas)

- bolts or lag bolts, as appropriate, to mount the controller and sampling modules on the support structure.
- wiring harness to connect the aerosol sampling modules to the controller module.
- vacuum tubing for each sampling module, long enough to run between the air sampling modules and pumps.
- one pump for each sampling module.
- one aluminum inlet stack long enough meet EPA requirements for each sampling module (see SOP 126 Figure 2). Modules with 2.5μm cut points ($PM_{2.5}$ samplers) require a pipe with 1/16" wall and outer diameter 1.5", modules with 10μm cut points (PM_{10} samplers) require a pipe with 1/16" wall and outer diameter 1.25".
- 1 cleaned, coated aluminum denuder, if a module to measure nitrates is being installed.
- one inlet head for each $PM_{2.5}$ sampling module. Note that inlet heads for all $PM_{2.5}$ modules are identical.
- one inlet head for the PM_{10} module, if a PM_{10} module is being installed. Note there are two brands of PM_{10} inlet heads used in the IMPROVE network; Wedding Corporation's 18.9 lpm low flow rate inlet, and Andersen Samplers Inc. 16.7 lpm

low flow rate inlet. Inter comparison studies have been done indicating that while the two have differing flow rates, the cut points and efficiencies are comparable.

- Plumb bob for installing the stacks
- Tool kit with 8" and 10" adjustable crescent wrench, channel lock pliers, needle nose pliers, cutting pliers, standard 1/4" through 11/16" combination wrench set, phillips and flat-head screwdrivers, wire snips, line powered drill, standard drill bit set, 1.25" and 1.5" hole saws for use with drill, wire ties, electrical tape, Teflon plumbers tape, hammer, tape measure, level.
- Silicone sealant
- 1 calibration orifice meter and calibration form
- 1 box of unexposed calibration filter cassettes

4.0 METHODS

This section describes site installation and documentation procedures, and includes two (2) major subsections:

4.1 Site Preparation and Communication Procedures
4.2 Installation and Calibration of Aerosol Samplers

4.1 Site Preparation and Communication Procedures

Prior to installation of an IMPROVE aerosol sampler, the local contact must ensure the site is prepared for sampler installation. The field specialist shall inform the local contact of the site preparation and installation requirements determined to be necessary by the field specialist and the project manager. The local contact shall then be responsible for ensuring the preparations are completed prior to the date set for site installation. The information communicated to the local contact shall include:

1. The selected site configuration, whether in an existing building, a newly constructed sampler shed, or on an outdoor stand. Samples of sheds (C76-NPS-2841, C76-NPS-2842) and outdoors stands (C76-IS-2430) for IMPROVE aerosol samplers may be found in the diagrams packet.
2. The basic requirements for the sampler module support structure are simple:
   a. The mounting surface on the structure should consist of two horizontal 2x4 studs separated by 18".
   b. The top of the lower 2x4 stud should be positioned roughly 52" above the floor to ensure the gauges are at or near eye level.
      - For an indoors site, the distance between the top of the upper stud and the top of the roof must be reported to the field specialist for calculation of the required inlet stack length.
      - For an outdoors site, unless there are unusual circumstances, the inlet stacks shall be 1 meter long.
   c. The mounting structure must be stable to avoid vibration or shifting of the sampler modules after installation.
   d. The mounting structure must be strong enough to support the weight of the sampler module(s). A single IMPROVE aerosol sampler (SIM) or a controller Module A weighs roughly 50 pounds. Each additional module weighs 35 pounds. A complete IMPROVE aerosol sampler, 4 modules, therefore weighs 155 pounds.
   e. The mounting structure must be long enough support all the modules. Each module is 11"x19"x20" (l x w x h), and an optimal spacing of roughly 12" between modules is preferred. The minimum spacing allowed between modules is 5". The preferred installation has all the modules along one wall, but if there is not enough space, other walls may be used as well, pending approval from the field specialist.
   f. For an indoors site, the mounting structure must be constructed in a location where holes may be drilled vertically through the roof above the modules once mounted.

g. Preparations for installation of samplers in pre-existing concrete and/or metal structures may be quite complicated. Careful discussion of sampler mounting options with property managers is required, as is assistance from the local contact and maintenance workers. Damage to structural integrity is possible, and on-site supervision of installation by personnel responsible for the structure is required. In these situations, for insurance purposes, the Air Quality Group requires the property managers to approve, oversee, and hire the appropriate personnel to attach the support structure, drill the holes for the stacks, and re-seal the roof once the samplers are installed. Due to these constraints, installation in pre-existing concrete or metal structures does not generally occur.

3. The number and type of modules to be installed.
   a. The exact location to install the sampler modules.
      - Which wall or surface will the sampler be mounted on? Note that if on an outdoor stand, the sampling modules are mounted facing north.
      - Where will each module be mounted on the wall or support structure? The modules are generally mounted roughly 52" above the floor or ground to put the gauges in the modules at eye level. Also, the modules cannot be mounted closer than 5" from a corner.
      - In what order will the modules be mounted? The modules are mounted, from left to right, in the following order: Controller module or Module A controller, module A, module B, module C, module D or module D/S. However, at an indoors site, the controller module is sometimes mounted below the module A or on another wall to save room, and at outdoors sites, the controller module is generally mounted on a different surface, facing west.
      - What will the spacing between the modules be? Sampling modules are mounted with 12" spacing between the modules, though spacing between modules may be reduced to as little as 5" if space is limited.
      - How tall must the inlet stacks be? The inlet stacks must extend from each sampling module into air at least 1 meter above any surface. The stack length necessary to meet this requirement must be measured by the local contact.
4. The power requirements for the sampler. The IMPROVE protocol aerosol sampler uses 10 to 12 Amps of 110 V, 60 Hz electrical power during normal use. However, when each vacuum pump starts, it momentarily draws up to 15 amps of power. It is therefore required that the sampler be assigned its own separate 20 Amp breaker.
   a. Some sites power the aerosol sampler with an electrical generator. This is not encouraged, but if it is necessary, the following requirements must be met. The generator must :
      - have enough power to start the sampler;
      - have enough fuel capacity to last for each sample period (24 hours);
      - be far enough downwind of the sampler so exhaust does not affect the sample;

- consistently provide up to 15 Amps of 110 V, 60 Hz of power. If not, the elapsed timers or clock controller will not function properly.

b. The power and wiring requirements for the three general sampler configurations; inside an existing building, inside a shed constructed to house the sampler, or on an outdoors stand, are listed below.
   - For a site installed in an existing building or in a newly constructed shed;
     i. verify that 10 to 12 Amp, 110 V, 60 Hz. electrical power is constantly available.
     ii. ensure the sampler power is from an exclusive 20 Amp breaker.
     iii. install a standard 2 plug outlet for the sampler within three feet of where the controller module will be installed.
     iv. install sufficient lighting
   - For a site to be installed outdoors on a stand;
     i. verify that 10 to 12 Amp, 110 V, 60 Hz. electrical power is constantly available.
     ii. ensure the sampler power is from an exclusive 20 Amp breaker.
     iii. cut a length of 3 wire electrical cable sufficient (with several feet to spare) to run between the breaker and the proposed sampling site. Put wire nuts or electrical tape on the ends of each of the wires at the sampler site to prevent shorting, if the electricity is accidentally turned on.
     iv. cut a length of 3/8" waterproof electrical conduit sufficient (with several feet to spare) to run between the breaker and the eastern edge of the stand being constructed to support the aerosol sampler. Install the 3 wire cable in the conduit.
     v. Open the breaker, so no power may flow, and fasten it in the open position. Label the breaker to prevent someone inadvertently closing it.
     vi. Connect the 3 wire electrical cable to the breaker.
     vii. Bury the conduit between the breaker and the eastern edge of the sampler stand to prevent damage to the power line. Leave the several extra feet of length at the sampler end on the surface, neatly coiled, with the end blocked and taped.

6. Obstructions to air flow, such as trees or bushes, that must be removed or trimmed.
7. Necessary site access path or road maintenance.
8. What assistance, in terms of tools and equipment (e.g. four wheel drive vehicles, concrete, etc.), will be necessary for the field technicians to complete installation of the sampler.

4.2 Installation of Aerosol Samplers

The IMPROVE protocol aerosol samplers are installed on walls or stands according to site requirements. The basic configuration requirements are that all modules, and inlets, are located within the same air mass, as required by EPA siting documents, and that the cyclones are mounted vertically for optimal efficiency. Installation procedures for IMPROVE protocol aerosol samplers are described in the following subsections:

4.2.1 Attachment of Aerosol Sampler to the Support Structure.

The local contact, prior to site installation, shall have constructed a support structure for the sampler module(s). The support must meet the requirements specified by the field specialist for strength and stability. Any special arrangements, such as for installing the samplers in a pre-existing building, shall have been made so that the installation process can proceed smoothly.

The modules are attached to the 2x4 studs with 1/4 x 20 x 1.5" lag screws or by 2 1/2" long 1/4 x 20 bolts with nuts and washers, if the back of the support is accessible. The modules are checked during mounting to insure the cyclones are vertical. The gauges should be at or near eye level.

The modules are installed in alphabetical order from left to right and along one wall, if possible. There must be enough space between modules to allow the doors to stay open. A spacing of 12" between modules is optimal. Larger spacing will require modification of the wiring harness connecting the modules, and should be requested from the Field Specialist before scheduling installation of the samplers.

4.2.2 Installation of Inlets and Inlet Stacks

Following the mounting of the aerosol sampler modules, the inlet stacks must be installed. The procedures for installation are listed below:

- Suspend a plumb bob from the ceiling above the modules so that the line passes through the center of the inlet bracket on the left side of Modules A, B, C or into the hole in the top of Module D. Mark each position on the ceiling.
- Drill or cut a 1¾" hole (1½" for D module) centered on the marks made on the ceiling.
- For modules A, B, and C, slide the 1.5" stacks through the holes in the roof and into the stack brackets on the sides of the modules. Twist the stacks into the aluminum stack connectors as far as they will go.
- For the D module stack, slide the 1.25" stack through the hole in the roof and in the top of the D module. Twist the stack into the top of the black funnel inside the module so that it forms a seal with both o-rings in the funnel.
- For the B module only, install the denuder in the stack
  a. Remove the stack bottom plug from the base of the stack Tee.
  b. Drill a 1/8" hole in the stack roughly 2" above the stack Tee.
  c. Clean the inlet stack by running a stack brush through it several times to remove any dust acquired in the installation procedure.
  d. Push the denuder up into the stack and hold it in position roughly 3" above the stack tee.

e. Install a self tapping, 8/32 x 1/4" sheet metal screw with an o-ring gasket in the hole drilled 2" above the Tee, threading it securely in place.
f. Lower the denuder. The sheet metal screw will extend into the stack far enough to prevent the denuder dropping past the screw.
g. Re-install the stack bottom plug.

- Clean the inlet stacks by removing the stack bottom plugs and running a stack brush through them several times to remove any dust acquired in the installation procedure. Be sure to re-install the stack bottom plugs.
- Install the inlets at the tops of the stacks by twisting them on.
- Slip a roof jack over each stack, nail it down, and seal around the edges of the roof jack and the stack with silicone caulk.

4.2.3 Wiring the IMPROVE Aerosol Sampler to Power

The IMPROVE Controller Module, the single IMPROVE aerosol sampler module (SIM) and the Controller Module A are the only modules containing control circuitry. Sampling modules not having controller circuitry are connected to a controller module by a six wire cable harness. This harness carries the 24VAC signals from the module that controls sampling. Once connected to the controller, the samplers are tested for functionality. Recall that there are three possible aerosol sampler controller configurations:

- IMPROVE Controller module, Figure 1, in which a separate module is installed containing the controller clock, fuses, relays, and transformers. This is connected to the sampling modules through a six wire cable. Since this type of controller module is connected directly into power, the wiring is complicated and is covered in detail in TI 151A. Also, though this configuration exists in the IMPROVE network, all new sites contain the IMPROVE Controller Module A, whose installation wiring shall be covered in this section.
- IMPROVE Controller Module A, Figure 2, in which Module A has been modified to act as a controller module. This is connected to any other sampling modules through a six wire cable.
- Single IMPROVE aerosol sampler module (SIM), in which Module A has been modified to have its own controller circuitry, but cannot act as a controller for other modules. Note the SIM module is identical to Figure 4.2, except that it has no circuitry for pump control, so it has no pump outlet box.

Figure 1 IMPROVE Controller Module

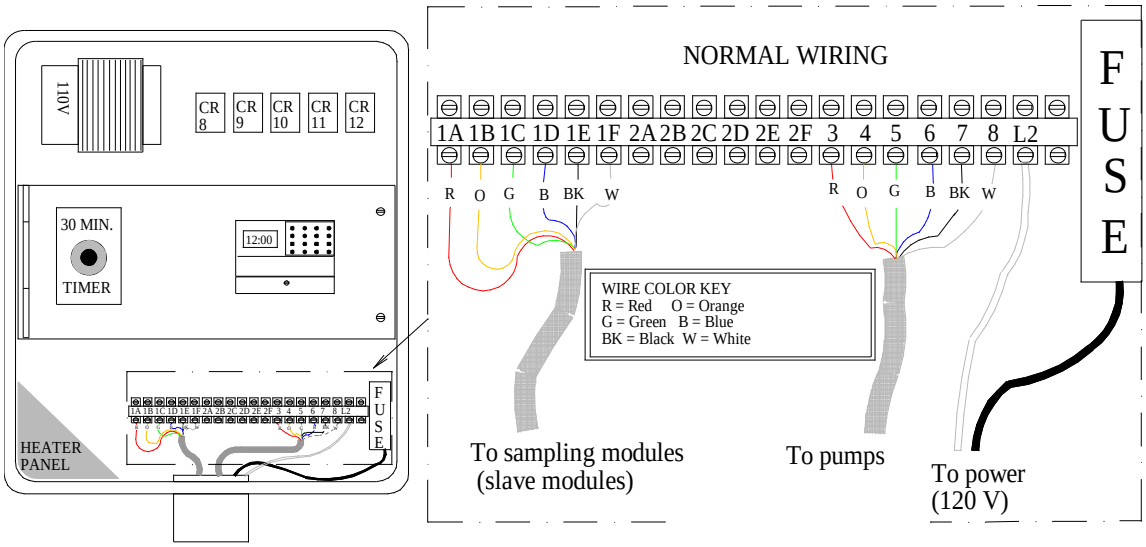
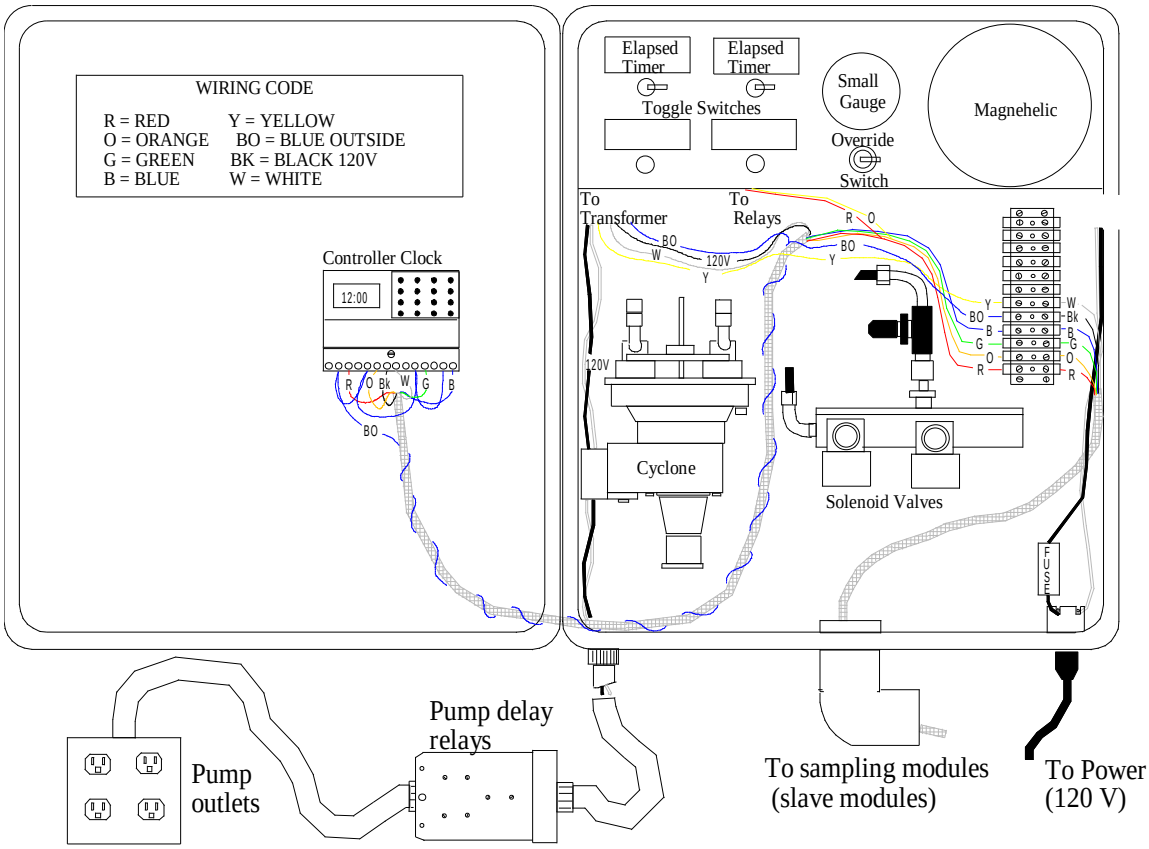


Figure 2 IMPROVE Module A Controller



Wiring and power installation procedures differ according to whether the controller module is an IMPROVE controller module or an IMPROVE Module A controller. Since the IMPROVE Module A controller is the version currently being installed at sites, this SOP shall describe the installation procedures for it. Wiring procedures for the IMPROVE Controller Module shall be relegated to a technical note, TI 151A. Wiring instructions are as follows. Please note that the installation of the PVC conduit between the modules is not required for indoors sites, though it's installation is encouraged.

1. For shipping, the four plug outlet box for the pumps is detached from the A module controller at a bulkhead fitting. The wires from the controller to the outlet box are not detached; care must be taken to avoid damaging these wires. The fitting on the flexible conduit to the outlet box should thread onto the bulkhead fitting to form a secure, watertight connection. If either fitting appears damaged, call for replacement parts and instructions.
2. Attach a conduit T to the bases of the IMPROVE Module A controller and each of the sampling modules, installing them along the width axis of the modules, such that conduit may be run between them.
3. Cut vacuum tubing into lengths appropriate to run, along the base of the samplers inside conduit, from the pumps to the brass fitting inside each sampling module. Leave several inches of spare length.
4. Thread the vacuum tubing lines straight through the T under the Module A controller, directing the line intended to run Module A up through the T and into the module.
5. Use a sharp knife or razor blade to cut the vacuum tubing cleanly and straight across its diameter. To connect the vacuum tubing to the module, slip a brass compression fitting over the end of the vacuum line, then tighten it to the brass elbow with a 5/8" wrench. This will seal the fitting to the vacuum hose. Extra brass vacuum line compression fittings are included in Ziplock™ bags attached to the vacuum tubing.
6. Uncoil the gray six wire electrical cable harness attached to the terminal strip in the Module A controller. Thread the free end through the T at the base of the IMPROVE Module A controller so that it runs toward the other sampling modules.
7. Cut a length of conduit to fit between the T of the controller module and the T of the nearest sampling module.
8. Thread the gray six wire electrical cable harness and the vacuum tubing through the section of conduit and through the T on the base of the sampling module.
9. Feed the first free set of panduit connectors on the six wire electrical cable into the aerosol sampling module through the T on the base of the module.
10. Connect the panduit connectors to the pins of the terminal strip on the right side of the module in the order Red, Orange, Green, Blue, Black, White, starting from the bottom of the terminal strip.
11. Thread the shortest length of vacuum tubing into the sampling module through the T on the base of the module.

12. Use a sharp knife or razor blade to cut the vacuum tubing cleanly and straight across its diameter. To connect the vacuum tubing to the module, slip a brass compression fitting over the end of the vacuum line, then tighten it to the brass elbow with a 5/8" wrench. This will seal the fitting to the vacuum hose. Extra brass vacuum line compression fittings are included in Ziplock™ bags attached to the vacuum tubing.
13. Cut a length of conduit to fit between the T of the current sampling module and the T of the next sampling module, or, if there are no more modules, put a cap on the open end of the T.
14. Repeat steps 7 through 12 until all the modules are connected to the controller module and all the vacuum lines are connected to modules.
15. Connect the Module A Controller to power by running an extension cord from power to the male inset plug on the base of the module.
16. Turn on the power. Turn on the white breaker ("on/off") switch below the solenoids in the Module A controller to power the sampler. The clock controller (located on the door) will come on a few seconds later and read 12:00.

4.2.4 Connecting Pumps to the Aerosol Sampler

The aerosol sampler uses external pumps, switched by the circuitry in the controller module, to produce the appropriate flow rate. External pumps reduce the weight of the sampler modules, and are easier to maintain or replace. The procedures for installing pumps are as follows:

1. Select the location to install the pumps.
   a. If the aerosol sampler has a Controller Module A, or an indoor IMPROVE controller module;
      - Select a location near the 4 outlet box connected to the controller module for the pumps.
      - Verify that the vibration from the pumps will not affect the sampling modules
      - Verify that there is adequate air flow around the pumps to prevent overheating during sampling.
   b. If the aerosol sampler is outdoors;
      - The pumps will be installed in the pump house.
2. Set vacuum pumps upright in the selected location.
3. Plug the pumps into the 4 outlet box connected to and switched by the controller module.
4. Connect the vacuum tubing from each module to the pump plugged into the outlet labeled as switching that module. Use a 5/8" wrench.
5. If the tubing is substantially longer than necessary, use a sharp knife or razor blade to cut the vacuum tubing to the required length. To connect the vacuum line to the pump, make sure the hose was cut cleanly and straight across, slip the compression fitting over the end of the vacuum line, then tighten the compression fitting onto the pump. It will automatically seal to the vacuum hose. Extra brass vacuum line compression fittings are included in Ziplock™ bags attached to the vacuum tubing.

6. Verify the functioning of the pumps.
    a. For an IMPROVE controller module A, switch the pump vacuum switch, located on the face plate of the module to "on" (or "manual"). The first pump should come on immediately, followed by the others at approximately 8 second intervals. Check to make sure the small gauge (vacuum) reads greater than 20" Hg for each module. If not, check the tubing connections for leaks.
    b. For an IMPROVE controller module, turn the override timer located in the module past the 5 minute mark. The first pump should come on immediately, followed by the others at approximately 8 second intervals. Check to make sure the small gauge (vacuum) reads greater than 20" Hg for each sampler module, except at high elevation sites (greater than 7000')where the readings may be as low as 18" Hg due to the low air pressure. If the vacuum gauge readings are low, check the tubing connections for leaks.

4.2.5 Sampler Function Check

Once the sampler has been installed, validation procedures to verify the correct wiring and functioning of the sampler components are necessary. The following are instructions for sampler validation checks:

4.2.5.1 Verify Correct Switching by the Clock Controller.

1. 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 the top row of override buttons will cycle through these options.
2. Verify that the appropriate channel, the one switched on by the clock controller, comes on in all sampling modules. Check the solenoid by holding your hand over the end of the solenoid valves to verify air flow. Verify the functioning of the elapsed timer by leaving the sampler running for a minute and observing the timer moving.
    a. 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 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.
    b. 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 volt meter. 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.

3. 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.

4.2.5.2 Verify Correct Switching by the Manual Toggle Switches.

1. First, turn on the pumps.
   a. For an IMPROVE controller module, turn the override timer in the controller module past 5 minutes and wait for the pumps to turn on. Note that the pumps will turn off when the timer reaches zero.
   b. For an IMPROVE Module A controller, turn the pump override switch on the face plate from "off " or "auto" to "on" or "manual".

NOTE: If the pumps do not come on, and the vacuum gauges in the sampling modules show greater than 5" of Hg, try pressing the toggle switch in a sampling module to release vacuum from the system.

2. 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.
   a. 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.
   b. 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.
3. Turn each channel off by releasing the toggle switch. To turn the pumps off, switch the pump override switch to "auto" or "off".

4.2.5.3 Verify the Integrity of the Vacuum System.

1. Connect a calibration cassette to solenoid #1 (the solenoid farthest to the left) and install it on a port on the cyclone filter mounting plate. The quick connect fitting between the hose from the solenoid and the filter cassette should snap and lock into position. Verify that all cyclone ports either have filters mounted on them and are connected to solenoids, or are covered by port caps to prevent leaks.
2. For an IMPROVE controller module, turn the override timer in the controller module past 5 minutes and wait for the pumps to turn on. Note that the pumps will turn off when the timer reaches zero. For an IMPROVE Module A controller, turn the pump override switch on the face plate from "off " or "auto" to "on" or "manual". If the pumps do not come on, and the vacuum gauges in the sampling modules show greater than 5" of Hg, try pressing the toggle switch in a sampling module to release vacuum from the system.
3. Record the maximum vacuum reading (Max. Vac.) from the vacuum gauge in each module on a sheet of scratch paper. Also record the sampler magnehelic reading when there is no flow for each module(Mag_o). Tap the gauges to be sure the needles are not sticking.
5. Remove the inlet cap from the top of the inlet stack.

6. Insert a spare stack plug into the top of the inlet stack.
7. Hold the filter 1 toggle switch in the open position (press to the left) to allow air flow through the calibration filter on solenoid 1. In this configuration, the module should have no leaks and the vacuum gauge reading should rise to the Max. Vac. reading recorded on the scratch paper for the module being tested. 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.
8. If leaks are found, check the following:
    a. Both the stack plugs must seal tightly to prevent air flow. Try to shift them, or replace them with new plugs to see if this reduces the leak.
    b. Filters and port plugs must be securely mounted on the cyclone. Ask an assistant to 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.
9. Repeat the procedures in section 4.2.5.3 for each of the sampling modules.