11.0 Instrument Equipment Testing, Inspection and Maintenance

Implementing an ambient air monitoring network, with the various types of equipment needed, is no easy task. Through appropriate testing, inspection and maintenance programs, monitoring organizations can be assured that equipment is capable of operating at acceptable performance levels. Every piece of equipment has an expected life span, and its use should be discontinued if its performance quality ceases to meet appropriate standards. For amortization purposes, EPA estimates a 7 year lifespan for most monitoring instruments and a somewhat longer lifespan for more permanent types of equipment (instrument racks, monitoring shelters etc.). This means that funds for replacing capital equipment are provided in resource allocations and monitoring organizations should make the best use of equipment replacement resources. Monitoring organizations may be able to prolong the life of equipment but in doing so they may run the risk of additional downtime, more upkeep and a greater chance of data invalidation, while losing out on newer technologies, better sensitivity/stability and the opportunities for better information management technologies.

Due to the many types of equipment that can be used in an ambient air monitoring program, this section provides general guidance on testing, inspection, and maintenance procedures for broad categories of equipment only. In most cases, equipment manufacturers include inspection and maintenance information in the operating manuals. The role of monitoring organizations, in developing a quality system, is to address the scheduling and documentation of routine testing, inspection, and maintenance. Detailed maintenance documents should be available for each monitoring site. Elements incorporated into testing, inspection and maintenance documents include:

- equipment lists - by organization and station;
- spare equipment/parts lists - by equipment, including suppliers;
- inspection/maintenance frequency - by equipment;
- testing frequency and source of the test concentrations or equipment;
- equipment replacement schedules;
- sources of repair - by equipment;
- service agreements that are in place; and
- monthly check sheets and entry forms for documenting testing, inspections and maintenance performed.

11.1 Instrumentation

11.1.1 Analyzers and Samplers

Aside from the specific exceptions described in Appendix C of Part 58[1], monitoring methods used for SLAMS monitoring must be a reference or equivalent method, designated as such by 40 CFR Part 53[2]. Reference or equivalent methods also must be used at NCore monitoring sites intended for comparison with any NAAQS. Among reference and equivalent methods, a variety of analyzer designs and features are available. For certain pollutants, analyzers employing different measurement principles are available. Some analyzer models only meet the minimum performance specifications (see Table 7-5), while others provide a higher level of performance. Section 7 provides information on what aspects to consider when selecting a particular monitoring instrument/analyzer. Upon receiving the new analyzer, the user should

[1] Code of Federal Regulations, Title 40, Part 58, Appendix C, U.S. Government Printing Office, 2006.
[2] Code of Federal Regulations, Title 40, Part 53, U.S. Government Printing Office, 2006.

carefully read the instructions or operating manual provided by the manufacturer. Information or instructions concerning the following should be found in the manufacturer's manual:

- unpacking and verifying that all component parts were delivered;
- checking for damage during shipment;
- checking for loose fittings and electrical connections;
- assembling the analyzer;
- installing the analyzer;
- calibrating the analyzer;
- operating the analyzer;
- electrical and plumbing diagrams;
- preventive maintenance schedule and procedures;
- troubleshooting; and
- a list of expendable parts.

Many vendors have specific time periods when the initial checks for damage in transit need to be made. The monitor should be assembled and set up according to the instructions in the manufacturer's manual. It may be important to do this initial set-up and testing at the main office or laboratory facility (see Section 11.1.3) before taking the equipment to the site. Following analyzer set-up, an initial verification of performance characteristics such as power flow, noise, and response time and a muti-point verification should be performed to determine if the analyzer is operating properly. These guidelines assume that the instrument was previously calibrated. If the instrument was disassembled after calibration, or no calibration of the instrument had previously been performed, the monitor must have a multi-point verification/calibration to ensure it is within acceptable calibration requirements prior to use. Short-term span, zero drift and precision should be checked during the initial calibration or measured using abbreviated forms of the test procedures provided in 40 CFR Part 53[3]. Acceptance of the analyzer should be based on results from these performance tests. Once accepted, reference and equivalent analyzers are guaranteed by the manufacturer to operate within the required performance specifications for one year[4], unless major repairs are performed or parts are replaced. In such instances, the analyzers must be recalibrated before use.

11.1.2 Support Instrumentation

Experiences of monitoring organization staff; preventive maintenance requirements, ease of maintenance and general reliability play crucial roles in the selection of support equipment. The following examples depict general categories of support equipment and typical features to look for when selecting this equipment. This list is meant to guide agencies in the selection of equipment and does not represent required specifications.

- **Calibration Standards:** Calibration standards fall into several categories:
  - mass flow controlled (MFC) devices;
  - standards that meet the 1997 Traceability Protocol for Gaseous Calibration Standards[5];
  - permeation devices;
  - photometers;

[3] Code of Federal Regulations, Title 40, Part 53, U.S. Government Printing Office, 2006.
[4] Code of Federal Regulations, Title 40, Part 53, U.S. Government Printing Office, 2006.
[5] EPA 600/R-97/121: Traceability Protocol for Gaseous Calibration Standards, September 1997

- flow measurement devices;
- water pressure measurement devices;
- barometric pressure measurement devices; and
- temperature measurement devices.

It is recommended that the devices be 110 VAC, be compatible with data acquisition systems for automated calibrations, and have digital compatibility or true transistor-transistor logic (TTL). The most common standards are MFC devices and permeation devices. Both use dilution air to obtain the needed output pollutant concentration.

- **Data Acquisition Systems (DAS):** DAS should have at least 32-bit logic for improved performance (DAS with at least 16-bit logic can still be used); have modem and internet capabilities; allow remote access and control; allow for digital input; and be able to initiate automated calibrations and polling. It is also recommended that DAS have software compatible with AQS and AQI reporting and editing. Both data loggers and analog chart recorders may be used for recording data; however, the storage, communicability, and flexibility of DAS coupled with data loggers makes the DAS systems the preferred option. More information on DAS is found in Section 14.

- **Instrument Racks:** Instrument racks should be constructed of steel and be able to accept sliding trays or rails. Open racks help to keep instrument temperatures down and allow air to circulate freely.

- **Instrument Benches:** Instrument benches should be of sufficient space to allow adequate room for multiple instruments with room to work and be capable of supporting a fair amount of weight (> 100 lbs). Slate or other hard, water-proof materials (e.g., steel) are recommended.

- **Zero Air Systems:** Zero air systems should be able to deliver 10 liters/min of air that is free of ozone, NO, NO_2, and SO_2 to 0.001 ppm and CO and non-methane hydrocarbons to 0.1 ppm. There are many commercially available systems; however, simple designs can be obtained by using a series of canisters.

11.1.3 Laboratory Support

While it is not required, monitoring organizations should employ full laboratory facilities. These facilities should be equipped to test, repair, troubleshoot, and calibrate all analyzers and support equipment necessary to operate the ambient air monitoring network. In cases where individual laboratories are not feasible, a monitoring organization may be able to find a central laboratory where these activities can be performed.

It is recommended that the laboratory be designed to accommodate the air quality laboratory/shop and PM_{10} and $PM_{2.5}$ filter rooms, as well as enforcement instrumentation support activities. The air quality portion consists of several benches flanked by instrument racks. One bench and rack are dedicated to ozone traceability. The other instrument racks are designated for calibration and repair. A room should be set aside to house spare parts and extra analyzers.

A manifold/sample cane should be mounted behind the bench. If possible, a sample cane that passes through the roof to allow analyzers that are being tested to sample outside air should be mounted to the

bench. This also allows any excess calibration gas to be exhausted to the atmosphere. It is recommended that the pump room be external to the building to eliminate noise.

Each bench area should have an instrument rack attached to the bench. The instrument rack should be equipped with sliding trays or rails that allow easy installation of instruments. If instrumentation needs to be repaired and then calibrated, this can be performed on the bench top or within the rack. Analyzers then can be allowed to warm up and be calibrated by a calibration unit. Instruments that are to be tested are connected to the sample manifold and allowed to sample air in the same manner as if the analyzer were being operated within a monitoring station. The analyzer is connected to an acquisition system (e.g., DAS, data logger, chart recorder, etc.) and allowed to operate. Any intermittent problems that occur can be observed on the data logger/chart recorder. The analyzer can be allowed to operate over several days to see if anomalies or problems reoccur; if they do, there is a record of them. If the instrument rack has a DAS and calibrator, nightly auto calibrations can be performed to see how the analyzer reacts to known gas concentrations. In addition, the ozone recertification bench and rack should be attached to a work bench. The rack should house the local ozone primary standard and the ozone transfer standards that are being checked for recertification. Zero air is plumbed into this rack for the calibration and testing of ozone analyzers and transfer standards.

11.2 Preventive Maintenance

Every monitoring organization should develop a preventive maintenance program. Preventive maintenance is what its name implies; maintaining the equipment within a network to prevent downtime and costly repairs and data loss. Preventive maintenance is an ongoing element of quality control and is typically enveloped into the daily routine. In addition to the daily routine, scheduled activities must be performed monthly, quarterly, semi-annually and annually.

Preventive maintenance is the responsibility of the station operators and the supervisory staff. It is important that the supervisor review the preventive maintenance work and continually check the schedule. The supervisor is responsible for making sure that preventive maintenance is being accomplished in a timely manner. Preventive maintenance is not a static process; procedures must be updated for many reasons, including, but not limited to, new models or types of instruments and new or updated methods. The preventive maintenance schedule is changed whenever an activity is completed or performed at an alternate time. For instance, if a multipoint calibration is performed in February instead of on the scheduled date in March, then the subsequent six-month calibration date moves from September to August. On a regular basis, the supervisor should review the preventive maintenance schedule with the station operators. Following all repairs, the instruments must be verified (multi-point) or calibrated.

Lists can facilitate the organization and tracking of tasks and improve the efficiency of preventive maintenance operations. A checklist of regular maintenance activities (e.g., periodic zero-span checks, daily routine checks, data dump/collection, calibrations, etc.) is recommended. A spare parts list, including relevant catalog numbers, is also recommended, as it facilitates the ordering of replacement parts. Such a list should be readily accessible and should include the types and quantities of spare parts already on-hand.

11.2.1 Station Maintenance

Station maintenance is an element of preventive maintenance that does not occur on a routine basis; rather, these tasks usually occur on an "as needed" basis. Station maintenance items are checked monthly or whenever an agency knows that the maintenance needs to be performed. Examples of station maintenance items include:

- floor cleaning;
- shelter inspection;
- air conditioner repair;
- AC filter replacement;
- weed abatement and grass cutting;
- roof repair;
- general cleaning;
- inlet and manifold cleaning;
- manifold exhaust blower lube;
- desiccant replacement; and
- ladder, safety rails, safety inspection, if applicable.

Simple documentation of these activities, whether in station logs or electronic logs, helps provide evidence of continuous attention to data quality.

11.2.2 Routine Operations

Routine operations are the checks that occur at specified periods of time during a monitoring station visit. These duties must be performed and documented in order to operate a monitoring network at optimal levels. Examples of typical routine operations are detailed in Table 11-1.

Table 11-1 Routine Operation Checks

Item	Each Visit	Weekly/Monthly	Minimum
Review Data	X		
Mark charts, where applicable	X		
Check/Oil Exhaust Blower	X		
Check Exterior		X	
Check/Change Desiccant	X		
Manifold Leak Test		X	
Inspect tubing	X		
Replace Tubing			Annually[1]
Inspect manifold and cane	X		
Clean manifold and cane			Every 6 months or as needed
Check HVAC systems		X	
Check electrical connections		X	
Field site supply inventory		X	

[1]If tubing is used externally as an inlet devices it may need to be replaced every 6 months or more frequently depending upon site specific issues.

In addition to these items, the exterior of the building, sample cane, meteorological instruments and tower, entry door, electrical cables, and any other items deemed necessary to check, should be inspected for wear, corrosion, and weathering. Costly repairs can be avoided in this manner.

11.2.3 Instrument and Site Logs

Each instrument and piece of support equipment (with the exception of the instrument racks and benches) should have an Instrumentation Repair Log (either paper or electronic). The log should contain the repair and calibration history of that particular instrument. Whenever multipoint calibration, instrument maintenance, repair, or relocation occurs, detailed notes are written in the instrumentation log. The log contains the most recent multipoint calibration report, a preventive maintenance sheet, and the acceptance testing information or reference to the location of this information. If an instrument is malfunctioning and a decision is made to relocate that instrument, the log travels with that device. The log can be reviewed by staff for possible clues to the reasons behind the instrument malfunction. In addition, if the instrument is shipped to the manufacturer for repairs, it is recommended that a copy of the log be sent with the instrument. This helps non-agency repair personnel with troubleshooting instrument problems. Improper recording of instrument maintenance can complicate future repair and maintenance procedures. The instrument log should be detailed enough to determine easily and definitively which instrument was at which sites over any given time period. If a problem is found with a specific instrument, the monitoring staff should be able to track the problem to the date it initially surfaced and invalidate data even if the instrument was used at multiple sites.

The site log is a chronology of the events that occur at the monitoring station. The log is an important part of station maintenance because it contains the narrative of past problems and solutions to those problems. Site log notes should be written in the form of a narrative, rather than shorthand notes or bulleted lists. Examples of items that should be recorded in the site log are:

- the date, time, and initials of the person(s) who have arrived at the site;
- brief description of the weather (e.g., clear, breezy, sunny, raining);
- brief description of exterior of the site. Any changes that might affect the data should be recorded – for instance, if someone is parking a truck or tractor near the site, this may explain high NO_x values;
- any unusual noises, vibrations, or anything out of the ordinary;
- records of any station maintenance or routine operations performed;
- description of the work accomplished at the site (e.g., calibrated instruments, repaired analyzer); and
- detailed information about the instruments that may be needed for repairs or troubleshooting.

It is not required that the instrument and site logs be completely independent of each other. However, there is an advantage to having separate instrument logs. If instruments go in for repair, they may eventually be sent to another site. Having a separate instrument log allows the log to “travel” with the instrument. Keeping electronic instrument and station maintenance logs at stations and at centralized facilities (see LIMS discussion Section 8) also has record keeping advantages, but there needs to be a way that these records can be considered official and not be tampered with or falsified. Newer electronic signature technologies are helping ensure that electronic records can be considered official. It is important, however, that all of the required information for each instrument and site be properly recorded using a method that is comprehensive and easily understood. Many monitoring organizations have developed standard station maintenance forms that contain all the items to be checked and the frequency of those checks. It then becomes a very simple procedure to use this form to check off and initial the activities that were performed.