United States
Environmental Protection
Agency

Air Pollution Training Institute
MD 20
Environmental Research Center
Research Triangle Park, NC 27711

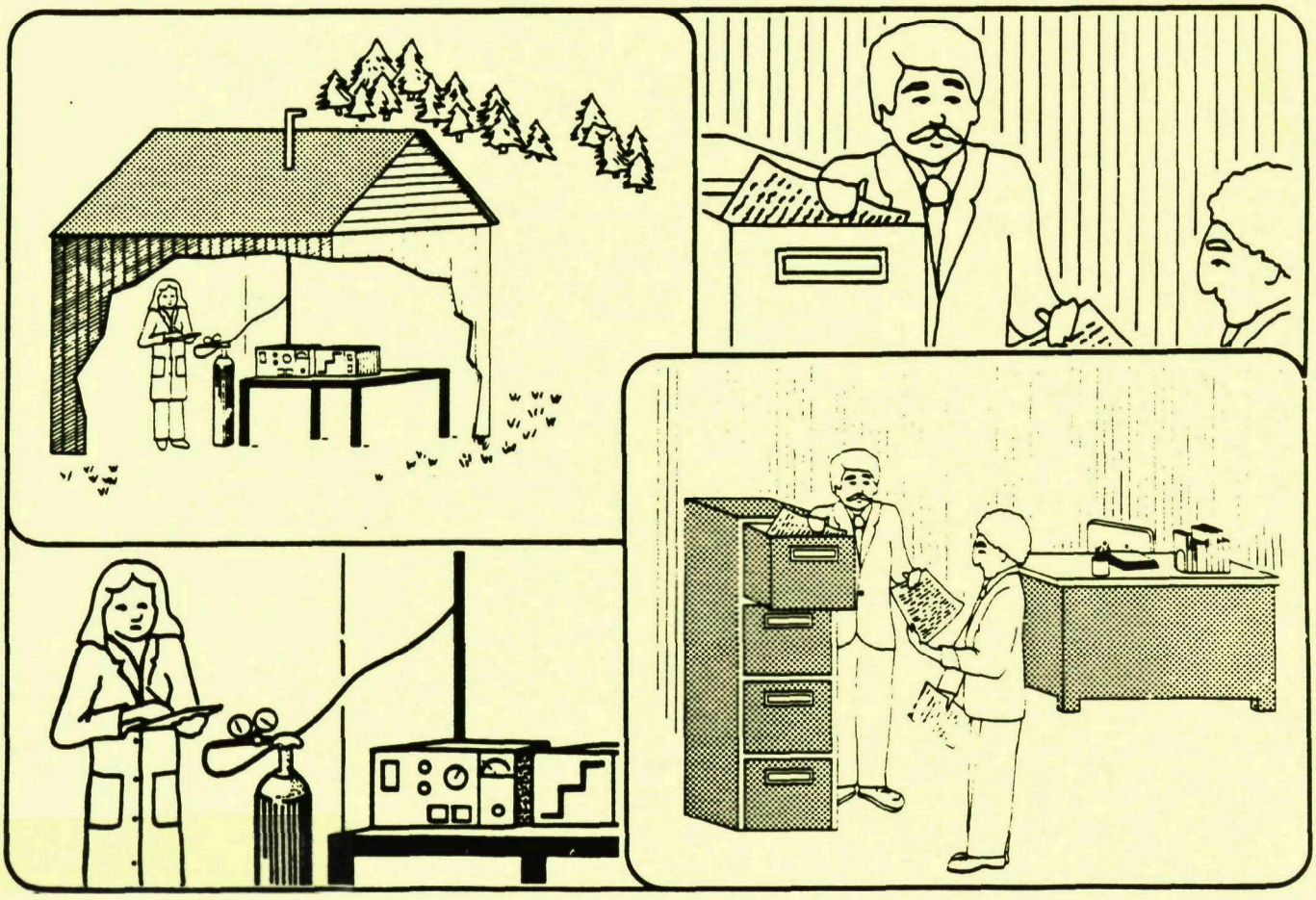
EPA 450/2-83-008
May 1984

Air

EPA

APTI Correspondence Course 471 General Quality Assurance Considerations for Ambient Air Monitoring

Guidebook



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APTI Correspondence Course 471 General Quality Assurance Considerations for Ambient Air Monitoring

Guidebook

Course Developed by:
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Instructional Design by:
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Northrop Services, Inc.
P.O. Box 12313
Research Triangle Park, NC 27709

Under Contract No.
68-02-3573
EPA Project Officer
R. E. Townsend

United States Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

Notice

This is not an official policy and standards document. The opinions and selections are those of the authors and not necessarily those of the Environmental Protection Agency. Every attempt has been made to represent the present state of the art as well as subject areas still under evaluation. Any mention of products or organizations does not constitute endorsement by the United States Environmental Protection Agency.

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Course Introduction

Overview of Course

Course Description

This training course is a 30-hour correspondence course concerning general quality assurance considerations for ambient air monitoring. It is a supplement for EPA APTI Course 470 *Quality Assurance for Air Pollution Measurement Systems.* Course topics include the following:

- quality assurance policy and principles,
- quality assurance for air quality monitoring systems,
- quality assurance for SLAMS and PSD air monitoring networks,
- performance auditing of air quality monitoring systems, and
- system auditing of SLAMS networks.

Course Goal

The purpose of this course is to familiarize you with general quality assurance considerations for ambient air monitoring.

Course Objectives

Upon completion of this course, you should be able to—

1. describe general principles of quality assurance,
2. describe general quality assurance considerations for the acquisition, installation, and operation of air quality monitoring systems,
3. describe quality control programs and data quality assessment for SLAMS and PSD air monitoring, and
4. describe audit criteria and procedures for air quality monitoring networks.

Sections and Trainee Involvement Time

Section number	Section title	Trainee involvement time (hours)
1	Quality Assurance Policy and Principles	3½
2	Quality Assurance for Air Quality Monitoring Systems	6
	Quiz 1	½
3	Quality Assurance for SLAMS and PSD Air Monitoring Networks	6
4	Performance Auditing of Air Quality Monitoring Systems	6
	Quiz 2	½
5	System Auditing of SLAMS Networks	6
	Final Examination	1½

Requirements for Successful Completion of this Course

In order to receive three Continuing Education Units (CEUs) and a certificate of course completion, you must fulfill the following requirements:

- take two supervised quizzes and a supervised final examination
- achieve a final course grade of at least 70 (out of 100), determined as follows:
  - 20% from Quiz 1
  - 20% from Quiz 2
  - 60% from the final examination.

Use of Course Materials

Necessary Materials

- EPA 450/2-83-008, *APTI Correspondence Course 471 General Quality Assurance Considerations for Ambient Air Monitoring: Guidebook*
- EPA 600/4-77-027a, *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II—Ambient Air Specific Methods*
- pencil or pen
- calculator

How to Use this Guidebook

Relationship Between Guidebook and Assigned Reading Materials

This guidebook directs your progress through Section 2.0 of Volume II of the *Quality Assurance Handbook for Air Pollution Measurement Systems.* Excerpts from Volume I are included in the guidebook to provide you with a basic introduction to quality assurance principles.

If you use the guidebook instructions with the provided reading material, we think you will find the subject material both interesting and enjoyable. Review exercises and problems focus on specific and important aspects of the quality assurance manual.

Description of Guidebook Sections

This guidebook contains reading assignment sections that correspond to lessons of the course.

Each section contains the following:

- reading assignment
- section's learning goal and objectives
- reading guidance
- review exercise.

Complete the review exercises immediately after reading the assigned materials. You may find it helpful to look over the review questions before reading. By having an idea of what to look for in the reading materials, your attention will be better focused and your study will be more efficiently directed.

NOTE: If more than one person will be using these materials, we recommend that you use a separate sheet of paper to record your answers to the review exercises.

Instructions for Completing the Quizzes and the Final Examination

- You should have received, along with this guidebook, a separate ***sealed*** envelope containing two quizzes and a final examination.
- You must arrange to have someone serve as your test supervisor.
- You must give the ***sealed*** envelope containing the quizzes and final examination to your test supervisor.
- At designated times during the course, under the supervision of your test supervisor, complete the quizzes and the final exam.
- After you have completed a quiz or the exam, your test supervisor must sign a statement on the quiz/exam answer sheet certifying that the quiz or exam was administered in accordance with the specified test instructions.
- After signing the quiz/exam answer sheet, your test supervisor must mail the ***quiz or exam and its answer sheet*** to the following address:

  Air Pollution Training Institute
  Environmental Research Center
  MD 20
  Research Triangle Park, NC 27711
- After completing a quiz, continue with the course. Do ***not*** wait for quiz results.
- Quiz/exam and course grade results will be mailed to you.

If you have questions, contact:

Air Pollution Training Institute
Environmental Research Center
MD 20
Research Triangle Park, NC 27711

Telephone numbers:
Commercial: (919) 541-2401
FTS: 629-2401

Section 1

Quality Assurance Policy and Principles

Reading Assignment

Read, in the following order:

- Pages 1-5 through 1-63 of this guidebook.
- Section 2.0.5 of *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II—Ambient Air Specific Methods,* EPA 600/4-77-027a.

Reading Assignment Topics

- USEPA's quality assurance policy
- Quality assurance principles
- Development and implementation of quality assurance programs

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with the USEPA's quality assurance policy and with general principles of quality assurance.

Learning Objectives

At the end of this section, you should be able to—

1. explain why quality assurance procedures are a vital part of the USEPA's air monitoring programs,
2. initiate the development of a quality assurance program for ambient air monitoring,
3. list at least eight elements of an effective quality assurance program,
4. define *quality assurance, quality control, accuracy, precision, quality assurance program plan, quality assurance project plan, performance audit,* and *system audit,*
5. describe the importance of a quality assurance program to an organization,
6. recognize the contribution of training programs to the reporting of high-quality data,

7. list at least four items that should be included in a quality assurance report to management,
8. distinguish between a quality assurance program plan and a quality assurance project plan, and
9. describe the responsibilities of the USEPA and State and local air pollution control agencies for the development and implementation of quality assurance programs.

Reading Guidance*

This assignment reviews the United States Environmental Protection Agency's quality assurance policy for air pollution data and guidance for the development of quality assurance programs. Memos giving the rationale for the development of quality assurance programs, and portions of Volume I of the USEPA *Quality Assurance Handbook* are included in this section.

In-depth training in the principles discussed in Volume I can be obtained by attending EPA APTI Course 470, *Quality Assurance for Air Pollution Measurement Systems.* This lecture course is designed for quality assurance coordinators or managers involved with quality assurance activities and for field and laboratory personnel working with air pollution measurements.

Volume I of the *Quality Assurance Handbook* focuses on 23 elements of a quality assurance program. Eight of these elements are considered essential for setting up a new program. The discussion given in Volume I for each of these eight elements is reproduced in this section for your review.

The following comments introduce you to the reading assignment. Read them along with the assignment; they will help familiarize you with some of the main ideas of quality assurance, and will make the reading assignment easier to understand.

1. Definition of quality assurance (QA)
   - Be sure to note the distinction between *quality control* and *quality assurance.*
   - What is the *product* with which USEPA quality assurance programs are concerned?
2. Elements of quality assurance
   - The elements have been placed on a wheel to indicate that the relative importance of individual elements depends on the measurement program objectives.

*This section has been adapted from J. A. Jahnke (1982), *APTI Correspondence Course 414 Quality Assurance for Source Emission Measurement Methods: Guidebook,* EPA 450/2-82-003.

- The eight elements reviewed here should be considered from the very beginning in the development of a program. They are as follows:
  (1) document control and revisions
  (2) policy and objectives
  (3) organization
  (4) training
  (5) audit procedures
  (6) quality reports to management
  (7) quality assurance program plan
  (8) quality assurance project plans.
- The 23 quality assurance elements can be grouped into four general categories:
  (1) management activities
  (2) measurement activities
  (3) routine systems for program operation and support
  (4) statistical techniques.

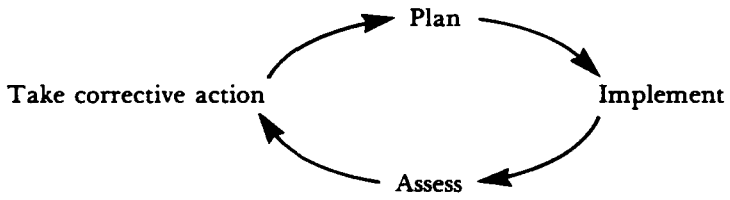
3. Document control and revisions
   - Note the indexing format of the Volume I excerpts included in the reading assignment. Also note the indexing format in Volume II. The format provides a means of tracking and updating entries in QA plans.
   - The purpose of document control is to provide the latest procedures to all concerned.

4. Quality assurance policy and objectives
   - The QA policy of an organization must have the support of upper-level management if the QA program is to be effective. Note the memos reproduced in the reading assignment.
   - When reading the discussion of this element, note that data quality objectives should be specified for:
     (1) completeness
     (2) precision
     (3) accuracy
     (4) representativeness
     (5) comparability.
     However, data use should be kept in mind.

5. Organization
   - Quality assurance is normally a separate function. The separation helps prevent bias and provides easier access to upper-level management.
   - A QA coordinator should be appointed and his function spelled out in a position description.

6. Training
   - You cannot produce high-quality data with people who do not know how to do their jobs. It is the responsibility of management to see that the job is done right.

7. Audit procedures
   - Audit procedures should be implemented as quickly as possible when setting up a QA program.
   - Audits are one of the best ways of checking the quality of data.
8. Quality reports to management
   - Feedback is very important for managers. Anything that affects management decisions should be included in the report.
   - Reports should be understood at a glance. When possible, use charts and graphs to present data, rather than tables.
9. The quality assurance program plan
   - Note that a quality assurance program plan is general. It covers QA for all of the projects of an organization.
10. The quality assurance project plan
    - Note that a quality assurance project plan gives the specific QA requirements for a measurement project.
    - In this sense, the USEPA *Quality Assurance Handbook,* Volume I, provides guidance for the development of an organization's QA program plan. Volume II provides guidance for the development of QA project plans for ambient air monitoring.
11. Although not included in the excerpts, it is important to mention the *QA cycle*. The cycle is shown below.



    The effect of applying quality assurance techniques should result in the development of an on-going corrective action system. Once a QA plan is written and implemented, assessment procedures point out necessary corrective action which, in effect, revises the plan. The cycle continues in this manner, providing quality air monitoring data.
12. Final note: The number of air monitoring organizations having formal quality assurance programs has greatly increased since the promulgation of Federal quality assurance regulations for ambient air monitoring (40 CFR 58, Appendixes A and B; May 10, 1979).

When you have finished the reading assignment, complete the review exercise that begins on page 1-65 and check your answers. The correct answers are listed on the page following the review exercise. After you have reviewed your incorrect answers (if any), proceed to Section 2 of this guidebook.

Attachment B

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D C 20460

THE ADMINISTRATOR

May 30, 1979

MEMORANDUM

TO: Deputy Administrator
Director, Science Advisory Board
Director, Office of Regional and Intergovernmental Operations
Regional Administrators
Assistant Administrators
General Counsel

SUBJECT: Environmental Protection Agency (EPA) Quality Assurance Policy Statement

The EPA must have a comprehensive quality assurance effort to provide for the generation, storage, and use of environmental data which are of known quality. Reliable data must be available to answer questions concerning environmental quality and pollution abatement and control measures. This can be done only through rigorous adherence to established quality assurance techniques and practices. Therefore, I am making participation in the quality assurance effort mandatory for all EPA supported or required monitoring activities.

An Agency quality assurance policy statement is attached which gives general descriptions of program responsibilities and basic management requirements. For the purpose of this policy statement, monitoring is defined as all environmentally related measurements which are funded by the EPA or which generate data mandated by the EPA.

A detailed implementation plan for a total Agency quality assurance program is being developed for issuance at a later date. A Select Committee for Monitoring, chaired by Dr. Richard Dowd, is coordinating this effort, and he will be contacting you directly for your participation and support. I know that each of you shares my concern about the need to improve our monitoring programs and data; therefore, I know that you will take the necessary actions that will ensure the success of this effort.

Douglas M. Costle

Attachment

Strategy for the Implementation
of the
Environmental Protection Agency's
Mandatory Quality Assurance (QA) Program

I. Introduction

The EPA must have a comprehensive QA program to provide for the generation, storage, and use of environmental data. Valid data of verifiable quality must be available to provide a sound basis for effective decisions concerning environmental quality, pollution abatement, and control measures. The QA program can succeed only through rigorous adherence to established QA techniques and practices.

In the past, there has been a high degree of fragmentation, lack of coordination, poorly identified needs and resources, and duplication of efforts in the QA program. For these reasons, it is now Agency policy, as enunciated by the Administrator in memoranda of May 30, 1979 and June 14, 1979, that all Regional Offices, Program Offices, EPA Laboratories, and those monitoring and measurement efforts supported or mandated through contracts, regulations, or other formalized agreements participate in a centrally managed QA program. Regional Offices should work cooperatively with States to assist them in developing and implementing QA programs.

The mandatory QA program covers all environmentally-related measurements. Environmentally-related measurements are defined as "essentially all field and laboratory investigations that generate data involving the measurement of chemical, physical, or biological parameters in the environment; determining the presence or absence of pollutants in waste streams; health and ecological effect studies; clinical and epidemiological investigations; engineering and process evaluations;

studies involving laboratory simulation of environmental events; and studies or measurements on pollutant transport, including diffusion models.

This document presents the strategy for the development of an Agency QA program in accordance with the Agency policy. This strategy describes, in general, the total program effort with respect to what must be done. This strategy does not attempt to describe how, in detail, the program is to be implemented within the individual Program and Regional Offices, or the EPA Laboratories. Subsequent guidance documents will enable the Program and Regional Offices and the EPA Laboratories to develop detailed QA plans.

II. Quality Assurance Goals and Objectives

The primary goal of the QA program is to insure that all environmentally-related measurements supported or required by the EPA result in data of known quality. To meet this goal, the QA program must provide for the establishment and use of reliable monitoring and measurement systems to obtain data of necessary quality to meet planned Agency needs.

Initial objectives are the development and implementation of QA program plans by each of the Program and Regional Offices and EPA Laboratories which will ensure that the QA goal can be achieved nationally.

Long-term objectives include (1) providing quantitative estimates of the quality of all data supported or required by the Agency, (2) improving data quality where indicated, and (3) documenting progress in achieving data quality.

A continuing objective is to promote and develop optimally uniform approaches,

procedures, techniques, reporting methods, etc., across media and across Regional Offices, Program Offices, and EPA Laboratories. It is important (and most efficient and effective) for all organizations within EPA to employ the same QA language, consistent policies, procedures, and techniques when interacting with the States, industry, the public, contractors, grantees, QA-involved professional societies, other Governmental agencies, and national and international organizations.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D C 20460

Attachment C

THE ADMINISTRATOR

June 14, 1979

MEMORANDUM

SUBJECT: Quality Assurance Requirements for all EPA Extramural Projects Involving Environmental Measurements

FOR: The Deputy Administrator
Assistant Administrators
Regional Administrators
General Counsel

Over the past several years, the EPA has become more and more dependent on extramural projects to provide the environmental measurements we use as a foundation for our standards, regulations and decisions. While in most instances these projects are providing data of proven quality that is acceptable for the Agency's purposes, there have been, regrettably, some instances of Agency funds paid for poor quality, unusable data.

In order to assure that all environmental measurements done by extramural funding result in usable data of known quality, I am making the inclusion of the attached "Quality Assurance Requirements" mandatory for all EPA grants, contracts, cooperative agreements, and interagency agreements that involve environmental measurements. In addition to these general requirements, I expect every Project Officer to include whatever additional specific quality assurance requirements are necessary in each extramural project under his control. Criteria and guidelines in this area will be forthcoming from the Agency's Quality Assurance Implementation Work Group. Further, I direct the Assistant Administrator for Planning and Management to provide the appropriate contract and grant regulations such that the attached form "Quality Assurance Review for Extramural Projects Involving Environmental Measurements" will be satisfactorily completed where appropriate prior to the approval of any contracts or grants in FY-80.

I recognize that this may increase the cost per environmental measurement, but the benefits of a credible Agency data base that provides a level of quality that meets the needs of users far outweigh any such increases.

Douglas M. Costle

Attachment

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D C 20460

THE ADMINISTRATOR

November 2, 1981

MEMORANDUM

TO: Associate Administrators
Assistant Administrators
Regional Administrators

SUBJECT: Mandatory Quality Assurance Program

One of the major concerns of this administration and myself is that we support all of our actions and decisions with statistically representative and scientifically valid measurement of environmental quality. To meet this objective, it is essential that each of you continue to support and implement the Agency's mandatory Quality Assurance program which is being implemented by the Office of Research and Development. It is especially essential that you assure that the appropriate data quality requirements are included in all of your extramural and intramural environmental monitoring activities. I also am particularly concerned that you do not sacrifice quality for quantity when adjusting your program to meet our new resource targets.

The attached Second Annual Quality Assurance Report demonstrates the importance of this program in achieving our goals and objectives. Recognizing its importance, I have asked Dr. Hernandez to closely monitor this program's implementation and advise me of any problems that affect the scientific data bases of the Agency.

Anne M. Gorsuch

Attachment

cc: Deputy Administrator
Office Directors

EPA-600/9-76-005
January 1976

QUALITY ASSURANCE HANDBOOK FOR AIR POLLUTION MEASUREMENT SYSTEMS

Volume I — Principles

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Environmental Monitoring and Support Laboratory
Research Triangle Park, North Carolina 27711

1.3 DEFINITION OF QUALITY ASSURANCE[1-6]

Quality assurance and quality control have been defined and interpreted in many ways. Some authoritative sources differentiate between the two terms by stating that quality control is "the operational techniques and the activities which sustain a quality of product or service (in this case, good quality data) that meets the needs; also the use of such techniques and activities," whereas quality assurance is "all those planned or systematic actions necessary to provide adequate confidence that a product or service will satisfy given needs."[1]

Quality control may also be understood as "internal quality control;" namely, routine checks included in normal internal procedures; for example, periodic calibrations, duplicate checks, split samples, and spiked samples. Quality assurance may also be viewed as "external quality control," those activities that are performed on a more occasional basis, usually by a person outside of the normal routine operations; for example, on-site system surveys, independent performance audits, interlaboratory comparisons, and periodic evaluation of internal quality control data. In this Handbook, the term quality assurance is used collectively to include all of the above meanings of both quality assurance and quality control.

While the objective of EPA's air programs is to improve the quality of the air, the objective of quality assurance for air programs is to improve or assure the quality of measured data, such as pollutant concentrations, meteorological measurements, and stack variables (e.g., gas velocity and mass emissions). Thus the "product" with which quality assurance is concerned is data.

Since air pollution measurements are made by numerous agencies and private organizations at a large number of field stations and laboratories, quality assurance is also concerned

with establishing and assessing comparability of data quality among organizations contributing to data bases.

1.3.1 REFERENCES

1. Juran, J. M. Quality Control Handbook, 3rd Ed. McGraw-Hill, 1974. Section 2.

2. ASTM. Designation E548-79, "Recommended Practice for Generic Criteria for Use in the Evaluation of Testing and Inspection Agencies."

3. ANSI/ASQC. Standard A3-1978. "Quality Systems Terminology."

4. ANSI/ASQC. Standard Z1.15-1980. "Generic Guidelines for Quality Systems."

5. Feigenbaum, A. V. Total Quality Control, Engineering and Management. McGraw-Hill, 1961.

6. Canadian Standards Association. CSA Standard Z299,1-1978. Quality Assurance Program Requirements.

1.4 ELEMENTS OF QUALITY ASSURANCE

A quality assurance program for air pollution measurement systems should cover a number of areas or elements. These elements are shown in Figure 1.4.1 in a "Quality Assurance Wheel." The wheel arrangement illustrates the need for a quality assurance system that addresses all elements and at the same time allows program managers the flexibility to emphasize those elements that are most applicable to their particular program. Quality assurance elements are grouped on the wheel according to the organization level to which responsibility is normally assigned. These organizational levels are the quality assurance coordinator (normally a staff function), supervisor (a line function), and the operator. Together the supervisor and quality assurance coordinator must see that all these elements form a complete and integrated system and are working to achieve the desired program objectives.

The three-digit numbers shown on the wheel show the location in Section 1.4 where a description of the element is provided. Each element is described in three subsections as follows:

1. ABSTRACT - A brief summary that allows the program manager to review the section at a glance.
2. DISCUSSION - Detailed text that expands on items summarized in the ABSTRACT.
3. REFERENCES - List of resource documents used in preparation of the discussion. In addition, where applicable, a list of resource documents for recommended reading is shown under BIBLIOGRAPHY.

The DISCUSSION subsection is designed to be relatively brief. In those cases where a topic would require considerable detailed discussion, the reader is referred to the appropriate

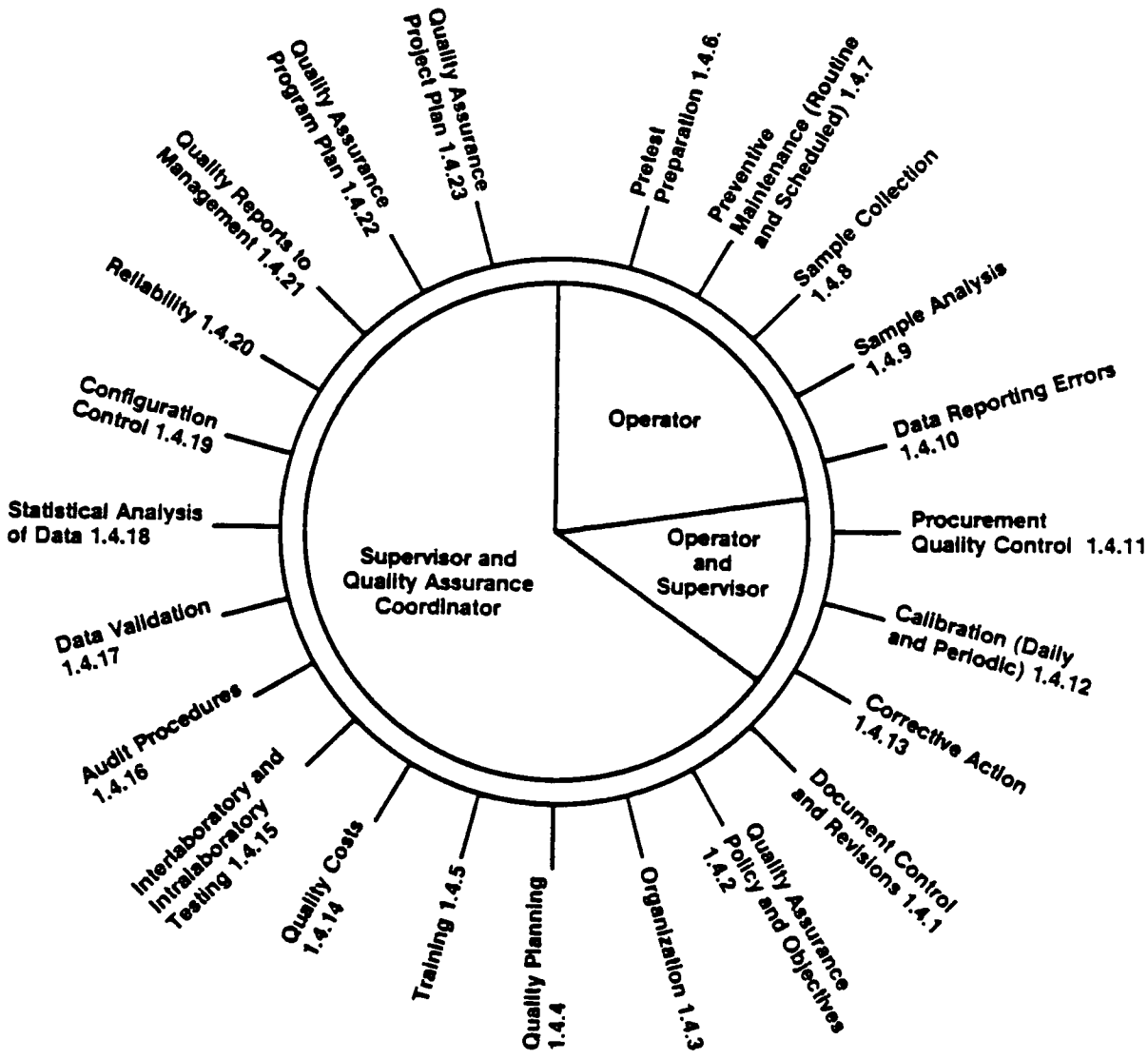
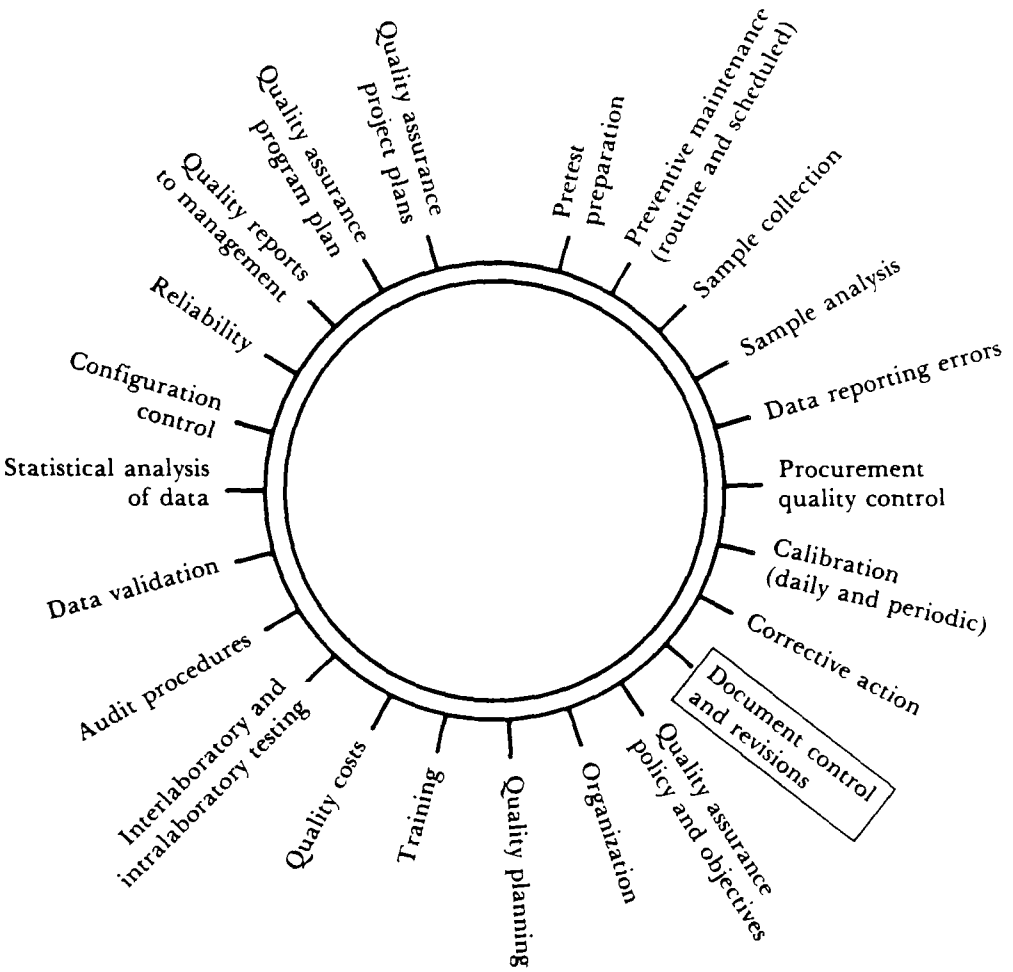


Figure 1.4.1. Quality assurance elements and responsibilities (the quality assurance wheel).

APPENDIX. A case in point is Section 1.4.18 on Statistical Analysis of Data. In this section the statistical methods are briefly summarized. For more details on the methods the reader is referred to the appropriate APPENDICES. For example, for statistical treatment of audit data the reader is referred to Appendix G.


Quality assurance project plans
Pretest preparation
Preventive maintenance (routine and scheduled)
Sample collection
Sample analysis
Data reporting errors
Procurement quality control
Calibration (daily and periodic)
Corrective action
Document control and revisions
Quality assurance policy and objectives
Organization
Quality planning
Training
Quality costs
Interlaboratory and intralaboratory testing
Audit procedures
Data validation
Statistical analysis of data
Configuration control
Reliability
Quality reports to management
Quality assurance program plan

1.4.1 DOCUMENT CONTROL AND REVISIONS

1.4.1.1 ABSTRACT

A quality assurance program should include a system for documenting operating procedures and subsequent revisions. The system used for this Handbook is described and is recommended.

1.4.1.2 DISCUSSION

A quality assurance program should include a system for updating the formal documentation of operating procedures. The suggested system is the one used in this Handbook and described herein. This system uses a standardized indexing format and provides for convenient replacement of pages that may be changed within the technical procedure descriptions.

The indexing format includes, at the top of each page, the following information:

Section No.
Date
Page

A digital numbering system identifies sections within the text. The "Section No." at the top of each page identifies major three-digit or two-digit sections, where applicable. Almost all of the references in the text are to the section number, which can be found easily by scanning the top of the pages. References to subsections are used within a section. For example, Section 1.4.4 represents "Quality Planning" and Section 1.4.5 represents "Training." "Date" represents the date of the latest revision. "Page No." is the specific page in the section. The total number of pages in the section is shown in the "Table of Contents." An example of the page label for the first page of "Quality Planning" in Section 1.4.4 follows:

For each new three-digit level, the text begins on a new page. This format groups the pages together to allow convenient revision by three-digit section.

The Table of Contents follows the same structure as the text. It contains a space for total number of pages within each section. This allows the Handbook user to know how many pages are supposed to be in each section. When a revision to the text is made, the Table of Contents page must be updated. For example, the Table of Contents page detailing Section 1.4 might appear as follows:

		Pages	Date
1.4.1	Document Control and Revisions	5	1-9-84
1.4.2	Quality Assurance Policy and Objectives	4	1-9-84
1.4.3	Organization	7	1-9-84

A revision to "Organization" would change the Table of Contents to appear as follows:

		Pages	Date
1.4.1	Document Control and Revisions	5	1-9-84
1.4.2	Quality Assurance Policy and Objectives	4	1-9-84
1.4.3	Organization	9	6-2-88

A Handbook distribution record has been established and will be maintained up to date so that future versions of existing Handbook sections and the addition of new sections may be distributed to Handbook users. In order to enter the user's name and address in the distribution record system, the "Distribution Record Card" in the front of Volume I of this Handbook must be filled out and mailed to the EPA address shown. (Note:

A separate card must be filled out for each volume of the Handbook). Any future change in name and/or address should be sent to the following:

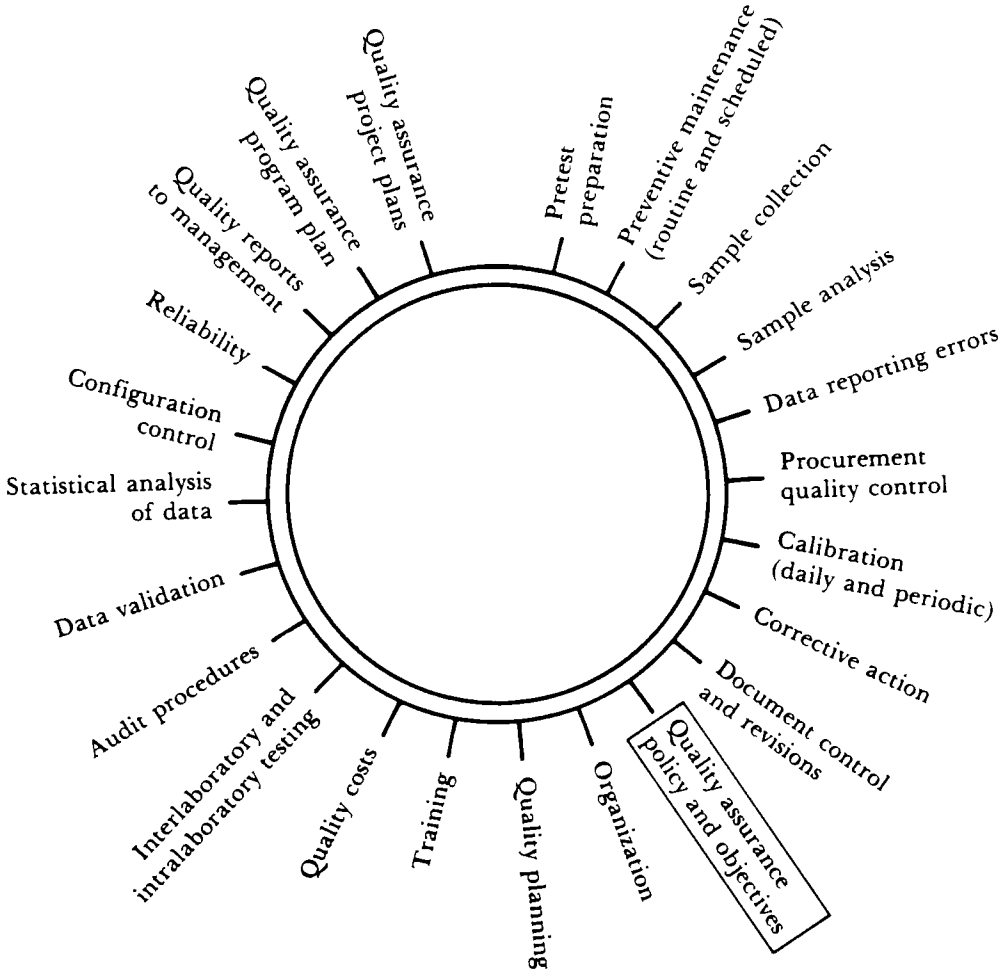
U.S. Environmental Protection Agency
ORD Publications
26 West St. Clair Street
Cincinnati, Ohio 45268

Attn: Distribution Record System

Changes may be made by the issuance of (1) an entirely new document or (2) replacement of complete sections. The recipient of these changes should remove and destroy all revised sections from his/her copy.

The document control system described herein applies to this Handbook and it can be used, with minor revisions, to maintain control of quality assurance procedures developed by users of this Handbook and quality assurance coordinators. The most important elements of the quality assurance program to which document control should be applied include:

1. Sampling procedures.
2. Calibration procedures.
3. Analytical procedures.
4. Data analysis, validation, and reporting procedures.
5. Performance and system audit procedures.
6. Preventive maintenance.
7. Quality assurance program plans.
8. Quality assurance project plans.


Quality assurance policy and objectives
Organization
Quality planning
Training
Quality costs
Interlaboratory and intralaboratory testing
Audit procedures
Data validation
Statistical analysis of data
Configuration control
Reliability
Quality reports to management
Quality assurance program plan
Quality assurance project plans
Pretest preparation
Preventive maintenance (routine and scheduled)
Sample collection
Sample analysis
Data reporting errors
Procurement quality control
Calibration (daily and periodic)
Corrective action
Document control and revisions

1.4.2 QUALITY ASSURANCE POLICY AND OBJECTIVES

1.4.2.1 ABSTRACT

1. Each organization should have a written quality assurance policy that should be made known to all organization personnel.

2. The objectives of quality assurance are to produce data that meet the users' requirements measured in terms of completeness, precision, accuracy, representativeness and comparability and at the same time reduce quality costs.

1.4.2.2 DISCUSSION

Quality assurance policy - Each organization should have a written quality assurance policy. This policy should be distributed so that all organization personnel know the policy and scope of coverage.

Quality assurance objectives[1,2,3] - To administer a quality assurance program, the objectives of the program must be defined, documented, and issued to all involved in activities that affect the quality of the data. Such written objectives are needed because they:

1. Unify the thinking of those concerned with quality assurance.
2. Stimulate effective action.
3. Are a necessary prerequisite to an integrated, planned course of action.
4. Permit comparison of completed performances against stated objectives.

Data can be considered to be complete if a prescribed percentage of the total possible measurements is present. Precision and accuracy (bias) represent measures of the data quality. Data must be representative of the condition being measured.

Ambient air sampling at midnight is not representative of carbon monoxide levels during rush hour traffic. Stationary source emission measurements are not representative if measured at reduced load production conditions when usual operation is at full load. Data available from numerous agencies and private organizations should be in consistent units and should be corrected to the same standard conditions of temperature and pressure to allow comparability of data among groups.

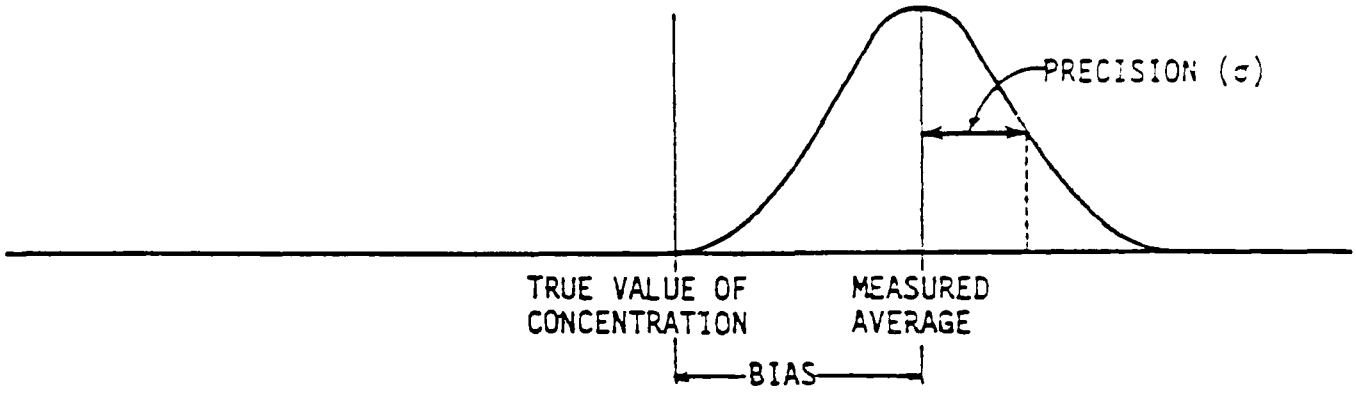
Figure 1.4.2.1 shows three examples of data quality with varying degrees of precision and bias. These examples hypothesize a true value that would result if a perfect measurement procedure were available and an infinitely large number of measurements could be made under specified conditions. If the average value coincides with the true value (reference standard), then the measurements are not biased. If the measurement values also are closely clustered about the true value, the measurements are both precise and unbiased. Figure 1.4.2.2 shows an example of completeness of data.

Each laboratory should have quantitative objectives set forth for each monitoring system in terms of completeness, precision, and bias of data. An example is included below for continuous measurement of carbon monoxide (nondispersive infrared spectrometry) to illustrate the point.

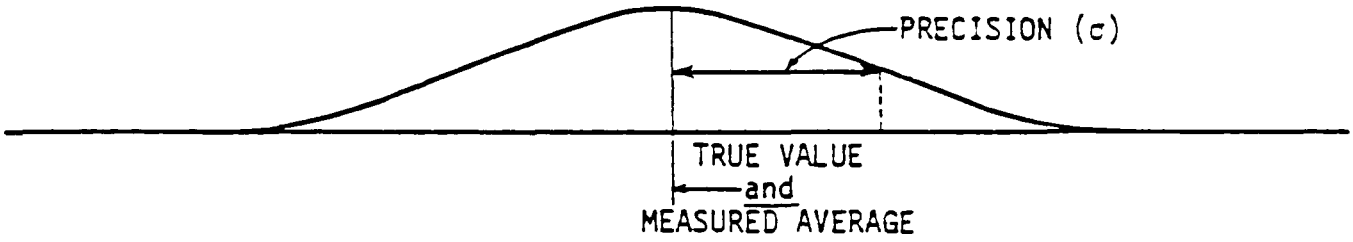
1. Completeness - For continuous measurements, 75 percent or more of the total possible number of observations must be present.[4]

2. Precision - Determined with calibration gases, precision is ±0.5 percent full scale in the 0 through 58 mg/m^3 range.[5,6]

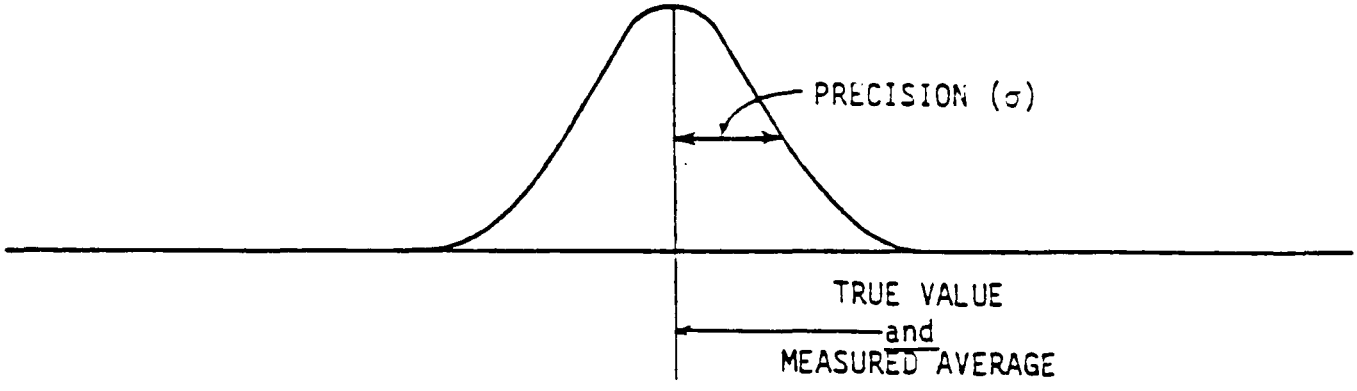
3. Accuracy - Depends on instrument linearity and the absolute concentrations of the calibration gases. An accuracy of ±1 percent of full scale in the 0 through 58 mg/m^3 range can be obtained.[5,6]



Example of Positive Biased but Precise Measurements



Example of Unbiased but Imprecise Measurements



Example of Precise and Unbiased Measurements

Figure 1.4.2.1. Examples of data with varying degrees of precision and bias (normal distribution assumed).

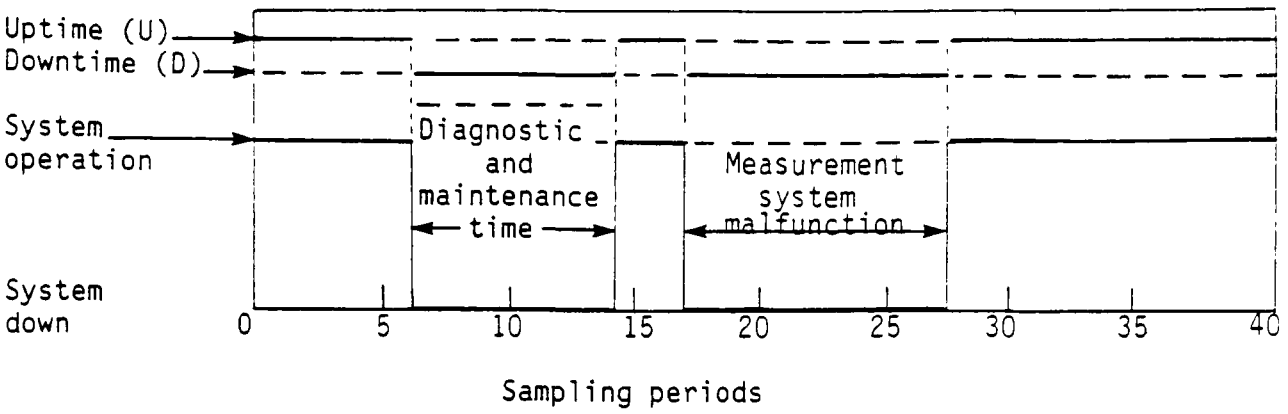


Figure 1.4.2.2. Example illustrating a measure of completeness of data, U/(D + U).

For further discussion of completeness, precision, accuracy and comparability, see the following:

1. Completeness and comparability, Section 1.4.17 of this volume.

2. Precision and accuracy, Appendix G of this volume.

Employment of the elements of quality assurance discussed in Section 1.4 should lead to the production of data that are complete, accurate, precise, representative, and comparable.

1.4.2.3 REFERENCES

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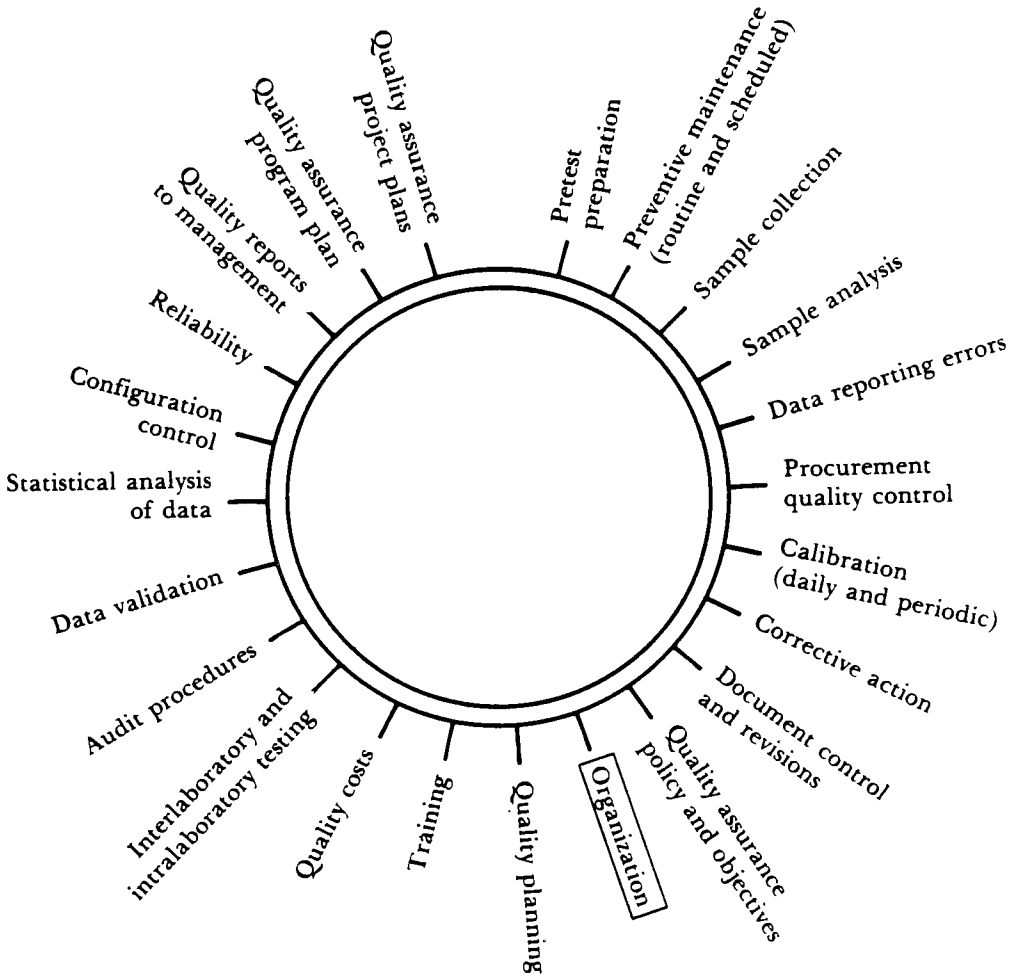
4. Nehls, G. J., and Akland, G. G. Procedures for Handling Aerometric Data. Journal of the Air Pollution Control Association, 23 (3):180-184, March 1973.

5. Appendix A - Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS), Federal Register, Vol. 44, Number 92, May 10, 1979.

6. Appendix B - Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring, Federal Register, Vol. 44, Number 92, May 10, 1979.


Organization
Quality assurance policy and objectives
Document control and revisions
Corrective action
Calibration (daily and periodic)
Procurement quality control
Data reporting errors
Sample analysis
Sample collection
Preventive maintenance (routine and scheduled)
Pretest preparation
Quality assurance project plans
Quality assurance program plan
Quality reports to management
Reliability
Configuration control
Statistical analysis of data
Data validation
Audit procedures
Interlaboratory and intralaboratory testing
Quality costs
Training
Quality planning

1.4.3 ORGANIZATION

1.4.3.1 ABSTRACT

1. Organizing a quality assurance function includes establishing objectives, determining the amount of emphasis to place on each quality assurance activity, identifying quality assurance problems to be resolved, preparing a quality assurance program and/or project plan, and implementing the plan.

2. The overall responsibility for quality assurance is normally assigned to a separate individual or group in the organization.

3. Quality assurance has input into many functions of an air pollution control agency. (See Figure 1.4.3.2 for details.)

4. The basic organizational tools for quality assurance implementation are:

a. Organization chart and responsibilities.

b. Job descriptions. (See Figure 1.4.3.3 for job description for the Quality Assurance Coordinator.)

c. Quality assurance plan.

1.4.3.2 DISCUSSION

Organizing the quality assurance function[1] - Because of the differences in size, workloads, expertise, and experience in quality assurance activities among agencies adopting the use of a quality assurance system, it is useful here to outline the steps for planning an efficient quality assurance system.

1. Establish quality assurance objectives (precision, accuracy, and completeness) for each measurement system (Section 1.4.2).

2. Determine the quality assurance elements appropriate for the agency (Figure 1.4.1).

3. Prepare quality assurance project plans for all measurement projects (Section 1.4.23).

4. Identify the quality assurance problems which must be resolved on the basis of the quality assurance project plan.

5. Implement the quality assurance project plan.

Location of the responsibility for quality assurance in the organization[2] - If practical, one individual within an organization should be designated the Quality Assurance (QA) Coordinator. The QA Coordinator should have the responsibility for coordinating all quality assurance activity so that complete integration of the quality assurance system is achieved. The QA Coordinator could also undertake specific activities such as quality planning and auditing. The QA Coordinator should, therefore, gain the cooperation of other responsible heads of the organization with regard to quality assurance matters.

As a general rule, it is not good practice for the quality assurance responsibility to be directly located in the organization responsible for conducting measurement programs. This arrangement could be workable, however, if the person in charge maintains an objective viewpoint.

Relationship of the quality assurance function to other functions - The functions performed by a comprehensive air pollution control program at the state or local level are shown in Figure 1.4.3.1.[3] The relationship of the quality assurance function to the other agency functions is shown in Figure 1.4.3.2. The role of quality assurance can be grouped into two categories:

1. Recommend quality assurance policy and assist its formulation with regard to agency policy, administrative support (contracts and procurements), and staff training.

2. Provide quality assurance guidance and assistance for monitoring networks, laboratory operations, data reduction and validation, instrument maintenance and calibration, litigation, source testing, and promulgation of control regulations.

Management Services

- Agency policy
- Administrative and clerical support
- Public information and community relations
- Intergovernmental relations
- Legal counsel
- Systems analysis, development of strategies, long-range planning
- Staff training and development

Technical Services

- Laboratory operations
- Operation of monitoring network
- Data reduction
- Special field studies
- Instrument maintenance and calibration

Field Enforcement Services

- Scheduled inspections
- Complaint handling
- Operation of field patrol
- Preparation for legal actions
- Enforcement of emergency episode procedures
- Source identification and registration

Engineering Services

- Calculation of emission estimates
- Operation of permit system
- Source emission testing
- Technical development of control regulations
- Preparation of technical reports, guides, and criteria on control
- Design and review of industrial emergency episode procedures

Figure 1.4.3.1. List of functions performed by comprehensive air pollution control programs.

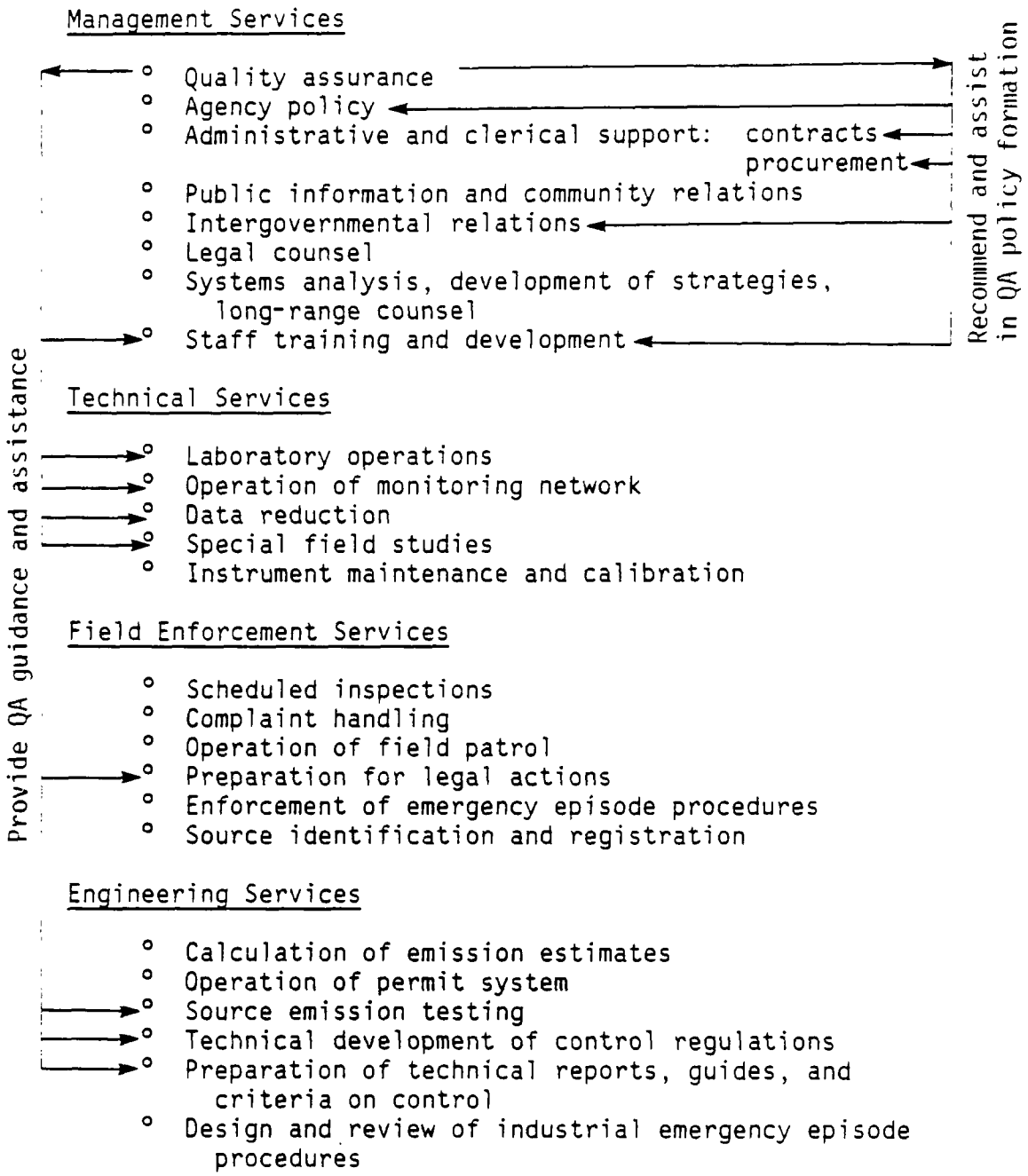


Figure 1.4.3.2. Relationship of the quality assurance function to other air pollution control program functions.

Basic organizational tools for quality assurance implementation are:

1. The organization chart[4] - The quality assurance organization chart should display line and staff relationships, and lines of authority and responsibility. The lines of authority and responsibility, flowing from the top to bottom, are usually solid, while staff advisory relationships are depicted by dashed lines.

2. The job description[5] - The job description lists the responsibilities, duties, and authorities of the job and relationships to other positions, individuals, or groups. A sample job description for a Quality Assurance Coordinator is shown in Figure 1.4.3.3.

3. The quality assurance plan - To implement quality assurance in a logical manner and identify problem areas, a quality assurance program plan and a quality assurance project plan are needed. For details on preparation of quality assurance program and project plans, see Sections 1.4.22 and 1.4.23, respectively.

TITLE: Quality Assurance Coordinator

Basic Function

The Quality Assurance Coordinator is responsible for the conduct of the quality assurance program and for taking or recommending measures.

Responsibilities and Authority

1. Develops and carries out quality control programs, including statistical procedures and techniques, which will help agencies meet authorized quality standards at minimum cost.

2. Monitors quality assurance activities of the agency to determine conformance with policy and procedures and with sound practice; and makes appropriate recommendations for correction and improvement as may be necessary.

3. Seeks out and evaluates new ideas and current developments in the field of quality assurance and recommends means for their application wherever advisable.

4. Advises management in reviewing technology, methods, and equipment, with respect to quality assurance aspects.

5. Coordinates schedules for measurement system functional check calibrations, and other checking procedures.

6. Coordinates schedules for performance and system audits and reviews results of audits.

7. Evaluates data quality and maintains records on related quality control charts, calibration records, and other pertinent information.

8. Coordinates and/or conducts quality-problem investigations.

Figure 1.4.3.3. Job description for the Quality Assurance Coordinator.

1.4.3.3 REFERENCES

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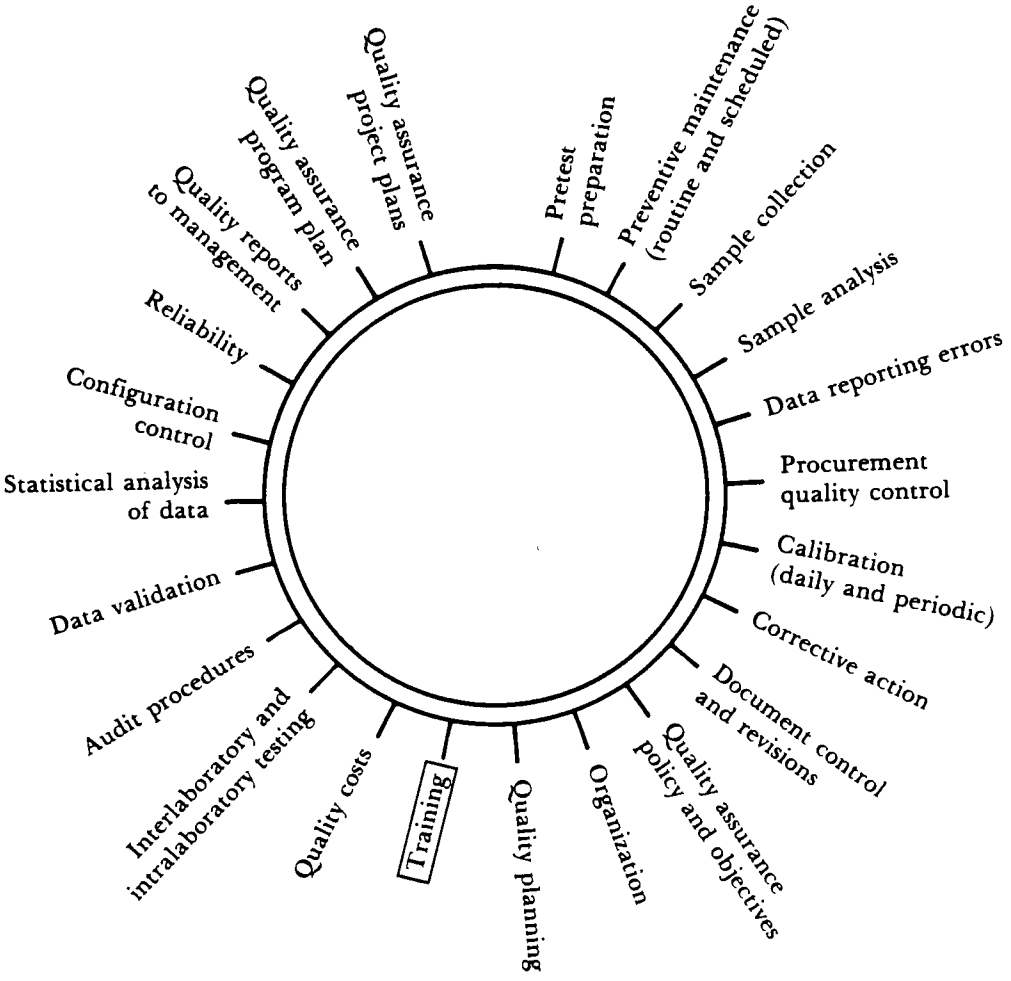
Quality assurance project plans
Quality assurance program plan
Quality reports to management
Reliability
Configuration control
Statistical analysis of data
Data validation
Audit procedures
Interlaboratory and intralaboratory testing
Quality costs
Training
Quality planning
Organization
Quality assurance policy and objectives
Document control and revisions
Corrective action
Calibration (daily and periodic)
Procurement quality control
Data reporting errors
Sample analysis
Sample collection
Preventive maintenance (routine and scheduled)
Pretest preparation

1.4.5 TRAINING

1.4.5.1 ABSTRACT

All personnel involved in any function affecting data quality (sample collection, analysis, data reduction, and quality assurance) should have sufficient training in their appointed jobs to contribute to the reporting of complete and high quality data. The first responsibility for training rests with organizational management, program and project managers. In addition, the QA coordinator should recommend to management that appropriate training be available.

The training methods commonly used in the air pollution control field are the following:

1. On-the-job training (OJT).
2. Short-term course training (including self-instruction courses). A list of recommended short-term training courses is in Figure 1.4.5.1.
3. Long-term training (quarter or semester in length).

Training should be evaluated in terms of the trainee and the training per se. The following are techniques commonly used in the air pollution control field to evaluate training.

1. Testing (pretraining and posttraining tests).
2. Proficiency checks.
3. Interviews (written or oral with the trainee's supervisor and/or trainee).

1.4.5.2 DISCUSSION

All personnel involved in any function affecting data quality should have sufficient training in their appointed jobs to contribute to the reporting of complete and high quality data. The first responsibility for training rests with organizational management, program and project managers. In addition,

Course number and title		Days/h	Contact
Quality Assurance /Quality Control Training			
470	Quality Assurance for Air Pollution Measurement Systems	4	APTI[a]
556	Evaluation and Treatment of Outlier Data	3	NIOSH[b]
587	Industrial Hygiene Laboratory Quality Control	5	NIOSH
597	How to Write a Laboratory Quality Control Manual	3	NIOSH
----	Quality Management	5	UC[c]
9104	Quality Engineering	5	ETI[d]
9108	Quality Audit-Development and Administration	3	ETI
9101	Managing for Quality	5	ETI
9114	Probability and Statistics for Engineers and Scientists	5	ETI
9113	Managing Quality Costs	3	ETI
514Y	Practical Application of Statistics to Quality Control	3	SAMI[e]
210Y	Quality Management	5	SAMI
215Y	Managing Quality Costs	3	SAMI
138Y	Quality Program - Preparation and Audit	5	SAMI
919Y	Software Quality Assurance	4	SAMI
284	Operating Techniques for Standards and Calibration	5	GWU[f]
641	Software Quality Assurance	3	GWU
----	Effective Quality Control Management	4	CPA[g]
----	Corporate Quality Assurance	3	MCQR[h]
Air Pollution Measurement Method Training			
413	Control of Particulate Emissions	4	APTI
415	Control of Gaseous Emissions	4	APTI
420	Air Pollution Microscopy	4.5	APTI
427	Combustion Evaluation	5	APTI
435	Atmospheric Sampling	4.5	APTI
444	Air Pollution Field Enforcement	3.5	APTI
450	Source Sampling for Particulate Pollutants	4.5	APTI
464	Analytical Methods for Air Quality Standards	5	APTI

Figure 1.4.5.1. Selected quality assurance and air pollution training available in 1984. (continued)

Course number and title	Days/h	Contact
Air Pollution Measurement Method Training		
468 Source Sampling and Analysis of Gaseous Pollutants	4	APTI
474 Continuous Emission Monitoring	5	APTI
Air Pollution Measurement Systems Training		
411 Air Pollution Dispersion Models: Fundamental Concepts	4.5	APTI
423 Air Pollution Dispersion Models: Application	4.5	APTI
426 Statistical Evaluation Methods for Air Pollution Data	4.5	APTI
452 Principles and Practice of Air Pollution Control	4.5	APTI
463 Ambient Air Quality Monitoring Systems: Planning and Administrative Concepts	5	APTI
482 Sources and Control of Volatile Organic Air Pollutants	4	APTI
Self Instruction, Video-Instruction, and Other Training		
406 Effective Stack Height/Plume Rise	10 h	APTI
422 Air Pollution Control Orientation Course (3rd Edition)	30 h	APTI
448 Diagnosing Vegetation Injury Caused by Air Pollution	30 h	APTI
473 Introduction to Environmental Statistics	70 h	APTI
472 Aerometric and Emissions Reporting System (AEROS)	-	APTI
475 Comprehensive Data Handling System (CDHS--AQDHS-II, EIS/P&R)	-	APTI
409 Basic Air Pollution Meteorology	25 h	APTI
410 Introduction to Dispersion Modeling	35 h	APTI
412A Baghouse Plan Review	20 h	APTI
414 Quality Assurance for Source Emission Measurements	35 h	APTI
416 Inspection Procedures for Organic Solvent Metal Cleaning (Degreasing) Operations	20 h	APTI
417 Controlling VOC Emissions from Leak Process Equipment	20 h	APTI
424 Receptor Model Training	30 h	APTI
431 Introduction to Source Emission Control	40 h	APTI
434 Introduction to Ambient Air Monitoring	50 h	APTI

Figure 1.4.5.1 (continued)

Course number and title		Days/h	Contact
436	Site Selection for Monitoring of SO_2 and TSP in Ambient Air	35 h	APTI
437	Site Selection for Monitoring of Photochemical Pollutants and CO in Ambient Air	35 h	APTI
412B	Electrostatic Precipitator Plan Review	20 h	APTI
412C	Wet Scrubbers Plan Review	-	APTI[i]
483A	Monitoring the Emissions of Organic Compounds to the Atmosphere	-	APTIi
476A	Transmissometer Operation and Maintenance	-	APTI[i]
438	Reference and Automated Equivalent Measurement Methods for Ambient Air Monitoring	30 h	APTI
443	Chain of Custody	2 h	APTI
453	Prevention of Significant Deterioration	15 h	APTI
449	Source Sampling Calculations	-	APTI
491A	NSPS Metal-Coil Surface Coating	-	APTI[i]
491B	NSPS Surface Coating of Metal Furniture	-	APTI[i]
491C	NSPS Industrial Surface Coating	-	APTI[i]
491D	NSPS Surface Coating Calculations	-	APTI[i]
428A	NSPS Boilers	-	APTI[i]

Additional information may be obtained from:

[a]Air Pollution Training Institute, MD-20, Environmental Research Center, Research Triangle Park, North Carolina 27711, Attention: Registrar.

[b]R&R Associates, Post Office Box 46181, Cincinnati, Ohio 45246, Attention: Thomas Ratliff.

[c]The University of Connecticut, Storrs, Connecticut 06268.

[d]Education and Training Institute , American Society for Quality Control, 161 West Wisconsin Avenue, Milwaukee, Wisconsin 53203.

[e]Stat-A-Matrix Institute, New Brunswick, New Jersey.

[f]George Washington University, Continuing Engineering Education, Washington, D. C. 20052.

[g]The Center for Professional Advancement, Post Office Box H, East Brunswick, New Jersey 08816.

[h]Paul D. Krensky Associates, Inc., Adams Building, 9 Meriam Street, Lexington, MA 02173.

[i]Completion planned by October 1984.

Figure 1.4.5.1 (continued)

the QA Coordinator should be concerned that the required training is available for these personnel and, when it is not, should recommend to management that appropriate training be made available.

Training objective[1,2] - The training objective should be to develop personnel to the necessary level of knowledge and skill required for the efficient selection, maintenance, and operation of air pollution measurement systems (ambient air and source emissions).

Training methods and availability - Several methods of training are available to promote achievement of the desired level of knowledge and skill required. The following are the training methods most commonly used in the air pollution control field; a listing of available training courses for 1984 is given in Figure 1.4.5.1.

1. On-the-job training (OJT) - An effective OJT program could consist of the following:

a. Observe experienced operator perform the different tasks in the measurement process.

b. Study the written operational procedures for the method as described in this Handbook (Volume II or III), and use it as a guide for performing the operations.

c. Perform procedures under the direct supervision of an experienced operator.

d. Perform procedures independently but with a high level of quality assurance checks, utilizing the evaluation technique described later in this section to encourage high quality work.

2. Short-term course training - A number of short-term courses (usually 2 weeks or less) are available that provide knowledge and skills for effective operation of an air pollution measurement system. Some of the courses are on the measurement methods *per se* and others provide training useful in the design

and operation of the total or selected portions of the measurement system. In addition, Figure 1.4.5.1 lists self-instruction courses and video-tapes available from:

Registrar
Air Pollution Training Institute (MD-20)
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711
(919) 541-2401

3. Long-term course training - Numerous universities, colleges, and technical schools provide long-term (quarter and semester length) academic courses in statistics, analytical chemistry, and other disciplines. The agency's training or personnel officer should be contacted for information on the availability of long-term course training.

Training evaluation - Training should be evaluated in terms of (1) level of knowledge and skill achieved by the trainee from the training; and (2) the overall effectiveness of the training, including determination of training areas that need improvement. If a quantitative performance rating can be made on the trainee during the training period (in terms of knowledge and skill achieved), this rating may also provide an assessment of the overall effectiveness of the training as well.

Several techniques are available for evaluating the trainee and the training *per se*. One or more of these techniques should be used during the evaluation. The most common types of evaluation techniques applicable to training in air pollution measurement systems are the following:

1. Testing - A written test before (pretest) and one after (post-test) training are commonly used in short-term course training. This allows the trainee to see areas of personal improvement and provides the instructor with information on training areas that need improvement.

2. Proficiency checks - A good means of measuring skill improvement in both OJT and short-term course training is to assign the trainee a work task. Accuracy and/or completeness

are commonly the indicators used to score the trainee's proficiency. The work tasks could be of the following form:

a. Sample collection - Trainee would be asked to list all steps involved in sample collection for a hypothetical case. In addition, the trainee could be asked to perform selected calculations. Proficiency could be judged in terms of completeness and accuracy.

b. Analysis - Trainee could be provided unknown samples for analysis. As defined here, an unknown is a sample whose concentration is known to the work supervisor (OJT) or training instructor (short-term course training) but unknown to the trainee. Proficiency could be judged in terms of accuracy of analysis.

c. Data reduction - Trainees responsible for data reduction could be provided data sets to validate. Proficiency could be judged in terms of completeness and accuracy.

If proficiency checks are planned on a recurring basis, a quality control or other type chart may be used to show progress during the training period as well as after the training has been completed. Recurring proficiency checks are a useful technique for determining if additional training may be required.

3. Interviews - In some cases, a written or oral interview with the trainee's supervisor and/or trainee is used to determine if the training was effective. This interview is normally not conducted until the trainee has returned to the job and has had an opportunity to use the training. This technique is most often used to appraise the effectiveness of a training program (OJT or short-term course) rather than the performance of the trainee.

1.4.5.3 REFERENCES

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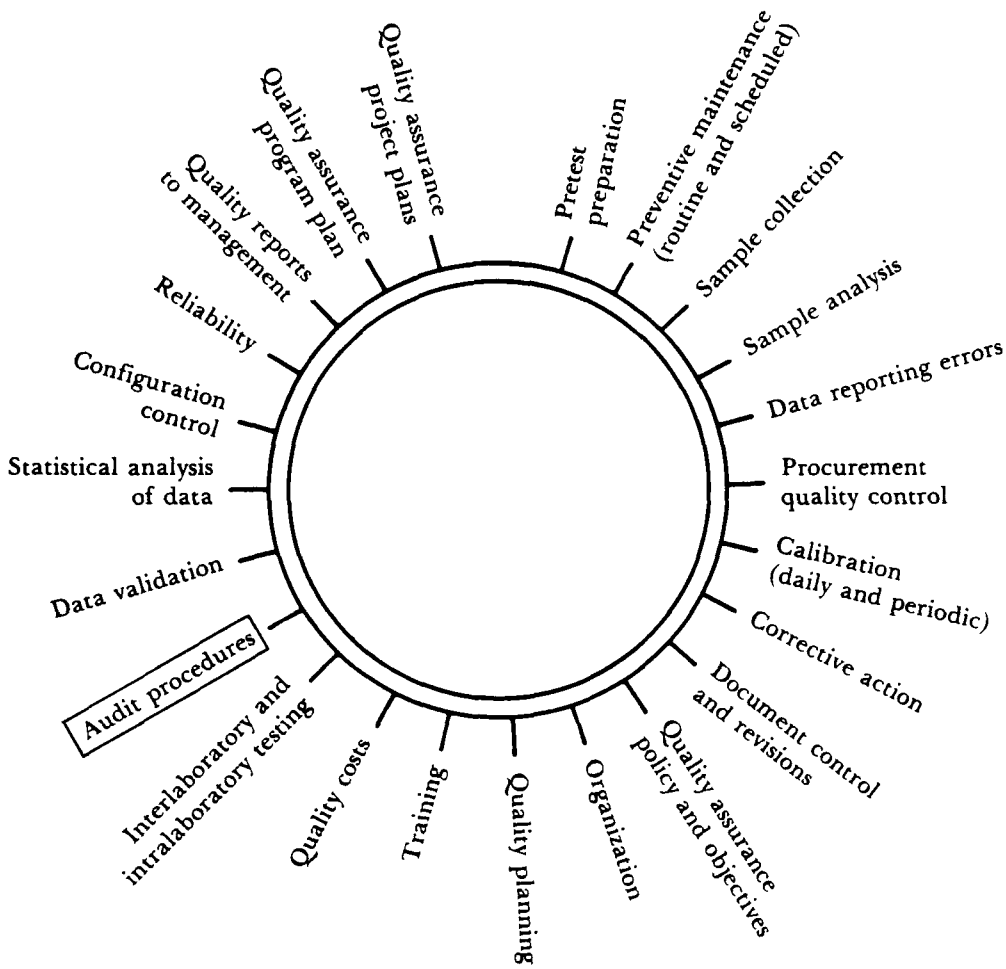
3. Industrial Quality Control, 23(12), June 1967. (All articles deal with education and training.)

4. Seder, L. A. QC Training for Non-Quality Personnel. Quality Progress, VII(7):9.

5. Reynolds, E. A. Training QC Engineers and Managers. Quality Progress, III(4):20-21, April 1970.


Quality assurance policy and objectives
Organization
Quality planning
Training
Quality costs
Interlaboratory and intralaboratory testing
Audit procedures
Data validation
Statistical analysis of data
Configuration control
Reliability
Quality reports to management
Quality assurance program plan
Quality assurance project plans
Pretest preparation
Preventive maintenance (routine and scheduled)
Sample collection
Sample analysis
Data reporting errors
Procurement quality control
Calibration (daily and periodic)
Corrective action
Document control and revisions

1.4.16 AUDIT PROCEDURES

1.4.16.1 ABSTRACT

1. Performance audits are made to quantitatively evaluate the quality of data produced by the total measurement system (sample collection, sample analysis and data processing). The individuals performing the audit, their standards and equipment are different from the regular team (operating the measurement system) and their standards and equipment in order to obtain an independent assessment. The performance audit is commonly limited to a portion of the total measurement system (e.g., flow rate measurement, sample analysis) but may include the entire measurement system (e.g., continuous ambient air analyzer).

2. A system audit is a qualitative on-site inspection and review of the the total measurement system. The auditor should have extensive background experience with the measurement system being audited.

1.4.16.2 DISCUSSION

1.4.16.2.1 <u>Performance Audits</u> - The purposes of performance audits include:

1. Objective assessment of the accuracy of the data collected by a given measurement system,
2. Identification of sensors out-of-control,
3. Identification of systematic bias of a sensor or of the monitoring network,
4. Measurement of improvement in data quality based on data from previous and current audits.

The role of audits in the overall management program is verification. While audits do not improve data quality if all work is correctly performed, they do provide assurance that the work prescribed for the measurement program has been conducted

properly. Audits conducted by individuals not responsible for the day-to-day operations provide a control and assessment mechanism to program managers. A performance audit procedure for continuous ambient air analyzers is given herein to illustrate items that must be considered in conducting a performance audit.

1. Select audit materials

a. Use high concentration (10 to 100 ppm) audit cylinder gas in conjunction with a dilution system. Advantage--better gas stability at high concentration; disadvantage--dilution system calibration errors are possible.

b. Use low concentration (<1 ppm except for CO) audit cylinder gas. Advantage--no dilution system needed; disadvantages--probability of gas instability and thus inaccurate concentration, and number of cylinders.

c. Use permeation tubes. Advantage--better stability than low concentration cylinder gas; disadvantages--permeation rate, which is temperature dependent, must stabilize before performing audit and possibility of dilution system calibration error.

d. Use materials traceable to NBS-SRM or commercial CRM if possible.

e. Table 1.4.16.1 lists the primary standards applicable to ambient audit equipment calibration. The list is not all inclusive but includes the standards of high accuracy that will fulfill the traceability requirements.

2. Select audit concentration levels - As a minimum, use a low scale and a high scale point in order to check the analyzer's linearity, and use a third point near the sites' expected concentration level. Audit concentration levels are specified in 40 CFR Part 58, Appendices A and B for a minimum QA program.[1,2]

3. Determine auditor's proficiency - Auditor must analyze audit materials (including the verification of their stability) and his results compared with the known values prior to his performing an audit.

TABLE 1.4.16.1. PRIMARY STANDARDS

Parameter	Range	Usable standard	Primary standard
Flow rate	0-3 ℓ/min	Soap bubble flow kit	NBS-traceable flow kit or gravimetrically calibrated flow tubes
Flow rate	0.5-3 ℓ/min	1 ℓ/revolution wet test meter 3 ℓ/revolution wet test meter	Primary standard spirometer
Flow rate	0.1-2.5 m^3/min	Positive displacement Roots meter	Roots meter
Time	0-5 minutes	Stopwatch	NBS-time
SO_2	0-0.5 ppm	Permeation tube	NBS-SRM 1626
	50-90 ppm	Cylinder gas (SO_2/N_2)	NBS-SRM 1693, 1694 or commercial CRM
$NO-NO_2-NO_x$	0-0.5 ppm	NO_2 permeation tube	NBS-SRM 1629
	50 ppm	NO cylinder gas (NO/N_2/GPT)	NBS-SRM 1683 or commercial CRM
O_3	0-1.0 ppm	O_3 generator/UV photometer	Standard laboratory photometer
CO	10-100 ppm	Cylinder gas CO/N_2 or CO/air	NBS-SRM 1677, 1678, 1679, 2635, 2612, 2613, 2614 or commercial CRM

Note: Descriptions of NBS-SRM are shown in Figure 1.4.12.3. A list of currently available CRM may be obtained from EPA at address shown in Section 1.4.12.

4. Select analyzers out-of-control limits - Select the maximum allowable difference between the analyzer and auditor results. For gaseous analyzers, limits of 10 to 20% are commonly used.

5. Conduct the audit in the field

a. Record site data (address, operating organization, type of analyzer being audited, zero and span post settings, type of in-station calibration used, and general operating procedures.

b. Mark the data recording, indentifying the time interval in which the audit was performed. A data stamp may be used to document the station data system. This will ensure that recorder traces cannot be switched in future reference.

c. Have the station operator make necessary notations on the data acquisition system prior to disconnecting a monitor or sampler from the normal sampling mode. Initiate the audit. Audit techniques are listed in Table 1.4.16.2.

d. Have the station operator convert all station data to engineering units (ppm, m^3/min, etc.) in the same manner that actual data are handled.

e. All pertinent data should be recorded in an orderly fashion on field data forms.

f. Return all equipment to normal sampling mode upon completion of the audit, so that no data are lost.

g. Make data computations and comparisons prior to vacating the test site. This is to ensure that no extraneous or inconsistent differences exist that are found after vacating the test site. It is often impossible to rectify a difference after leaving the test site. Hence calculations and comparisons made in the field are cost effective. Verbally relate as much information as possible to the analyzer operator immediately after the audit.

6. Verify the audit material stability after the audit (e.g., reanalysis of audit material).

TABLE 1.4.16.2. AUDIT TECHNIQUES

Pollutant/ parameter	Audit technique	Audit standard	Traceability to primary standard
SO_2	Dynamic dilution of a stock cylinder	50 ppm SO_2 in air or N_2	NBS-SRM 50 ppm SO_2/N_2 standard
			or
SO_2	Dynamic dilution of a permeation tube	Permeation tube	NBS-SRM permeation tube
CO	Dynamic dilution of a stock cylinder	900 ppm CO in air or N_2	NBS-SRM 1000 ppm CO/N_2 standard
CO	Separate cylinders	5, 20, 45 ppm CO in air or N_2 cylinders	NBS-SRM 50 ppm CO/N_2 standard
$NO-NO_x-NO_2$	Dynamic dilution/gas phase titration	50 ppm NO/N_2 with 0.5 ppm NO_2 impurity	NBS-SRM 50 ppm NO/N_2
$NO-NO_x-NO_2$	Dynamic dilution of stock cylinder/dynamic permeation dilution	50 ppm NO/N_2 cylinder; NO_2 permeation tube	NBS-SRM 50 ppm NO/N_2 cylinder; NBS NO_2 permeation tube
O_3	O_3 generation with verification by UV photometry	Standard photometer	Standard laboratory maintained UV photometer
TSP flow rate	Simultaneous flow rate comparison	ReF device	Primary standard Roots Meter system

7. Prepare Audit Report - Prepare a written report and mail to the pertinent personnel, it should include:

a. Assessment of the accuracy of the data collected by the audited measurement system

b. Identification of sensors out-of-control

c. Identification of monitoring network bias

d. Measurement of improvement in data quality since the previous audit(s).

8. Corrective Action - Determine if corrective actions are implemented.

Detailed guidance to State and local agencies on how to conduct performance audits of ambient air measurement systems are described in Section 2.0.12 of Volume II of this Handbook.

System Audit - Detailed guidance to State and local agencies for conducting a system audit of an ambient air monitoring program are in Section 2.0.11 of Volume II of this Handbook. Data forms are provided as an aid to the auditor. These forms should be submitted to the agency being evaluated 4 to 6 weeks prior to the on-site system audit. This allows the agency to locate and enter detailed information (often not immediately accessible) required by the forms. When the completed forms are returned, they should be reviewed and the auditor should prepare a list of specific questions he would like to discuss with the agency. An entrance interview date should be arranged to discuss these questions.

The next step is the systems audit. A convenient method is to trace the ambient data from the field measurement through the submittal to EPA, noting each step in the process, documenting the written procedures that are available and followed, and noting the calibration and quality control standards that are used.

After the auditor collects the information, an exit interview is conducted to explain the findings of the evaluation to

the agency representatives. A written report is then prepared as soon as possible to summarize the results of the audit.

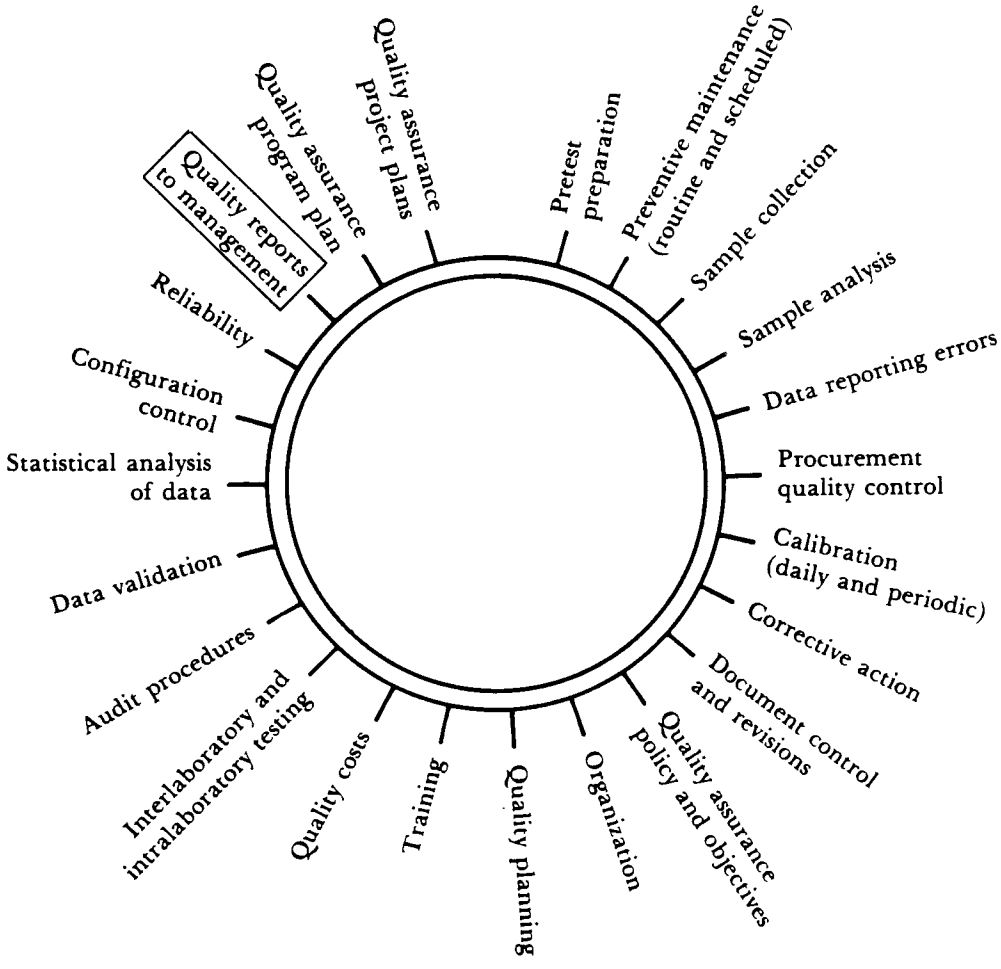
Guidance on how to evaluate the capabilities of a source emission test team are described in Reference 3. Data forms are included as an aid to the auditor.

1.4.16.3 REFERENCES

1. Appendix A - Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS), Federal Register, Vol. 44, Number 92, May 19, p. 27574-27582.

2. Appendix B - Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring, Federal Register, Vol. 44, Number 92, May 1979, p. 27582-27584.

3. Estes, E. D. and Mitchell, W. J., Technical Assistance Document: Techniques to Determine A Company's Ability to Conduct A Quality Stack Test, EPA-600/4-82-018, March 1982.


Quality reports to management
Quality assurance program plan
Quality assurance project plans
Pretest preparation
Preventive maintenance (routine and scheduled)
Sample collection
Sample analysis
Data reporting errors
Procurement quality control
Calibration (daily and periodic)
Corrective action
Document control and revisions
Quality assurance policy and objectives
Organization
Quality planning
Training
Quality costs
Interlaboratory and intralaboratory testing
Audit procedures
Data validation
Statistical analysis of data
Configuration control
Reliability

1.4.21 QUALITY REPORTS TO MANAGEMENT

1.4.21.1 ABSTRACT

Several reports are recommended in the performance of the quality assurance tasks. Concise and accurate presentation of the data and derived results is necessary. Some of the quality assurance reports for management are:

1. Data quality assessment reports (e.g., those specified in 40 CFR, Part 58, Appendices A and B),
2. Performance and system audit reports,
3. Interlaboratory comparison summaries,
4. Data validation reports,
5. Quality cost reports,
6. Instrument or equipment downtime,
7. Quality assurance program and project plans, and
8. Control charts.

Reports should be prepared with the following guidelines as appropriate.

1. All raw data should be included in the report when practical.
2. Objective of the measurement program, in terms of the data required and an uncertainty statement concerning the results.
3. Methods of data analysis should be described unless they are well-documented in the open literature.
4. A statement on any limitation and on applicability of the results should be included.
5. Precision and accuracy of the measurement methods should be stated.
6. Quality control information should be provided as appropriate.

7. Reports should be placed into a storage system in order that they may be retrieved as needed for future reference.

1.4.21.2 DISCUSSION

There are several quality assurance reports that should be prepared periodically (quarterly or annually) summarizing the items of concern. These reports will be briefly discussed below.

1. Data Quality Assessment Reports

40 CFR Part 58, Appendices A and B require that reports of the precision and accuracy calculations be submitted each quarter along with the air monitoring data. See References 1 and 2 for details of the calculations and for specific data/ results to be reported.

2. Performance and System Audit Reports

Upon completion of a performance and/or system audit, the auditing organization should submit a report summarizing the audit and present the results to the auditee to allow initiation of any necessary corrective action.

3. Interlaboratory Comparison Summaries

EPA prepares annual reports summarizing the interlaboratory comparisons for the National Performance Audit Program. In addition, the results from this audit are submitted to the participating labs as soon as possible after the audit. These data can then be used by the participants to take any necessary corrective action with regard to their measurement procedures. See Appendix K for a further discussion of the contents of the annual report.[3,4]

4. Data Validation Report

It is recommended in Section 1.4.17 that a data validation process be implemented in order to minimize the reporting of data of poor quality. A periodic report of the results of the

data validation procedure should be made summarizing, for example, the number of items (values) flagged as questionable, the result of followup investigations of these anomalies, the final number of data values rejected or corrected as a result of the procedure, corrective action recommended, and effectiveness of the data validation procedures.[5,6]

5. Quality Cost Report

A quality cost system is recommended in Section 1.4.14. After the system has been implemented, a quality cost report should be made periodically to include the prevention, appraisal, and correction costs.[7]

6. Instrument or Equipment Downtime

In Section 1.4.7 it is recommended that records be maintained of the equipment in terms of failures, cause of failures, repair time, and total downtime. These data should be summarized periodically and submitted to management as an aid in future procurement.

7. Quality Assurance Program (or Project) Plans

Although these are not reports on results, they are plans for the QA activities for a QA program or project. They are the reports which indicate which QA reports should be prepared.

8. Control Charts

The control charts are a visual report of the analytical work and hence they are a significant part of the reporting system. A summary of the results of the control chart applications should appear in the summary report to management.

Some guidelines in the preparation of these reports are given in the Abstract portion of this section.

1.4.21.3 REFERENCES

1. Appendix A - Quality Assurance Requirements for State and Local Air Monitoring Stations (SLAMS), Federal Register, Vol. 44, Number 92, May 1979.

2. Appendix B - Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring, Federal Register, Vol. 44, Number 92, May 1979.

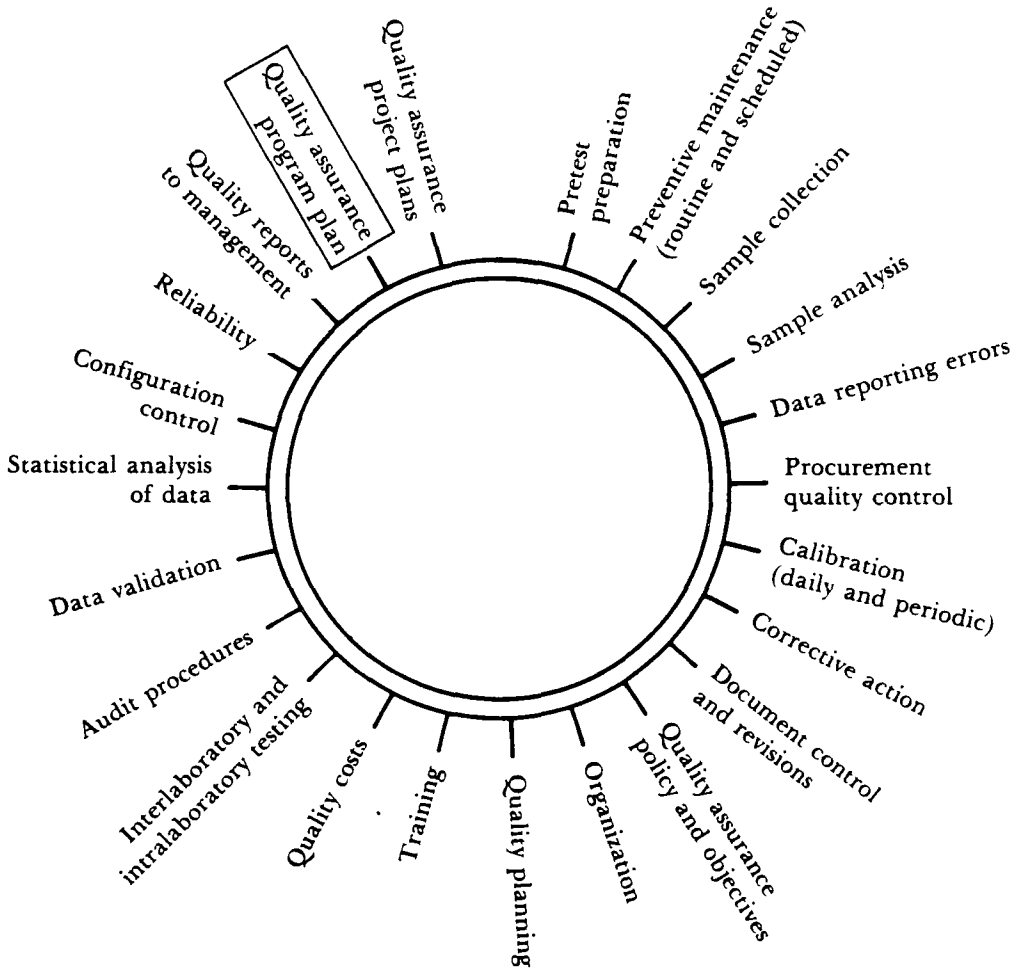
3. Streib, E. W. and M. R. Midgett, A Summary of the 1982 EPA National Performance Audit Program on Source Measurements. EPA-600/4-88-049, December 1983.

4. Bennett, B. I., R. L. Lampe, L. F. Porter, A. P. Hines, and J. C. Puzak, Ambient Air Audits of Analytical Proficiency 1981, EPA-600/4-83-009, April 1983.

5. Nelson, Jr., A. C., D. W. Armentrout, and T. R. Johnson. Validation of Air Monitoring Data, North Carolina, EPA-600/4-80-030, June 1980.

6. U.S. Environmental Protection Agency. Screening Procedures for Ambient Air Quality Data. EPA-450/2-78-037, July 1978.

7. Strong, R.B., J.H. White and F. Smith, "Guidelines for the Development and Implementation of a Quality Cost System for Air Pollution Measurement Programs," Research Triangle Institute, Research Triangle Park, North Carolina, 1980, EPA Contract No. 68-02-2722.


Quality assurance program plan
Quality assurance project plans
Pretest preparation
Preventive maintenance (routine and scheduled)
Sample collection
Sample analysis
Data reporting errors
Procurement quality control
Calibration (daily and periodic)
Corrective action
Document control and revisions
Quality assurance policy and objectives
Organization
Quality planning
Training
Quality costs
Interlaboratory and intralaboratory testing
Audit procedures
Data validation
Statistical analysis of data
Configuration control
Reliability
Quality reports to management

1.4.22 QUALITY ASSURANCE PROGRAM PLAN[1]

1.4.22.1 ABSTRACT

1. The QA Program Plan is a document which stipulates the policies, objectives, management structure, responsibilities, and procedures for the total QA programs for each major organization.[1] The EPA policy requires participation by all EPA Regional Offices, EPA Program Offices, EPA Laboratories, and States in a centrally managed QA program, and includes all monitoring and measurement efforts mandated or supported by EPA through regulations, grants, contracts, or other formalized means not currently covered by regulation.

2. Each EPA Program Office, EPA Regional Office, EPA Laboratory, and State and other organizations, is responsible for the preparation and implementation of the QA Program Plan to cover all environmentally-related measurement activities supported or required by EPA. A basic requirement of each plan is that it can be implemented and that its implementation can be measured.

3. Each QA Program Plan should include the following elements:

a. Identification of office/laboratory submitting the plan,

b. Introduction - brief background, purpose, and scope,

c. QA policy statement,

d. QA management structure,

e. Personnel qualification and training needs,

f. Facilities, equipment, and services - approach to selection, evaluation, calibration, operation, and maintenance,

g. Data generation - procedures to assure the generation of reliable data,

h. Data processing - collection, reduction, validation, and storage of data,

i. Data quality assessment - accuracy, precision, completeness, representativeness, and comparability of data to be assessed,

j. Corrective action - QA reporting and feedback channels established to ensure early and effective corrective action, and

k. Implementation requirements and schedule.

4. Plans should be submitted through normal channels for review and/or approval.

1.4.22.2 DISCUSSION

QA Program Plan is an orderly assembly of management policies, objectives, principles, and general procedures by which an agency or laboratory outlines how it intends to produce quality data. The content of the plan (outlined in 1.4.22.1) is briefly described below; eleven essential elements should be considered and addressed.

1. Identification - Each plan should have a cover sheet with the following information: document title, document control number, unit's full name and address, individual responsible (name, address, and telephone number), QA Officer, plan coverage, concurrences, and approval data.

2. Introduction - Brief background, purpose and scope of the program plan is set forth in this section.

3. QA policy statement - The policy statement provides the framework within which a unit develops and implements its QA program. It must emphasize the requirements and activities needed to ensure that all data obtained are of known quality.

4. QA management - This section of the plan shows the interrelationships between the functional units and subunits which generate or manage data. This includes the assignment of responsibilities, communications (organizational chart to indicate information flow), document control, QA program assessment.

5. Personnel - Each organization should ensure that all personnel performing tasks and functions related to data quality have the needed education, training, and experience; personnel qualifications and training needs should be identified.

6. Facilities, equipment, and services - The QA Program Plan should address the selection, evaluation, environmental aspects of equipment which might have an impact on data quality, maintenance requirements, monitoring and inspection procedures, for example.

7. Data generation - Procedures should be given to assure the generation of data that are scientifically valid, defensible, comparable, and of known precision and accuracy. QA Project Plans (as described in Section 1.4.23) should be prepared and followed. Standard operating procedures (SOP) should be developed and used for all routine monitoring programs, repetitive tests and measurements, and for inspection and maintenance of facilities, equipment, and services.

8. Data processing - The plan should describe how all aspects of data processing will be managed and separately evaluated in order to maintain the integrity and quality of the data. The collection, validation, storage, transfers, and reduction of the data should be described.

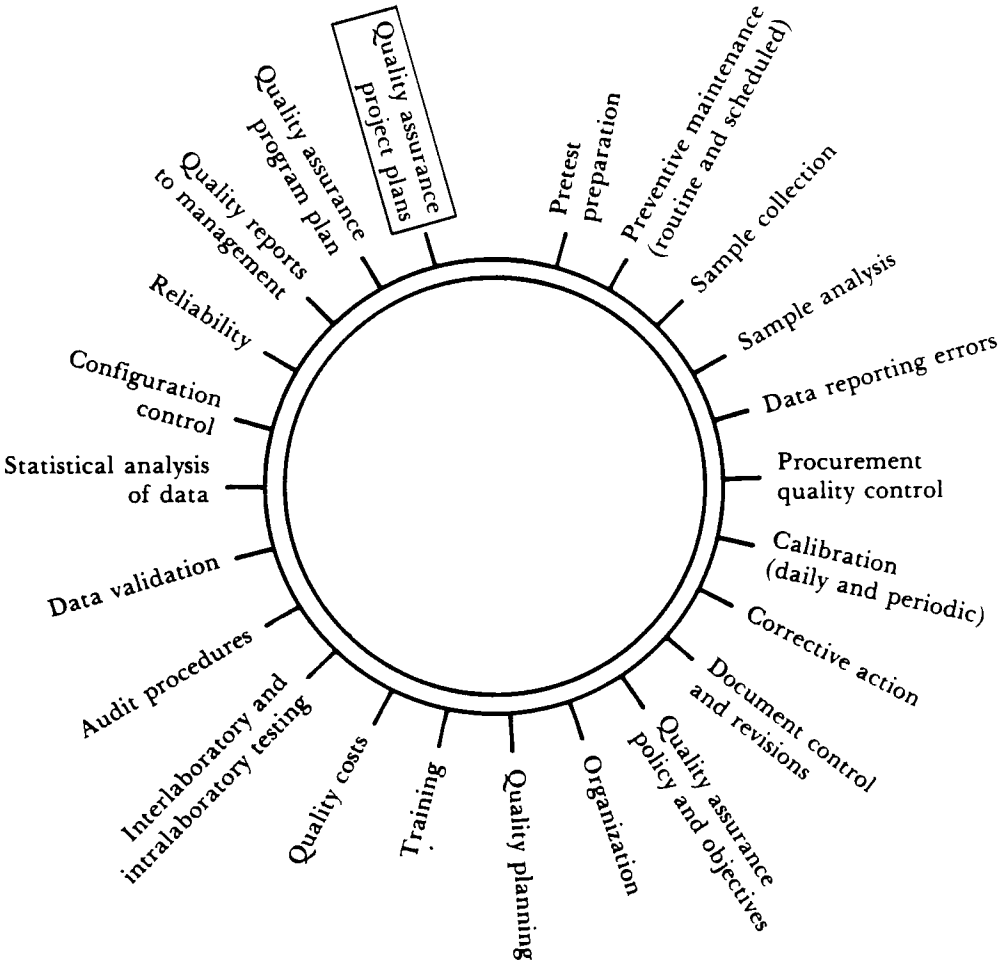
9. Data quality assessment - The plan should describe how all generated data are to be assessed for accuracy, precision, completeness, representativeness, and comparability.

10. Corrective action - Plans should describe the mechanism(s) to be used when corrective actions are necessary. Results from the following QA activities may initiate a corrective action: performance audits, system audits, interlaboratory comparison studies, and failure to adhere to a QA Program or Project Plan or to SOP.

11. Implementation requirements and schedule - A schedule for implementation is given in Reference 1.

1.4.22.3 REFERENCE

1. Guidelines and Specifications for Preparing Quality Assurance Program Plans, Quality Assurance Management Staff, Office of Research Development, USEPA, Washington, D.C., QAMS-004/80, September 1980. This document (EPA-600/8-83-024; NTIS PB 83-219667) may be obtained from the National Technical Information Service, 5885 Port Royal Road, Springfield, Virginia 22161.


Quality assurance project plans
Quality assurance program plan
Quality reports to management
Reliability
Configuration control
Statistical analysis of data
Data validation
Audit procedures
Interlaboratory and intralaboratory testing
Quality costs
Training
Quality planning
Organization
Quality assurance policy and objectives
Document control and revisions
Corrective action
Calibration (daily and periodic)
Procurement quality control
Data reporting errors
Sample analysis
Sample collection
Preventive maintenance (routine and scheduled)
Pretest preparation

1.4.23 QUALITY ASSURANCE PROJECT PLAN[1]

1.4.23.1 ABSTRACT

1. A QA Project Plan is an orderly assembly of detailed and specific procedures by which an agency or laboratory delineates how it produces quality data for a specific project. A given agency or laboratory would have only one QA Program Plan, but would have a project plan for each project or for each group of projects using the same measurement methods, (e.g., a laboratory service group might develop a plan by analytical instrument since the same service is provided to several projects). Every project that involves environmentally-related measurements should have a written and approved QA Project Plan.

2. Each of the 16 items listed below should be considered for inclusion in each QA Project Plan.[1]

1. Title page, with provision for approval signatures
2. Table of contents
3. Project description
4. Project organization and responsibilities
5. QA objectives for measurement data in terms of precision, accuracy, completeness, representativeness and comparability
6. Sampling procedures
7. Sample custody
8. Calibration procedures and frequency
9. Analytical procedures
10. Data analysis, validation, and reporting
11. Internal quality control checks and frequency
12. Performance and system audits and frequency
13. Preventive maintenance procedures and schedules

14. Specific procedures to be used to routinely assess data precision, accuracy, and completeness of specific measurement parameters involved

15. Corrective action

16. Quality assurance reports to management.

It is EPA policy that precision and accuracy of data must be assessed on all monitoring and measurement projects. Therefore, Item 14 must be described in all QA Project Plans.

1.4.23.2 DISCUSSION

The guidelines and specifications for preparing QA Project Plans are in Appendix M. Appendix M also includes pertinent references, definition of terms, availability of performance audit materials/devices and QA technical assistance, and a model QA Project Plan.

1.4.23.3 REFERENCE

1. Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, Quality Assurance Management Staff, Office of Research Development, USEPA, Washington, D.C., QAMS-005/80, December 1980. This document (EPA-600/4-83-004; NTIS PB-83-170514) may be obtained from the National Technical Information Service, 5885 Port Royal Road, Springfield, Virginia 22161.

Review Exercise

Now that you've completed the assignment for Section 1, please answer the following questions. These will help you determine whether you are mastering the material.

1. Valid and verifiable air quality monitoring data are needed by regulatory agencies ____(?)____.
   a. so that air monitoring costs can be increased
   b. to provide a sound basis for regulatory decisions
   c. to derive theoretical models for combustion processes
   d. to ensure that data follow a log-normal distribution

2. Which one of the following is **not** a long-term objective of the USEPA's mandatory QA program?
   a. to provide quantitative estimates of data quality
   b. to document progress in improving the quality of environmental measurements reported to the agency
   c. to improve data quality
   d. to increase the number of quality assurance coordinators

3. The USEPA's mandatory QA program affects ____(?)____.
   a. USEPA laboratories
   b. organizations receiving USEPA grants or contracts
   c. organizations having cooperative agreements with the USEPA
   d. all of the above

4. True or False? The USEPA's mandatory QA program is applicable only to air pollution measurements.

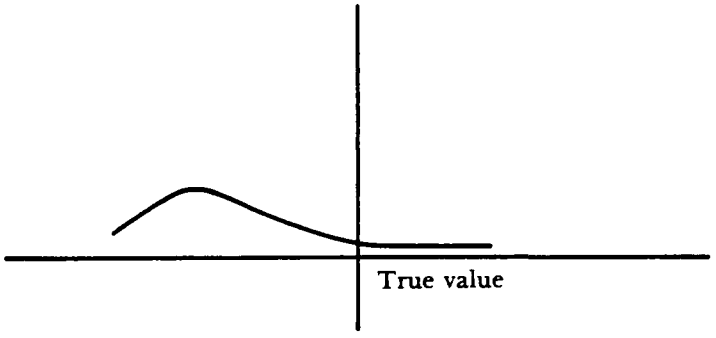
5. Quality control is ____(?)____.
   a. a system of management equivalent to a quality assurance system
   b. a system of data management used to ensure correct reporting of test results
   c. the system of statistical procedures used to ensure data quality
   d. the system of activities used to sustain a quality of product or service

6. Quality assurance is ____(?)____.
   a. the system of activities used to provide assurance that a product or service will satisfy given needs
   b. the system of activities used to statistically determine confidence levels for air quality data
   c. the system of activities used to sustain a quality of product or service
   d. the system of activities used to provide assurance that air quality is improving

7. The quality assurance wheel illustrates ____(?)____.
   a. the elements that should be considered when planning a quality assurance program
   b. the costs associated with quality assurance programs
   c. mandatory requirements for any quality assurance program
   d. the management structure of the USEPA Quality Assurance Division

8. The objectives of a quality assurance program should be to produce data that are:
   a. _____(?)_____.
   b. _____(?)_____.
   c. _____(?)_____.
   d. _____(?)_____.
   e. _____(?)_____.

9. The data illustrated below are ____(?)____.



   a. both precise and accurate
   b. precise but not accurate
   c. both imprecise and inaccurate
   d. accurate but not precise

10. The quality assurance coordinator of an air monitoring organization should ____(?)____.
   a. be the newest employee of the organization
   b. be a supervisor
   c. be independent from other organizational programs
   d. report to the laboratory supervisor

11. List the three most common training methods used in the field of air pollution control.
   a. _____(?)_____
   b. _____(?)_____
   c. _____(?)_____

12. List three techniques that can be used to check the effectiveness of a training program.
   a. _____(?)_____
   b. _____(?)_____
   c. _____(?)_____

13. An auditing procedure is one of the elements of a QA program that should be implemented as soon as possible. What are two types of audits that could be set up in an air monitoring QA program?
   a. _____(?)_____
   b. _____(?)_____

14. True or False? A performance audit is qualitative, whereas a system audit is quantitative.

15. Which of the following should be included in a QA report to management?
    a. performance and system audit results
    b. major quality problems and planned or implemented corrective action
    c. both a and b, above

16. True or False? A quality assurance program plan contains general QA requirements and information for an organization, whereas a quality assurance project plan contains specific QA requirements and information for a project of the organization.

17. True or False? State and local air pollution control agencies are responsible for the implementation of QA programs for their monitoring activities.

Section 1
Answers to Review Exercise

1. b
2. d
3. d
4. False
5. d
6. a
7. a
8. a. complete
   b. precise
   c. accurate
   d. representative
   e. comparable
9. c
10. c
11. a. on-the-job
    b. short-term
    c. long-term
12. a. written tests
    b. proficiency checks
    c. interviews
13. a. performance audit
    b. system audit
14. False
15. c
16. True
17. True

Section 2

Quality Assurance for Air Quality Monitoring Systems

Reading Assignment

Read, in the following order, sections 2.0.1, 2.0.2, 2.0.4, 2.0.7, 2.0.3, and 2.0.6 of *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II—Ambient Air Specific Methods,* EPA 600/4-77-027a.

Reading Assignment Topics

- Sampling network design and site selection
- Sampling considerations
- Reference and equivalent methods
- Gas traceability protocol for calibrations and audits of ambient air analyzers
- Data handling and reporting
- Chain-of-custody procedures for ambient air samples

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with quality assurance considerations for the acquisition, installation, and operation of air quality monitoring systems.

Learning Objectives

At the end of this section, you should be able to—

1. recognize the need to define the objectives of a monitoring program before designing the air quality monitoring network,
2. identify at least six factors that are involved in collecting air quality samples to meet defined monitoring objectives,
3. recognize at least six site characteristics that should be included in the description of an air quality monitoring station,
4. identify at least four environmental parameters that must be controlled to obtain a representative air quality sample,
5. describe the design, siting, and maintenance of sampling manifolds and probes,

6. recognize the need to carefully select air quality analyzers,
7. describe a protocol for certifying the concentrations of standard gases as traceable to National Bureau of Standards (NBS) standard reference materials (SRMs) or to certified reference materials (CRMs),
8. identify information that should be recorded on air quality data forms,
9. describe operational checks and maintenance of strip-chart recorders,
10. describe manual and automated techniques for data validation,
11. recognize the purpose of chain-of-custody procedures for ambient air samples, and
12. identify air monitoring activities that should be subjected to chain-of-custody procedures.

Reading Guidance

This assignment reviews general quality assurance and quality control guidance for constructing and operating ambient air quality monitoring networks. Each section of the *Quality Assurance Handbook* included in the assignment addresses an aspect of network construction or operation.

Considerations for obtaining air quality data that represent what is intended to be measured are addressed in Section 2.0.1. Data representativeness depends on designing a monitoring network so that it meets the objectives of its associated monitoring program. Therefore, the types and quantities of monitoring systems, the location of monitoring systems, and the frequency of monitoring must correspond to specific monitoring purposes.

The approximate numbers of SO_2 and TSP National Air Monitoring Stations (NAMS), stations selected from State and Local Air Monitoring Stations (SLAMS) networks, required for urban areas are described in Table 1.4 of Section 2.0.1. Note that as the population or pollutant concentration for an urban area increases, so does the number of required NAMS. This is because the primary monitoring objective of NAMS networks is to monitor in areas where pollutant concentrations and population exposure are expected to be the highest.

Also, considerations for siting monitors to meet monitoring objectives are described in Section 2.0.1. In addition to information presented in this section, two correspondence courses concerning the siting of ambient air quality monitors, APTI Course 436, *Site Selection for the Monitoring of SO_2 and TSP in Ambient Air,* and APTI Course 437, *Site Selection for the Monitoring of CO and Photochemical Pollutants in Ambient Air,* have been prepared for the USEPA. If you would like information concerning these courses, contact the USEPA's Air Pollution Training Institute at the address or phone number given in the Course Introduction section of this guidebook. Also, a document concerning quality assurance for meteorological measurements, *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV—Meteorological Measurements* (EPA 600/4-82-060), has been published by the USEPA. For information concerning this document, contact USEPA, ORD Publications, 26 West St. Clair Street, Cincinnati, Ohio 45268.

The designing and siting of sampling manifolds and probes are discussed in Section 2.0.2. In addition to the information presented in the section, the following should be considered when designing a sampling manifold:

- suspending strips of paper in front of the blower's exhaust permits a visual check of blower operation,
- positioning air conditioner vents away from the manifold reduces condensation of water vapor in the manifold, and
- positioning sample ports of the manifold toward the ceiling reduces the potential for accumulation of moisture in analyzer sampling lines.

Also, probe-siting criteria for Pb NAMS and SLAMS have been added to 40 CFR 58 since the publication of Section 2.0.2 (July 1, 1979). The following information is provided to update Table 4 of the section.

Table 2-1. Probe-siting criteria for Pb NAMS and SLAMS.

Pollutant	Scale	Height above ground, meters	Distance from supporting structure, meters		Other spacing criteria
			Vertical	Horizontal[a]	
Pb	Micro	2-7	—	>2	1. Should be >20 meters from trees. 2. Distance from sampler to obstacle, such as a building, must be at least twice the height that the obstacle protudes above the sampler. 3. Must have unrestricted airflow 270° around the sampler. 4. No furnace or incineration flues should be nearby.[b] 5. Must be 5 to 15 meters from major roadway.
	Middle, neighborhood, urban, and regional	2-15	—	>2	1. Should be >20 meters from trees. 2. Distance from sampler to obstacle, such as a building, must be at least twice the height that the obstacle protrudes above the sampler. 3. Must have unrestricted airflow 270° around the sampler. 4. No furnace or incineration flues should be nearby.[b] 5. Spacing from roads varies with traffic (see Table 4 of Appendix E[c]).

[a] When a probe is located on a rooftop, this separation is in reference to walls, parapets, or penthouses located on the roof.

[b] Distance is dependent on the height of the furnace or the incineration flue, the type of fuel or waste burned, and the quality of the fuel (sulfur and ash content). This is to avoid undue influences from minor pollutant sources.

[c] 40 CFR 58.

Information concerning USEPA-designated reference and equivalent measurement methods for air quality monitoring is presented in Section 2.0.4. Note that the designation program does not guarantee that a designated analyzer **will** operate properly; the program guarantees only that a designated analyzer is **capable** of operating properly. It is the user's responsibility to ensure the adequate performance of designated reference and equivalent methods by implementing a quality assurance program. The quality assurance program should include quality control for the procurement of air quality analyzers. An excellent discussion of procurement quality control is given by M. J. Kopecky and B. Rodger (Wisconsin Department of Natural Resources) in "Quality Assurance for Procurement of Air Analyzers," *1979 ASQC Technical Conference Transactions—Houston, Texas* (American Society for Quality Control, 1979:35-40).

A protocol for certifying the concentrations of gases used to calibrate or audit air quality analyzers as traceable to National Bureau of Standards (NBS) standard reference materials (SRMs) is described in Section 2.0.7. The following list expands on the partial listing of SRM cylinder gases provided in Table 7.1 of the section.

Table 2-2. SRM cylinder gases.

SRM	Type	Certified component	Nominal concentration	
1658a	Methane in air	CH_4	1	ppm
1659a	Methane in air	CH_4	10	ppm
1660a	Methane-propane in air	CH_4/C_3H_8	4/1	ppm
1661a	Sulfur dioxide in nitrogen	SO_2	500	ppm
1662a	Sulfur dioxide in nitrogen	SO_2	1000	ppm
1663a	Sulfur dioxide in nitrogen	SO_2	1500	ppm
1664a	Sulfur dioxide in nitrogen	SO_2	2500	ppm
1665b	Propane in air	C_3H_8	3	ppm
1666b	Propane in air	C_3H_8	10	ppm
1667b	Propane in air	C_3H_8	50	ppm
1668b	Propane in air	C_3H_8	100	ppm
1669b	Propane in air	C_3H_8	500	ppm
1670	Carbon dioxide in air	CO_2	0.033	percent
1671	Carbon dioxide in air	CO_2	0.034	percent
1672	Carbon dioxide in air	CO_2	0.035	percent
1674b	Carbon dioxide in nitrogen	CO_2	7.0	percent
1675b	Carbon dioxide in nitrogen	CO_2	14.0	percent
1677c	Carbon monoxide in nitrogen	CO	10	ppm
1678c	Carbon monoxide in nitrogen	CO	50	ppm
1679c	Carbon monoxide in nitrogen	CO	100	ppm
1680b	Carbon monoxide in nitrogen	CO	500	ppm
1681b	Carbon monoxide in nitrogen	CO	1000	ppm
1683b	Nitric oxide in nitrogen	NO	50	ppm
1684b	Nitric oxide in nitrogen	NO	100	ppm
1685b	Nitric oxide in nitrogen	NO	250	ppm
1686b	Nitric oxide in nitrogen	NO	500	ppm
1687b	Nitric oxide in nitrogen	NO	1000	ppm
1693	Sulfur dioxide in nitrogen	SO_2	50	ppm
1694	Sulfur dioxide in nitrogen	SO_2	100	ppm
1696	Sulfur dioxide in nitrogen	SO_2	3500	ppm

Table 2-2. SRM cylinder gases (continued).

SRM	Type	Certified component	Nominal concentration	
1805	Benzene in nitrogen	C_6H_6	0.25	ppm
1806	Benzene in nitrogen	C_6H_6	10	ppm
1808	Tetrachloroethylene in nitrogen	C_2Cl_4	0.25	ppm
1809	Tetrachloroethylene in nitrogen	C_2Cl_4	10	ppm
2612a	Carbon monoxide in air	CO	10	ppm
2613a	Carbon monoxide in air	CO	20	ppm
2614a	Carbon monoxide in air	CO	45	ppm
2619a	Carbon dioxide in nitrogen	CO_2	0.5	percent
2620a	Carbon dioxide in nitrogen	CO_2	1.0	percent
2621a	Carbon dioxide in nitrogen	CO_2	1.5	percent
2622a	Carbon dioxide in nitrogen	CO_2	2.0	percent
2623a	Carbon dioxide in nitrogen	CO_2	2.5	percent
2624a	Carbon dioxide in nitrogen	CO_2	3.0	percent
2625a	Carbon dioxide in nitrogen	CO_2	3.5	percent
2626a	Carbon dioxide in nitrogen	CO_2	4.0	percent
2627	Nitric oxide in nitrogen	NO	5	ppm
2628	Nitric oxide in nitrogen	NO	10	ppm
2629	Nitric oxide in nitrogen	NO	20	ppm
2630	Nitric oxide in nitrogen	NO	1500	ppm
2631	Nitric oxide in nitrogen	NO	3000	ppm
2632	Carbon dioxide in nitrogen	CO_2	300	ppm
2633	Carbon dioxide in nitrogen	CO_2	400	ppm
2634	Carbon dioxide in nitrogen	CO_2	800	ppm
2635	Carbon monoxide in nitrogen	CO	25	ppm
2636	Carbon monoxide in nitrogen	CO	250	ppm
2637	Carbon monoxide in nitrogen	CO	2500	ppm
2638	Carbon monoxide in nitrogen	CO	5000	ppm
2639	Carbon monoxide in nitrogen	CO	1	percent
2640	Carbon monoxide in nitrogen	CO	2	percent
2641	Carbon monoxide in nitrogen	CO	4	percent
2642	Carbon monoxide in nitrogen	CO	8	percent
2643	Propane in nitrogen	C_3H_8	100	ppm
2644	Propane in nitrogen	C_3H_8	250	ppm
2645	Propane in nitrogen	C_3H_8	500	ppm
2646	Propane in nitrogen	C_3H_8	1000	ppm
2647	Propane in nitrogen	C_3H_8	2500	ppm
2648	Propane in nitrogen	C_3H_8	5000	ppm
2649	Propane in nitrogen	C_3H_8	1	percent
2650	Propane in nitrogen	C_3H_8	2	percent
2651	Propane and oxygen in nitrogen	C_3H_8/O_2	0.01/ 5.0	percent
2652	Propane and oxygen in nitrogen	C_3H_8/O_2	0.01/10.0	percent
2653	Nitrogen dioxide in air	NO_2	250	ppm
2654	Nitrogen dioxide in air	NO_2	500	ppm
2655	Nitrogen dioxide in air	NO_2	1000	ppm
2656	Nitrogen dioxide in air	NO_2	2500	ppm
2657	Oxygen in nitrogen	O_2	2	percent
2658	Oxygen in nitrogen	O_2	10	percent
2659	Oxygen in nitrogen	O_2	21	percent

In addition to the permeation tubes listed in Table 7.1, a benzene permeation device is available from NBS. Purchase orders or quotation requests for SRMs should be addressed to the Office of Standard Reference Materials, Room B311, Chemistry Building, National Bureau of Standards, Washington, DC 20234 (telephone number: 301-921-2045).

Since the publication of Section 2.0.7, Federal air quality monitoring regulations have been revised to allow certified reference materials (CRMs) to be substituted for SRMs in calibration and audit activities that previously required traceability to only SRMs. CRMs are prepared in batches by gas manufacturers. Each batch is audited by the USEPA and approved by NBS. For a list of CRMs, including vendor information, contact USEPA, EMSL, QAD, MD 77, Research Triangle Park, North Carolina 27711.

Considerations for the processing and reporting of air quality data are discussed in Section 2.0.3. Validation is a critical step in data processing because it helps to ensure that only sound data are reported. In addition to data-validation information presented in this section, an excellent document concerning this topic, *Validation of Air Monitoring Data* (EPA 600/4-80-030), has been published by the USEPA. It is available as document number PB 81 112534 from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

Chain-of-custody procedures needed for proving the legal integrity of air pollution samples and data are described in Section 2.0.6. Such procedures should be established before sampling begins, and each individual involved should be aware of his responsibilities in the chain.

Chain-of-custody procedures are used to document who did what to samples or data, and when and how they did it. The chain of custody begins with the preparation of anything that becomes an integral part of the sample (such as a filter) and continues through to the disposal of the sample and its associated sampling data.

When you have finished the reading assignment, complete the review exercise that follows and check your answers. The correct answers are listed on the page following the review exercise. After you have reviewed your incorrect answers (if any), take Quiz 1. Follow the directions listed in the Course Introduction section of this guidebook. After completing Quiz 1, proceed to Section 3 of this guidebook.

Review Exercise

Now that you've completed the assignment for Section 2, please answer the following questions. These will help you determine whether you are mastering the material.

1. The objective(s) of a monitoring program should be clearly defined ____(?)____ the designing of the monitoring network that is associated with the monitoring program.
   a. before
   b. during
   c. before and, if necessary, revised during
   d. after

2. The spatial scale represented by an air sample measured at a monitoring site should be ____(?)____ the appropriate spatial scale for the site's monitoring objective.
   a. greater than
   b. less than
   c. the same as

3. True or False? The frequency of sampling can affect the representativeness of the samples obtained.

4. True or False? A sampling site for one pollutant may be inappropriate for another pollutant.

5. True or False? Noncontinuous sampling for TSP, SO_2, and NO_2 at the most polluted sites in an urban area should take place every six days.

6. To calculate a pollutant's 24-hour average concentration using continuous measurement methods, at least ____(?)____ hourly concentration averages for the pollutant must be present.
   a. 12
   b. 16
   c. 18
   d. 22

7. To calculate a pollutant's monthly average concentration using continuous measurement methods, at least ____(?)____ daily concentration averages must be present.
   a. 14
   b. 18
   c. 21
   d. 26

8. Air quality is usually monitored continuously in areas ____(?)____.
   a. having poor air quality
   b. having high population densities
   c. both a and b, above

9. True or False? The identification record for a monitoring site should include the data acquisition objective for the site.

10. True or False? Unless an emergency episode monitoring site has an automatic data-transmission system, personnel should be present at the site during an episode.

11. True or False? During operation, air quality analyzers do not need to be located in a temperature-controlled environment.

12. Which of the following sampling manifolds should be constructed of inert materials?
    a. vertical laminar flow
    b. conventional
    c. both a and b, above

13. Significant losses of reactive gas concentrations have been observed in glass and Teflon® sampling lines when the sample residence times exceeded ____(?)____ second(s).
    a. 1
    b. 5
    c. 20

14. Appendix E of 40 CFR 58 requires that the probe of an SO_2 monitor be located away from obstacles such as buildings, so that the distance between an obstacle and the probe is at least ____(?)____ times the height that the obstacle protrudes above the probe.
    a. 2
    b. 4
    c. 5
    d. 10

15. True or False? The flow rate of sample air through a manifold should equal the sum of the individual flow rates required by the sampling systems connected to the manifold.

16. Which of the following activities should be performed in obtaining reagent water?
    a. development of purchasing guidelines
    b. testing water for conductivity
    c. both a and b, above

17. True or False? The use of new calibration gases should be overlapped with the use of old calibration gases.

18. True or False? Reference or equivalent methods are generally not required in SLAMS monitoring networks.

19. Requiring the use of reference or equivalent methods helps to assure that air quality measurements are made with methods that are capable of having adequate ____(?)____.
    a. accuracy
    b. reliability
    c. both a and b, above

20. True or False? The designation status of an analyzer can be determined by referring to its model number.

21. True or False? Any modification to a reference or equivalent method made by a user must be approved by the USEPA if the method's designation status is to be maintained.

22. True or False? No competitive differences exist among designated analyzers.

23. True or False? A quality assurance program is not needed for designated reference or equivalent methods.

24. The USEPA's traceability protocol requires that true concentrations of standard gases be determined using ____(?)____.
    a. NBS Class S weights
    b. air quality analyzers that have been calibrated with NBS SRMs or CRMs
    c. both a and b, above

25. True or False? Gas manufacturers are required to provide traceability for all standard gases that they sell.

26. For establishing traceability of commercial cylinder gases to NBS SRM or CRM cylinder gases, the USEPA traceability protocol requires that an analyzer be calibrated using zero gas and ____(?)____ NBS SRM or CRM cylinder gas(es).
    a. 1
    b. 2
    c. 3
    d. 6

27. True or False? The USEPA traceability protocol does not require zero and span checks of analyzers having linear responses.

28. For establishing the true concentration of a cylinder gas, the USEPA traceability protocol requires that the cylinder gas be analyzed ____(?)____ time(s).
    a. 1
    b. 2
    c. 3

29. True or False? For establishing the true permeation rate of a permeation tube, the USEPA traceability protocol requires the analysis of one pollutant concentration generated by the tube.

30. True or False? The USEPA traceability protocol requires that the stability of cylinder gases be verified before they are used.

31. The USEPA traceability protocol requires reanalysis of ____(?)____.
    a. cylinder gases
    b. permeation tubes
    c. permeation devices
    d. all of the above

32. The USEPA traceability protocol requires that commercial permeation tubes or devices be equilibrated at a specified temperature for at least ____(?)____ hours.
    a. 3
    b. 12
    c. 24
    d. 36

33. True or False? Identification numbers of NBS SRMs or CRMs used as primary standards should be included in traceability records for cylinder gases and permeation tubes.

34. Ambient air monitoring data forms should include ____(?)____.
    a. pollutant information
    b. monitoring site identification
    c. both a and b, above

35. Which of the following is an(are) advantage(s) of using preprinted data forms?
    a. minimizes identification errors
    b. ensures that everyone is using up-to-date forms
    c. both a and b, above

36. Suspended particulate matter concentrations (μg/std m^3) should be reported to ____(?)____ decimal place(s).
    a. 0
    b. 1
    c. 2
    d. 3

37. True or False? The timing of the chart drive of a strip-chart recorder should be verified periodically.

38. True or False? A strip-chart-recorder trace having a cyclic pattern could be caused by analyzer-shelter temperature fluctuations that are beyond the operating temperature limits of the analyzer.

39. True or False? Data validation should be performed by personnel who are directly involved in collecting the data.

40. Manual scanning of data sets is most appropriate for detecting ____(?)____.
    a. unusually high or low values
    b. erroneous intermediate values
    c. both a and b, above

41. True or False? Erroneous intermediate values of a data set are more easily detected using automated validation procedures.

42. Systematic data management ____(?)____ duplicate reporting of data.
    a. increases
    b. decreases
    c. does not affect

43. True or False? Chain-of-custody procedures are necessary to make a *prima facie* showing of the representativeness of sampling data.

44. Which of the following should be subjected to chain-of-custody procedures?
    a. preparation of sampling equipment and reagents
    b. samples
    c. sampling data
    d. both b and c, above
    e. a, b, and c, above

45. True or False? Chain-of-custody procedures should be applied only during sample collection and transport to the laboratory.

46. True or False? Original sampling and analysis records may be discarded after completion of their associated final report.

Section 2
Answers to Review Exercise

1. c
2. c
3. True
4. True
5. False
6. c
7. c
8. c
9. True
10. True
11. False
12. b
13. c
14. a
15. False
16. c
17. True
18. False
19. c
20. False
21. True
22. False
23. False
24. b
25. False
26. b
27. False
28. c
29. False
30. True
31. d
32. d
33. True
34. c
35. a
36. a
37. True
38. True
39. False
40. a
41. True
42. b
43. True
44. e
45. False
46. False

Section 3

Quality Assurance for SLAMS and PSD Air Monitoring Networks

Reading Assignment

Read, in the following order, sections 2.0.9 and 2.0.8 of *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II—Ambient Air Specific Methods,* EPA 600/4-77-027a.

Reading Assignment Topics

- Quality control programs for SLAMS and PSD air monitoring
- Precision and accuracy assessment for SLAMS and PSD air monitoring data

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with quality control programs and data quality assessment for SLAMS and PSD air monitoring.

Learning Objectives

At the end of this section, you should be able to—

1. recognize the two principal objectives of quality control programs for SLAMS and PSD air monitoring networks,
2. describe guidance for the calibration of automated air quality analyzers, including the use of Level 1 and Level 2 zero and span checks,
3. describe guidance for calibration, performance evaluation, and operational checks of manual air quality measurement methods,
4. recognize monitoring activities that require written operational procedures,
5. recognize that standard gases used in SLAMS or PSD air monitoring networks must be certified as traceable to NBS SRMs or CRMs,
6. identify recommended recalibration frequencies for flow rate measuring devices,
7. recognize activities that are required for assessing precision and accuracy of SLAMS and PSD air monitoring data, and
8. calculate precision and accuracy estimates for SLAMS and PSD air monitoring data.

Reading Guidance

This assignment reviews quality control guidance and required data quality assessment for SLAMS and prevention of significant deterioration (PSD) air monitoring. Recommendations for developing and implementing quality control programs are given in Section 2.0.9. Section 2.0.8 contains procedures required for estimating the precision and accuracy of air monitoring data.

The USEPA reference method for SO_2 has been revised since the publication of Section 2.0.9 (July 11, 1979). Because of these revisions, some of the recommendations described in Section 2.0.9 do not reflect present Federal requirements described in the revised reference method. These recommendations are contrasted with present Federal requirements below.

Table 3-1. Section 2.0.9 recommendations versus SO_2 reference method.

Recommendation described in Section 2.0.9 (as of July 11, 1979)	Federal requirement described in revised SO_2 reference method (after July 11, 1979)
The wavelength calibration of the spectrophotometer should be verified when the spectrophotometer is initially received.	The wavelength calibration of the spectrophotometer should be verified when the spectrophotometer is initially received **and** after each 160 hours of normal use or every 6 months, whichever comes first.
The flow rate through the sampler may be calibrated in the laboratory.	The flow rate through the sampler must be determined at the sampling site.
No specification is given for the correlation coefficient of the calibration curve.	The correlation coefficient of the calibration curve must be greater than 0.998.
The difference between measured and known values of control-standard solutions should not be greater than ± 0.07 μg SO_2/mL.	The difference between measured and known values of control-standard solutions should not be greater than 1 μg SO_2.
The temperature of the sample during sampling, storage, and transport following sampling must be maintained between 5° and 25°C. During storage and transport, the temperature should be maintained as close to 5°C as possible.	The temperature of the sample must be maintained between 5° and 25°C during sampling and between 0° and 10°C after sampling.
If the difference between the initial and final sampling flow rates is more than 10% of the initial flow rate, corrective action should be performed.	If the difference between the initial and final flow rates is more than 5% of the final flow rate, the sample must be invalidated.
Control-standard solutions containing 1.0 μg SO_2/mL should be analyzed during sample analysis.	Control-standard solutions containing approximately 5 μg SO_2 and 15 μg SO_2 must be analyzed during sample analysis.

Also, *Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD),* given as a reference in Section 2.0.9, has been revised since the publication of the section. Its present publication number and publication date are EPA 450/4-80-012 and November 1980.

As described in Section 2.0.8, the accuracy of air monitoring data obtained from air quality analyzers is estimated by auditing the analyzers within specific concentration ranges. Since the publication of Section 2.0.8 (July 1, 1979), the specified range of 0.40 to 0.45 ppm for SO_2, NO_2, and O_3 analyzers and the specified range of 40 to 45 ppm for CO analyzers have been changed to 0.35 to 0.45 ppm and 35 to 45 ppm, respectively.

Procedures for assessing the precision and accuracy of lead monitoring data have been added to 40 CFR 58 since the publication of Section 2.0.8. Estimates of precision and accuracy are obtained in different ways, depending on whether a SLAMS or PSD air monitoring network is involved, and whether the reference method or an equivalent method for lead monitoring is used.

For a SLAMS network, lead monitoring data are obtained by using either the lead reference method or an equivalent measurement method. If the lead reference method is used, the data's precision is estimated by analyzing duplicate strips of lead filter samples collected at the monitoring site where the highest lead concentrations are expected to occur. If an equivalent measurement method is used, the data's precision may be estimated by analyzing duplicate aliquots of the lead samples. In either case, the analytical results are used to calculate 95% probability limits for precision. Probability limits for the precision of lead monitoring data are calculated using the equations described in Section 2.0.8 for calculating the precision of TSP monitoring data.

For a PSD network, lead monitoring data are obtained by using either the lead reference method or an equivalent measurement method. In either case, the data's precision is estimated by analyzing lead samples from two collocated samplers at one monitoring site. The analytical results are used to calculate 95% probability limits for precision. Probability limits are calculated using the equations described in Section 2.0.8 for calculating the precision of TSP monitoring data.

The accuracy of lead monitoring data is estimated from audit results. Audit results are obtained by auditing the flow rate measurements of lead samplers and analyzing lead audit samples.

For a SLAMS network that uses the lead reference method, the number of lead and TSP high-volume samplers are combined for auditing purposes. The flow rate measurements of 25% of the combined number of samplers are audited once each calendar quarter. Audit procedures and calculations described in Section 2.0.8 for estimating the accuracy of TSP monitoring data are used. In addition, three audit samples prepared by depositing a lead solution on unexposed filter strips and having known lead concentrations from each of the two concentration ranges, 100 to 300 μg Pb and 600 to 1000 μg Pb, are analyzed each calendar quarter that lead air samples are analyzed. The analytical results are used to calculate 95% probability limits for accuracy. Probability limits are calculated using the equations described in Section 2.0.8 for calculating the accuracy of SO_2 and NO_2 monitoring data obtained from manual measurement methods.

For a PSD network that uses the lead reference method, the flow rate measurements of each lead sampler are audited once each sampling quarter. Audit procedures and calculations described in Section 2.0.8 for estimating the accuracy of TSP monitoring data are used. In addition, audit samples prepared by depositing a

lead solution on unexposed filter strips and having a known lead concentration from each of the two concentration ranges, 100 to 300 μg Pb and 600 to 1000 μg Pb, are analyzed each day that lead air samples are analyzed. The analytical results are used to calculate percentage differences. Percentage differences are calculated using the equations described in Section 2.0.8 for calculating single-analysis-day accuracy for SO_2 and NO_2 monitoring data obtained from manual measurement methods.

For both SLAMS and PSD air monitoring networks, the accuracy of a lead equivalent measurement method is assessed in the same manner as described above for the lead reference method. However, the flow rate auditing device and the lead analysis audit samples must be compatible with the specific requirements of the equivalent method.

In many cases, data quality assessment requirements for SLAMS and PSD air monitoring are the same. However, there are some differences. These differences are listed below.

Table 3-2. Differences between data quality assessment requirements for SLAMS and PSD air monitoring.

Topic	SLAMS	PSD
Audit rates for accuracy assessment		
• Automated measurement methods	25% per quarter	100% per quarter
• Manual measurement methods	Hi-vol samplers: 25% per quarter Pb analysis: 3 times per quarter SO_2 and NO_2: Each analysis day	100% per quarter Each analysis day Manual measurement methods for SO_2 and NO_2 are not allowed.
Precision assessment		
• Collocated sampling	2 sites for SO_2, NO_2, and TSP	1 site for TSP and Pb
• Pb precision assessment	Analysis of duplicate filter strips or duplicate aliquots of Pb samples	Collocated sampling
Reporting period for data quality assessment	Calendar quarter	Sampling quarter
Reporting of data quality assessment	Assessment reported for organization	Assessment reported for each monitoring system

In addition to data quality assessment information presented in Section 2.0.8, the USEPA has published a document, *Guideline on the Meaning and Use of Precision and Accuracy Data Required by 40 CFR Part 58, Appendices A and B* (EPA 600/4-83-023), that contains a detailed discussion of the concepts and uses of precision and accuracy data required for ambient air quality monitoring. It is available as document number PB 83 238949 from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

When you have finished the reading assignment, complete the review exercise that follows and check your answers. The correct answers are listed on the page following the review exercise. After you have reviewed your incorrect answers (if any), proceed to Section 4 of this guidebook.

Review Exercise

Now that you've completed the assignment for Section 3, please answer the following questions. These will help you determine whether you are mastering the material.

1. The principal objective(s) of quality control programs for SLAMS and PSD air monitoring is(are) to ____(?)____.
   a. provide data of adequate quality to meet monitoring objectives
   b. increase the number of quality assurance coordinators
   c. minimize loss of air quality data
   d. both a and b, above
   e. both a and c, above

2. Reference or equivalent methods are generally required in ____(?)____ monitoring networks.
   a. SLAMS
   b. PSD
   c. CEM
   d. both a and b, above
   e. both a and c, above

3. Automated air quality analyzers used for SLAMS or PSD air monitoring should be recalibrated at least every ____(?)____.
   a. two weeks
   b. month
   c. three months
   d. year

4. Level 1 zero and span checks of automated air quality analyzers should be used to ____(?)____.
   a. make analyzer zero and span adjustments
   b. decide on the need for analyzer recalibration
   c. invalidate monitoring data
   d. all of the above

5. True or False? Level 2 zero and span checks of automated air quality analyzers should be used to decide on the need for analyzer recalibration.

6. Control charts should be maintained for Level 1 zero and span checks of automated air quality analyzers so that ____(?)____.
   a. control limits can be determined
   b. warning limits can be determined
   c. drift patterns can be readily identified
   d. all of the above

7. Under the conditions described below, the span drift of an automated air quality analyzer is ____(?)____ percent.
   a. 0.10
   b. 10
   c. 0.15
   d. 15

   Given: Unadjusted span reading: 0.900 ppm
   Zero drift: 0.020 ppm
   Span gas concentration: 0.800 ppm

8. True or False? Results from quarterly performance audits of automated air quality analyzers should be directly used for data validation.

9. Operational procedures should be written for which of the following activities?
   a. analyzer calibration
   b. Level 1 and 2 zero and span checks
   c. data validation
   d. both a and b, above
   e. a, b, and c, above

10. True or False? Air quality analyzers should be subjected to a performance audit as soon as possible after an air pollution episode.

11. True or False? After maintenance is performed on a high-volume sampler's motor, the sampler's flow rate measuring device should be recalibrated.

12. The flow rate through an SO_2 sampling train should be determined ____(?)____.
    a. before and after each sampling period
    b. once per week
    c. once per month
    d. once per quarter

13. A high-volume sampler should be recalibrated if a performance audit results in a relative difference of greater than ± ____(?)____ percent between the sampler's measured flow rate and the audit flow rate.
    a. 3
    b. 7
    c. 15
    d. 20

14. True or False? Control standards should be periodically analyzed, using an atomic absorption spectrophotometer, during the analyses of lead samples.

15. Which of the following is a(are) desirable characteristic(s) of glass-fiber filters used to collect particulate lead?
    a. minimal variation of lead content from filter to filter
    b. high lead content
    c. both a and b, above

16. ____(?)____ should be used directly to validate air quality data collected by manual measurement methods.
    a. Results from quarterly performance audits
    b. Results from operational checks
    c. both a and b, above

17. Which of the following standard gases used in SLAMS or PSD air monitoring networks must be certified as traceable to NBS SRMs or CRMs?
    a. SO_2
    b. CO
    c. O_3
    d. both a and b, above
    e. a, b, and c, above

18. True or False? Mass flowmeters do not require periodic recalibration.

19. Results of ____(?)____ are used to assess the precision of TSP, SO_2, and NO_2 data collected by manual measurement methods in SLAMS monitoring networks.
    a. routine operational checks
    b. collocated sampling
    c. audits

20. Results of ____(?)____ are used to assess the accuracy of SLAMS and PSD air monitoring data.
    a. routine operational checks
    b. collocated sampling
    c. audits

21. Precision checks of SO_2, NO_2, O_3, and CO automated analyzers of SLAMS and PSD air monitoring networks must be performed at least once every ____(?)____.
    a. week
    b. two weeks
    c. month
    d. quarter

22. True or False? Equipment used for calibrating SLAMS and PSD air monitoring methods may also be used for auditing the methods.

23. True or False? The routine operators of PSD automated air monitoring methods may also audit the methods.

24. A precision check that is made in conjunction with a zero/span adjustment must be made ____(?)____ the adjustment.
    a. before
    b. after
    c. during

25. True or False? During a precision check, the test atmosphere must pass through as much of the ambient inlet system as is practicable.

26. Under the conditions described below, the upper and lower 95% probability limits for the precision of TSP monitoring data collected by the reporting organization are ____(?)____ percent and ____(?)____ percent, respectively.

a. 2, 5
b. −1, −6
c. 1, −7
d. 0, −6

Given:

Collocated TSP Sampling Data for the Reporting Organization Sampling Site 1

Sampling period	Duplicate sampler results (μg/std m^3)	Official sampler results (μg/std m^3)
1	227	236
2	268	275
3	258	256

Sampling Site 2

Sampling period	Duplicate sampler results (μg/std m^3)	Official sampler results (μg/std m^3)
1	245	257
2	227	240
3	164	166
4	212	221

27. Under the conditions described below, the upper and lower 95% probability limits for the precision of CO monitoring data collected by the CO analyzer are ____(?)____ percent and ____(?)____ percent, respectively.

a. 4, −4
b. 6, −6
c. 0, −4
d. 0, −6

Given:

Precision Check Data for the CO Analyzer

Precision check	Measured CO concentration (ppm)	Known CO concentration (ppm)
1	9.1	9.0
2	8.9	9.0
3	9.2	9.0
4	9.3	9.0
5	8.6	9.0
6	8.8	9.0

28. Under the conditions described below, the upper and lower 95% probability limits for the accuracy of CO monitoring data within the 15- to 20-ppm range for the reporting organization are ____(?)____ percent and ____(?)____ percent, respectively.

a. 13, −20
b. 8, −16
c. 8, −20
d. 13, −16

Given:

Audit Data for CO Analyzers

Analyzer audit	Measured CO concentration (ppm)	Known CO concentration (ppm)
1	16	18
2	17	18
3	19	18

Section 3
Answers to Review Exercise

1. e
2. d
3. c
4. d
5. False
6. c
7. b
8. False
9. e
10. True
11. True
12. a
13. b
14. True
15. a
16. b
17. d
18. False
19. b
20. c
21. b
22. False
23. False
24. a
25. True
*26. d
*27. b
*28. a

*Solutions for questions 26, 27, and 28 follow.

Solution for Question 26

1. For site 1, calculate the percentage difference (d_i) for each pair of results using the following equation:

$$d_i = \left(\frac{y_i - x_i}{x_i}\right)100$$

Where: y_i = duplicate sampler result
x_i = official sampler result

Calculated percentage differences:

Sampling period	
1	$d_1 = \left(\frac{227-236}{236}\right)100 = -3.8$
2	$d_2 = \left(\frac{268-275}{275}\right)100 = -2.5$
3	$d_3 = \left(\frac{258-256}{256}\right)100 = 0.8$

2. Calculate the average percentage difference ($\bar{d}_j$) for site 1 using the following equation:

$$\bar{d}_j = \frac{\Sigma d_i}{n}$$

Where: n = the number of pairs of results

Calculated average percentage difference:

$$\bar{d}_1 = \frac{-3.8 + (-2.5) + 0.8}{3}$$
$$= -1.8$$

3. Calculate the standard deviation of the percentage differences (s_j) for site 1 using the following equation:

$$s_j = \left[\frac{\Sigma d_j^2 - (\Sigma d_j)^2/n}{n-1}\right]^{1/2}$$

Where: n = the number of pairs of results

Calculated standard deviation of the percentage differences:

$$s_1 = \left(\frac{\left[(-3.8)^2 + (-2.5)^2 + (0.8)^2\right] - \frac{[(-3.8)+(-2.5)+(0.8)]^2}{3}}{3-1}\right)^{1/2}$$
$$= \left(\frac{21.33 - 10.08}{2}\right)^{1/2}$$
$$= 2.4$$

4. Calculate percentage differences (d_i), average percentage difference ($\bar{d}_j$), and standard deviation of the percentage differences (s_j) for site 2.

Calculated percentage differences:

Sampling period	
1	$d_1 = \left(\frac{245-257}{257}\right)100 = -4.7$
2	$d_2 = \left(\frac{227-240}{240}\right)100 = -5.4$
3	$d_3 = \left(\frac{164-166}{166}\right)100 = -1.2$
4	$d_4 = \left(\frac{212-221}{221}\right)100 = -4.1$

Calculated average percentage difference:

$$\bar{d}_2 = \frac{-4.7+(-5.4)+(-1.2)+(-4.1)}{4}$$
$$= -3.8$$

Calculated standard deviation of the percentage differences:

$$s_2 = \left(\frac{\left[(-4.7)^2+(-5.4)^2+(-1.2)^2+(-4.1)^2\right] - \frac{[(-4.7)+(-5.4)+(-1.2)+(-4.1)]^2}{4}}{4-1}\right)^{1/2}$$
$$= \left(\frac{69.50-59.29}{3}\right)^{1/2}$$
$$= 1.8$$

5. Calculate the average percentage difference ($\bar{D}$) for sites 1 and 2 using the following equation:

$$\bar{D} = \frac{n_1\bar{d}_1 + n_2\bar{d}_2}{n_1+n_2}$$

Calculated average percentage difference:

$$\bar{D} = \frac{(3)(-1.8)+(4)(-3.8)}{3+4}$$
$$= -2.9$$

6. Calculate the pooled standard deviation (s_a) for sites 1 and 2 using the following equation:

$$s_a = \left[\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - k} \right]^{1/2}$$

Where: k = the number of collocated sampling sites

Calculated pooled standard deviation:

$$s_a = \left[\frac{(3-1)(2.4)^2 + (4-1)(1.8)^2}{3+4-2} \right]^{1/2}$$

$$= 2.1$$

7. Calculate the upper 95% probability limit using the following equation:

$$\text{Upper 95\% probability limit} = \overline{D} + \frac{(1.96)s_a}{\sqrt{2}}$$

Calculated upper 95% probability limit:

$$\text{Upper 95\% probability limit} = -2.9 + \frac{(1.96)(2.1)}{\sqrt{2}}$$

$$\boxed{\text{Upper 95\% probability limit} = 0.0 \text{ or } 0}$$

8. Calculate the lower 95% probability limit using the following equation:

$$\text{Lower 95\% probability limit} = \overline{D} - \frac{(1.96)s_a}{\sqrt{2}}$$

Calculated lower 95% probability limit:

$$\text{Lower 95\% probability limit} = -2.9 - \frac{(1.96)(2.1)}{\sqrt{2}}$$

$$\boxed{\text{Lower 95\% probability limit} = -5.8 \text{ or } -6}$$

Solution for Question 27

1. Calculate the percentage difference (d_i) for each precision check using the following equation:

$$d_i = \left(\frac{y_i - x_i}{x_i}\right)100$$

Where: y_i = measured CO concentration
x_i = known CO concentration

Calculated percentage differences:

Precision check	
1	$d_1 = \left(\frac{9.1 - 9.0}{9.0}\right)100 = 1.1$
2	$d_2 = \left(\frac{8.9 - 9.0}{9.0}\right)100 = -1.1$
3	$d_3 = \left(\frac{9.2 - 9.0}{9.0}\right)100 = 2.2$
4	$d_4 = \left(\frac{9.3 - 9.0}{9.0}\right)100 = 3.3$
5	$d_5 = \left(\frac{8.6 - 9.0}{9.0}\right)100 = -4.4$
6	$d_6 = \left(\frac{8.8 - 9.0}{9.0}\right)100 = -2.2$

2. Calculate the average percentage difference ($\bar{d}$) using the following equation:

$$\bar{d} = \frac{\Sigma d_i}{n}$$

Where: n = the number of precision checks

Calculated average percentage difference:

$$\bar{d} = \frac{1.1 + (-1.1) + 2.2 + 3.3 + (-4.4) + (-2.2)}{6}$$

$$= -0.2$$

3. Calculate the standard deviation of the percentage differences (s) using the following equation:

$$s = \left[\frac{\Sigma d_i^2 - (\Sigma d_i)^2/n}{n-1}\right]^{1/2}$$

Where: n = the number of precision checks

Calculated standard deviation of the percentage differences:

$$s = \left(\frac{\left[(1.1)^2 + (-1.1)^2 + (2.2)^2 + (3.3)^2 + (-4.4)^2 + (-2.2)^2\right] - \frac{[(1.1) + (-1.1) + (2.2) + (3.3) + (-4.4) + (-2.2)]^2}{6}}{6-1} \right)^{1/2}$$

$$= \left(\frac{42.35 - 0.20}{5} \right)^{1/2}$$

$$= 2.9$$

4. Calculate the upper 95% probability limit using the following equation:

$$\text{Upper 95\% probability limit} = \bar{d} + (1.96)s$$

Calculated upper 95% probability limit:

$$\text{Upper 95\% probability limit} = -0.2 + (1.96)(2.9)$$

$$\boxed{\text{Upper 95\% probability limit} = 5.5 \text{ or } 6}$$

5. Calculate the lower 95% probability limit using the following equation:

$$\text{Lower 95\% probability limit} = \bar{d} - (1.96)s$$

Calculated lower 95% probability limit:

$$\text{Lower 95\% probability limit} = -0.2 - (1.96)(2.9)$$

$$\boxed{\text{Lower 95\% probability limit} = -5.9 \text{ or } -6}$$

Solution for Question 28

1. Calculate the percentage difference (d_i) for each analyzer audit using the following equation:

$$d_i = \left(\frac{y_i - x_i}{x_i} \right) 100$$

Where: y_i = measured CO concentration
x_i = known CO concentration

Calculated percentage differences:

Analyzer audit	
1	$d_1 = \left(\frac{16-18}{18} \right) 100 = -11.1$
2	$d_2 = \left(\frac{17-18}{18} \right) 100 = -5.6$
3	$d_3 = \left(\frac{19-18}{18} \right) 100 = 5.6$

2. Calculate the average percentage difference ($\overline{D}$) using the following equation:

$$\overline{D} = \frac{\Sigma d_i}{k}$$

Where: k = the number of analyzer audits

Calculated average percentage difference:

$$\overline{D} = \frac{-11.1 + (-5.6) + 5.6}{3}$$

$$= -3.7$$

3. Calculate the standard deviation of the percentage differences (s_a) using the following equation:

$$s_a = \left[\frac{\Sigma d_i^2 - (\Sigma d_i)^2/k}{k-1}\right]^{1/2}$$

Where: k = the number of analyzer audits

Calculated standard deviation of the percentage differences:

$$s_a = \left(\frac{\left[(-11.1)^2 + (-5.6)^2 + (5.6)^2\right] - \frac{[(-11.1) + (-5.6) + (5.6)]^2}{3}}{3-1}\right)^{1/2}$$

$$= \left(\frac{185.93 - 41.07}{2}\right)^{1/2}$$

$$= 8.5$$

4. Calculate the upper 95% probability limit using the following equation:

$$\text{Upper 95\% probability limit} = \overline{D} + (1.96)s_a$$

Calculated upper 95% probability limit:

$$\text{Upper 95\% probability limit} = -3.7 + (1.96)(8.5)$$

$$\boxed{\text{Upper 95\% probability limit} = 13.0 \text{ or } 13}$$

5. Calculate the lower 95% probability limit using the following equation:

$$\text{Lower 95\% probability limit} = \overline{D} - (1.96)s_a$$

Calculated lower 95% probability limit:

$$\text{Lower 95\% probability limit} = -3.7 - (1.96)(8.5)$$

$$\boxed{\text{Lower 95\% probability limit} = -20.4 \text{ or } -20}$$

Section 4

Performance Auditing of Air Quality Monitoring Systems

Reading Assignment

Read, in the following order, sections 2.0.12 and 2.0.10 of *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II—Ambient Air Specific Methods,* EPA 600/4-77-027a.

Reading Assignment Topics

- General guidance for conducting performance audits of air quality measurement systems
- Performance audit procedures for SO_2, NO_2, CO, and O_3 analyzers
- Performance audit procedure for TSP high-volume samplers
- Interpretation of performance audit results
- USEPA's national performance audit program

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with performance audit procedures for air quality monitoring systems and with the USEPA's national performance audit program.

Learning Objectives

At the end of this section, you should be able to—

1. describe, in sequence, the activities involved in conducting a performance audit,
2. recognize equipment requirements, including critical specifications and operating parameters, for conducting performance audits of SO_2, NO_2, CO, and O_3 analyzers and high-volume samplers,
3. describe performance-audit procedures for SO_2, NO_2, CO, and O_3 analyzers and high-volume samplers,
4. describe techniques for the interpretation of performance audit data,

5. recognize that organizations operating SLAMS or PSD air monitoring networks are required to participate in the USEPA's national performance audit program,
6. recognize the two purposes of the USEPA's national performance audit program, and
7. identify audit materials for ambient air monitoring that are presently used in the USEPA's national performance audit program.

Reading Guidance

This assignment reviews performance auditing of ambient air quality monitoring systems. Audit procedures for SO_2, NO_2, CO, and O_3 analyzers and TSP high-volume samplers are described in Section 2.0.12. Section 2.0.10 contains information concerning the USEPA's national performance audit program for ambient air quality monitoring.

At first glance, Section 2.0.12 appears to be lengthy. However, much of it consists of redundant information and audit data forms. Descriptions of flow controllers, flowmeters, mixing chambers, output manifolds, and sampling lines are generally the same for all of the analyzer audit systems discussed. Procedures for auditing SO_2 and CO analyzers are the same except for the specification and calculation of audit gas concentrations. Also, the calculation of audit results is the same for all of the analyzers. After you have thoroughly read this information once, you can just skim it in subsequent parts of the section.

The USEPA reference method for suspended particulate matter and the reference measurement principle and calibration procedures for CO have been revised since the publication of Section 2.0.12 (July 1, 1980). Therefore, some of the recommendations described in Section 2.0.12 do not reflect present Federal requirements described in the revised reference method and in the revised reference measurement principle and calibration procedure. These recommendations are contrasted with present Federal requirements below.

- Section 2.0.12 states that TSP high-volume samplers not equipped with constant flow controllers are usually calibrated in terms of actual flow rates. However, the revised reference method requires that **all** high-volume samplers be calibrated in terms of standard flow rates.
- Section 2.0.12 states that zero air, nitrogen, or helium may be used to dilute CO used in auditing CO analyzers. However, the revised reference measurement principle and calibration procedure requires that CO used in **calibrating** CO analyzers be diluted with zero air.

In addition to the above revisions, note the following as you read Section 2.0.12:

- The nitrogen oxides analyzer that is included in the description of the gas phase titration audit system is not needed for the described NO_2 audit procedure.
- The second and third pages of the gas phase titration audit data report form are reversed.

- In the description of the dilution air source for the carbon monoxide dynamic dilution audit system, NO_2 should be nitrogen.
- The variance equations presented in Table 12.10 should be

$$S_y^2 = \frac{\Sigma y^2 - \frac{(\Sigma y)^2}{N}}{N-1} \quad \text{and} \quad S_x^2 = \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{N}}{N-1}$$

- The y-intercept (b) of the line depicted in Figure 12.16 is -0.014, not -0.009 as indicated.

Materials that are used in the USEPA's national performance audit program for auditing ambient air quality monitoring systems are described in Section 2.0.10. The USEPA periodically sends these materials to air quality monitoring organizations, where they are used to audit the performance of manual and automated air quality measurement methods. The organizations report their audit results to the USEPA. Subsequently, the USEPA analyzes the audit results and reports its findings back to the organizations.

Since the publication of Section 2.0.10 (July 1, 1979), a device for auditing SO_2 automated analyzers has been added to the performance audit program. It consists of a cylinder of SO_2, a cylinder of zero air, and a dynamic gas dilution system. Seven SO_2 concentrations, including a zero concentration, can be generated using the device (Figure 4-1).

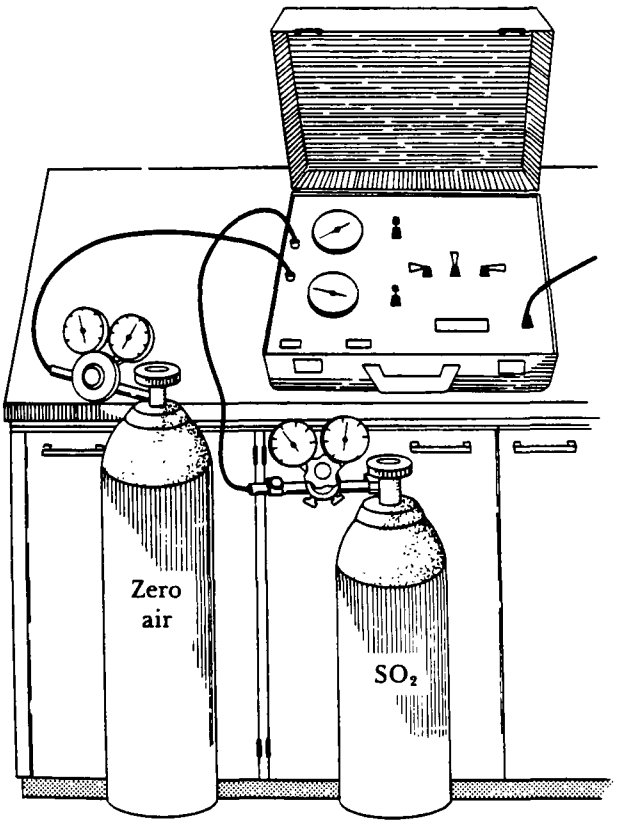


Figure 4-1. Audit device for SO_2 analyzers.

Source emission measurement methods are also audited in the USEPA's national performance audit program. If you are interested in participating in these audits, contact the USEPA, Quality Assurance Division, EMSL, Research Triangle Park, North Carolina 27711.

When you have finished the reading assignment, complete the review exercise that follows and check your answers. The correct answers are listed on the page following the review exercise. After you have reviewed your incorrect answers (if any), take Quiz 2. Follow the directions listed in the Course Introduction section of this guidebook. After completing Quiz 2, proceed to Section 5 of this guidebook.

Review Exercise

Now that you've completed the assignment for Section 4, please answer the following questions. These will help you determine whether you are mastering the material.

1. True or False? The operator of an air monitoring site should be informed of performance auditing results immediately following an audit.
2. True or False? During a performance audit, the auditor should convert analyzer responses to pollutant concentrations.
3. Audit responses of an analyzer, whose responses are routinely telemetered to a computer, should be obtained from ____(?)____.
   a. a strip-chart recorder
   b. a digital voltmeter
   c. the computer
4. Audit gas manifolds for air quality analyzers should be composed of ____(?)____.
   a. polypropylene
   b. glass
   c. Teflon®
   d. either b or c, above
5. True or False? Preparing an audit gas by dynamic dilution requires accurate flow rate measurements.
6. Which of the following must be complied with when auditing an air quality analyzer?
   a. audit gas manifold vented to the outside atmosphere
   b. audit gases introduced through analyzer's calibration port
   c. gas flow to audit gas manifold 10 to 50% greater than analyzer's sample flow demand
   d. a and c, above
   e. a, b, and c, above
7. Dilution air used in the audit of flame photometric SO_2 analyzers should contain which of the following?
   a. $20.9 \pm 0.2\%$ oxygen
   b. nitrogen
   c. approximately 350 ppm carbon dioxide
   d. a and b, above
   e. a, b, and c, above
8. Audit gases must be delivered to the inlet of an air quality analyzer ____(?)____ ambient pressure.
   a. at
   b. below
   c. above

9. Gases used to audit SO_2, NO_2, and CO analyzers should be traceable to a ____(?)____.
   a. standard reference material of the National Bureau of Standards
   b. certified reference material
   c. either a or b, above

10. ____(?)____ cylinder regulators should be composed of stainless steel.
   a. SO_2
   b. NO
   c. CO
   d. both a and b, above
   e. both a and c, above

11. ____(?)____ must be removed from regulators of SO_2, NO, and CO cylinders that are used for auditing air quality analyzers.
   a. N_2
   b. O_2
   c. Ar

12. True or False? In auditing an NO_2 analyzer, data resulting from an audit of the analyzer's NO response are used to determine the concentrations of NO_2 audit gases.

13. Which of the following is(are) evaluated during a performance audit of an NO_2 analyzer?
   a. calibration of the analyzer's NO_x response
   b. calibration of the analyzer's NO_2 response
   c. the efficiency of the analyzer's converter
   d. both a and b, above
   e. a, b, and c, above

14. In auditing O_3 analyzers, audit gas concentrations are verified using ____(?)____.
   a. gas-phase chemiluminescence
   b. ultraviolet photometry
   c. flame photometry
   d. nondispersive infrared spectroscopy

15. The identity(ies) of which of the following should be documented during a performance audit?
   a. the measurement system that is audited
   b. the audit system
   c. the auditor
   d. both a and b, above
   e. a, b, and c, above

16. Which of the following equations is used to calculate percentage differences of performance audit data?

a. $\% \text{ Difference} = \left(\frac{C_A - C_M}{C_A}\right) 100$

b. $\% \text{ Difference} = \left(\frac{C_A - C_M}{C_M}\right) 100$

c. $\% \text{ Difference} = \left(\frac{C_M - C_A}{C_A}\right) 100$

d. $\% \text{ Difference} = \left(\frac{C_M - C_A}{C_M}\right) 100$

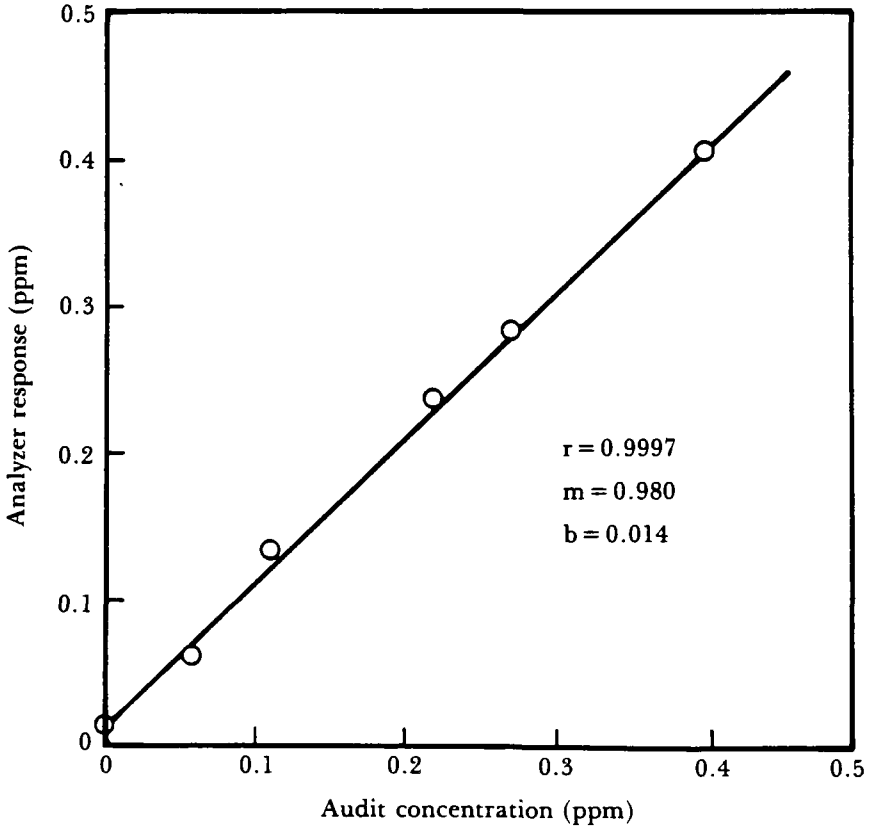
Where: C_A = audit value
C_M = measurement system response

17. True or False? A Reference Flow (ReF) device can be used to audit the flow rate calibrations of high-volume samplers.

18. Which of the following is a(are) possible cause(s) for the audit data described below?
    a. The audit system's zero air source has a positive bias.
    b. The analyzer has a positive zero drift.
    c. The audit system's zero air source has a negative bias.
    d. either a or b, above
    e. either b or c, above

    Given:

Audit point no.	Audit concentration (ppm)	Analyzer response (ppm)	% Difference
1	0.000	0.013	—
2	0.056	0.064	14.3
3	0.116	0.132	13.8
4	0.221	0.235	6.3
5	0.276	0.282	2.2
6	0.405	0.409	1.0



19. Organizations that operate ____(?)____ monitoring networks must participate in the USEPA's national performance audit program.
    a. SLAMS
    b. PSD
    c. either a or b, above

20. The purpose(s) of the USEPA's national performance audit program is(are) to ____(?)____.
    a. provide participating organizations with a means of self-appraisal for specific operations audited
    b. increase the number of quality assurance coordinators
    c. provide information concerning the quality of monitoring data reported to the USEPA
    d. both a and b, above
    e. both a and c, above

21. True or False? CO cylinder gases are used in USEPA's national performance audit program.

Section 4
Answers to Review Exercise

1. True
2. False
3. c
4. d
5. True
6. d
7. e
8. a
9. c
10. d
11. b
12. True
13. e
14. b
15. e
16. c
17. True
18. d
19. c
20. e
21. True

Section 5

System Auditing of SLAMS Networks

Reading Assignment

Read Section 2.0.11 of *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II—Ambient Air Specific Methods,* EPA 600/4-77-027a.

Reading Assignment Topics

- System audit criteria for SLAMS networks
  - Laboratory operations
  - Field operations
- System audit procedure

Learning Goal and Objectives

Learning Goal

The purpose of this section is to familiarize you with criteria and procedures for the system auditing of SLAMS networks.

Learning Objectives

At the end of this section, you should be able to—

1. identify items that should be evaluated during a system audit,
2. recognize criteria that should be used for evaluating items during a system audit, and
3. describe, in sequence, the activities involved in conducting a system audit.

Reading Guidance

Specific criteria and a procedure for conducting system audits of agencies that operate SLAMS networks are presented in this assignment. Much of the audit criteria described in Section 2.0.11 have been discussed in previous reading assignments, so this part of the assignment serves as a review of this information. A system auditing procedure is also described in Section 2.0.11. An important con-

sideration that is not addressed in the procedure is the need to determine if corrective action recommended in the audit report is actually performed by the audited agency. This determination is necessary because unresolved problems may affect data quality.

Questionnaires to aid in conducting system audits are also provided in Section 2.0.11. You do not need to read these thoroughly. However, skim them to become familiar with their formats.

The USEPA reference methods for suspended particulate matter and SO_2 have been revised since the publication of Section 2.0.11 (July 1, 1980). Therefore, some of the information given in Section 2.0.11 does not reflect present Federal requirements described in the revised reference methods. These recommendations are contrasted with present Federal requirements below.

Table 5-1. Section 2.0.11 information versus reference methods for total suspended particulate matter and sulfur dioxide.

Information given in Section 2.0.11 (as of July 1, 1980)	Federal requirements described in revised suspended particulate matter and SO_2 reference methods (after July 1, 1980)
The high-volume filter conditioning room or desiccator must be maintained between 15° and 35°C and at less than 50% relative humidity.	The high-volume filter conditioning environment must be maintained between 15° and 30°C with less than a ±3°C variation and at less than 50% relative humidity, constant within ±5%.
Glass-fiber filters should be used for TSP sampling.	TSP sampling filters may be composed of glass fibers or other inert, nonhygroscopic material.
Equipment specifications for TSP and lead sampling are described in the following sections of 40 CFR 50, Appendix B: Flow rate measuring device: 5.1.3 Orifice calibration unit: 5.1.4 and 5.1.5 Positive-displacement meter: 5.1.6 Timers: 2.2 Barometer: 5.1.7	Equipment specifications for TSP and lead sampling are presently described in the following sections of 40 CFR 50, Appendix B: Flow rate measuring device: 7.4.1 and 7.4.2 Flow rate transfer standard: 7.8 Positive-displacement meter: 9.2.1 Timers: 7.7.2 Barometer: 7.6
Equipment specifications for SO_2 sampling are described in the following sections of 40 CFR 50, Appendix A: Sample train: 5.1.1 and 5.1.2 Flow rate measuring device: 5.1.3 Temperature-control equipment: 7.1.2 Barometer: 5.1.7 Pump: 5.1.2 Vacuum gauge: 5.1.2 Impinger gauge: 5.1.1 Thermometers: 8.2.1, 8.2.2.1, and 9.1	Equipment specifications for SO_2 sampling are presently described in the following sections of 40 CFR 50, Appendix A: Sample train: 7.1.2 through 7.1.6 and 7.1.8 Flow rate measuring device: 7.1.7 Temperature-control device: 7.1.10 Barometer: No specifications are given. Pump: 7.1.9 Vacuum gauge: 7.1.9 Impinger gauge: 7.1.3 Thermometers: No specifications are given.

Design criteria for lead SLAMS and NAMS have been added to 40 CFR 58 since the publication of Section 2.0.11. At least two lead SLAMS are required in areas where the national ambient air quality standard (NAAQS) for lead is currently being exceeded, and may be required in areas where the lead NAAQS has been exceeded since January 1, 1974. Two lead NAMS are required in urbanized areas having populations greater than 500,000.

Because Table 11-6 of Section 2.0.11 contains several errors, refer to Table 4 of Section 2.0.2 for correct probe-siting criteria. Also, note the following as you read Section 2.0.11:

- Subsection 11.1.5.1.e should be "control checks and their frequency," not "control checks for their frequency."
- In Table 11.7, $\leq 60,000$ should be $\geq 60,000$.
- In Table 11.9, $\geq 10,000$ should be $\leq 10,000$.
- The superscript that appears in the footnote of the questionnaire entitled "V. Analytical Methodology Operations: Total Suspended Particulates*" should be 21, not 18.
- The superscripts that appear in the footnotes of the questionnaire entitled "VI. Analytical Methodology Operations: SO_2* and NO_2† Impinged Bubbler Samples" should be 22 and 23, not 19 and 20.

When you have finished the reading assignment, complete the review exercise that follows and check your answers. The correct answers are listed on the page following the review exercise. After you have reviewed your incorrect answers (if any), take the final examination for this course. Follow the directions listed in the Course Introduction section of this guidebook. Your course grade results will be mailed to you.

Review Exercise

Now that you've completed the assignment for Section 5, please answer the following questions. These will help you determine whether you are mastering the material.

1. Which of the following activities would **not** be performed during a system audit of an air quality monitoring program?
   a. reviewing standard operating procedures
   b. evaluating laboratory facilities
   c. challenging air quality analyzers with audit gases
   d. reviewing records of monitoring sites

2. True or False? During a system audit of an air quality monitoring program, the air pollution training and experience of the program's staff should be reviewed.

3. Which of the following should be evaluated during a system audit of an air quality monitoring program?
   a. laboratory space
   b. office space
   c. field monitoring facilities
   d. both a and c, above
   e. a, b, and c, above

4. Questionnaires should be submitted ____(?)____ a system audit.
   a. 4 to 6 weeks before
   b. during
   c. immediately after

5. True or False? Answers to system audit questionnaires should be typed.

6. When should system audit interviews be conducted?
   a. before the audits
   b. after the audits
   c. both a and b, above

7. A convenient method for conducting a portion of a system audit is to trace ambient air quality data from field measurement through ____(?)____.
   a. data recording
   b. data validation
   c. data reporting

8. True or False? During a system audit, the auditor should determine if written procedures are available and followed.

9. True or False? A written system audit report is not necessary if an exit interview is conducted.

10. During a system audit, the ____(?)____ of equipment should be determined.
    a. quantity
    b. condition
    c. both a and b, above

Section 5
Answers to Review Exercise

1. c
2. True
3. e
4. a
5. False
6. c
7. c
8. True
9. False
10. c

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16. ABSTRACT

This guidebook was developed for use in the Air Pollution Training Institute's Correspondence Course 471, "General Quality Assurance Considerations for Ambient Air Monitoring." It contains reading assignments and review exercises covering the following topics:

--Quality Assurance Policy and Principles
--Quality Assurance for Air Quality Monitoring Systems
--Quality Assurance for SLAMS and PSD Air Monitoring Networks
--Performance Auditing of Air Quality Monitoring Systems
--System Auditing of SLAMS Networks

This guidebook is designed for use in conjunction with "Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II--Ambient Air Specific Methods" (EPA 600/4-77-027a).

17. KEY WORDS AND DOCUMENT ANALYSIS

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