APTD-1347

GUIDELINES FOR TECHNICAL SERVICES OF A STATE AIR POLLUTION CONTROL AGENCY

U. S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air Programs
Stationary Source Pollution Control Programs
Research Triangle Park, North Carolina 27711

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OF A
STATE AIR POLLUTION CONTROL AGENCY

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GUIDELINES FOR TECHNICAL SERVICES OF A STATE AIR POLLUTION CONTROL AGENCY

1.0 INTRODUCTION

1.1 Objective and Scope

The purpose of this document is to present guideline information which will assist the user in detailing the needs and requirements of a statewide air pollution control technical services system stressing laboratory operations.

A number of State, regional, and local agencies, all operating or cooperating in the provision of services to support total agency functions, were visited. Their individual situations and operational programs were compiled into "case histories" which formed the data base utilized in this effort. These data were then analyzed and the subsequent evaluations used to assist in documenting a significant number of elements or factors which will, in a given situation, influence the organization of a statewide laboratory system.

In order for this document to be useful, the reader must acquire a basic understanding of the responsibilities which any State agency has to the governmental groups structured both above and below it: A State agency must relate to both its regional and local agencies in varying degrees of assistance and surveillance, as well as to the Federal agency which oversees it, supplies guidance to it, and supplements its funding. A local agency must recognize its relationship with and responsibilities to the State and, at the same time, fulfill its obligations to municipal government. Conversely, the Environmental Protection Agency (EPA) is required to implement its grant programs, assure reasonable progress toward attainment of air quality standards, and provide overall technical leadership without negating the influence and authority of the State. Thus, the State program generally finds itself "in the middle".

This document will attempt to provide administrators and those faced with planning for new, modified, or expanded State technical service groups, with guidelines for operating in the areas of organization, management, program element definition, legal considerations, technical functions, and quality control.

1.2 Role of Technical Services

1.2.1 Role of the Director

Before attempting to describe the role of the technical services group, we should consider the position of the technical services group manager (or chief, director, head, etc.). This person does exactly as the title indicates: he manages or directs the activity; he does not do all the work. Although he may take care of some of the detail, his prime function is to see that it gets done. He may not make all the decisions, but he sees to it that the required information and services are available. His function and responsibilities may be tabulated as follows:

(a) Planning the program and establishing overall project schedules;

(b) Planning the group's budget and controlling the expenditure of approved funds;

(c) Recruiting, selecting, and continuous training of staff;

(d) Selecting equipment, approach, methodologies, and outside services when required;

(e) Obtaining necessary commitments from both in-house and outside elements;

(f) Organizing, staffing, controlling, and directing all projects from initiation through completion of final report;

(g) Providing assistance and support to all other program elements;

(h) Maintaining a dynamic communications system.

These functions are graphically displayed in Figure 1.

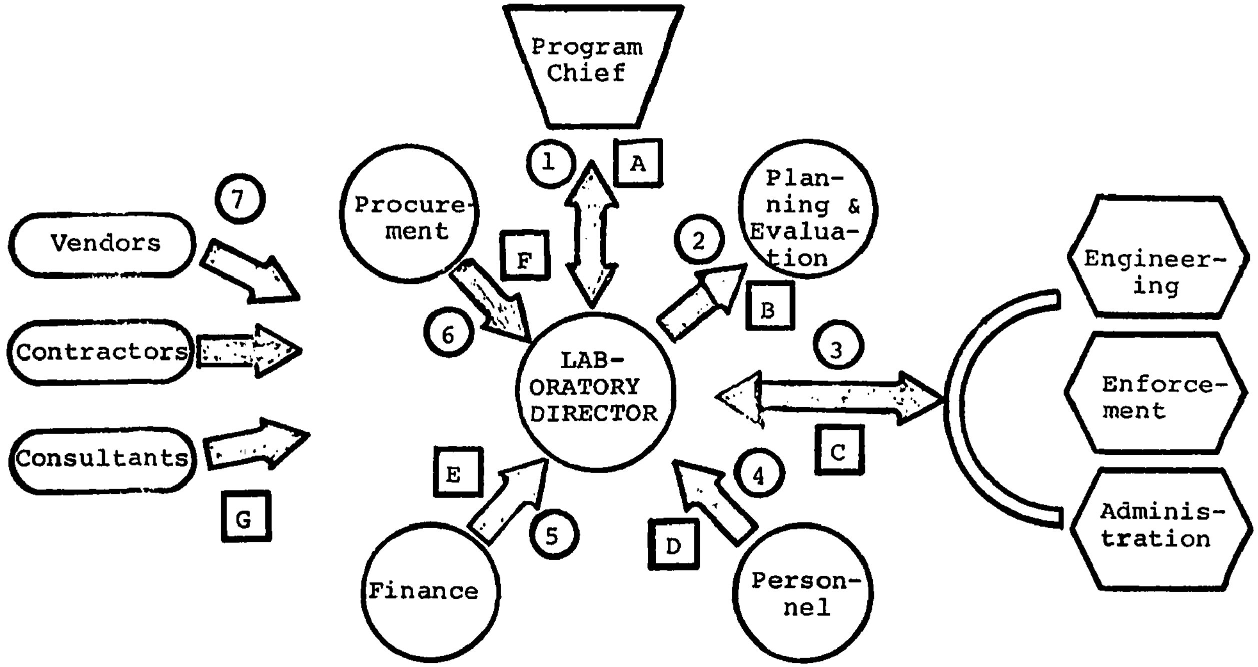
1.2.2 Role of the Group

The primary role of the technical services group including its laboratory is to provide timely support services to all other program elements.

Figure 2 presents the primary and secondary service areas encompassed by typical air pollution technical services and lists the major functions within each service area. However, considerable variability in the scope of these functions can exist. The following brief discussion exhibits how this variability can influence the structure of several technical service program areas.

1.2.3 Operations

An air quality surveillance program is composed of three distinct but interrelated elements: sampling networks, laboratory support, and data acquisition and analysis. Network design entails such considerations as the number and type of stations needed, their location, frequency of sampling, duration of each sample, the type and effort of analysis, and the like. The kind of network specified for a given region will also determine the requirements for laboratory and data



INPUTS		OUTPUTS	
1.	Proposals, Reports	A.	Decisions, Directions
2.	Plans, Evaluations	B.	Budget, Schedules
3.	Support Services	C.	Problem Definition
4.	Job Descriptions, Requests	D.	People
5.	Payment Authorizations	E.	Accounting, Checks
6.	Specifications, Sources	F.	Expediting, Contracting
7.	Orders, Contracts	G.	Equipment, Supplies, Services

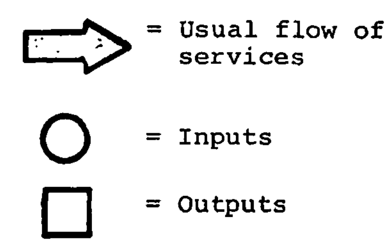


Figure 1. Functional relationships of technical services manager.

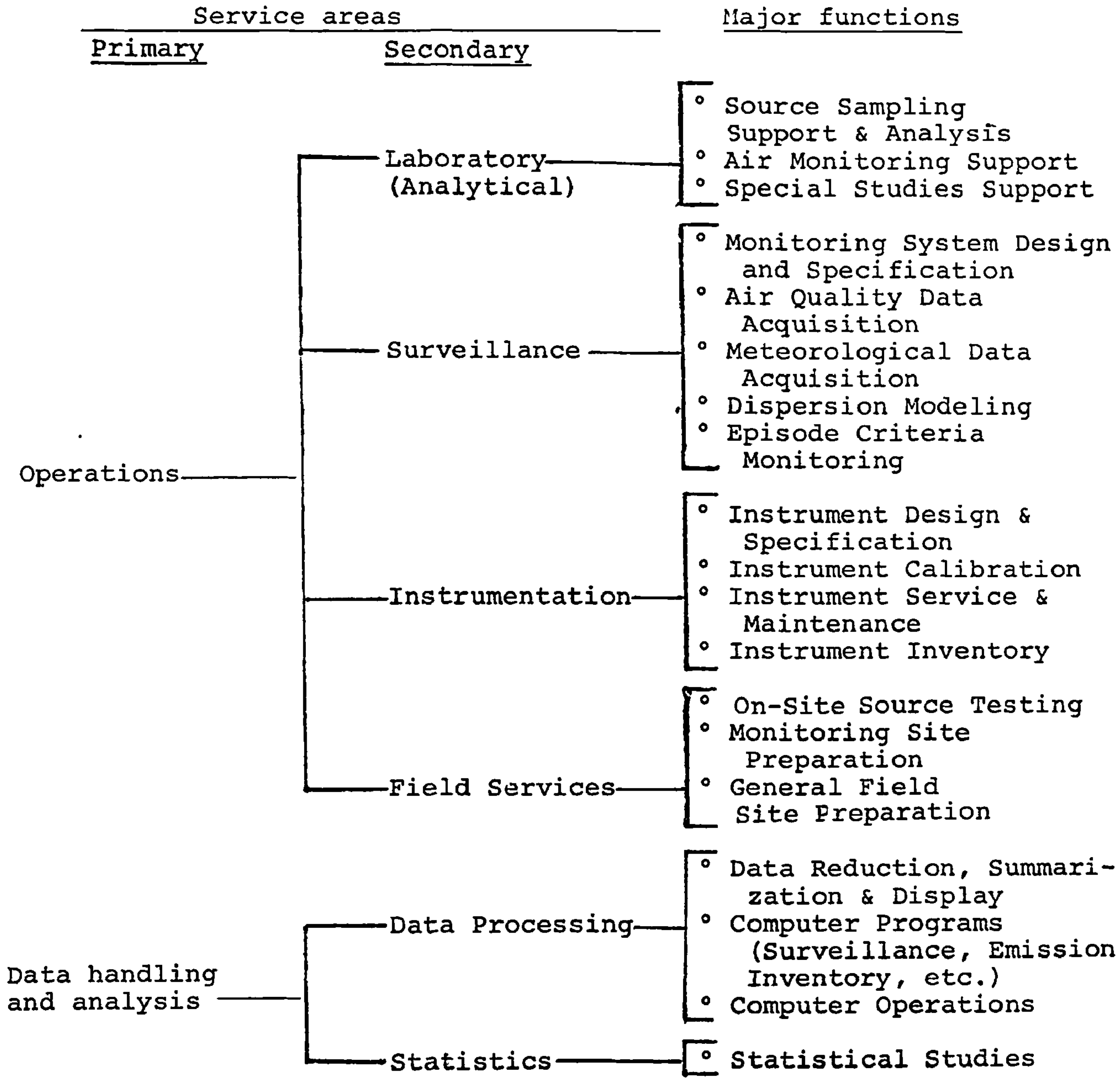


Figure 2. Typical air pollution technical services.

acquisition and analysis procedures. For example, with automatic (continuous) instrumentation, the need for routine laboratory support is greatly reduced but the amount of data transmission, validation, and reduction is significantly increased.

Support of surveillance networks requires laboratory operations ranging from very simple to highly complex. The requirements for laboratory support, in terms of size and complexity, will be specified by the pollutants of interest in the region, size of the networks, and the degree of pollution. Generally, the laboratory must at least be equipped for analysis of ambient samples for which Air Quality Standards have been established, and should provide for calibration of all collecting and measuring devices and preparation of reagents.

Some regions will require laboratory capability for analyses of hazardous materials such as beryllium, mercury, and asbestos. Analyses of fluorides and other more unique pollutants, such as polycyclic organic matter, along with fuels and solvents must often be provided.

1.2.4 Data Handling and Analysis

The development of data handling procedures is an essential function of the total laboratory facility. The requirements for the flow of data between cooperating agencies coupled with the reporting requirements, defined in the Federal Register of August 14, 1971, demand a defined data flow (1) between State and regional/local agencies, and (2) between the Federal and State agencies. Following the definition of data flow, formats for recording basic data and for routine and specialized reports plus reporting procedures must be designed to provide pertinent information in a timely fashion.

1.3 Relationship of Technical Services Group to Other Agency Elements

In an air pollution control agency, the technical services group provides across-the-board services to the other major program elements: administrative, enforcement, and engineering. Figures 3, 4, and 5 graphically display the primary and secondary responsibilities and functions usually assigned to each of these three agency elements. In many of these functional areas, the technical services group including its laboratory provides a significant amount of technical support. These areas of related activity are designated on each table by the symbol (L) . Detailed exploration of these interagency relationships will be performed in the subsequent sections of this document.

1.4 Functions of the Technical Services Group

In order to establish an understanding of what is encompassed by our general definitions of technical services, the functions given in Figure 2 are described.

1.4.1 Operations

1.4.1.1 Analytical Laboratory. Its functions include receiving, logging, preparation, and analysis of submitted samples. Samples can include those collected in the ambient atmosphere and in source emission tests; samples of liquid and solid fuels; samples of materials collected by particulate and gaseous control devices; and samples of materials, vegetation, and body fluids resulting from complaint investigations or special studies. Analytical methods employed can range from simple gravimetric/volumetric procedures to sophisticated physical/optical

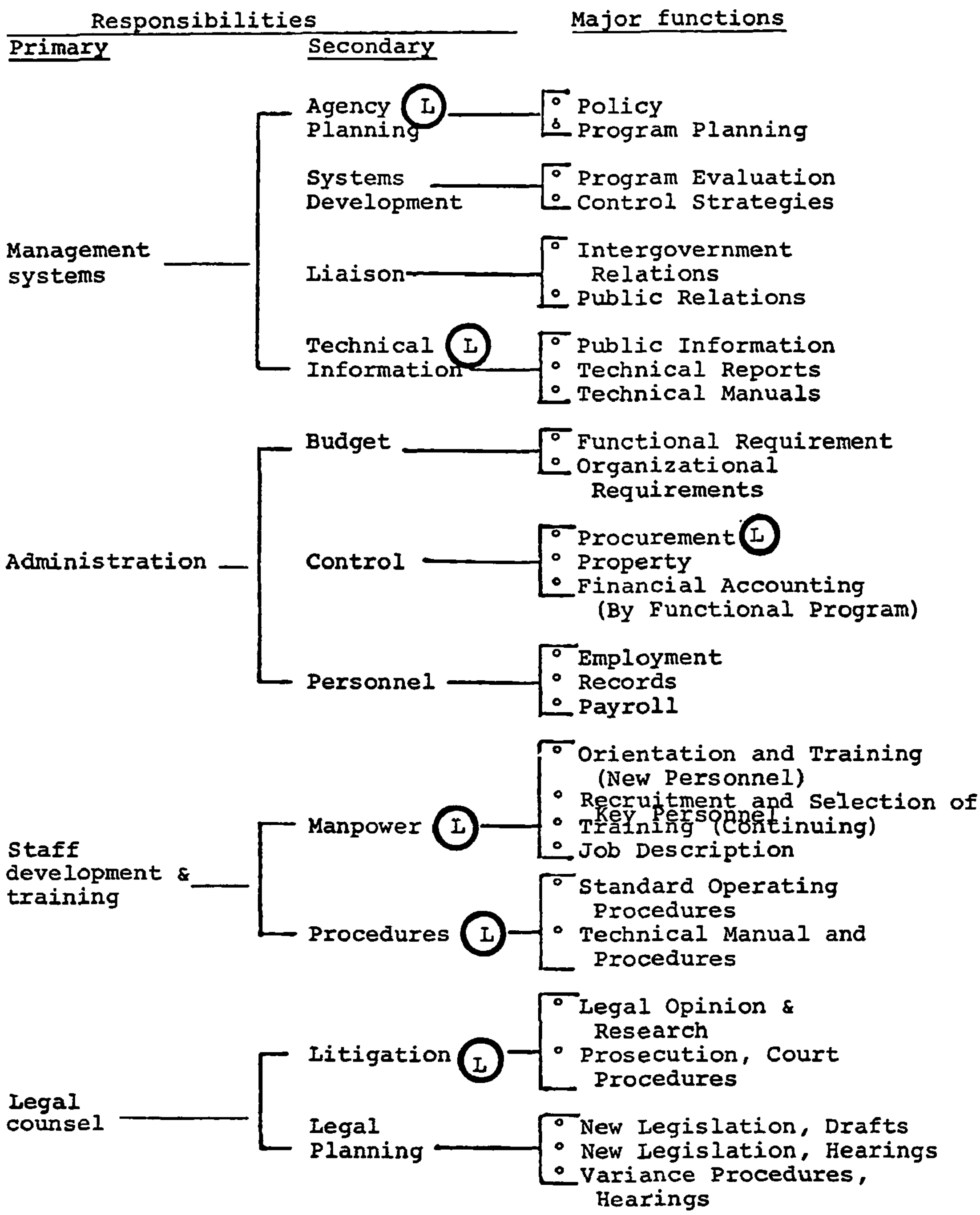


Figure 3. Administrative management services.

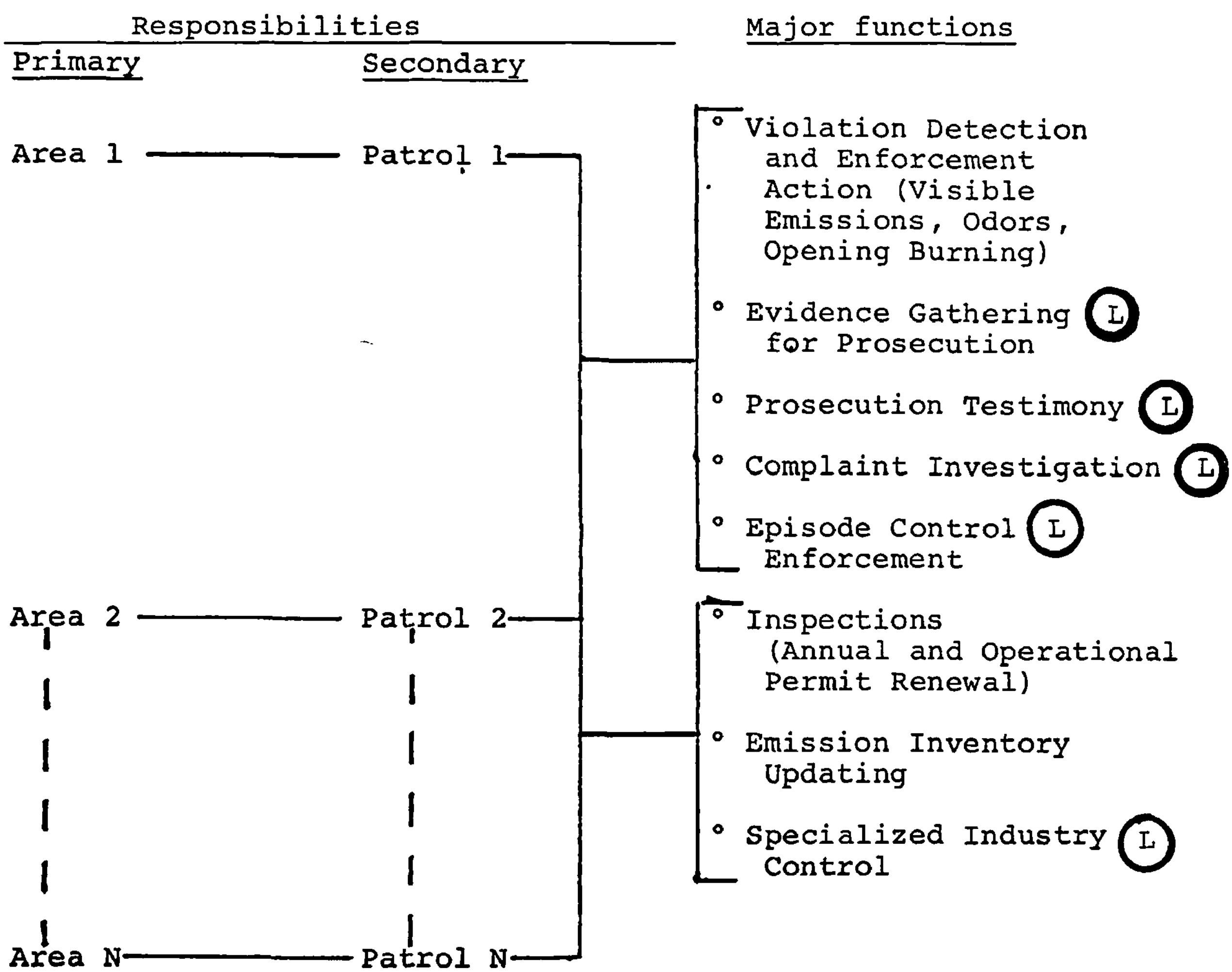


Figure 4. Enforcement services.

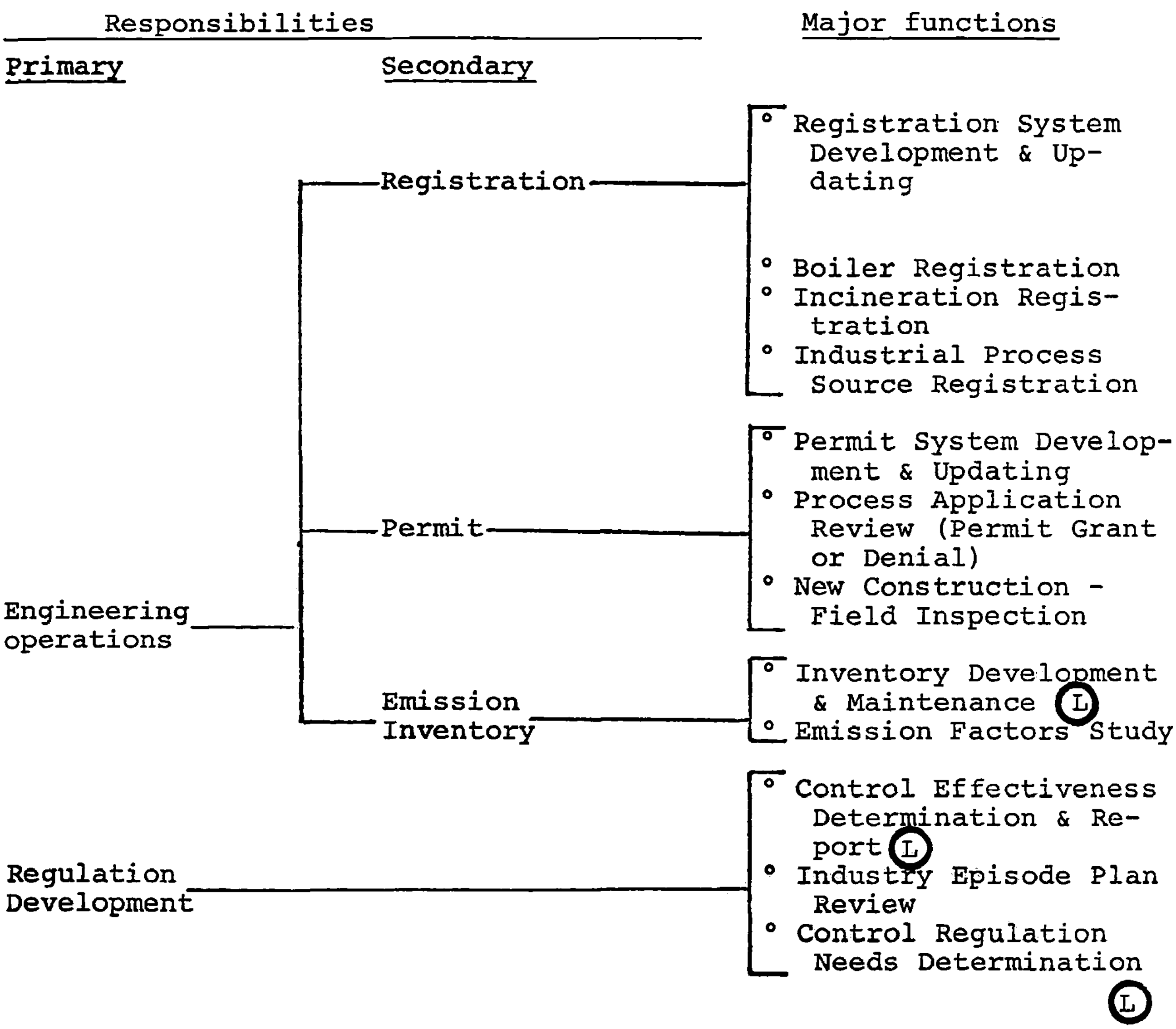


Figure 5. Engineering services.

techniques requiring complex and expensive equipment. Also included are: the calibration of all laboratory devices, standardization and preparation of all sampling media, housekeeping, preparation and updating of laboratory methods manuals, implementation of a quality control program, and maintenance of chain of custody and integrity of data to provide legal evidence in support of enforcement.

1.4.1.2 Surveillance. This function includes planning and designing of all air quality monitoring networks and studies (both long- and short-term), providing the sampling site operators and routine maintenance services, and acquiring all raw air quality and meteorological data. This function may include competency in meteorological modeling and provision of this expertise for control strategy evaluation and episode control. This function also includes coordinating the acquisition of data from intensified air quality monitoring during air pollution episodes.

1.4.1.3 Instrumentation. This function includes the installation, calibration, and specialized repair of all aerometric monitors. This also provides evaluation of new or improved sensors (pollutant and meteorological), as well as specifications for procurement. It also services and maintains all equipment utilized in source testing and special studies. This function is usually responsible for the shop and storage areas and equipment, and maintains the hardware inventory. It may provide equipment or device fabrication services.

1.4.1.4 Field Services. This function includes provision of equipment operators and site preparation for emission source tests, installation of services and shelter (when required) for air quality monitoring equipment, and general field operation services.

1.4.2 Data Handling and Analysis

1.4.2.1 Data Processing. This function includes the reduction of all raw data to summary tabulations and graphic displays. This function provides programming services for enforcement management systems, for updating and analyzing data, and for control strategy evaluations and forecasts. This function may also include the provision of computer operations and services. Also included are the data storage and retrieval responsibilities of the program.

1.4.2.2 Statistics. This function includes the provision of expertise in the manipulation, analysis, and specialized evaluation of data generated by both the program and outside sources.

2.0 ORGANIZATION STRUCTURE

The organization structure of the air pollution control agency employed at the State level must be examined in order to obtain an optimum operation of the technical services group functions. There exists among the 50 States a variety of agency organization structures. These various structures can be grouped into three major categories:

(a) The air pollution control agency within the health department;

(b) The air pollution control agency as an independent agency;

(c) The air pollution control agency within a total environmental program: environmental protection agency.

Table 1 lists the existing State agencies with respect to these categories. Approximately 50 percent of the State agencies fall under the health department classification; approximately 30 percent can be classified as an environmental-protection-type (EP-type) agency. Those agencies with two or more environmental programs, such as air and water together, are considered as EP-type agencies. The remaining State agencies fall into the separate agency classification.

Organizational structure on the local level has a tendency to become more diversified. Local agencies have been found within such disciplines as building departments, sewer districts, recreation commissions, and health and safety divisions, in addition to structures similar to those above. Considerations within this chapter are addressed to the State agency level but can be applied to all levels of air pollution control agencies.

There are many similarities among these three structures. The top echelon of authority is the Governor of the State. This position

Table 1. CLASSIFICATION OF ORGANIZATION STRUCTURE OF STATE AIR POLLUTION CONTROL AGENCIES

Air pollution control agency within health department	Air pollution control agency within total environmental agency	Independent air pollution control agency
Alabama	Alaska	Arkansas
Arizona	California	Florida
Colorado	Connecticut	Minnesota
Georgia	Delaware	Missouri
Hawaii	Illinois	New Hampshire
Idaho	Maine	South Carolina
Indiana	Mississippi	Virginia
Iowa	Nebraska	West Virginia
Kansas	New Jersey	
Kentucky	New Mexico	
Louisiana	New York	
Maryland	North Carolina	
Massachusetts	Oregon	
Michigan	Pennsylvania	
Montana	Vermont	
Nevada	Washington	
North Dakota	Wisconsin	
Ohio		
Oklahoma		
Rhode Island		
South Dakota		
Tennessee		
Texas		
Utah		
Wyoming		

will have no direct bearing on the technical services group functions. The next common constituent will be a board or a commission, as the case may be. As a result of the requirements under the Clean Air Act of 1970, each State has adopted a board or commission to promulgate regulations and provide a means for decisionmaking in regard to program directives and policy. Many times this governing body will have a direct effect on the technical services group functions. As a result of the formulation and adoption of air pollution regulations, additional requirements are placed on the technical services group. Normally input from this area is necessary prior to the formulation of the regulation and after adoption there is the need for analytical support of enforcement efforts which follow.

For these reasons a majority of the board members should be technically qualified in the field of air pollution. Without such a background the technical personnel will have difficulty in communicating with the board on these matters; as a result, the effectiveness of the program will be decreased.

The remaining organization entities are similar in purpose, but have definite differences in their structures which result in assets or liabilities to the individual program. Typical organizational structures, representing these three primary classifications are presented below and their impact on the laboratory functions are considered.

2.1 Health Department Structure

Historically, many of the State agencies found outside the health department today can trace their origin to the health department. This is a result of the initial recognition of air pollution impact on the population and its health effects. After a period of development, many agencies within the health department began to meet responsibilities which were considered outside the primary function of the health department. These areas included such activities as monitoring, enforcement, and engineering. Many of the agencies grew in staff and facilities, and frequently the air pollution entity became as large as or even larger than other sections within the health department. For these reasons, the agencies disassociated themselves from the department. Nevertheless, a majority of the States' air pollution control agencies still reside within the health department structure.

A typical health department structure is presented in Figure 6. As one can see, there are many activities within this structure which are not related to and normally have little effect on the air program. However, situations sometimes arise, particularly in newly formed agencies, whereby the agency is dependent upon the technical services of the health department. The ramifications of this situation are discussed under Section 2.1.1.

The executive officer or the program director, as the case may be, is normally next in the chain of organization structure, beneath the Governor and the board. Often when the State air program is relatively small, this position is filled by the health commissioner who is a member of the medical profession. A person in this position needs the ability to communicate on technical matters to the board as well as provide technical direction to this subordinate staff. Larger, well-established comprehensive programs normally find that this position is best filled with a person qualified in the technical aspects of environmental sciences in addition to having management capabilities.

The remaining structure of the organization is usually divided into management, technical services, engineering, and enforcement groups. For the purpose of this document, only the functions of the technical services group will be considered.

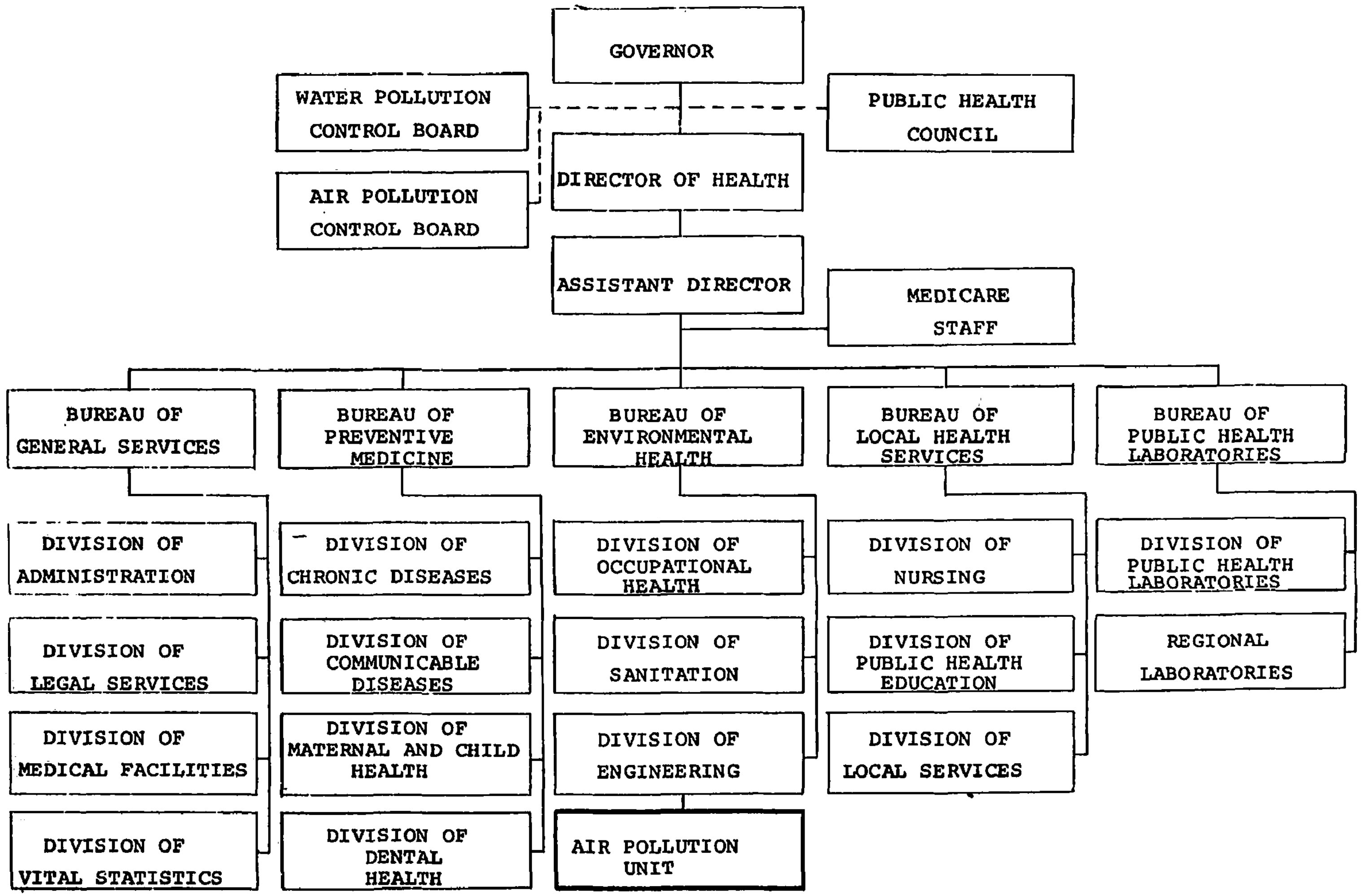


Figure 6. Typical State health department organizational structure.

2.1.1 Technical Services Group Organization Within the Health Department

Among the major areas of endeavor that can be found in technical services programs are laboratory analysis, monitoring, and data handling. Within the other activities of the health department, there exist similar functions in two of these areas, the laboratory and data handling. The cooperative use of personnel, facilities, and equipment in these areas result in an economic advantage. For this reason the technical service requirements of the air program are normally included with the other technical service needs of the health department.

The manager of the technical services group must have a wide technical background in such areas as biochemistry, bacteriology, radiology, milk and food sanitation, air and water chemistry, and competencies in the related fields of instrumentation and computer sciences. Efficient supervision of such a varied technical services group will require expert management capabilities and experience.

Five major disadvantages associated with this type of comprehensive technical services group program with respect to the needs of the State agency are as follows:

(a) Priority Requirements--Often the priority given to the analysis of air pollution samples are secondary to that of those of the health department.

(b) Level of Competencies--As a result of the diversity of the analytical activities, a lower level of competency is sometimes maintained in the air pollution area. This is especially true in those cases where the air pollution control agency is in its early stages of development.

(c) Personnel Management--As a result of the many activities carried out by the same group, additional supervision, personnel scheduling, and work shifts are sometimes required to meet the needs of the total department. Often this is a source of personnel problems.

(d) Communications--Often communication problems arise as a result of the varied interests and backgrounds of the personnel within the department.

(e) Flexibility and Responsiveness--The analytical needs of the air pollution control agency can be quite variable. The rigid structure of the health department technical services group normally does not respond well to those needs.

One working solution to these problems is to establish within the health department technical services group a separate air pollution control technical services section. This section would be under the direction of one individual with a separate staff. This approach is commonly employed in large, well-developed agencies within health department structures. It eliminates many of the disadvantages associated with comprehensive health department technical services, but the economic advantage of the cooperative usage of facilities and equipment remains. As an agency develops, so will the technical service requirements. At some point in this development these requirements will be sufficient to support a limited staff of three to four technical people. At this point the formation of this separate technical service section to meet the agencies needs is advisable.

Advantages resulting from the technical services within the health department organizational structure can be outlined as follows:

(a) Availability of Additional Staff--The agency can call on the large number of health department inspectors and field personnel to support short-term or intermittent activities, such as odor surveys, special effect studies, episode surveillance, and the collection of intermittent air pollution samples. These personnel are usually available but are not trained or experienced. This aspect could become a problem if the other more numerous agencies call upon the air agency for temporary support.

(b) Medical Consultation--The excellent rapport with the medical profession which exists within the health department becomes advantageous during episodal periods and for long-range health effect studies.

(c) Equipment and Facilities--The equipment and facilities found within the health department laboratories are normally directly adaptable to needs of the technical requirements of the air pollution agency. Therefore, their cooperative usage can be advantageous.

2.2 Environmental-Protection-Type Agency Structure

The environmental-protection-type agency structure initially appears extremely complex. This "super" agency in reality is only a vehicle for assembling and administering the total environmental program of the State. Figure 7 depicts a typical statewide environmental protection agency. Often each individual environmental activity within this agency performs its designated function independently of each other. As a result, many air pollution agencies within this structure

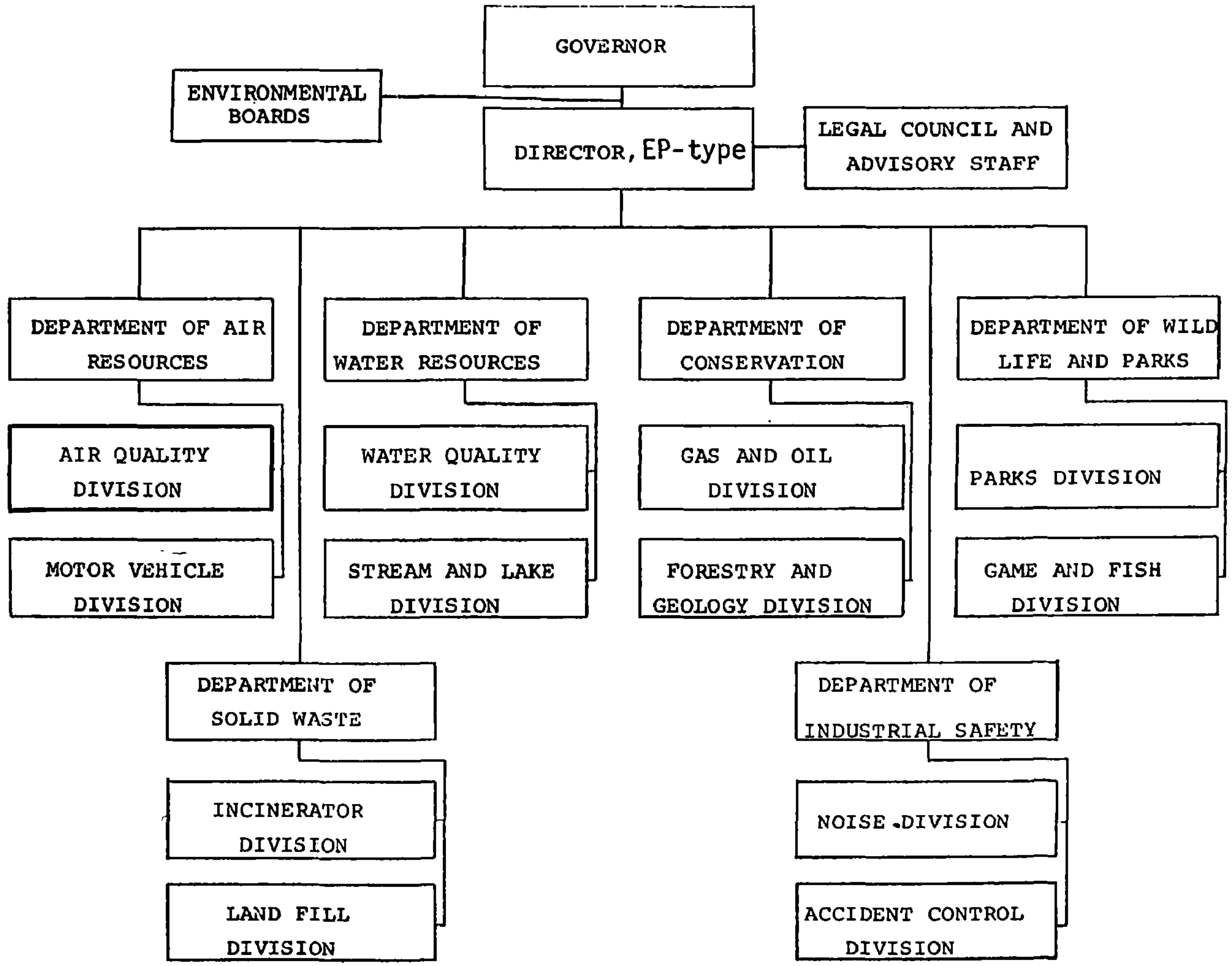


Figure 7. Organizational structure of typical statewide environmental protection agency.

can be considered as a separate agency. The majority of the well-established, comprehensive state air pollution control programs fall within this category.

2.2.1 Technical Service Organization Within the Environmental-Protection-Type Agency

After the common elements of the board and program director, the technical services group manager is the next element in the organization structure. This position requires competency in the fields of environmental engineering and chemistry, particularly analytical. Expertise in biochemistry, bacteriology, radiology, and milk and food sanitation is not required as it is when the position is within health department structure. Normally, because this person does not have to be qualified in fields irrelevant to air pollution, he will be better qualified to perform the function of this position.

The activities of the technical services group under this structure with regard to air pollution control activities, are the same as described under the health department structure. Within the EP-type structures existing today, two levels of activities are evident. In the case of the well-established, comprehensive State agency, a high degree of responsiveness and comprehensiveness can be found. These State agencies, as stated before, appear to function independently of other agencies within the EP-type structure.

There appear to be no inherent disadvantages as a result of the EP-type structure with regard to these agencies. The advantages are the same as those discussed in Section 2.3: Separate Air Pollution Control Agency. The other level of technical service function, found to exist with the remaining agencies with EP-type structures, is normally less responsive and comprehensive. These agencies for the most part are in their formative stages. Within these agencies one can find many interagency cooperative endeavors, the most common of which is the function of laboratory and data handling. For example, air and water laboratory service functions are commonly found combined. Also, State-owned computer hardware is normally shared by all agencies. This combination of efforts is usually more compatible than the cooperative efforts within the health department structure. The reason for the higher degree of compatibility can be found in the common goals, requirements, and related expertise of the cooperating agencies. Problems or disadvantages can occur as a result of these cooperative efforts. These disadvantages are similar to those found within the health department structure and are summarized as follows:

(a) Priority Requirements--Often the priority given to the analysis of air pollution samples is secondary to that of those of the other cooperating agencies.

(b) Level of Competencies--As a result of the diversity of the analytical activities, a lower level of competency is sometimes maintained in the air pollution area. This is especially true in those cases where the Air Pollution Control Agency is in its early stages of development

(c) Personnel Management--As a result of the many activities carried out by the same group, additional supervision, personnel scheduling, and work shifts are sometimes required to meet the needs of all the cooperating agencies. Often this is a source of personnel problems.

The advantages of intercooperative endeavors within the EP-type structure outweigh the disadvantages; therefore, these endeavors are encouraged. The most prevalent advantages resulting from these cooperative endeavors are:

(a) Equipment and Facilities--The joint use of technical service equipment and facilities for the related agencies within the EP-type agency is a definite economic advantage.

(b) Personnel Compatibility--As a result of the similarity in the technical backgrounds of the EP-type agency personnel involved in these joint endeavors, communications and personnel compatibility among the staff are facilitated.

(c) Flexibility--The increased resources of both material and personnel as a result of the cooperative endeavor provides the EP-type agency with a higher degree of flexibility and responsiveness during short periods of increased responsibility.

2.3 Separate Air Pollution Control Agency

Structurally the separate State agency exists as an independent State agency or as an independent entity of a larger State agency. Separate air pollution control agencies are commonly found within health department and EP-type agencies. Normally these agencies operate completely independent of their sister or parent agencies. A typical organizational structure of this agency is shown in Figure 8. The board, manager and technical service positions can be considered identical to those presented in Section 2.2.

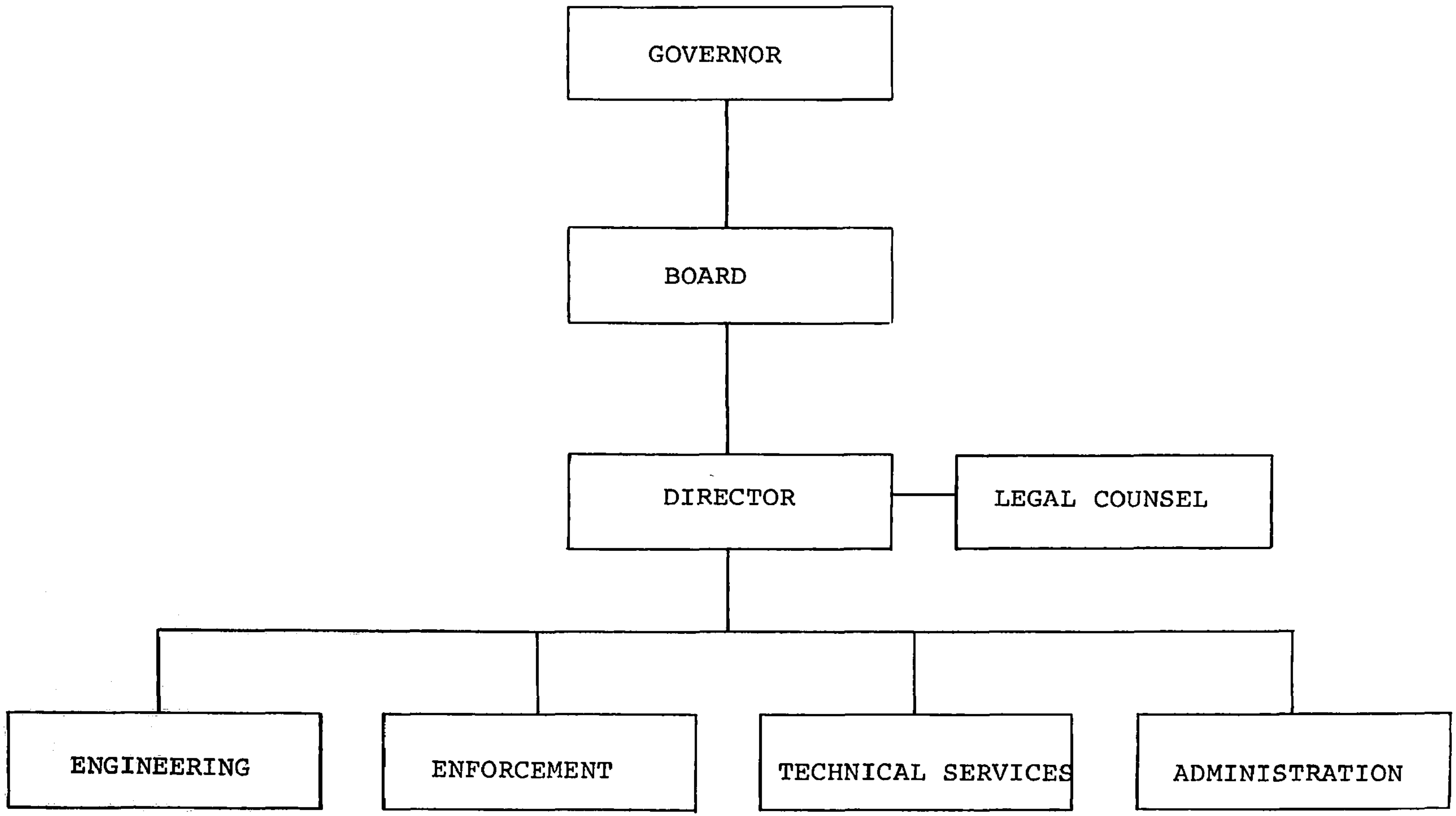


Figure 8. Typical organization structure of the separate air pollution control agency.

2.3.1 Technical Service Functions Within the Separate Agency

The degree of effectiveness with respect to such functions as the laboratory, monitoring, and data handling will be directly proportional to the resources of the agency. The only disadvantage with this structure is realized in the case of the newly formed agency with inadequate personnel and physical resources. Since these agencies operate separately, the effect of cooperative ventures is not realized. Program cost per amount of services received can be expected to be higher in the case of the smaller agencies but for the larger agencies the cost efficiency should be the same.

The advantages realized as a result of this type of organization structure can be summarized as follows:

(a) Priority Requirements--The total efforts of this function can be directed toward the needs of the agency.

(b) Level of Competency--As a result of the single field of endeavor, the staff members tend to develop a higher degree of expertise in their individual area.

(c) Personnel Management--Better personnel relations tend to exist as a result of the well-defined program directives.

(d) Flexibility and Responsiveness--The needs of the agency can be given the total attention of the technical services group; as a result a high degree of flexibility and rapid response to the changing requirement can be achieved.

2.4 Evaluation of the Technical Service Operations Within the Three Organization Structures

As a result of personal interviews with several agencies, published and unpublished State agency yearly progress reports, Federal grant

Table 2. RELATIVE DEGREE OF EFFECTIVE TECHNICAL OPERATION WITHIN THE THREE ORGANIZATION STRUCTURES

Requirements	Agency within health dept.	Agency within total EP-type and independent agency
Routine analyses	G	E
Special analyses	F	E
Research/development	F	G
Continuous monitoring	F	G
Laboratory Q.C.	G	G
Episode monitoring	G	G
Calibration	F	E
Data evaluation	G	E
Field investigation and support	F*, E*	G
Support facilities and equipment	E	G

Degrees of effective operation are:

F - Fair
G Good
E - Excellent

* Ability to respond with additional field personnel support excellent but special analytical requirements resulting from this activity would be fair.

application information, and Federal EPA reports evaluating State and local agencies, a comparison of relative effectiveness of the technical operations of the three organizational structures was made and is presented in Table 2.

Two of the organizational structures, the independent and the EP-type, resulted in the same advantages for the well-established agency. However, it should be noted that for a newly formed agency, the ability to enter into cooperative ventures with sister agencies would be a definite advantage; therefore, under this circumstance the EP-type structure would be more desirable.

3.0 ANALYSIS OF TECHNICAL SERVICE OPERATIONS

The air pollution technical services group operates much as the typical "support services" type of organization. It has its routine and regular activities, both within the laboratory proper and in the field. It has the usual demands placed on it for immediate response to unfamiliar situations, nonroutine investigations and analysis, and modification or development of techniques and equipment. Of course, what makes this technical services group with its facilities and resources unique are the activities to which it is applied. This section is devoted to a discussion of these categorical operations.

3.1 Air Quality Monitoring

Surveillance of air quality has become an increasingly important function of an air pollution control agency, particularly at the State level. Surveillance is usually the only program element for which technical services takes primary, rather than support, responsibility. Initially, the agency must determine the magnitude and scope of its air pollution problem, i.e., the extent to which air quality standards are being exceeded. These data may then be used to fit a simulation model for the area or, as input to a relationship based on proportional reduction or roll-back techniques, to develop an effective emission control plan. Following the adoption of emission regulations, atmospheric surveillance is required to evaluate the progress toward the attainment of air quality goals. Additionally, for those areas having possible periods of high air pollution (episodes), surveillance becomes a vital part of the Emergency Action Plan.

The Clean Air Act of 1970 stresses the importance of air quality surveillance as an integral part of the State's implementation plan.

Specifically, Section 110(a) (2) (c) of the Act requires that,

> "it (the implementation plan) includes provisions for establishment and operation of appropriate devices, methods, systems, and procedures necessary to (i) monitor, compile, and analyze data on ambient air quality and (ii) upon request, make such data available to the Administration."

Recently, the Environmental Protection Agency has summarized the objectives of air quality monitoring.[1] Air quality surveillance within a region must provide information to be used as a basis for the following actions:

(a) To judge compliance and/or progress made toward meeting ambient air quality standards.

(b) To activate emergency control procedures to prevent air pollution episodes.

(c) To observe pollution trends throughout the region including the nonurban areas. (Information on the nonurban areas is needed to evaluate whether air quality in the cleaner portions of a region is deteriorating significantly and to gain knowledge about background levels.)

(d) To provide a data base for application in evaluation of effects; urban, land use, and transportation planning; development of abatement strategies; and development and validation of diffusion models.

Sampling site and equipment requirements are generally divided into three categories, consistent with desired averaging times:

(a) Automatic--Pollutant concentrations measured with a continuous analyzer and results recorded automatically;

(b) Intermittent--Pollutant concentrations determined from integrated hourly or daily samples on a fixed schedule;

(c) Static--Pollutant estimates or effects determined from weekly or monthly exposure of qualitative measurement devices or materials.

3.1.1 Primary Networks

Air quality surveillance networks that employ automatic equipment to continually sample and analyze pollutant levels may be classified as primary. Primary monitoring stations are generally located in areas where pollutant concentrations are expected to be among the highest in the area and in areas of highest population density. In addition, these stations are designated as a part of the air pollution episode warning system.

General guidelines applicable to sampling station location include the following:

(a) Avoid locations that have restrictions to air flow in the vicinity of the air inlet, such as adjacent buildings, parapets, trees;

(b) Avoid sampling locations that are unduly influenced by downwash from a minor local source or by reentrainment of ground dust, such as a stack located on the roof of a building where the air inlet is located or close to ground level near an unpaved road;

(c) Avoid locations that are inaccessible with regard to adverse weather conditions, subject to vandalism, or are otherwise insecure.

Specific sampling location guidelines, recently developed by EPA, are found in Appendix A.

3.1.1.1 Operations. The technical services group must supply a highly skilled technician who is responsible for the routine operation of one or more primary sites. Typical qualifications and job descriptions for such personnel are presented in Appendix B.

Provision for reagent preparation, spare parts, and instrument calibration must also be considered. The magnitude of this requirement will vary depending on the number of stations and their proximity to each other and to a central support laboratory. In all cases, equipment such as an analytical balance, colorimeter, calibration equipment, and a source of pure water (distilled or deionized) will be required to support the primary station. Much of this equipment could be maintained at a central support laboratory and used as needed in the field.

The Federal Continuous Air Monitoring Program, as well as agencies such as the California Air Resources Board, the New Jersey Department of Environmental Protection, the Los Angeles County and Bay Area Air Pollution Control Districts, and the New York Department of Environmental Conservation, have developed a series of internal information memorandums covering operational protocols, spare parts requirements, logistics, and the like that can serve as examples. Generally speaking, all of these organizations have established technical information offices which will supply data upon request or arrange your itinerary should you wish to visit specific agency personnel.

3.1.1.2 Maintenance and Trouble Shooting. Continuous monitors,[2] like most electromechanical equipment, require general maintenance for prolonged satisfactory operation. With proper care and replacement of expendable parts, extended and trouble-free operation can be obtained with these devices. Manuals should cover the following areas:

(a) Routine Maintenance[3]--Procedures for the care and cleaning of the monitors on a regular schedule must be prepared. Such activities insure that the station operator is pursuing a continuous surveillance program relative to the operational parameters of each monitoring system;

(b) Preventive Maintenance[3]--General schedules for the replacement of mechanical, electrical, chemical, and optical components must be developed. The necessity of replacement should be established through a predetermined set of inspections and tests designed to give a warning to the operator of prospective trouble.

The basic philosophy for operational manuals dealing with troubleshooting air monitors is to develop systematic and simplified procedures for checking the operability and accuracy of the system.

A system of go/no-go checks[2] should be developed to determine the operability of the equipment. This simple series of checks is designed to locate the problem area in one of three general categories: electrical, mechanical, or chemical. A tabulation of the most commonly occurring failures and remedies for these possible problems should be presented.

Instructions must be provided for the logging of pertinent operational data, e.g., zero drift, calibration checks, malfunctions, and the like. Formats[2] should be developed for recordkeeping. Data validation procedures should be established relative to the various modes of data reduction (on-line computer, semiautomatic, manual) currently utilized for continuous equipment output. Recommended data reduction schemes that are based on the objectives and needs of the State and cooperating agencies must be implemented.

3.1.1.3 Field Calibration and Validation of Data. The accuracy and hence the usefulness of data from air monitoring programs are dependent to a great extent upon the ability to calibrate the instrument under actual operating conditions. For continuous automated measurements, a dynamic calibration is required whereby the measuring instrument is calibrated with a known quantity of gaseous pollutant while the complete system is operational in the field. Under field conditions, absolute calibrations are difficult and often impossible to achieve; however, reliable quantitative analyses can be accomplished if equivalent calibrations are performed against an acceptable standard.

Since most present-day monitoring instrument systems are subject to drift and variation in internal parameters, they cannot be expected to maintain accurate calibration over long periods of time. Therefore, it is necessary to check and standardize operating parameters on a periodic basis; a direct, dynamic calibration utilizing the pollutant species being monitored is desirable.

Dynamic calibration techniques have been described in a prior guideline manual entitled "Field Operations Guide for Automatic Air Monitoring Equipment". These as well as other published techniques applicable for field calibration of air monitors[4-10] should be consulted.

3.1.2 Secondary Networks

Air quality surveillance networks that employ equipment to provide intermittent hourly or daily integrated samples, which are subsequently analyzed in the laboratory to determine pollutant levels, may be classified as secondary. Secondary monitoring stations are generally located to coincide with population and emissions density. Their objective is to define concentration levels that are representative of any area of a region where air quality standards have the potential to be exceeded.

Guidelines applicable to primary site location are applicable to secondary as well.

3.1.2.1 Operations. The technical services group must supply a trained technician who is responsible to the routine operation of at least several secondary sites. Typical qualifications and job descriptions for such personnel are presented in Appendix B.

As stated in Section 3.1.1.1, provision for expendable supplies (filters, reagents, etc.), spare parts (motor brushes, pumps, bubblers, etc.), and instrument calibration (flow meters, volt-ohm meters, etc.) must be considered in light of the number of stations, their proximity to each other, and the central support laboratory or satellite office. Again, the agencies cited previously have developed standard operations procedures which can be used for reference.

3.1.2.2 Maintenance and Calibration. The basic equipment utilized at secondary sites consists of samplers for particulates and specific gases. Procedures for maintenance and calibration of such devices are supplied by the respective manufacturer. Also, maintenance, calibration, and general good practice guidelines are found in "standard" or "reference" techniques which have been reported for particulates (suspended and soiling)[11-15] and gases.[16,17] Of course, the Federal Register of November 25, 1971, presents the reference methods for the National Primary and Secondary Ambient Air Quality Standards.[18]

3.1.3 Tertiary Networks

Air quality surveillance networks that employ static equipment or materials, which are subsequently analyzed in the laboratory to estimate pollutant levels or effects, may be classified as tertiary. Tertiary monitoring stations are generally located geographically, either across the board on a grid basis to obtain areawide relative measurements, or specifically clustered to determine point source impact.

3.1.3.1 Operations. The technical services group must supply a semiskilled technician who is responsible for the routine operation of many tertiary sites. Typical qualifications and job descriptions for such personnel are presented in Appendix B.

3.1.3.2 Static Systems. Static or effects sampling systems are designed to be used in estimating the nature and extent of air pollution on a long-term basis. Individual components used are selected because of their simplicity and relatively low cost of preparation, operation, and analysis. In keeping with the concepts of simplicity and low cost, the systems are designed as static testing devices requiring no electricity. As a result, they can be easily located in remote locations.

In a recent report[19] that evaluated the performance of regional effects sampler networks, the following conclusions were reached:

(a) The effects sampler is capable of detecting the existence of five major pollutants--sulfur oxides, particulates, nitrogen oxides, hydrogen sulfide, and acid aerosols--and one potential problem, oxidation potential. The conclusion is based upon either direct correlation of sampler data with air quality or emissions data, or on strong evidence of source-receptor relationships.

(b) The effects sampler can be used to detect gross differences in pollution levels. This conclusion was substantiated either by the differences observed in the frequency distribution of pollutants at various classes of stations or by comparison of pollutant levels with emission levels, and by correlations with air quality data.

(c) Components of the sampler can provide evidence of air pollution effects. The most notable effects are related to corrosion; however, damage to rubber and nylon was noted.

(d) Evaluation shows that the eight components listed in Table 3 provide valid data relative to the pollutant or effect cited.

Effects networks have limitations:

(a) Exposure periods for the components vary from 7 days to 1 year, which makes it difficult to analyze the results;

(b) Air pollutants or their effects cannot be determined over short time intervals;

Table 3. COMPONENTS USED IN EFFECTS SAMPLING

Component	Pollutant or effect
Sulfation plate	Sulfur dioxide
Sticky paper	Soiling potential, particulate
Dustfall	Soiling potential, settleable particulate
Quarterly steel	Corrosion
Fabric No. 3	Oxides of nitrogen
Silver plate	Hydrogen sulfide
Rubber strip	Oxidation potential
Monthly nylon	Acid aerosol

(c) Data provided by some of the components are unreliable in that they lack specific knowledge of the measured pollutant(s);

(d) Detailed knowledge of replicate sampling errors for the individual components is not available;

(e) The network does not permit a detailed assessment of meteorological influences on the data;

(f) Since the methods are nonspecific, quantitative estimations are not valid.

However, results from these types of static sampling networks can often assist the administration by pointing out pollution problems in areas where few data are available and by providing preliminary information for future commitment of resources.

Most of the analyses of effects monitoring components can be accomplished with routine laboratory equipment. If fabric fading or reflectance measurements are desired, specialized optical meters[19] or contracted analytical services must be provided.

3.1.4 Network or Survey Protocols

After the technical services group decides to establish an air quality monitoring network, or even a relatively short-term aerometric survey with a specific objective, it should draft a protocol that outlines the general plan, delineates responsibilities, and sets schedules and assignments. A typical protocol should cover the following points:

(a) Introduction--This defines the scope and objectives of the effort, for example: "To assess the sources, characteristics, concentrations, and intrastate movement of air pollution that may affect health and welfare in the metropolitan regions of the State, and to enhance the development of an effective program for abatement and control of air pollution throughout the State."

(b) Area--The boundary designations are especially necessary in the specific survey effort that is often aimed at assessing the impact of a single source.

(c) Measurement program--This defines the categorical measurements to be accomplished and their sampling frequency. Major items to be covered include:

(1) Air quality measurements,

(2) Effects of pollution,

(3) Meteorology,

(4) Calibration.

(d) Participating agencies--This defines, when applicable, the cooperating parties (Federal, State, local, private) and should also include a listing of the personnel, equipment, and any other resources committed to the effort by all of the participants.

(e) Schedule--This presents the general schedule of operations, including the conduct of on-site field operations as well as the laboratory analyses program, reduction and summarization of data, and reporting due-dates.

(f) Administrative operations--This establishes the intergovernmental relationships and responsibilities and should stipulate the following:

   (1) Each participant will provide salary, travel, per diem, and administrative support for its personnel assigned or detailed to the activity;

   (2) Each participant will maintain and operate air sampling equipment and provide supplies as necessary for equipment that it devotes to the activity;

   (3) The State program will establish field liaison with operating elements of all participants and will provide overall supervision.

(g) Exchange of data--This establishes the procedures and responsibilities of data transmission and should stipulate that all data obtained by the participants must be forwarded to the State on a predetermined schedule, and,that the State technical services group will tabulate and distribute data summaries at appropriate intervals.

3.1.5 Network Design Considerations

In designing an air quality surveillance program, the following four criteria for locating sites must be considered:

(a) Monitoring stations must be pollution oriented;

(b) Monitoring stations must be population oriented;

(c) Monitoring stations must be source oriented;

(d) Monitoring stations must provide areawide representation of air quality.

In order to select locations according to these criteria, it is necessary to have detailed information on the location of sources of emission, the geographical variability of ambient pollutant concentrations, meteorological conditions, and population density.

Therefore, the selection of the number, location, and type of sampling stations within an AQCR is a complex problem without a purely objective solution. The variability of sources and their intensity, terrain, meteorological conditions, and demographic features requires that each network be developed individually. The network chosen will be the result of subjective judgments, based upon available evidence and the experience of the decision team.

The sampling site selection process involves consideration of economic, logistic, atmospheric, and pollutant reaction factors in addition to the motivation for and the objective of the sampling program. None of the factors stands alone; each is dependent in part upon the others. However, the objective of the sampling program must be clearly defined before the selection process can be initiated. The initial definition of priorities may have to be reevaluated after consideration of the remaining factors before the final locations are chosen.

The economic considerations are rather clearly defined. The amount of money required for data gathering (instrumentation, installation, maintenance, data retrieval system), data analysis (subjective or objective), and data interpretation must be balanced against the available monies (current and projected) and the cost-benefits of additional or relocated sampling sites.

The logistical problems involve the means of obtaining, analyzing, and interpreting the data. It must be determined whether the current staff can manage the proposed system, or more or fewer persons are required to accomplish the tasks. It is important to decide if the information derived is necessary on a real-time basis or if several weeks may elapse before it is needed.

The atmospheric problems pertain to definition of the spatial and temporal variability of the pollutants and their transport. Local effects upon the air trajectories by buildings, terrain, and heat sources or sinks can produce local anomalies of excessive pollutant concentration. Wind velocity, wind shear, and atmospheric stability greatly influence the dispersal of pollutants.

Additionally, a sampling site or an array of sites for one pollutant may be inappropriate for another pollutant species because of the configuration of sources, local meteorology, or terrain. Atmospheric chemical reactions such as the production of ozone in the presence of nitrogen oxides and hydrocarbons, and the time delay between nitrogen oxides and hydrocarbons emissions and the peak ozone values may require either a sampling network for the precursors of ozone and/or a different network for the actual ozone measurement. Pollutants undergo changes in their composition between their emission and their detection; therefore, the impact of that change upon the measuring system should be considered.

While the interaction of the factors identified in the above paragraphs is complex, the siting problem can be resolved. It requires experience in the operation of air quality measurement systems, estimates of air quality, field and theoretical studies of atmospheric diffusion, consideration of atmospheric chemistry, and air pollution effects; this combined expertise provides the input for determination of optimum sampling site selection.

An application of the above-noted considerations in the design of an air monitoring program is found in the New York-New Jersey Air Pollution Abatement Activity.[20,21] A detailed summary of this effort is presented in Appendix C.

3.2 Surveillance Monitoring Required by Air Quality Standards

Criteria for determining the number of monitoring sites required for adequate surveillance in an Air Quality Control Region were published in the Federal Register,[18] by the Environmental Protection Agency. The criteria are based on the priority (I, II, III) assigned to a region (see Table 4).

The minimum requirements for the establishment of an air quality monitoring system based on the priority classification of a region are presented in Table 5. One or more monitoring sites are required for each of the five pollutants in a Priority I region. For regions

Table 4. CRITERIA FOR CLASSIFICATION OF AIR QUALITY CONTROL REGIONS
Concentrations in micrograms per cubic meter (ppm in parentheses)

Pollutant	Priority		
	I	II	III
Sulfur oxides			
Annual arithmetic mean	> 100 (.04)	60-100 (.02-.04)	< 60 (.02)
24-hour maximum	> 455 (.17)	260-455 (.10-17)	< 260 (.10)
3-hour maximum		> 1300 (.50)	< 1300 (.50)
Particulate matter			
Annual geometric mean	> 95	60-95	< 60
24-hour maximum	> 325	150-325	< 150
Carbon monoxide			
8-hour maximum	≥ 14[a] (12)		≤ 14[a] (12)
1-hour maximum	≥ 55[a] (48)		< 55[a] (48)
Nitrogen dioxide			
Annual arithmetic mean	≥ 110 (.06)		< 110 (.06)
Photochemical oxidants			
1-hour maximum	≥ 195 (.10)		< 195 (.10)

[a] Concentration in milligrams per cubic meter.

classified as Priority II or III, the minimum requirements provide for monitoring suspended particulates and sulfur dioxide with 24-hour sampling every 6 days.

It must be kept in mind that these criteria establish *minimum* requirements and do not necessarily limit the size and scope of a network designed to monitor the progress toward the attainment of air quality standards.

Table 5. RECOMMENDED NUMBER OF AIR QUALITY MONITORING SITES

Regional classification	Pollutant	Measurement method[i]	Region population	Minimum number of air quality monitoring sites[a]	Minimum frequency of sampling
I	Suspended particulates	High volume sampler	Less than 100,000	4	One 24-hour sample every 6 days[c]
			100,000-1,000,000	4 + 0.6 per 100,000[b]	
			1,000,000-5,000,000	7.5 + 0.25 per 100,000[b]	
			Above 5,000,000	12 + 0.16 per 100,000[b]	
		Tape sampler	--	One per 250,000[b] up to 8 sites	One sample every 2 hours
	Sulfur dioxide	Pararosaniline or equivalent[d]	Less than 100,000	2	One 24-hour sample every 6 days (gas bubbler)[c]
			100,000-1,000,000	2.5 + 0.5 per 100,000[b]	
			1,000,000-5,000,000	6 + 0.15 per 100,000[b]	
			Above 5,000,000	11 + 0.05 per 100,000[b]	
			Less than 100,000	1	Continuous
			100,000-5,000,000	1 + 0.15 per 100,000[b]	
			Above 5,000,000	6 + 0.05 per 100,000[b]	
	Carbon monoxide	Nondispersive infrared or equivalent[e]	Less than 100,000	1	Continuous
			100,000-5,000,000	1 + 0.15 per 100,000[b]	
			Above 5,000,000	6 + 0.05 per 100,000[b]	
	Photochemical oxidants	Gas phase chemiluminescence or equivalent[f]	Less than 100,000	1	Continuous
			100,000-5,000,000	1 + 0.15 per 100,000[b]	
			Above 5,000,000	6 + 0.05 per 100,000[b]	
	Nitrogen dioxide	24-hour sampling method (Jacobs-Hochheiser method)	Less than 100,000	3	One 24-hour sample every 14 days (gas bubbler)[g]
			100,000-1,000,000	4 + 0.6 per 100,000[b]	
			Above 1,000,000	10	

Table 5 (continued). RECOMMENDED NUMBER OF AIR QUALITY MONITORING SITES

Regional classification	Pollutant	Measurement method[1]	Region population	Minimum number of air quality monitoring sites[a]	Minimum frequency of sampling
II	Suspended particulates	High volume sampler	--	3	One 24-hour sample every 6 days[c]
		Tape sampler	--	1	One sample every 2 hours
	Sulfur dioxide	Pararosaniline	--	3	One 24-hour sample every 6 days (gas bubbler)[c]
			--	1	Continuous
III[h]	Suspended particulates	High volume sampler	--	1	One 24-hour sample every 6 days[c]
	Sulfur dioxide	Pararosaniline	--	1	One 24-hour sample every 6 days (gas bubbler)[c]

[a] In interstate regions, the number of sites required should be prorated to each State on a population basis.

[b] Total population of a region. When required number of samplers includes a fraction, round off to nearest whole number.

[c] Equivalent to 61 random samples per year.

[d] Equivalent methods are (1) Gas Chromatographic Separation-Flame Photometric Detection (provided Teflon is used throughout the instrument system in parts exposed to the air stream), (2) Flame Photometric Detection (provided interfering sulfur compounds present in significant quantities are removed), (3) Coulometric Detection (provided oxidizing and reducing interferences such as O_3, NO_2, and H_2S are removed), and (4) the automated Pararosaniline Procedure.

[e] Equivalent method is Gas Chromatographic Separation - Catalytic Conversion - Flame Ionization Detection.

[f] Equivalent methods are (1) Potassium Iodide Colorimetric Detection (provided a correction is made for SO_2 and NO_2), (2) UV Photometric Detection of Ozone (provided compensation is made for interfering substances), and (3) Chemiluminescence Methods differing from that of the reference method.

Table 5 (continued). RECOMMENDED NUMBER OF AIR QUALITY MONITORING SITES

FOOTNOTES (continued)

[g] Equivalent to 26 random samples per year.

[h] It is assumed that the Federal motor vehicle emission standards will achieve and maintain the national standards for carbon monoxide, nitrogen dioxide, and photochemical oxidants; therefore, no monitoring sites are required for these pollutants.

[i] All measurement methods, except the Tape Sampler method, are described in the national primary and secondary ambient air quality standards published in the Federal Register on April 30, 1971 (36 F.R. 8186). Other methods together with those specified under footnotes (d), (e), and (f) will be considered equivalent if they meet the following performance specifications:

	Pollutants				
Specification	Sulfur dioxide	Carbon monoxide	Photochemical oxidant*	Nitrogen dioxide	Hydrocarbons (CH_4)
Range	0-2620 μg/m^3 (0-1 ppm)	0-58 mg/m^3 (0-50 ppm)	0-880 μg/m^3 (0-0.5 ppm)	0-1880 μg/m^3 (0-1 ppm)	0-16 mg/m^3 (0-25 ppm)
Minimum detectable sensitivity	26 μg/m^3 (0.01 ppm)	0.6 mg/m^3 (0.5 ppm)	20 g/m^3 (0.01 ppm)	19 μg/m^3 (0.1 ppm)	0.16 mg/m^3 (0.25 ppm)
Rise time, 90%	5 min.	5 min.	5 min.	5 min.	5 min.
Fall time, 90%	5 min.	5 min.	5 min.	5 min.	5 min.
Zero drift	± 1% per day and ± 2% per 3 days	± 1% per day and ± 2% per 3 days	± 1% per day and ± 2% per 3 days	± 1% per day and ± 2% per 3 days	± 1% per day and ± 2% per 3 days
Span drift	± 1% per day and ± 2% per 3 days	± 1% per day and ± 2% per 3 days	± 1% per day and ± 2% per 3 days	± 1% per day and ± 2% per 3 days	± 1% per day and ± 2% per 3 days
Precision	± 2%	± 4%	± 4%	± 4%	± 4%
Operation period	3 days	3 days	3 days	3 days	3 days
Noise	± 0.5% (full scale)	± 0.5% (full scale)	± 0.5% (full scale)	± 0.5% (full scale)	± 0.5% (full scale)
Interference equivalent	26 μg/m^3 (0.01 ppm)	1.1 mg/m^3 (1 ppm)	20 μg/m^3 (0.01 ppm)	19 μg/m^3 (0.01 ppm)	.32 mg/m^3 (0.5 ppm)
Operating temperature fluctuation	± 5° C	± 5° C	± 5° C	± 5° C	± 5° C
Linearity	2% (full scale)	2% (full scale)	2% (full scale)	2% (full scale)	2% (full scale)

*Corrected for NO_2 & SO_2

(continued)

Table 5 (continued). RECOMMENDED NUMBER OF AIR QUALITY MONITORING SITES

FOOTNOTES (continued)

* Corrected for NO_2 and SO_2.

** These specifications are defined below:

<u>Range</u>: The minimum and maximum measurement limits.

<u>Minimum detectable sensitivity</u>: The smallest amount of input concentration which can be detected as concentration approaches zero.

<u>Rise time 90%</u>: The interval between initial response time and time to 90% response after a step increase in inlet concentration.

<u>Fall time 90%</u>: The interval between initial response time and time to 90% response after a step decrease in the inlet concentration.

<u>Zero drift</u>: The change in instrument output over a stated time period of unadjusted continuous operation, when the input concentration is zero.

<u>Span drift</u>: The change in instrument output over a stated period of unadjusted continuous operation, when the input concentration is a stated upscale value.

<u>Precision</u>: The degree of agreement between repeated measurements of the same concentration (which shall be the midpoint of the stated range) expressed as the average deviation of the single results from the mean.

<u>Operation period</u>: The period of time over which the instrument can be expected to operate unattended within specifications.

<u>Noise</u>: Spontaneous deviations from a mean output not caused by input concentration changes.

<u>Interference equivalent</u>: The portion of indicated concentration due to the total of the interferences commonly found in ambient air.

<u>Operating temperature fluctuation</u>: The ambient temperature fluctuation over which stated specifications will be met.

<u>Linearity</u>: The maximum deviation between an actual instrument reading and the reading predicted by a straight line drawn between upper and lower calibration points.

3.3 Responsibilities in Support of Implementation Plans

The technical services group must be responsive to the needs of the administration and enforcement elements of the control program. Laboratory and supporting field activities that best illustrate these special investigative requests are:

(a) Source emissions testing;

(b) Emergency episode monitoring;

(c) Analysis of special samples;

(d) Measurement of defined point source impact on air quality.

Following is a general discussion of these work areas which attempts to define the role of the technical services group. It must be remembered that in all cases, these are "joint ventures" with the general objectives and directions for the tasks coming from the agency personnel charged with making the decision or defining the problem with the input data supplied by the technical services group.

3.3.1 Source Emissions Testing

The primary function of source sampling is to obtain reliable emission data. The exact duties assigned to the source sampling unit in order to perform this function vary widely from agency to agency depending on the potential work load, the emission regulations, and the availability of other agency personnel when required. In small organizations, in which source sampling may not be a full-time activity, some personnel who are actually a part of another unit, such as engineering, may be loaned to the technical services group as the need arises. In this case, when sampling is required, personnel will have to reschedule their other work, perform the test work and analysis, then return to their routine duties.

In contrast to this part-time activity, a large agency with many requirements for source testing will need a full-time staff performing tests. This staff will include chemists as well as technicians who maintain the sampling equipment, perform calibrations, assist in stack testing, and make routine calculations. These technicians support the engineering staff who perform sampling site surveys, plan the test procedures, set the schedule, supervise the actual tests, review calculations, and prepare the final report. Generally, a senior technician is assigned to the sampling group. This person should be responsible for all routine laboratory analysis and serve as coordinator between the laboratory and engineering groups.

A recent report[22] prepared for EPA lists the specific duties of the source emissions testing unit. Those duties asterisked(**) are generally assigned to the technical services group.

(a) Technical Duties

- (1)** Develop and update reliable source testing procedures for particulate and gaseous emission;
- (2)** Calibrate and maintain all equipment;
- (3) Plan and conduct source tests as required;
- (4)** Perform and check all test calculations;
- (5)** Prepare analytical reports and summaries of emission data;
- (6) Review source tests conducted by private firms.

(b) Administrative Duties

- (1)** Train personnel;
- (2)** Procure equipment to conduct source tests;

(3)** Maintain a file of all source tests data;

(4) Prepare annual reports and budget requirements;

(5) Make contacts with plant personnel;

(6) Schedule tests;

(7)** Coordinate source test activities with other agency elements.

A wide variety of sampling trains are available for determining particulate emissions. These trains have been described in the literature, and each has its particular advantages and disadvantages depending on the sampling conditions and the object of the test. In all cases, however, the trains consist of a carefully sized sampling nozzle or probe tip, a probe to convey the gases, a filter, collector or solid/gas separating device, a pump, and a gas meter. When hot gases (higher than about 150°F) are sampled, a condenser or similar cooling device is also used to protect the pump and meter.

It is especially important that all components that contact the sampling stream be carefully cleaned. Proper cleaning and lubrication will also insure a leak-tight assembly. Any other suspected malfunctions in the sampling train are also best diagnosed and fixed in the laboratory or shop. Frequent sources of mechanical problems include defective pumps (usually broken or stuck vanes), dry gas meter (erratic dial readings), timer or clock malfunctions, loose or broken electrical wires, damaged nozzle or Pitot tube openings, and cracked glass parts.

EPA has prepared a document[23] dealing with specifics of maintenance, calibration, and operations of source emissions testing.

3.3.2 Emergency Episode Monitoring

The technical services group is invariably turned to for emergency atmospheric monitoring. Two specific situations can occur: an atmospheric stagnation-induced areawide episode, or an accident or industrial spill. Both require an immediate response mechanism to evaluate the magnitude of the problem and to provide information on real-time levels of hazardous or toxic contaminants.

3.3.2.1 Episode Control. In the case of the meteorological episode, preplanning and utilization of established equipment and resources reduces much of the pressure on the technical services group since a contingency plan will have been devised and the staff will know their specific assignments and duties.

A recent EPA publication[24] details all of the factors and agency interrelationships involved in planning for episode avoidance, establishment of an Emergency Operations Control Center (EOCC), and standard operating procedures for all agency elements. The service functions to be provided by the combined technical services staff are summarized as follows:

(a) Provide continuous, valid data regarding air contaminants with priorities given to those pollutant sampling instruments that are necessary to provide criteria for the various stages of the alert;

(b) Provide supplemental data needed to support information and decisions during this period;

(c) Analyze and reduce raw data to meaningful information;

(d) Make such minor adjustments, calibration, and repairs to instruments as necessary to provide continuous data;

(e) Set up and maintain instruments as necessary at supplemental monitoring stations;

(f) Provide sufficient sampling supplies and media in predesignated inventory quantities to support the intensified level of air quality monitoring;

(g) Reduce, log, and post the air quality measurement data in the EOCC. Provide interpretation of the measured values relative to temporal and spatial factors and make recommendations relative to expanded or modified operations.

3.3.2.2 Accident Control. Accident control, by its very nature, does not easily lend itself to specific planning. An unplanned and unexpected release of volatile materials can become a localized occupational health hazard as well as a significant air pollution source. Rupture of reaction vessels and pipelines, collision of truck and rail tankers, and spillage during transfer from container-to-container represent potential sources for the major release of toxicants and/or pollutants. In anticipation of such local pollution situations, it is desirable to have a contingency plan for action.

At the present time, several States have established disaster control programs and centers. In all other instances, the State and regional police initially investigate and coordinate all efforts to minimize the impact of accidents on the affected community.

Therefore, until such time as air pollution agencies formulate and implement regulations requiring the immediate report and control of accidental spills or emissions, the following procedure could be established:

(a) An emergency kit, consisting of various testing equipment--primarily detector tubes, written reference source materials, and safety equipment--is located at key police locations throughout the State;

(b) In the event of an accident, the police notify the agency and transport the kit to the scene;

(c) The agency dispatches the most suitable, available team of investigators to the scene to conduct an investigation and to make necessary judgments for control of the problem;

(d) The State agency would also provide the cooperating police units with listings of responsible local air pollution personnel who would be familiar with the test equipment and who could provide initial immediate assistance until the State investigators arrive.

3.3.3 Analyzing Special Samples

3.3.3.1 Nuisance and Complaint. The public nuisance and complaint is usually an urban problem. Complaints invariably increase with industrialization, population, and rapid, unplanned growth patterns. Complaint reaction to nuisance situations generally stems from the emission of malodorous gases or vapors; deposition of and soiling from fly ash, mineral dusts, and other miscellaneous particulate matter; and stains on or erosion of materials resulting from impaction of liquid particles, usually acidic or otherwise corrosive.

In certain nuisance situations, e.g., particulate deposition or materials damage, the laboratory is employed to perform chemical or physical (including microscopic) analysis of a sample taken by the enforcement inspector. Usually, these data are sufficient to allow identification of the source category and the inspector can place suspected emitters under surveillance.

It is difficult to list all of the possible sample categories that the laboratory might be called upon to analyze. Generally, the laboratory of a comprehensive State program will have the necessary equipment and staff experience to perform this particular type of "qualitative analysis". Some typical samples brought in by inspectors would include:

(a) Particulate matter deposited on private property, collected from gutters, porches, siding, etc.;

(b) Materials such as curtains, drapes, screens, etc., that have been soiled, stained, or corroded;

(c) Indigenous vegetation (flowers, leaves, etc.) that exhibit symptoms of disease or pollutant damage.

Additionally, static sampling media are often used by enforcement personnel to establish the source of a nuisance or complaint situation. In these cases, the laboratory may be called on to:

(a) Chemically analyze particulate matter collected on impaction plates (coated glass or metal slides);

(b) Physically identify particulates collected on impaction plates, sticky paper, or cheesecloth;

(c) Chemically analyze impregnated media (sulfation or fluoridation rate, etc.) for reaction with gaseous pollutants.

All of the techniques utilized by the laboratory in these efforts are found in standard chemical analysis texts, standard methods, or referenced in specific sections of this document. However, one reference that should be noted in connection with particle identification is the McCrone Atlas.[25]

3.3.3.2 Fuels. Often the laboratory is requested to perform analysis of fossil fuels, e.g., coal or oil. This can be a major analysis load in States that prescribe in specific regulations the allowable amounts of sulfur and ash in fuels. Standard tools such as the calorimeter and combustion trains are used and many reference methods exist.[26-28]

In some special cases, mobile source fuels may be analyzed in the State laboratories. However, this activity is usually associated with automotive emissions testing programs which, except for the California Air Resources Board, are only in the formative development or planning stages.

3.3.4 Defining Source Impact

Monitoring the effect of a point source on ambient air may be conducted for one or more purposes:

(a) To evaluate compliance with ambient air quality standards:

   (1) Before and after monitoring may be specified for a proposed plant in order to obtain a permit to construct and/or operate;

   (2) Monitoring may be necessary to measure the pollutant effects of an existing source upon the surrounding community.

(b) To monitor an area of concern outside the region of maximum concentration:

   (1) Where a complaint has been substantiated;

(2) Where a populated or otherwise important area warrants monitoring to obtain concentration levels.

Specification of the quantity and location of sampling devices for a long-range source investigation is difficult. Wind variables will change greatly during the seasons so that the area of concern may be downwind of the plant in summer, while in the colder months the plume may reverse direction.

As a point source emits a pollutant into the atmosphere, it is transported to another coordinate by the wind. Variances in wind direction and speed can cause a parcel of air to have a history of appreciable directional and velocity changes.

It is evident that a surveillance system totally surrounding the point source is needed to insure protection against the varying plume characteristics. The major portion of monitors is placed in the area where the concentration is most likely to be the highest. This area can be determined from the annual prevailing wind direction. A smaller number of instruments completes the monitoring network.

3.4 Special Studies

Normally, the air pollution technical services group is concerned with the program support activities that have been previously described. However, in some State and regional agencies, specific studies involving some research, development, and applied research have been and will continue to be undertaken. Several examples, chosen to illustrate these areas, are covered below.

3.4.1 Instrument Evaluation

Occasionally, the technical services group may be asked to perform an investigation of one or more types of air quality monitors. This need will arise when instrument evaluation tests by the vendor have been conducted on a limited scale and sufficient data are not available to determine if a particular instrument or instrumental technique meets the needs of the control agency for reliable and accurate measurements. These data can be obtained only through comprehensive instrument evaluation programs designed to obtain the required performance data.

A general set of performance criteria can be specified that are independent of the type of instrument being evaluated or the application in which it is to be used. The following characteristics that describe instrument performance criteria should be considered:

(a) Physical Characteristics--Portability, size, weight, space requirements, auxiliary equipment, power requirements, versatility, and hazards;

(b) Performance Specifications--Temperature effect, interferences, interference equivalent, volumetric flow rate range, setup time, warmup time, response time, lag time, rise time to 95%, total time to 95%, and sensitivity;

(c) Data Quality--Calibration requirements, stability, accuracy, precision, zero drift, span drift, linearity, calibration reproducibility, minimum detectable sensitivity, minimum detectable change, and detection limit;

(d) Functional Capability--Fragility, durability, serviceability, zero failure period, maintenance requirements, operational period, and equipment cost.

The performance of an instrument must ultimately be determined under actual field conditions for its complete evaluation. A partial evaluation can be performed in the laboratory, and the results may provide the basis as well as the justification for field evaluation, but a complete field test evaluates not only the instrument but the performance of the operator and the facility as well. To determine the effect of various combinations of pollutants in urban environments on instrumental response, instrument evaluations should be conducted in several geographical areas.

3.4.2 Atmospheric Chemistry Studies

Photochemical reactivity of atmospheric constitutents has been defined as the tendency of these materials to undergo a series of chemical reactions under the influence of ultraviolet irradiation and meteorological turbulence. The chemical reactions are initiated principally by the photochemical dissociation of nitrogen dioxide by solar energy below 4000 angstrom units.

This chemical activity or reactivity can be measured by various types of human and animal response (eye irritation, plant damage, breathing difficulty, visibility reduction) and by various techniques associated with analytical and physical chemistry. Some of the more common evaluations of this latter type are as follows:

(a) Determination of the rates of disappearance of various hydrocarbons upon irradiation;

(b) Determination of the rate of photochemically induced conversion of nitric oxide to nitrogen dioxide in the presence of hydrocarbons;

(c) Determination of the rates of formation of selected photo-oxidation products such as aldehydes, ketones, carbon monoxide, total oxidant, ozone peroxyacetylnitrates, and peroxides.

3.5 In-House Laboratory Considerations

Currently, with very few exceptions, the analytical laboratory is an element of the air pollution control program. Since the internal chemical staff is often small (usually < 20), it can operate in an informal manner. As a result there is usually no need for organizational subdivisions; each chemist and technician is familiar with most of the laboratory procedures and only a few of the professionals "specialize." Depending on the thrust of the air pollution control program as well as its stage of development, the laboratory load of nonroutine samples will vary. If the agency is seriously involved in source emissions testing or has regulations demanding materials compliance testing (fuels and solvents), the nonroutine sample analysis might well utilize 70 to 80 percent of the available man-hours.

Requests for analytical services, an important item, should be briefly developed at this point. It is recommended that samples submitted for analysis be treated as follows:

(a) Laboratory Services Request Form (see Figure 9) is filled out in detail; all data pertaining to the sample and the type of analyses required are included on the form;

(b) The sample and request form is then inspected and either accepted or rejected by the chief chemist; often the sample is of insufficient size or is not representative enough for analyses;

(c) The accepted sample is then logged into the laboratory record book and processed for the analyses.

Sample Description and Designation

Submitted by: ______________ EPA Division & Branch: ______________

External Source: ______________ Date Received: ______________

AQAL Sample No: ______________ Submittal No: ______________

Sample Description:

Solid ☐ Liquid ☐ Gas ☐ Hygroscopic ☐ Vol: ______________

General Description: ______________

Sampling time ______________ Air flow ______________ Air volume ______________

Analyses Desired

Inorganic Ions and Gases

		Approximate Concentration			Approximate Concentration
NO_3^-	☐	______	NO_2	☐	______
SO_4	☐	______	SO_2	☐	______
NH_4^+	☐	______	Others:	______	______
Cl^-	☐	______		______	______
F^-	☐	______			

Organic Compounds

		Approximate Concentration
Benzo(a)pyrene	☐	______
Benzanthrone	☐	______
Benzene Soluble Organics	☐	______
Others: ______		______
______		______
______		______
______		______

Figure 9. Laboratory services request form (an example).

Other

β Count ☐   pH ☐   Conductivity ☐

UV Spectrum ☐   IR Spectrum ☐

Special Analyses Desired:

____

____

____

Trace Metals and Nonmetals

☐ All by ES

Element	Method AA	Method ES	Method Other (specify)	Approx. conc.	Element	Method AA	Method ES	Method Other (specify)	Approx. conc.
Be	☐	☐	____	____	Re	☐		____	____
Ti	☐	☐	____	____	Ag	☐		____	____
V	☐	☐	____	____	Ca	☐		____	____
Cr	☐	☐	____	____	Zn	☐	☐	____	____
Mn	☐	☐	____	____	Al	☐	☐	____	____
Fe	☐	☐	____	____	As	☐	☐	____	____
Co	☐	☐	____	____	Ba	☐	☐	____	____
Ni	☐	☐	____	____	Sr	☐	☐	____	____
Cu	☐	☐	____	____	Te		☐	____	____
Mo	☐	☐	____	____	Zr		☐	____	____
Cd	☐	☐	____	____	Sm		☐	____	____
Sn	☐	☐	____	____	Tl		☐	____	____
Sb	☐	☐	____	____	Pt	☐		____	____
Pb	☐	☐	____	____	Bi	☐	☐	____	____
B	☐		____	____	Hg	☐		____	____
Mg	☐				Se	☐			

ATTENTION: For all samples collected on solid absorbents or in solution appropriate samples of the solid absorbent or collecting solution must be supplied in order to determine correct blank values.

Figure 9 (continued). Laboratory services request form (an example).

Table 6. TABULATION OF IN-HOUSE LABORATORY ANALYSIS FUNCTIONS

Sample	Analysis usually performed	Technique employed	Equipment utilized
Ambient			
Gases	SO_2, NO_2, oxidant, H_2S;	Colorimetry;	Spectrophotometer;
	Hydrocarbons & CO	Chromatography	Gas chromatography
Particulates	Suspended, settleable;	Gravity;	Analytical balance;
	Metals, i.e., Fe,Cu,Pb,etc.;	Atomic adsorption;	A.A. spectrophotometer;
	Particle size (sticky paper impaction)	Microscopy	Microscope
Effects	Sulfation rate;	Turbidimetry;	Spectrophotometer;
	Metal corrosion;	Gravimetry;	Analytical balance;
	Color fading;	Colorimetry	Color difference meter
	Material Deterioration		
	Nylon;	Microscopy;	Microscope;
	Rubber;	Microscopy;	Microscope;
	Silver	Reflectometry	Reflectance meter
Source emissions			
Gases	SO_2, SO_3, NO_x, Cl;	Colorimetry;	Spectrophotometer;
	Hydrocarbons	Chromatography	Gas chromatograph
Particulates	Total weight;		
	Particle size	Gravimetry;	Analytical balance;
		Microscopy or Air Centrifugation	Microscope; Bahco Micro-Particle Classifier
Fuels			
Stationary source	Btu;	Calorimetry	Calorimeter;
	Sulfur;	Combustion train;	Volumetric analysis;
	Moisture ash;	Gravimetry;	Analytical balance;
Mobile source	Bromine number	Colorimetry	Spectrophotometer

It is vital that formal procedures for acceptance of samples be established. When a laboratory workload reaches the level of approximately 300 samples per month, a "sample clearinghouse" approach would be useful.

In order to generally summarize the analytical service functions, Table 6 has been developed. While it may not include all of the specific sample categories nor detail alternate procedures or equipment, it should provide a general feel for the scope of work and the range of technology implemented in existing State or regional laboratories.

4.0 LOCATION AND DIVISION OF TECHNICAL SERVICES RESPONSIBILITIES

4.1 Overall State Program--Division of Responsibilities

Each State program will carry out its technical service responsibilities and laboratory functions as defined in its implementation plan. In many cases, comprehensive municipal, county, and regional agencies are already in existence dealing with the local air pollution control problems. In other cases, local agencies either do not exist or are concerned with only fragments of a minimum air pollution control program.

The major local air pollution control (APC) agencies will assist and cooperate with the State APC agency in carrying out a large measure of the statewide program. Each of these local agencies will be responsible for the bulk of the management, enforcement, engineering, and technical services within their own jurisdictions. The local agencies will handle complaints, conduct scheduled inspections, patrol in the field, make emission estimates, operate monitoring networks, set local policy, and gather information necessary for legal actions. These activities will differ in type and scope from agency to agency, requiring varying levels of manpower and funding. Such activities will be accomplished largely by independent action. Other APC program functions require much closer intergovernmental cooperation, both intrastate and interstate. Plans for the prevention of air pollution emergency episodes are a prime example of an area requiring complete, coordinated, and well-defined and understood interstate intergovernmental cooperation.

The minimum EPA program criteria require that an agency have the technical and administrative capability to perform at least the following functions: air quality monitoring, scheduled inspections, complaint handling, operation of a field surveillance program, preparation for legal actions, and source identification and registration. If the local agency cannot or will not meet these requirements, the State agency must physically fill in the gaps in the areas of need. This is accomplished by assisting in the development of a local agency which at least meets the minimum requirements or by creating a State satellite office to serve the jurisdiction.

4.2 State Technical Services--Division of Responsibility

There are presently no guidelines or scientific methodologies which can be used to determine the ideal number, types, and locations of technical services installations within the State APC agency. Until such time as these tools become available, it is useful to define several of the influencing parameters which, when given proper consideration, are useful in determining allocation of functional responsibilities.

4.2.1 Types of Technical Service Facilities

The needs of most State programs can be met with two types of facilities: the central or primary facility and the satellite facility. The primary facility would normally have the capabilities and resources to support all technical services functions carried out within the State program. The satellite facility is usually employed to support the functions of field-related activities. The extent of equipment and personnel located at the satellite facility will be proportional to the activities which the facility serves. Often the satellite facility will be located with other agency field activities such as engineering or enforcement. In many instances these satellite facilities are extensions of a local agency, whereby the State provides, under cooperative agreements, personnel and support for activities beyond the local jurisdiction.

4.2.2 Location of the Technical Service Facilities

Several factors affecting the location of technical services common to most State agencies are as follows:

4.2.2.1 Technical Service Requirements. The heaviest demands for technical services in relation to the geographical area of the State will result from those areas of maximum population density.

Oftentimes, within a State, the number of these maximum population areas will be less than five. As a guide, the population density will exceed 1,000 persons per square mile, and the area will be greater than 100 miles. In these areas the demand for technical services will be sufficient to support a satellite facility.

The remaining technical services effort will be directed to the large unpopulated areas of the State. These areas require limited technical services: but due to the large size of such areas, as found in many States, the effort becomes substantial.

4.2.2.2 Travel and Communications. Travel and communication costs should be kept minimal. As a result, the agency will find it more economical to support satellite facilities in remote areas. Normally, the one-way distance from the furthest point of responsibility within an area to the technical support facility should be less than a two-hour automobile drive.

4.2.2.3 Expenses--Facilities and Operational. The use of existing State-owned facilities can be advantageous from an economic viewpoint. The use of State-owned facilities within the jurisdiction of a competent local agency can lead to an inefficient duplication of resources and effort. It would be desirable in this instance for the State to support and use the local agency's facility on a cooperative basis.

Operational costs are not greatly influenced by geographical location, but the number of required facilities are. Therefore, every effort should be made to develop cooperative agreements with existing local agencies.

4.2.2.4 Public Relations Influence. The public relations factor cannot be overlooked whenever issues such as this are involved. There will exist pressures from the political element to locate facilities in one geographical area in preference to another. Often this factor can be used to the program's advantage, but care should be exercised so that the selection of a geographical location is not based on these factors alone.

4.2.3 Allocation of Technical Functions

As a result of the nature of the functions themselves, some are best performed at a central location while others are more efficiently carried out at field locations. The determining factor for the separation of these functions is based on the most efficient utilization of resources with a minimum of effort duplication. The technical services functions can be divided into two categories, i.e., those best suited for performance at the central technical facility and those which can best be performed at the field office or satellite facility (Table 7).

Table 7. ALLOCATION OF TECHNICAL SERVICES FUNCTIONS

Technical services function	Execution of function*	
	From central facility	From satellite facility
Analyses--ambient and source samples	A	B
Source sampling	A	A
Air monitoring	A	A
Special studies	A	B
Data acquisition	C A**	A
Instrument calibration	A	A
Instrument maintenance	B	A
Monitor site selection	B	A
Data reductions	C A**	A
Computer program	A	C
Data summary	A	B
Statistical studies	A	C
Meteorological studies	A	C

* Execution of the functions with respect to these two types of facilities.

** Telemetered data acquisition systems only.

Code:

A - Well Suited
B = Moderately Suited
C = Ill Suited

Centralized laboratory and data operations result in a considerable savings in equipment and personnel. The other technical services activities pertain primarily to operations performed in a field and, therefore, lend themselves to operation from a satellite or field facility.

4.2.4 Number of Technical Services Facilities

The number of technical services facilities required to service a statewide program will be dependent upon the area, population, and presence of existing local agencies. In all States there is generally a need for at least a central technical facility. Such a facility could be operated by the State or by a local agency under contract to that State.

4.3 Organizational Considerations

4.3.1 The Independent State Agency

Several State agencies operate independently, i.e., without the existence of local agencies within their State. Normally, under these circumstances, a larger number of satellite facilities will be required to service the program.

The governing factor in this situation is the geographical size of the State. New Jersey, for example, is a relatively small State and is able to provide complete technical services from one central facility, located in Trenton, without the need for satellite facilities. Larger States, operating without local agencies, would require additional satellite facilities to minimize travel and communications expense.

4.3.2 The State and Local Agency Co-op

A more common situation existing today is that of the State program and several local programs working together toward a common goal as established by the statewide implementation plan. Under this framework, much of the State's responsibility can be delegated to the larger local agencies. These agencies can be considered a central or primary facility, and oftentimes they possess greater competence and experience than the

Table 8. ALLOCATION OF RESPONSIBILITY FOR TECHNICAL SERVICES FUNCTIONS REQUIRING INTERGOVERNMENTAL COOPERATION

Organizational element	Technical services functions					
	Laboratory	Surveillance	Instrumentation	Field services	Statistics	Data processing
State technical services unit	A	A	A	A	A	A
State agency central laboratory	C	C	C	C	C	C
State agency regional primary laboratory	F	F	F	F	F	F
State agency satellite laboratory	P	F	F	F	P	P
Local agency primary laboratory	F	F	F	F	F	F
Local agency satellite laboratory	P	F	F	F	P	P

Code:

A = Administrative responsibility
B = Coordinating responsibility
F = Full responsibility
P = Partial responsibility

State program. The cooperative employ of these agencies by the State can be one of the most valuable resources available to the State program. In addition, the smaller local agencies can participate as satellite facilities, providing supportive and field capabilities to the State agency's central laboratory or to a neighboring primary facility operated by a local agency.

4.3.3 Intergovernmental Responsibilities

As previously pointed out, a number of administrative options are available depending upon the empirical nature of the State's organization.

State agencies having an in-house central laboratory capability are responsible for overall administrative and technical coordination of the statewide technical services activity. State agencies without in-house central laboratory facilities will maintain administrative control while establishing technical competency in regional State laboratories and strong local agency laboratories. Each of these designated "primary" laboratories will coordinate with other "primary" laboratories and will provide direction and back-up capabilities to State and local agency satellite operations, which need not or cannot maintain complete technical services facilities.

Table 8 is presented as an example of State agency responsibility for overall coordination and regional or local laboratory responsibility for functional services.

5.0 LEGAL CONSIDERATIONS

Ambient and source sampling provide the basic measurements for an air quality management program. This chapter discusses the pitfalls which may render test data useless from a legal standpoint. A broad discussion of the legislative and other legal requirements is presented to give the reader an overview of the importance of the sampling program and the limitations inherent in a program which necessarily restricts the use of private property. Procedures are suggested for maintenance and calibration of equipment, data recordation, and analysis. This procedure, if followed, will buttress the data as evidence in any subsequent litigation and, more importantly, will reduce the possibility of a successful court challenge.

5.1 Requirements for Jurisdictional Samples

5.1.1 Definition

The term "jurisdictional samples" means those samples which are collected for use by a State or local air pollution control agency as opposed to those taken by or for the owner or operator of an air pollution emission source. While such samples will generally be ambient or source samples extracted from the air or gas stream by means of instruments or measuring devices, they may also include such items as sweepings, leaves, animal bones, and the like which are descriptive of conditions in a particular area. For the sake of clarity, jurisdictional samples will be classified herein as ambient, source, and descriptive.

5.1.2 Regulatory Authority--General Considerations

The expertise required for a proper air quality management program necessitates specialized administration. Unlike traffic laws, whereby the State legislature itself establishes speed limits and the like, the authority to set air pollution limitations is delegated by the legislature to an administrative body. This type of legislation is called "enabling legislation" and the administrative body generally takes the form of a health department, air pollution control board or commission, or a multifaceted State environmental protection agency.

The powers of administrative agencies are generally limited by the intent of the legislature as expressed in the enabling legislation. Administrative agencies have no inherent powers; therefore, it is necessary that the statute specifically provides that the agency is empowered to adopt and enforce emission standards, conduct tests, and perform acts incidental to the accomplishment of the agency's purpose. This administrative authority should be discussed in depth in the State's implementation plan and it is suggested that the reader refer to the appropriate section of that document.

Establishment and enforcement of emission limitations are an exercise of the Government's police power. Such regulation is a valid restraint on the use of private property if the regulation is reasonable and reasonably related to the public health, safety, or general welfare. Thus, if it is established that a specified concentration of pollutant in the ambient air is a threat to public health, safety, or welfare, reasonable means may be taken to remove that threat. Valid emission regulations must be based on sound ambient air quality data. There must be a relationship between the regulation and the condition to be corrected.

5.1.3 Purpose of the Clean Air Act

Congress has found that increasing urbanization and industrial development have resulted in complex air pollution problems affecting public health and welfare. It was determined that, while the prevention and control of air pollution at its source is the primary responsibility of State and local governments, Federal leadership and assistance is essential to development of the State and local programs. Thus the Clean Air Act of 1970 was passed to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and to provide assistance to State and local governments in developing air pollution prevention and control programs.

5.1.4 Requirements Under the Clean Air Act

The Clean Air Act accomplishes its purpose by requiring the States to adopt and enforce emission limitations for stationary air pollution sources as required to meet federally adopted ambient air quality standards. To the extent that the Clean Air Act requires the States to adopt necessary emission regulations therefore, it requires a program for ambient air quality surveillance.

Whether specific sources are in compliance is generally determined by source samples. It is therefore necessary that the State agency have the authority and capability to conduct or have conducted source tests.

5.1.5 Jurisdictional Samples as a Basis for Regulations--Program Criteria

The imposition of emission regulations is an exercise of the State's police power which is that degree of interference with the use of private property which is neither arbitrary nor oppressive, is equally applied, and bears a real and substantial relationship to public health, safety, morals, or welfare. This definition points out the importance of solid ambient air quality data. This is particularly so in those areas where very stringent limitations have been adopted.

The exercise by which the emission limitations are selected is known as a "control strategy". The applicable control strategies are shown in the implementation plans which the States are required to submit to the Administrator of the Federal Environmental Protection Agency. While mathematical estimates* of existing air quality based on current emissions were, of necessity, used in some plans, the acquisition of representative air quality is the ultimate proof that air quality standards are being achieved. Therefore, emission limitations based on faulty ambient data may be deemed an unreasonable exercise of the Government's police powers. The cardinal rule in designing and operating an ambient air monitoring network is to follow accepted procedures with standardized techniques. It is possible that current emission regulations may be insufficient to reach the specified air quality levels. Only a properly designed monitoring network can perform trend evaluation to determine the effectiveness of current regulations.

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* The diffusion model developed by Miller and Holzworth was used for area emissions while a modification of Turner's dispersion model was used for large point sources. See EPA's Requirements for Preparation, Adoption, and Submittal of Implementation Plans.[29]

Proper instrumentation, methods, calibration, and maintenance are all essential to a legally acceptable program. However, where the data are to be used to establish emission regulations, a singularly important design facet is instrument siting.

A common siting system is the area system whereby stations are distributed uniformly throughout the area. This method will provide a good indication of average ambient air quality. However, emission regulations based on such data will not produce the desired air quality in the so-called hot spots since the average will consist of both high and low readings. Also there is no way to determine the actual existing air quality in the hot-spots. In short, regulations based on data obtained from an area-type monitoring system may be deemed inadequate.

Perhaps the most common siting system is the target system which relies on data obtained solely from the hot-spots, the rationale being that if the resultant regulations achieve the air quality standards in the heavily polluted areas, all other areas will automatically meet the ambient standards. One disadvantage of the target system is that it results in an imposition of stricter emission limitations than is needed for many processes in large areas of the region. This is disadvantageous because the regulated sources may seek to have the regulations struck down on the basis that the emission regulations are unrelated to the achievement of the Federal ambient air quality standards and that such regulations violate the constitutional mandate of equal protection. While the current climate is favorable to stringent regulation, it may be wise to avoid regulation which invites litigation.

A combination of the two siting systems appears to be the most desirable approach to the problem from a legal point of view since it is the only known way to obtain a representative picture of the effect of regulations and emission sources on air quality.

In summary, the following salient points should be remembered:

(a) Before property use is restricted, an evil must exist (unacceptable air quality);

(b) The restriction must bear a substantial relationship to the solution (limit pollutant emissions);

(c) The restriction must not be oppressive (avoid overkill);

(d) A well-designed, well-operated ambient air quality network considers: siting, instrumentation, calibration, maintenance, meteorology, and terrain.

5.2 Samples Used as Legal Evidence

Every test should be conducted as if it will ultimately be used as evidence in court. The collection and analysis of jurisdictional samples should become a routine matter to the State agency personnel involved. However, it must be remembered that this routine procedure is esoteric to the layman and, therefore, is subjected to greater scrutiny whenever the agency has to rely on these results. It is imperative that sampling and analysis be done under standard procedures and that each step be well documented. In short, the report may ultimately be subjected to the requirements of the Rules of Evidence.

In attacking the validity of the sampling results, the adverse party will concentrate on four main items relative to taking the sample: (a) the sampling procedure, (b) the recorded data and calculations, (c) the test equipment, and (d) the qualifications of the test personnel.

The State agency must keep in mind the possibility of adverse inferences that may arise from the use of unorthodox or new procedures. Therefore, deviations from the standard procedure must be kept to a minimum and applied only where absolutely necessary to obtain an accurate sample. Changes in methodology must be based on sound engineering judgment and must be carefully documented. Standard procedures* which should receive particular attention are:

(a) Location of sampling station,

(b) Number and size of sampling zones in the duct,

(c) Use of recommended sampling equipment,

(d) Careful determination of gas velocities,

(e) Maintenance of isokinetic sampling conditions,

(f) Proper handling of the collected sample and recording of container and filter numbers.

5.2.1 Purpose of Samples

Most samples are taken for internal agency use rather than pursuant to enforcement proceedings. While routine samples will rarely be used as evidence of a violation, the possibility remains. Regardless of the end use of the sample, care should be exercised to maintain its integrity as a matter of sound policy. Table 9 illustrates the purposes for which samples may be taken.

5.2.2 Rules of Evidence

Rules of evidence have been formulated to insure that whatever is presented to the court is a bona fide representation of the item or occurrence it purports to be. Source samples and ambient samples will

* In general, see New Source Performance Standards.[30]

Table 9. USE OF JURISDICTIONAL SAMPLES AND AMENABILITY TO CHALLENGE

Type of Sample	Purpose	Chances of judicial challenge
Ambient	Routine ambinet surveillance	Slight
Ambient	Routine source surveillance	Slight
Ambient	Establish and maintain basis for regulation	Fair
Source	Source surveillance	Good
Descriptive	Source surveillance	Good

rarely be used as direct evidence. The evidentiary matter will actually consist of a report based on the samples since the samples, without further analysis, convey nothing. The conversion of field samples to material evidence is a four-step process: (a) taking the sample, (b) transporting and handling the sample prior to analysis, (c) analyzing the sample, and (d) reporting on the findings.

5.2.3 Taking the Sample

The sample must accurately represent the conditions at the time and place from which it is taken. Particular attention must be paid to the procedural steps outlined in Table 10.

5.2.3.1 Location. Where a sample is extracted from a gas stream such as in source sampling, location of the test station must be in accordance with good practice so as to obtain a representative sample.

When sampling for particulate matter and aerosol mists, the primary criterion in selecting the test site is that the sample extracted from this site be representative of the main gas stream. Relatively

Table 10. RELATION OF SAMPLING PROCEDURES TO EVIDENCE

Type of sample	Procedure	Evidentiary element
Source	Location of test port	Representative sample
	Test procedures	Representative sample
	Equipment	Representative sample
	Recording of data	Representative sample
	Personnel	Accuracy
	Marking of samples	Identification
Ambient	Location of equipment	Representative sample
	Test procedures	Representative sample
	Equipment	Representative sample
	Personnel	Representative sample
	Marking of samples	Identification
Descriptive	Location from which sample was taken	Representative sample
	Marking of samples	Identification

little is known about the disposition of particulate within any specific moving gas stream. Therefore, every effort should be made to obtain a site in which the particulate-gas mixture is as homogeneous as possible. Homogeneity is best achieved in straight vertical ducts. Ideally, the gas flow should not be disturbed by any obstruction or change in direction for approximately 7 to 8 hydraulic diameters* upstream and 2 to 4 diameters downstream from a proposed test location.

In addition to flow considerations, accessibility to the site is an important consideration. Safety, as well as clearance for the probe and sampling apparatus, availability of electricity, weather exposure,

* Hydraulic diameter $= \frac{\text{Area of duct cross-section}}{\text{Duct perimeter}} \times 4$.

presence of toxic or explosive gases, etc., must all be considered in selecting a site.

Because of these many considerations, compromises must be made in test site selection although ideal flow conditions should be sought. In some cases, a suitable test site may not be available without major changes in the duct work. If these changes cannot be made, a meaningful sample may not be practical, and only approximate emission results will be obtained. While approximations made pursuant to good engineering practices are generally admissible as evidence, reliance on them is to be avoided where noncompliance with emission regulations is only slight.

If the owner of the process to be tested is required to furnish sampling ports, reliable data can be obtained. For example, the Bay Area APCD requires the owner to provide test facilities (Regulation 2, § 3210). It behooves the owner to provide a proper site since, if the site does not meet the requirements of good practice (as set forth in Regulation 2, § 2036), the emissions will be calculated based on a single measurement taken at the site provided. This reading is considered to be the average for the entire cross-sectional area at the test site (Regulation 2, § 2038).

Location of ambient sampling equipment is not amenable to objective criteria because so many variables are involved. These variables include terrain, meteorology, power source, permission of the owner of the realty, elevation requirements, and purpose for which the sample is taken.

As a general rule, ambient samples that are to be used for air quality determination should be taken from representative locations.

Avoid locations where fumigation effects are obvious. On the other hand, the opposite is true where the purpose of the ambient sample is source surveillance. This rule is also applicable to descriptive samples such as dustfall jars, vegetation, and the like. Static monitors are helpful in determining the overall system design and their use in this regard should be documented.

5.2.3.2 Test Procedures. Both source and ambient samples should be extracted according to recognized good practice. Adjustments to compensate for sample decay, collector efficiency, and the like, should be avoided as much as possible. Test periods should be long enough to collect a sufficient quantity of pollutant. Be aware of the limitations of certain sampling methods and calibration techniques. Above all, use proper test procedures and attempt to use the best sampling method available keeping the end use of the results in mind. One recent court decision has held reliance solely on Ringelmann observations to be insufficient evidence where more accurate tests could have been made.[31]

There are two commonly used methods for source testing for particulate matter--the dry train and the wet train. Many methods exist for extracting gaseous source samples. All source sampling must be done in accordance with the standards set forth in the control regulations. Do not attempt to use samples taken with a wet train when the regulations are written for a dry train, for example. If the air pollution control regulations do not specify source sampling methods, consult your agency's legal counsel. He should be apprised of the fact that more than one source-test method often exists. When source sampling, particular attention should be paid to the following elements of field procedure as applicable to the sampling method used:

Element	Pollutant
° Velocity traverse	Solid
° Isokinetic conditions	Solid
° Number of zones from which sample is extracted	Solid
° Disassembly of train and cleanup	Solid
° Check apparatus immediately prior to use	Solid, mist, gas
° Reagent or water used in train	Solid, mist, gas
° Record data at proper intervals	Solid, mist, gas
° Length of sampling time	Solid, mist, gas

A very important procedural aspect of ambient sampling is that the sample time should correspond with the existing or proposed ambient air quality standards. Attention must also be directed to the reagent and problems of sample decay in the case of some bubbler techniques. If, for example, a sample is subject to decay, it should always be analyzed within the proper time frame. For example, the sample should generally be picked up promptly when only one sample is taken per week. Care must also be taken to avoid the introduction of error due to vandalism and the like. These items must be considered when the network is designed.

5.2.3.3 Equipment. Use of proper procedures implies the use of proper equipment. In addition, it is important that the equipment be capable of extracting a representative sample. This means that the equipment must be adequately maintained and calibrated to function properly.[23] Maintenance schedules should be formulated and records kept. Measuring devices should be calibrated frequently. Where reagents are used, make certain that they are sufficiently fresh.

No hard and fast rule can be given for frequency of maintenance and calibration since these depend on experience with the equipment itself. When new sampling equipment is received, it should be calibrated and maintenance procedures initiated in accordance with the manufacturer's equipment manual. All these manuals should be properly filed. Adjust the frequency of maintenance and calibration as your experience records indicate.

To insure that each piece of equipment is adequately maintained and calibrated, each should be uniquely numbered and records kept on that basis. While a standardized maintenance checklist would be helpful and provide an excellent record, it is not necessary for recordkeeping purposes. A notebook in which the action taken is noted will suffice. As a minimum the record should include:

(a) Date,

(b) Equipment number,

(c) Action taken,

(d) Observation,

(e) Name of person who performed the work.

See Figure 10 for a typical entry in a maintenance journal which records the calibration of a dry gas meter used for a source test.

Reagent records should appear in the chemist's notebook, a routine procedure for all laboratory work.

DATE	EQUIP. NO.	ACTION TAKEN	OBSERVATION	NAME
1-19-72	16	Calibrated against spirometer; adjusted dial linkage.	Recorded flow was 3% high	Doe

Figure 10. Typical maintenance journal entry.

Bear in mind that the absence of consistent and timely maintenance records will cast doubt on the accuracy of the test equipment. Failure to produce these records upon request can result in an impeachment of the test report or may even render the entire report inadmissible as evidence. Where the results of source or ambient samples are the basis for a conviction or an emission regulation, inadmissibility of the test report would be disastrous.

Finally, the field personnel should record the equipment number of each major piece of equipment in use so that the field reports and maintenance-calibration reports dovetail.

In summary, observe the following:

(a) Use equipment numbers,

(b) Establish maintenance procedures,

(c) Maintain your equipment,

(4) Keep maintenance records.

5.2.3.4 Recording of Data. Manual recording of data is required for source tests. Standardized forms should be utilized to insure that the necessary information is obtained. These forms should be designed to clearly identify the process tested, the date and time, location of test station, sampling personnel, and the person who recorded the data. During the actual test period, the meter readings, temperature readings, and other pertinent data should be recorded in the provided spaces immediately upon observation. These data determine the accuracy of the test and should not be erased or altered. Any errors should be crossed out with a single line and the correct value recorded above the crossed-out number.

Do not discard the original field records even if they become soiled. These original records are the best evidence since mere copies are not admissible as evidence. For neatness, the field data may be transcribed or copied for incorporation in the final report but the originals should be kept on file. Since these records may be subpoenaed, it is important that all field notes are legible.

Ambient sampling field records generally consist of an automatic recorder chart. Where such charts are incorporated in the equipment, they should be identified with the equipment number, dated, and signed after being removed from the instrument. Since these charts are original documents, they should be filed for possible future use.

Simply stated, field records should be:

(a) Legible,

(b) Identifiable,

(c) Accessible.

5.2.3.5 Personnel. Samples must be taken by qualified personnel. Before operating continuous analyzers or source sampling, special training or experience is required to insure the accuracy of the data upon which the report is to be based. Also, it is necessary to have a sufficient number of personnel to perform the test. Extensive training is not always required for routine ambient sampling, but the operator should know how to operate the samplers and properly handle the filters, reagent, and samples since he is subject to having his qualifications challenged on the witness stand.

5.2.3.6 Marking of Samples. Care must be taken to properly mark the sample for positive identification throughout the test and analysis procedures. The Rules of Evidence require impeccable procedures for identification of samples, the analysis of which is the basis for future evidence. An admission by the laboratory analyst that he could not be positive whether he analyzed sample No. 6 or sample No. 9, for example, could destroy the validity of the entire report. Positive identification must be provided for the filters and the containers used in any specific monitoring activity.

Filters should be marked for positive identification. The ink on the filter must be indelible and unaffected by the gases and temperatures to which it will be subjected. Filters must be marked before determining the tare weights. If another method of identification is desired by the agency, it should be kept in mind that the means of identification must be positive and must not impair the ability of the filter to function.

Containers in which samples, reagents, and washings are held should also be positively marked. Some agencies have found it desirable to etch a permanent number in each glass container. However, temporary marking, if positive, is adequate.

Both filter and container numbers must be recorded on the field data form if the analysis is to be properly identified with the test.

See Figure 11 for an example of how this requirement is met on a particulate matter source test form.

5.2.4 Transporting and Handling the Sample

Of primary importance in transporting the sample to the laboratory is that precautions are made to eliminate the possibility of tampering, accidental destruction, and/or physical and chemical action on the sample.

To reduce the possibility of invalidating the results, all components of the sample must be carefully removed from the sampling train and placed in sealed, nonreactive, numbered containers. The sample should then be delivered to the laboratory for analysis. It is recommended that this be done on the same day that the sample is taken. If this is impractical, all samples should be placed in a carrying case (preferably locked) in which they are protected from breakage, contamination, and the possibility of loss.

To insure the integrity of the sample, the Rules of Evidence require that a "chain of custody" be established. A good general rule to follow in this respect is, "the fewer hands the better." Containers should not be opened during chain of custody since this could lead to a presumption of tampering. Each person who handles the sample must be able to remember from whom he received it and to whom he delivered it. This requirement is best satisfied by having each recipient sign a receipt which accompanies the sample. In this way it is possible to refute any possible charge of tampering with the sample by having each recipient testify if necessary. Figure 11 shows how the chain of custody is provided on a standard preprinted form.

ANALYSIS AND RECEIPT FORM FOR SAMPLES

(This form to accompany samples from field to lab)

See Sec. 5.2.3.6

Plant ______________________

Run No. ______________________

Location ______________________

Filter No. ______________________

Received from ______________________

by __________ date __________

Received from ______________________

by __________ date __________

Received from ______________________

by __________ date __________

WEIGHT OF PARTICULATE COLLECTED

FIELD CONTAINER NO.	CONTENTS	TOTAL FINAL WEIGHT (mg.)	TARE WEIGHT (mg.)	WEIGHT GAIN (mg.)
	Filter		____ Filter ____ Container	
	Probe & Cyclone Washings			
	Impinger Washings			
	Acetone Washings			

See Sec. 5.2.4

See Sec. 5.2.3.6

TOTAL WEIGHT OF PARTICULATE COLLECTED, W_p = x 2.2×10^{-6} = Pounds

x 15.4×10^{-3} = Grains

VOLUME OF MOISTURE COLLECTED

	FINAL VOLUME (ml.)	INITIAL VOLUME OR WEIGHT	VOLUMETRIC GAIN (ml.)
Impingers		- ml.	
Silica Gel Container No.		- gm.	

Analyzer ______________________

Date analyzed ______________________

TOTAL VOLUME OF WATER COLLECTED, V_T = ml. x 0.047 = scf

Figure 11. Example of preprinted form for analysis and receipt of source samples.

5.2.5 Analysis

Source and ambient samples are transformed into useful information or evidence by laboratory analysis or quantitative measurement. There are four elements to consider:

(a) Equipment must be adequate to properly analyze,

(b) Personnel must be qualified to make analysis,

(c) Analytical procedures must be in accordance with accepted good practice,

(d) Proper records must be kept.

The first three elements are similar to those discussed under Section 5.2.3 and further elaboration is not required. Proper records generally consist of a laboratory notebook. Where practical, standard preprinted forms should also be used. Do not discard these records since it is possible that they will be required to substantiate the final report in the future. Figure 11 shows a typical source test form which is used both in the field and laboratory.

5.2.6 Report on the Findings

Descriptive samples are themselves material evidence. As previously stated, however, source and ambient samples must be analyzed. The report of the analysis is the material evidence. Just as the procedures and data leading up to the final report are amenable to the Rules of Evidence, so is the report itself amenable. Written documents, generally speaking, are considered to be hearsay and, therefore, are not admissible as evidence without a proper foundation. A proper foundation consists of introducing the report by the principal author(s), who should personally testify. Thus in the case of a source sample, the chief of the field team and the laboratory analyst would both be required to lay the foundation for the introduction of the test report as evidence. However, the foundation laying is greatly simplified, though still required, under statutory exceptions to the Hearsay Rule found in the Official Reports as Evidence Acts and Business Records as Evidence Acts which various States have adopted.

The rationale of the Official Reports exception is the assumption that a public officer performing a particular duty performs that duty properly and is under no motive to distort the truth. Basically, the Official Reports exception exists to avoid the necessity and expense of calling as witnesses various persons who may have collaborated in making the records.

To insure the benefit of these statutory exceptions to the Hearsay Rule, all monitoring reports should be filed in a safe place by a custodian who has responsibility for the files. Generally, although the field notes and calculations need not be included in the summary report, this material may be required at a future date to bolster the acceptability and credibility of the report as evidence in an enforcement proceeding. Therefore, the full report including all original notes and calculation sheets should be kept in the file. Signed receipts for all samples should also be filed with the test data.

Public records are also subject to the Best Evidence Rule which basically states that the original of a document is the best evidence and that a mere copy is not admissible as evidence. Microfilm, snap-out carbon copies, and similar contemporary business methods of producing copies are acceptable in many jurisdictions if the original is not reasonably available, its unavailability is adequately explained, and the copy was made in the ordinary course of business.

In summary, the final report based on data obtained from source or ambient samples need not include all the original calculations and test data. However, the original forms and calculations should be kept in the agency's files. It is necessary to keep the actual samples. The original final report should also be filed. It is a good rule to file all reports in the same place. Remember, reasonableness is the key to keeping these reports and data. It is not necessary to keep these documents under lock and key but, by the same token, it may someday be necessary for the author of the report to testify that he knows where the report has been kept since he wrote it.

6.0 MANAGEMENT OF THE TECHNICAL SERVICES GROUP

As discussed in Section 1.3, the technical services group of an air pollution control agency is related to the other three major functional areas--management, enforcement, and engineering. Figure 1 presents the primary and secondary services areas and major functions of the typical technical services group. The relationships between the services rendered by the technical services group and management, engineering, and enforcement groups lie primarily in these listed major functions.

For example, the technical services group can provide analytical data and expert witness to an enforcement group engaged in the preparation of prosecution testimony.

The technical services group must manage its own personnel; in addition, it must provide information to the agency's management (Office of the Director) in the various functional areas presented in Figure 3.

The administrative group is concerned with the management requirements of the overall air pollution control agency, including the technical services group. In order to carry out its function, the administrative group reporting to the Agency Director must rely on the input and assistance of the laboratory or technical services group manager in the various areas of management functions: program planning, budget, personnel, training, litigation, and public relations. Section 6.1 discusses the general requirements of a program management system as it applies directly or is indirectly related with the air pollution control agency's technical services functions. Section 6.2 and those following, present the more specific areas of management which must be dealt with in planning, executing, and evaluating the performance of the technical services group.

6.1 General System Management

The three major management functions of an organization involved in technical services are (a) program planning, (b) execution of processes concerned with achievement of identifiable program objectives, and (c) program evaluation. Since these functions are highly interrelated and thus interdependent, they comprise a total system.

Each of these functional areas can be subdivided into functional areas of smaller breadth, each area having a multitude of interrelationships with other subareas. The following categories and subcategories are listed because they are generally applicable to technical programs and will be subsequently discussed as they relate to the supply and support of technical services functions to the air pollution control agency:

(a) Program Planning:

  (1) Identification of Objectives,

  (2) Organization,

  (3) Staff,

  (4) Budget.

(b) Program Execution:

  (1) Direction,

  (2) Coordination.

(c) Program Evaluation:

  (1) Analysis,

  (2) Report.

In an operation, each of these categories is dependent on each of the other categories. None can be considered static or merely "once a year" tasks. An event or effect causing a change in one subcategory will probably generate changes or require adjustments in other categories; these adjustments, in turn, may effect still other changes in other categories. Thus, in actual practice, the entire management system is dynamic and highly integrated. In any particular management system, certain relationships between categories may be stronger than others, but none is completely independent of the other.

Management of the technical services group must allow and provide for the accomplishment of its operational functions while complying with the structure and specific organization of the air pollution control agency being served. The general objective of "management" is to accomplish the required operational functions in an optimal manner within the limits of available technology and within the constraints imposed by statutes and regulations, budget, availability of personnel, and organizational structure external to the technical services group. These factors are illustrated in the following discussions of subcategory management functions.

6.1.1 Planning

Planning requires the identification of specific objectives to be achieved. Basic objectives for a technical services group may be identified by determining what must be done to meet the requirements imposed by State law or regulation, by approved State implementation plans, and by its parent agency. Review of pertinent documents permits listing of such requirements. When several means are available for meeting these requirements, the practical alternatives may be listed and judgments made regarding the combination of alternatives. In some cases, quantitative procedures can be applied to the selection of an alternative; in others, a subjective judgment on the part of the group manager must be made.

Identification of legal and other requirements permits the development of objectives. Stated objectives, to be useful in program management, must be quantitative. For example, ". . . to operate a comprehensive air quality monitoring system in an efficient manner . . .," is not an adequate statement of objective. Such a statement may serve as a general goal for a technical services group, but it will not serve as a specific objective since it is nonspecific and is incapable of quantification. Specific objectives pertinent to such an air monitoring goal might be stated as follows:

> "To maintain and operate an air quality monitoring system to satisfy the laws and regulations of the State of __________, and the requirements of the Implementation Plan for (pollutants) approved by the Administrator of the Federal Environmental Protection Agency on (date).
>
> "1. Operate a network of (number) high volume filter samplers for suspended particulate matter as described in the (identify) Implementation Plan, to yield valid samples no less than ___ percent of the time for the network average and no less than ___ percent of the time for any one station.
>
> "2. Operate a network of (number) (type) air samplers for sulfur dioxide, etc. . . ."

Such specific objectives are of use to the technical services group manager in a variety of ways, including his estimation of budget and staffing needs, and as a base for use in evaluating accomplishments of the group during and at the end of the period covered by the plan.

While basic objectives may be identified in an examination of requirements, legal and otherwise, that are imposed on the group, other objectives which are important to the long range functioning of the group may not be made apparent by that examination. Obviously, such objectives may relate specifically to matters such as data processing, public information, or staff training. Needs of these types will vary from program to program and will no doubt lead to the identification of others.

6.1.2 Organizing

A variety of organizational classifications found among State agencies is described in Chapter 2. The advantages and disadvantages of locating technical services and laboratory functions either within or external to the State agency are discussed in that chapter. Some management factors pertinent to the matter of organization, wherever the activity is located, will be examined here.

Development and revision of organizational structure is a management function. Conventional formal organizational structures, such as those ordinarily used for technical services functions, are pyramidal in nature with responsibility and authority increasing with successively higher positions. The span of control is a matter of considerable importance in the organization of a technical services group. In a highly repetitive and routine endeavor, one supervisor may perform satisfactorily with 10, 20, or even 100 direct subordinates. Such situations are seldom if ever found in even the largest and most stable technical services groups in air pollution control agencies. While a satisfactory span of control for any given activity will vary somewhat with the organization and with the qualifications and characteristics of the supervisor and his subordinates, in highly technical activities it should generally be small, on the order of five or fewer direct subordinates per supervisor.

Figure 12 presents the organizational elements and managerial configuration for a typical technical services group. The concept of line and staff positions in the organization will not be discussed here in detail. However, in the conventional concept, line positions are those through which operating authority flows, while staff positions

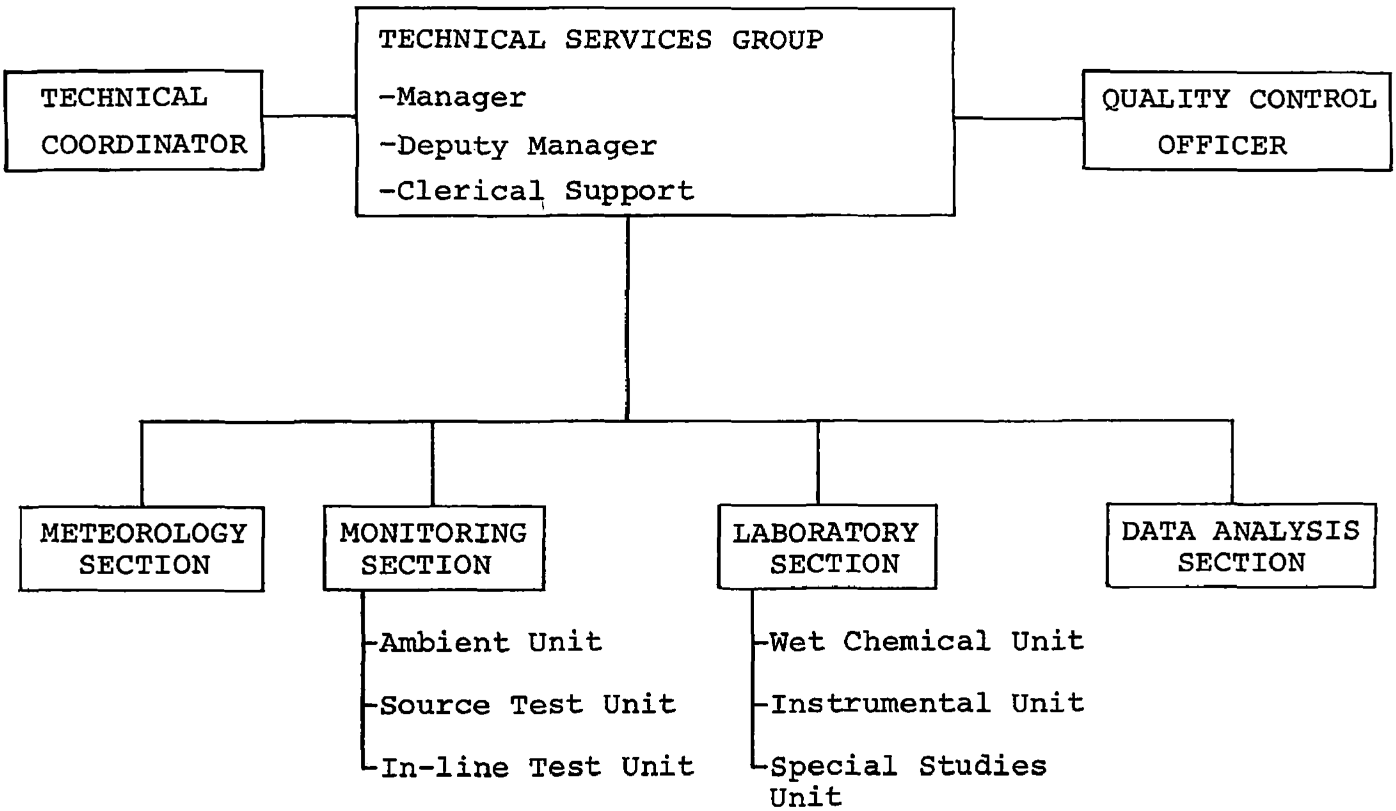


Figure 12. Typical organization chart for technical services group.

are those of a functional advisory nature who report to, and assist, a particular line manager. In this concept the operating responsibility and authority reside in the line manager, not in members of his staff. It is important for line managers of all levels to recognize, however, that staff positions in reality often exercise a considerable degree of authority in their functional areas. Many matters of budget, personnel, facilities, technical information, quality control, and the like, which are often handled in functional staff offices, have as great an impact upon program operations as do decisions made in the line management hierarchy.

The formal organizational structure for a function such as technical services in an air pollution control agency is ordinarily designed to accommodate a continuing long-range program. Such an organizational structure may not be very appropriate for nonroutine projects which must be undertaken periodically. Development of an ad hoc project group, without altering the established organization, is appropriate in such cases. The project manager may be drawn from any element of the organization, and his coworkers from his and other elements; their participation in project activities may be on a part- or full-time basis. Project responsibility in the group need not necessarily be assigned in the order of rank or position in the parent organization. Upon completion of a project, the project group is inactivated and its members continue in their assigned positions in the formal organization. It is important that the line of reporting for individuals assigned in project groups be clearly defined since they have two supervisors--the organization supervisor and the project supervisor. Depending on such factors as project priority and agency policy, a person so assigned to a project group might be directed to report first through his functional supervisor, then through the project manager. However, this should be decided at a higher level of management than either the person's immediate supervisor or his assigned project manager.

6.1.3 Staffing

Year-by-year and long-range program plans should identify manpower needs on a functional element basis. It is not necessary that all manpower needs be satisfied by in-house staff. Use of extramural manpower resources is discussed in Chapters 4 and 9.

The characteristics of job classification, and schedules for grades and salaries, are often prescribed by the State, or perhaps by the parent agency within which a group functions. The provision of technical services within a State air pollution control agency involves some highly technical activities. In some States, restrictions on grade and salary have hindered the satisfactory staffing of such technical groups. Sought through proper channels of appeal, means sometimes can be found to ease such restrictions and facilitate recruitment. When restrictions are encountered, a thorough effort to find the means for relief is in order. Competent staff is vital to success of the program and to proper utilization of the resources which are devoted to it.

A continuing program of staff training, both short courses on technical and administrative topics, and long-term professional training for selected staff members, merits the attention of managers at all levels. Long-term benefits in the form of increased quality and efficiency in operations, staff retention, and recruitment of better job candidates, accrue from a liberal and vigorous training program. Some training can be conducted in-house within a State agency's on-the-job training program, in addition, training courses on specialized topics are available at the Federal agency level.

6.1.4 Budgeting

Budgeting format and procedures for the technical services group of an air pollution control agency are ordinarily dictated by State or local agency requirements. The required procedure may or may not involve budget development by line item on a function by function basis. Functions to be used are those as determined in an activity plan as discussed in subsection 6.1.1.

Typical line items that must be included in developing a group's planning budget are salaries, personnel costs (insurance, retirement, incentive compensation, etc.), facility costs (rent, utilities, etc.), equipment acquisition and maintenance, supplies and materials, travel, communications, and contractual services. If the established budget development procedure does not involve a listing which permits identification of funds for these elements, serious consideration should be given to construction of such a listing. It is a useful management tool, both in budget development and in evaluation of progress in various projects through the time interval covered by the plan.

Not all costs for all functions will appear in the budget of a group if services are received from other elements of government and the costs of these services are included in their budgets. Unreimbursed services received from a State forestry service or agriculture department, for example, or from a city or county government, represent a project cost which does not appear in the air pollution control agency budget. Such costs must be recognized and included in assessing total cost of a project and in judging relative costs of various alternative means for achieving any particular program objective.

A common difficulty among governmental agencies involved in technical programs such as air pollution control is inbalance in funds for personnel services (salary and other related services) and other operating funds (travel, communications, equipment, etc.). Line items to be included in operating budgets may vary from agency to agency, and the operating expenses will not be the same among all agencies. A new or expanding activity, for example, may require more funds for equipment acquisition than does an established activity. In general, however, experience has shown that for technical programs whose budgets include the range of line items listed above, funds committed to personnel services should not exceed about 65 percent of the total budget. Programs can operate successfully with personnel services greater than 65 percent of budget, but it is suggested that managers carefully scrutinize programs showing personnel services budgeted substantially higher than this level to determine whether performance might be improved by adjustment of funds distribution. As the ratio of personnel service expenditures increased, more manpower is available, but this larger working group has fewer resources with which to work. An increase in funds expended for personnel services from 65 to 80 percent of budget, for example, increases manpower by less than one-fourth, but decreases to about one-half the nonpersonnel services resources available per man. The lack of adequate nonpersonnel service resources may seriously inhibit the operation of a technical services group and prevent achievement of objectives which could actually be reached with fewer people having better facilities and greater flexibility for action.

6.1.5 Directing

The management function of program direction is generally that of motivating and controlling the activities of subordinates. It is of particular importance in the technical services functions of air pollution control agencies that operations be so conducted that they are consistent with laws, standards, regulations, and policies applicable to the jurisdiction within which the agencies operate. Some standardization of technical procedures is ordinarily practiced, especially when the results may be used in a regulatory or judicial action. The establishment and documentation of procedures by means of operating manuals, memorandums of instruction, and the like, is of value in this regard. With established procedures and clear enunciation of agency policies, the process of "management by exception" can be practiced. In this process, decisions relative to day-by-day operations are made at each level of supervision according to established practices and policies of the agency. When a situation arises at any level of supervision which is an exception to the established practice at that level, the matter is taken to successively higher levels of management until it is resolved.

6.1.5.1 Responsibility Succession. The technical services group of an air pollution control agency may have specific responsibility for action in regulatory or episode avoidance procedures. The laws or regulations governing such responsibility, or the assignment of such responsibility within the agency, may specify an officer of the group as having responsibility and authority to act. Some designated person must be available to act at all times, yet a single individual cannot be constantly accessible. Thus, a succession of responsibility should be established and documented within the group. This document should list, in order, each person to whom authority and responsibility are delegated in absence of persons whose names appear earlier in the list. In the development of this listing of persons in succession of responsibility, it is well to seek advice of legal counsel to assure that all persons listed meet any requirements imposed by law or regulation.

6.1.6 Coordinating

Technical service functions of an air pollution control agency by their very nature, have a high degree of interaction with other functions of the agency, and other elements of the State or community. Coordination of the technical services functions as they relate to these extra-agency elements is a management function. The coordination function in some cases may be highly specific. For example, participation in the SAROAD program of the Federal Environmental Protection Agency requires adherence to agreed performance criteria regarding methodology, data format, and the like which may influence major portions of the technical functions. The conduct of joint projects and intergovernmental cooperation as described in Chapter 4 imposes a coordination role upon project managers. This is especially important in interstate and multiagency activities. A general agency policy, consistent with State laws and regulations, regarding exchange of data, review of draft reports, assignment of personnel, equipment, and facilities, is a useful guide for technical services managers in their relations with extra-agency elements.

6.1.7 Analysis

Evaluation of the effectiveness of a technical services group in an air pollution control agency requires relating accomplishments in its various projects to stated program objectives. A summary evaluation should be made each year for use in planning, programming, and budgeting processes. Evaluations less comprehensive than the annual evaluation should be undertaken at more frequent intervals, perhaps on a bimonthly schedule, to permit assessment of progress toward meeting the year's objectives. Special attention should be given to activities which depart markedly from a reasonable time schedule, particularly those which fall behind schedule. A senior person in the management group or the technical coordinator, a staff position in the immediate office of the technical services group manager, should have specific responsibility for conducting the interim and annual evaluations, and for coordinating input for them. He should provide interim summary reports of progress to the technical services group manager.

The evaluation process is also the means by which various alternatives are weighed and by which choices are made for improvements in program operations. Determination of the optimal mode of operation requires evaluation of the relative efficiencies of performing various subfunctions within the technical services group, by other agencies or service elements, or by commercial contractors.

A systematic approach to efficient management is possible through techniques of cost/benefit analyses, efficiency studies, staff selection procedures, and facility arrangements evaluation. Trade-offs between capital expenditures and operating costs must be evaluated, and current and anticipated funding levels must be considered continually. Such an approach presumes that the functions and subfunctions of the technical services group are well defined.

6.1.8 Reporting

The reporting function for a technical endeavor such as the technical services group of an air pollution control agency takes several forms. In-house operational reports such as data tabulations, project progress reports, etc., are necessary for information exchange within the group and with its parent agency. Reports relating in whole or in part to technical services functions are necessary for exchange by the parent agency with other governmental agencies such as the Federal Environmental Protection Agency, the State legislature, or regional and local air pollution control agencies. Reports of technical advances or new findings made in the course of work should be made to the technical and scientific community through the technical journals or through direct publication by the agency. Finally, reports must be made to the public to fulfill requirements imposed by legislation, on initiative of the agency, and in response to inquiry.

Supervision of the reporting process by assuring the preparation of required reports, identification of additional reporting needs, maintaining high quality of reports, and the timely completion of reports, is a management function whose importance can hardly be overstated. A technical program excellent in all other respects, but deficient in reporting, may be ineffective in achieving its goals.

The public relations function is of some importance. This function is the means through which the community is informed and educated regarding existing and prospective air pollution problems, and is told of the means and need for prompt, effective solutions. Professional public relations services for the technical services group should be sought in its parent agency or government department. In-house responsibility for technical information dissemination functions can be delegated to a staff position such as that of the technical coordinator or technical advisor to the technical services group manager.

6.2 Specific Systems Management

The following subsections are devoted to specific management functions which are of direct concern to the technical services manager and his administrative staff. As discussed in the preceding subsection (6.1), a multitude of interrelationships exist among the various management categories and subcategories; this is particularly due to the recurrent nature of the planning-execution-evaluation management system. Thus the technical services group manager must consider his resources, both personnel and facilities, in both the planning and evaluation phases of management. He must be concerned with existing operational efficiencies, logistical considerations, and cost/benefit relationships in the execution and evaluation phases of management. Such specific responsibilities are, of course, overall program responsibilities and as such are part of the agency's management services functions. It must be remembered, however, that the technical services group manager and certain members of his staff are "management" personnel, serving as extensions to the management services group by delegation of responsibility. The information and management functions resulting from this responsibility at the technical services function level serve as inputs to the air pollution control agency's overall management system. It is necessary, therefore, that the technical services group maintain a continuing management function, keeping up-to-date records and staying abreast of state-of-the-art planning-execution-evaluation techniques.

6.2.1 Resources: Personnel

6.2.1.1 Number of Staff Required. Several techniques are available for estimating the number of the several categories of people required to provide the technical services necessary for an effective air pollution control agency. None of these techniques provides a number that can be accepted without question--the results of each must be adjusted on the basis of the agency's experience, professional judgment, and special characteristics of the State's pollution problems and agency's interests. The latter factor is significant since it is reasonable to assume that ambient air monitoring requirements are established by more-or-less fixed characteristics of the industrial and commercial geography, and the demography and the terrain of the State, but that the scope and extent of special air quality investigations are determined primarily by the interests of agency personnel.

Minimum requirements for a statewide air quality surveillance system have been established by the Federal EPA,[29] and are shown in Section 3.2. Agency resource requirements are necessarily related to the designated pollutant measurement method, the sampling frequency, and the monitoring site number and type (continuous, intermittent, or static).

Approaches for defining the manpower needed to staff a technical services group are, of necessity, related to the staffing requirements for the total air pollution control agency. Estimation of agency manpower needs include the following methods:

(a) Extension of existing operation data,

(b) Utilization of empirical correlation (i.e, manpower models),

(c) Professional judgment based on experience,

(d) Combinations of the above.

The first approach is limited to operating agencies and to the functions conducted by their agencies. If an agency already has a monitoring network and is expanding into a larger area with more stations or is increasing the capabilities of the stations (e.g., bubblers to continuous monitors, or two pollutants to five pollutants),it should not be difficult to estimate additional or new manpower requirements.

It is sometimes beneficial to look at the manpower requirements for an ongoing, effective air pollution control agency outside of one's own jurisdiction. This outside agency could be a State or local air pollution control program with operational characteristics and problems similar to one's own. Table 11, for example, describes the monitoring network and manpower estimates for operation and routine servicing for a designated air quality control region.[32] Such a manpower summary is based on "rule of thumb" factors: 0.5 man-year per continuous station or 0.6 man-year if the continuous station includes a meteorological package; 0.1 man-year per intermittent sampler/station. Another useful estimate is 0.1 man-year per sensor for the entire network exclusive of static samplers.

When the professional judgment approach is taken, more fundamental manpower estimates can be made using first-hand experience. For example, to estimate manpower requirements for a monitoring network, the station's location, accessibility, and types of monitoring equipment are considered. Considerations include travel time, frequency of site visits, and average station time based on routine operations as well as maintenance requirements.

Table 11. SUMMARY OF MONITORING NETWORK ST. LOUIS AIR QUALITY CONTROL REGION (Ref. 32)

Ultimate network	Number of stations	Estimated man-years for operation
Missouri		
Continuous operating station[a]	2[c]	1.1
Intermittent sampling station[b]	7	1.4
Total	--	2.5
Illinois		
Continuous operating station	1	0.5
Intermittent sampling station	6	1.2
Total	--	1.7

[a] Continuous operating station. Assume 0.5 man-year per station; 0.6 man-year per station when meteorological instruments also present.

[b] Intermittent sampling station. Assume 0.1 man-year/sensor/station when operated every 3rd day per year. However, they are operated more frequently during emergency episode surveillance. Intermittent sampling stations usually contain 2 sensors, namely SO_2 bubblers and high volume samplers.

[c] Meteorological instruments at station located in high pollution area.

If the air pollution control agency is new or is otherwise inaccessible to basic manpower data, from existing operations, it can make use of an empirical approach such as the Air Pollution Control Agency Manpower Model.[33] The Manpower Model represents the collective experience of several existing programs and is structured to provide an estimate of manpower needs for each of the established agency functions, including that involving technical services support. The model is based on four readily available characteristics[34,35] of the agency's jurisdiction (land area, population, number of manufacturing establishments, and capital expenditures) and is built around four key agency functions: air monitoring, scheduled inspections, field patrol and complaint handling, and operation of the permit system. This model is presented in Appendix D.

6.2.1.2 Level of Training and Experience. The training and experience required of an individual filling a specific position within an organization is directly related to the responsibility and authority delegated to that individual as the incumbent. The discipline or field in which one has been trained carries more importance in the professional grades, particularly if the position is at the "working" or nonsupervisory level.

In general, at the entry level of professional work, whether it be as a chemist or one of the branches of engineering (e.g., mechanical, environmental, sanitary, etc.), only appropriate education is required, as represented by a bachelor's degree from a recognized institution, or by a combination of some years of formal education, but no degree, supplemented by experience in the field. Sometimes experience is accepted on a one-to-one basis in lieu of formal education for no more than two years. At the entrance level, the professional employee is not assigned supervisory responsibility but, in fact, is subject to direct supervision himself.

The entrance level requirements establish the base on which the entire professional grade structure within an air pollution control agency is developed. Advancement to higher grades (or entrance at a higher grade level) is dependent upon satisfying the entrance level requirement plus the accumulation of experience. Typical requirements for experience for several categories of chemists and engineers as well as for technicians are given in Table 12. It should be pointed out, however, that if the highest technical level of education is the master's degree level, the technical depth of the group could (not necessarily always) be low. The grade levels (GS ratings) are related to the duties and responsibilities of the position itself. In-grade or step levels within each grade (ten sublevels) are indicative of job performance. Subpar performance may result in an in-grade demotion or no increase; adequate performance results in annual or periodic step increases; superior performance deserves multiple step increases. Appendix B contains examples of job responsibilities or position descriptions for various technical service grade levels.

6.2.1.3 Salary. In the rapidly expanding field of air pollution control, the demand for trained personnel has resulted in a general upgrading of salary levels. It is difficult to say whether this trend will continue. Also, salaries for positions with identical descriptions may differ from agency to agency as a result of the necessity to meet the demands of the competitive labor market. A 1969 survey conducted by the National Society of Professional Engineers indicated that the New England and Middle Atlantic regions are areas of highest pay for engineers. Relative salary levels for the South, West, Midwest, Southwest, and Plains region were 92, 92, 89, 87, and 84 percent of the New England and Middle Atlantic level, respectively. Salary surveys for chemists appear annually in Chemical and Engineering News.

Rather than attempt to discuss and justify actual salaries, an effort is made here to show the relationship between salaries for the several grades mentioned in the preceding subsection (Table 12).

Table 12. TECHNICAL SERVICES PERSONNEL LEVELS AND REQUIREMENTS

Labor rating	Position	Qualifications (minimum requirements)	Minimum education (or equivalent)	Minimum experience (years)	Equivalent grade level	Base salary levels
1	Assistant AP tech.	Semiskilled aide with limited background	HSG/AA	--	GS 3 to 5	5800-7300[a]
2	AP tech.	Experienced aide with background technique and some knowledge of chemistry	HSG/AA	0-2	GS 4 to 6	6500-8200
3	Assistant AP chemist/ junior engineer	Professional with modest training and experience	BS	0-2	GS 5 to 7	7300-9000
4	Expert AP tech.	Proven experience in highly specialized area	AA	2-4	GS 7	9000-11700[b]
5	Supervisory tech.	Project management ability plus firm technical background	AA	4-6	GS 7	9000-11700[b]
6	AP chemist/ engineer/ analyst	Wide experience in air pollution chemistry, engineering or systems analysis, computer programming	BS	2-4	GS 7 to 9	9000-11000
7	Senior scientist/ engineer	Experience in complex and specialized areas of analytical chemistry/ environmental engineering	BS/MS	4-6	GS 11 to 13	13300-18700
8	Supervisory professional	Experienced at project management level; firm background in all technical areas	BS/MS	4-6	GS 12 to 14	15900-22000

[a] In-grade level; step one.

[b] In-grade range.

HSG - High School Graduate
AA - Technical School Graduate
BS - Undergraduate Degree
MS - Graduate Degree

Relative annual salaries, and the range of salary for each grade, are shown in Table 13.

6.2.1.4 Training Programs. It is anticipated that formal training programs will be required in several technical service areas. Often training courses will be conducted by the State agency headquarters for each of the cooperating laboratories, both local agency and satellite State operations. In addition, reliance is placed on the training programs conducted by the EPA to keep State agency personnel abreast of approved techniques and procedures. Information and guidance obtained at EPA training sessions are disseminated within the State agency through on-the-job training and agency memorandums or directions.

On-the-job training offers the most practical method of increasing the proficiency of technical services personnel. In addition, full advantage should be taken of instruction offered by manufacturers for

Table 13. RELATIVE ANNUAL SALARIES AND WITHIN-GRADE SALARY RANGES

Grade level	Base salary[a]	
	Step No. 1	Step No. 10
3	5,800	7,500
4	6,500	8,500
5	7,300	9,500
6	8,200	10,600
7	9,000	11,700
8	10,000	13,000
9	11,000	14,400
10	12,100	15,800
11	13,300	17,300
12	15,900	20,600
13	18,700	24,400
14	22,000	28,300
15	25,600	33,300

[a] Overhead rates associated with the base salary must be included for budgeting.

both the operation and maintenance of their specialized equipment or instrumentation. Periodic meetings, for example, of air monitoring program personnel to discuss problems encountered with instrument operation and solutions to such problems can be a useful training device. Similar sessions appropriately scaled are essential for the indoctrination of personnel when new instruments, procedures, or methods are introduced.

6.2.2 Resources: Facilities

6.2.2.1 Space Requirements. The source sampling operation within the technical services group requires both office and workshop space.[22] Shop space allocation is approximately 70 square feet of shop area per man.

Office space is normally determined by administrative policy, and space requirements are often considered on a basis of the number and type of desks. A minimum of 50 square feet is required pe· desk. Small private offices require at least 80 square feet. Many organizations figure their space requirements on the basis of the number of professionals employed. A common guide of 130 to 150 square feet of office space per professional is used by organizations engaged in scientific and technical activity. Space costs in leased office buildings are on the order of $5 to $6 per square foot per year.

There is no single design for a remote air sampling station. The design chosen depends on such factors as agency needs, climate, equipment contained, neighborhood, and mobility. In cases where the station is used without additional support laboratory facilities, extra space is required. The need for mobility, of course, is a space limiting factor.

In general, a self-sustaining remote air sampling station has the following minimum space requirements:[2]

Instrumentation and laboratory area	150 sq. ft.
Work area (desk and sink)	30
Compressed gas cylinder storage	15
Miscellaneous storage	10
Toilet facilities	15
Sampling equipment area	40
	260 sq. ft.

The sampling equipment area must be an elevated surface, such as the building roof or separate structure. The area must have sufficient structural support and roofing material and must be accessible by stairs or ladder. The overall cost of a remote shelter varies widely throughout the country because of the changing labor situation. Mobile facilities are more costly than conventional stationary sites. A good estimate of shelter costs based on facilities for heating, cooling, sink, toilet, elevated work platform, and electrical services would be in the $30 to $40 per square foot range. A more reasonable alternative would be the remodeling costs which would run about $10 to $15 per square foot. If plumbing or electrical services were not readily available, this cost would, of course, increase.

Laboratory space requirements vary depending on the number of analysts, the equipment used (wet lab versus instrument lab), and the need for storage of reagents, sample containers, and the like. Rules of thumb allocations are 200 square feet of space per laboratory module; 150 to 250 square feet of space per analyst; and 10 running feet of bench space per analyst. Leased space costs for an analytical laboratory are in the $10 to $20 per square foot per year range.

The laboratory contains sinks, hoods, laboratory benches and desks, a water demineralizer or still, hoods, muffle furnaces, and facilities for gas and water service. It is a laboratory in which the preparation of reagents for the air monitoring stations, calibration of instruments, and maintenance of equipment is done. Also, fuel oil and coal analysis plus source testing and special sample analysis are accomplished. These latter functions are usually performed in a separate module.

Another space in the laboratory, usually separate from the wet bench areas, is the instrument shop and storage area. This space is used for maintenance, repair, and routine cleaning of air monitoring equipment and sampling gear. Usually 1,000 to 1,500 sq. ft. is a desirable storage and shop area for large agencies.

Where required in State programs, motor vehicle testing occupies offices, laboratories, storage rooms, and a large open work area. The laboratory is used primarily for testing and calibrating the program's equipment as well as providing for general research requirements. The large open work area is used to test fleets of vehicles for motor vehicle emissions. The open work area contains dynamometers, all the program's diagnostic equipment, and automobile tune-up facilities.

6.2.2.2 Equipment Requirements. The major equipment items for a source test program are the sampling trains, vehicles for equipment transportation, and associated laboratory equipment.[22] A new panel truck or station wagon costs in the $4,000 to $5,000 range. A complete sampling train costs $3,500. At least two complete trains are normally required.

Associated laboratory equipment and miscellaneous hardware, which can be shared by more than one team, costs about $2,000. Such equipment includes an analytical balance, desiccator, Orsat apparatus, and calibration devices (spirometer, mass flowmeters, or calibrated orifice). Additional costs to be considered are equipment and vehicle maintenance and depreciation costs.

A complete listing of automatic air monitoring equipment costs can be found in Appendix A of reference 2. In addition, a recent journal article described the current state of the art of air monitoring and related equipment costs.[36] Common ambient air pollution monitoring techniques were discussed in terms of sampling and analysis costs for static, mechanized, and automatic equipment. In general, a Hi-Volume sampler costs $300 to $400. A gas bubbler system costs $700 to $1000. Laboratory-type recorders cost $1,000 to $1,500 each.

Capital laboratory equipment costs vary with the monitoring network, source sampling program, and special studies undertaken. The samples to be analyzed from these three sources may require only an analytical balance for gravimetric suspended particulate determinations or a whole array of instrumental hardware for such things as metal analysis (atomic absorption and emission spectroscopy), asbestos analysis (electron microscopy), polynuclear hydrocarbons (thin layer chromatography plus spectrophotofluorescence analysis), sulfur compounds (flame photometry, coulometry), and gas analysis (gas chromatography, spectrophotometry).

Other pieces of equipment used in air pollution research or special studies include mass spectrometers, X-ray fluorescence instruments, and radioactivity counters. Equipment costs range from a simple colorimeter at $2,000 to a mass spectrometer costing over $100,000. Atomic absorption instruments, gas chromatographs, spectrophotometers, and related laboratory equipment are priced in the $5,000 to $15,000 range.

6.2.3 Specific Techniques for Technical Services Group Management

6.2.3.1 Cost/Benefit Analysis. There are several reasons why the technical services group manager may wish to conduct a cost analysis. It will be useful in planning next year's budget, especially if expanded operations are foreseen; it will help in the evaluation of current operations; and it will be a worthwhile tool in project execution, in that in-house costs can be properly weighed against the employment of the outside contractual mechanism. Not only cost but related benefit must be considered. For example, a benefit of keeping an operation in-house is that the investment in personnel training and equipment purchase can be utilized in future related work requiring the same skill level and/or the same piece of equipment. On the other hand, a benefit of conducting a project or laboratory operation through an outside contractor is that it can free the technical services group to work on higher priority matters. There are many other benefits that can be realized by either keeping a technical services function in-house or contracting it out.

Comparative costs of performing certain defined categorical subfunctions can be derived by comparing the estimated costs of performing the tasks within the technical services group with the costs of using facilities and personnel of other departments or agencies, or contracting the job or service outside the government structure. In estimating costs of performing the subfunction within the technical services group, the volume of work to be done, the man-hours required, the equipment needed, the space required, the time distribution of the work load needed, and the response priority that must be given the subfunction must all be considered.

Another factor that must be considered is the importance of foregone tasks, i.e., those tasks which could be done in-house if the categorical subfunction under consideration were contracted out. For example, an agency might not be able to perform microscopic analysis of particulates without decreasing the manpower available for analysis of gas bubblers. If the decision were made to perform the particulate analysis at the sacrifice of less bubbler analysis, the bubbler analysis would be the foregone task.

As discussed in Chapter 9, there are several important considerations in determining whether or not a particular task or study would be better conducted in-house or by contract. Two very critical factors are task priority (how quickly the results must be ready) and task compatibility (how the proposed work will affect the existing program). In some cases, the priority and/or capability benefits of conducting a project on contract far outweigh the increase in cost outlay. In other situations, priority and compatibility are not the major considerations; direct labor costs, equipment costs, and overhead costs become determining factors in evaluating in-house versus outside contractor cost-benefit.

Economy of scale is an important factor in cost analysis. If, for example, a task requires special equipment and a skilled operator, costs per job will be high if the work volume is so low that the equipment, operator, and work area (space) are idle a significant portion of the day. While "convenience" and "independence" factors will carry some weight in the management decisions, idle equipment, personnel, and space are difficult to justify, since they represent a portion of the overhead costs to be assigned to the particular project, task, or laboratory operation under consideration.

Detailed cost analysis can be applied at several levels: to the overall technical services program, to the technical services program's organizational subelements, to specific projects performed within the program, or to individual laboratory and field operations. Basically, the costs are broken down into the line items (and subitems) of direct costs, overhead costs, and general and administrative costs (G&A). The overhead and G&A costs are often referred to as combined overhead costs and average about 33-1/3 percent of direct costs for an air pollution control agency.[37]

Direct labor costs for individual laboratory operations can be determined by defining the number of supervisory, professional, and technician man-hours required per unit operation; the skill level for each of these personnel categories; and the average hourly rates for each skill level. Burdened rates for specific laboratory or field operations must consider not only the agency's current overhead rate, but the additional costs of idle personnel and equipment downtime related specifically to that operation.

6.2.3.2 Efficiency Studies. Another beneficial management tool is efficiency studies to help in the planning, execution, and performance evaluation of the technical services program. Efficiency studies can be used either to determine desirable equipment characteristics or to fit the right man in the right job. Over-trained as well as under-trained personnel can result in lower efficiency. It has been found that poorly educated persons do well in carrying out certain types of routine operations; a more educated individual tends to think too much about what he is doing instead of developing a routine procedure.

Many subfunctions of the technical services group involve tasks that are amenable to automation. A number of factors enter into the decision as to the most effective method--manual or automatic--of accomplishing such tasks. One constraint in these efficiency studies is that 11 of the alternative methods or procedures considered must be acceptable under either Federal and State or local regulations. Further, it is suggested that the appropriate city, county, or State attorney who will be responsible for litigation of air pollution cases be consulted to determine if results of the various alternative methods are equally acceptable under the Rules of Evidence and by precedent.

Once the legal acceptability of the alternative methods has been established, performance characteristics of the specific devices or procedures being considered can be assessed. In particular, reproducibility, resolution, sensitivity, and response time or time constant are of concern. Also of importance is the reliability of the devices or systems being considered, a factor which might be measured in terms of the mean time between failures, and the percentage of observations lost during some selected period as a result of failures, maintenance, or waiting for replacement parts.

If performance characteristics of the alternative methods are satisfactory and comparable, a comparative cost analysis can be made, keeping in mind that the proposed methods may require increased technical skills and, consequently, additional employee training or replacement. The purchase of an automated spectrophotometer for a State agency's central laboratory would not be difficult to justify; on the other hand, small local agencies and State satellite laboratories can often do better with a rather inexpensive colorimeter.

Work volume is a critical factor in analyzing the relative efficiencies of manual and computer data processing. For small amounts of data, charges for keypunch, verification, computer operator, and computer time itself may generate relatively high costs per unit output. When data quantities are small, it will ordinarily be found that a clerk using a desk calculator can provide data processing service at a lower unit cost than that for computer processing. A single ambient continuous station or several intermediate stations can be handled manually. An episode alert network or a group of three or more continuous ambient stations normally require computer processing for reasons of immediacy and cost, respectively.

Efficiency studies directed toward choices other than that between automated and manual operations will also prove useful. An increase in operating efficiency of a laboratory frequently can be achieved through changes in work patterns of personnel or by simple physical rearrangement of furniture, equipment, storage or supply facilities, etc. If formalized, studies of such factors are classed as time and motion studies; the basic concept is to make the facility "convenient" for the workers.

Similarly, attention should be given to the activities of field personnel: whether they have appropriate tools and materials for their jobs; whether the vehicles being used are suited to their purposes;

whether successive assignments are being undertaken in the most efficient order; and whether the routes being followed are the most efficient, when both time and distance are considered. Such activities merit investigation; consultation with field personnel is essential in arriving at the answers to these questions concerning efficiency and appropriateness.

6.2.3.3 Logistics. The logistics operations of a technical services group include the acquisition, storage, and distribution of laboratory and field supplies, spare parts and chemicals, and the packaging, transportation, and storage of collected samples before and after analysis.

Initial quantities of supplies, spare parts, and chemicals must be based on manufacturer's recommendations, the sampling plan (number of stations, sampling interval, etc.), and shelf deterioration or reagent stability. After a sufficient period of operating time has elapsed, stock levels to be maintained can be derived from experience, if adequate records have been kept. Records of consumption of supplies and reagents, and requirements for repair should be kept for each instrument, rather than just by station, for obvious reasons. Experience will soon indicate whether the technical skills of the personnel permit the stocking of instrument parts, or whether subassemblies, components, or modules are required.

The sample-analysis schemes for atmospheric samples present varying logistics problems. Samples that are taken in the field and simultaneously analyzed with an automatic instrument present no sample deterioration problem. Samples taken in the field that are analyzed manually in the field present a relatively minor sample deterioration problem. Gaseous samples that must be taken from the field to the laboratory for analysis can be transported "as is" in an evacuated flask or plastic bag or can be absorbed in liquid or solid media, with or without chemical reaction. In choosing the method for sample transport, one must consider sample deterioration as well as media shelf life. Certain atmospheric components store better in Pyrex; others in Mylar, Tedlar or other plastic containers.[38-41] Whenever sample or reagent instability is a definite problem, the use of portable instrumentation or a mobile van with laboratory equipment can provide a short-term solution. For longer periods, methods which can utilize automatic sampling-analysis instrumentation are required.

6.2.3.4 Example Situations. The technical services group manager will be confronted with numerous decisionmaking situations. If he is the manager of a satellite laboratory in a strong-State, weak-local-agency structure, he must assess the advantages and disadvantages of analyzing sulfur dioxide bubbler samples in his own laboratory compared with sending the samples to the State's central laboratory for analysis. If he is the manager of a strong local agency laboratory, he must determine the cost and efficiency of conducting manual colorimetric analyses for sulfur dioxide compared with using an automated analyzer. If he is the manager of the State's headquarters laboratory, he must determine whether to perform pesticide and fuel analyses in-house or to use an outside contractor.

Cost analysis can be applied to each of these types of situations. For example, each laboratory operation carried out in-house has a cost from three major factors: labor, equipment, and space. Labor costs are related directly to manpower requirements, both man-hours and personnel levels. Equipment costs depend on capital expenditures, depreciation rates, and the percentage of time that the equipment is "sold" for the laboratory operation in question and for other laboratory operations. Space costs, of course, are dependent on the personnel and equipment requirements.

Table 14 is an example of a labor-factor cost analysis for three distinct manual laboratory operations: colorimetric sulfur dioxide analysis, fuel analysis, and pesticide analysis. In each case, the manpower requirements are defined in terms of the manpower contribution from supervisory, professional, and technician personnel, and in terms of the skill level of these personnel. Unit operation costs are calculated using the salary rate ranges listed in Table 12. In addition, Table 14 presents the daily labor cost for each operation based on an average daily work load. The equipment costs for sulfur dioxide analysis will vary widely depending on the price of the colorimeter or spectrophotometer and the extent of cost sharing with other colorimetric laboratory operations such as methods for nitrogen dioxide, oxidant, and hydrogen sulfide analysis.

Equipment cost for analyzing various fuels for their Btu content is similar to the price of the bomb colorimeter. Although this equipment can be used for determining heats of combustion, oxygen bomb methods which include chemical analysis are available for determining fuel content of sulfur, halogen, arsenic, boron, and many other elements. Equipment costs for pesticide analysis is the price of the gas chromatograph system. The gas chromatograph is a very versatile instrument and can be used for analysis of several other pollutant species. An increasing need for gas chromatographic analysis of reactive hydrocarbons

Table 14. MANPOWER-LABOR COST REQUIREMENTS FOR LABORATORY OPERATIONS

Laboratory operation	Man-hours S[a]	Man-hours P[b]	Man-hours T[c]	Skill level grades[d] S	Skill level grades[d] P	Skill level grades[d] T	Cost per unit operation	No. of operations required per unit time	Labor cost per unit time
SO_2 analysis (colorimetric)	0.1	--	1.0	5	--	2	\$3.47 to \$4.27	20/day	\$69.40 to \$85.40/day
Fuel analysis (B.t.u. calorimetry)	0.2	1.6	0.2	8	6	2	\$9.08 to \$11.05	5/day	\$45.40 to \$55.25/day
Reactive hydrocarbon analysis (gas chromatography)	0.1	1.0	--	8	7	--	\$7.15 to \$9.89	2/day	\$14.30 to \$19.78/day

[a] S = Supervisory

[b] P = Professional

[c] T = Technician

[d] See Table 12 for skill level grade ratings; annual rates can be converted to hourly rates by dividing by 2080 (hours per year).

and oxidant materials would spread equipment costs over several different laboratory operations.

Efficiency studies can also be used in meeting decisionmaking situations. In setting up a statewide technical services function, an efficiency study can be used to determine how best to locate, outfit, and staff laboratory components in support of existing monitoring networks, engineering functions, and enforcement functions. In established technical services groups, efficiency analysis of individual laboratory operations can provide for the maximum utilization of equipment, space, and personnel. For example, an efficiency study of the statewide program may indicate that the State would be best served by a weak-State, strong-local-agency organizational structure. The State agency headquarters would have minimum internal laboratory capabilities but would coordinate and oversee all of the State's satellite and local agency laboratory activities. An efficiency study of an individual laboratory within the technical services program would indicate the types of personnel and equipment needed, preferred work patterns, recommended spatial arrangement of equipment, offices, storage facilities, and laboratory bench areas.

7.0 DATA HANDLING

Activities of the State air pollution control agency generate large quantities of data. In addition for those States with comprehensive local agencies, it is important that data collected by the local agencies be made available to the State agency. Expanded program activities by the State and local control agencies, especially in the area of air quality monitoring, will greatly increase the quantity of data to be handled. Since the technical services group has responsibility for the collection and analysis of air quality data, it is important that the development of data handling procedure be considered in the design of the laboratory and its operating procedures. These procedures must specify the flow of data within the technical services group as well as between the technical services group and local agencies and between the laboratory and the Federal Environmental Protection Agency.

In order to be responsive to the needs of management, the data handling procedures must be flexible enough to satisfy a number of requirements. First of all, provisions must be included for the very rapid flow of data required by the emergency action p'an. Provisions must also be made for the transmittal of data in a routine day-to-day basis. Finally, the procedures must define the types and frequency of preparation of routine and specialized statistical summaries.

7.1 Data Flow

The technical services group has the responsibility for the collection, storage, and dissemination of data. Its relationship with the Federal Environmental Protection Agency is one of providing data which can be used for evaluating the progress toward the attainment and maintenance of national air quality standards. In addition, the technical services group must provide data to EPA during periods of high air pollution to demonstrate that the public is being protected from imminent and substantial endangerment.

The relationship of technical services with local control agencies is primarily supportive. In the case of a comprehensive local agency, the technical services group may require a daily air quality status report during normal conditions and hourly reports during air pollution episodes. In addition, the local agency may be required to submit detailed air quality data and data summaries on a monthly or quarterly basis. Local control agencies with limited resources may assist the State through the operation of monitoring stations. Under these conditions the State technical services group provides analytical services and reports its results to the local agency on a monthly or quarterly basis. In areas with no local control agency, the State technical services group is responsible for the field operations of the air monitoring program.

7.1.1 Local to State

Data may be transported from the local agency (or satellite laboratory) in a number of ways: (a) on data record forms, (b) on punched cards or magnetic tape, and (c) over the telephone by voice communication or a telemetry system. The method of transmittal is dependent upon the type of local agency (or satellite laboratory), the quantity of data involved, and whether or not the data are essential to the emergency action plan.

7.1.1.1 Noncomprehensive Local Agency. An agency of this type generally provides field operations support for the statewide air monitoring program. Typically, this support involved servicing air monitoring equipment such as high volume samplers and 24-hour gas bubblers. The field man sets out the sample media and records the initial air flow. Following the termination of the sampling interval, the air flow is again recorded. The field record and the sampling media are forwarded to the State air pollution control agency.

Local agency personnel may also be responsible for the operation of continuous monitoring stations. In this situation the operator is generally required to submit a daily air quality status report by telephone to the State agency. The contents of the status report will be dictated by the data reporting requirements of the emergency action plan. Upon activation of the emergency action procedures, the field operator may be required to submit reports by telephone on an hourly basis. At weekly intervals, the station operator sends strip charts and the output from the data acquisition system to the State laboratory for subsequent data processing.

7.1.1.2 Comprehensive Local Agency. A comprehensive local agency typically has sufficient resources to operate its air monitoring program including an analytical laboratory. Air quality data collected with intermittent type sampling devices are submitted to the State agency on a monthly or quarterly basis. Data of this type may be submitted on data record forms, punched cards, or even magnetic tape.

Local agencies whose atmospheric surveillance activities include continuous air monitoring devices may submit data to the State agency in two ways: (a) hourly average pollutant concentration may be visually scanned from strip charts and manually entered on data record forms or (b) hourly average concentration may be computer processed and written on a magnetic tape. When computer services are available to the local agency, the monthly, quarterly, and annual reports may be also sent to the State agency.

Consistent with the emergency action plan adopted by the State, the local agency will submit daily air quality status reports by telephone. Hourly status reports may be required when the emergency action procedures are invoked.

7.1.2 State to Local Agency

The State's technical services group operates in support of the local control agencies. As such, the technical services group should not duplicate any activities carried out at the local level. Therefore, the flow of data from the State to the local agency must be sufficiently flexible to fulfill the needs of these agencies.

7.1.2.1 Noncomprehensive Local Agencies. In situations where the State's technical services group is responsible for the analysis of intermittent air samples and the processing of continuous sampling data, it is more important that air quality data be provided to the local agency. The State should provide tabulations of the 24-hour measurements made by the intermittent sampling devices and the hourly averages computed from the data for the continuous analyzers. These tabulations should be provided on either a monthly or quarterly basis. In addition, statistical summaries should be provided to the local agency on both a quarterly and an annual basis. The quarterly summaries may be the same type of summary that is used by the State to submit information to EPA.

7.1.2.2 Comprehensive Local Agencies. For the most part, comprehensive local agencies will have sufficient need for prompt access to air quality data that they will install and utilize the Air Quality Data Handling System (AQDHS) to satisfy their immediate needs. This system is currently being developed by EPA for State and local agencies. In so doing these agencies will maintain their own data storage and retrieval system. Agencies of this type will be most interested in statewide data summaries and statistical analyses which only the State agency or technical services group will be in a position to prepare. Data of this type provides the local agency the opportunity to compare its progress in attaining air quality standards with that of other areas in the State.

7.1.3 State to Federal

The State is required to submit air quality data to EPA on a quarterly basis commencing with the first full quarter after the approval of the Implementation Plan. Submission of such data would be in one of the following ways: (a) SAROAD form, (b) on punched cards in SAROAD formats, or (c) on magnetic tape in SAROAD format. It can be expected that the format of their data summaries will be published in the Federal Register at an early date.

7.1.4 Federal to State

The State technical services group receives selected summaries of all quality data which are submitted to the National Aerometric Data Bank. Detailed data tabulations and statistical summaries of all data submitted to the Data Bank by all State and local agencies throughout the country are prepared annually by EPA. Copies of these publications are widely distributed. Additional requests for selected data tabulations and statistical summaries may be submitted to the National Aerometric Data

Bank. The extent to which such requests can be fulfilled is dependent upon resources available within EPA.

7.2 Records

7.2.1 Reporting Formats

The technical services group will find it necessary to develop a variety of reporting formats to handle the data generated by the air monitoring activities of the State and local agencies. While these formats will differ somewhat from State to State, it may be practicable to modify one or more of the following formats to meet the needs of a particular technical services group.

7.2.1.1 Intermittent Sampling. A form is required to record the field data, relative to the air sampling device, and the laboratory data, both of which are necessary to compute the 24-hour pollutant concentration. A typical form for use with 24-hour particulate samples is shown in Figure 13.

When a computer-oriented storage and retrieval system is used, it is necessary to prepare data for key punching. Since it is usually sufficient to update master files containing 24-hour data on a monthly basis, a form similar to that shown in Figure 14 or 15 is recommended. A form of this type can be used for as many as 4 to 6 pollutants at an individual station. Since the pollutant name is coded and entered in the boxes entitled "Parameter Code" (Figure 15), the form can be used for any 24-hour pollutant measurements. A form of this type provides for updating master files on a monthly basis.

7.2.1.2 Continuous Sampling. If a continuous air monitoring device is not equipped with a data acquisition system of some type,

SAMPLE NO._______________

STATION NO.______________

	START OF SAMPLING	FINISH OF SAMPLING
DATE		
TIME		
FLOW RATE		

DATE		
FILTER WEIGHT		
ROOM TEMPERATURE		
RELATIVE HUMIDITY		

TOTAL VOLUME SAMPLED________________CUBIC METERS

TOTAL WEIGHT GAINED_________________MILLIGRAMS

DUST LOADING________________________μGMS/M^3

STATION OPERATOR________________

WEIGHING OPERATOR_______________

BAAPCD
WS:fm
10/8/70

Source: Bay Area Air Pollution Control District

Figure 13. Particulate sampling record.

Time

Raw Sampling and Lab Data
(Coding form)

Start

Filter # ____________

Stop

Format	Cnty	City	Site	Yr	Mon	By	Hr	Time	Type	Agency	Time Run	Flow Start Stop
(1)	(2)	(4)	(6)	(8)	(10)	(12)	(14)	(16)	(17)	(19)	(20)	(24)
A												

Pollutant	Method	Total Vol.	Aliquot	Sample Wt.	DP	Blank	% Filter	
								(28-52)
								(53-77)

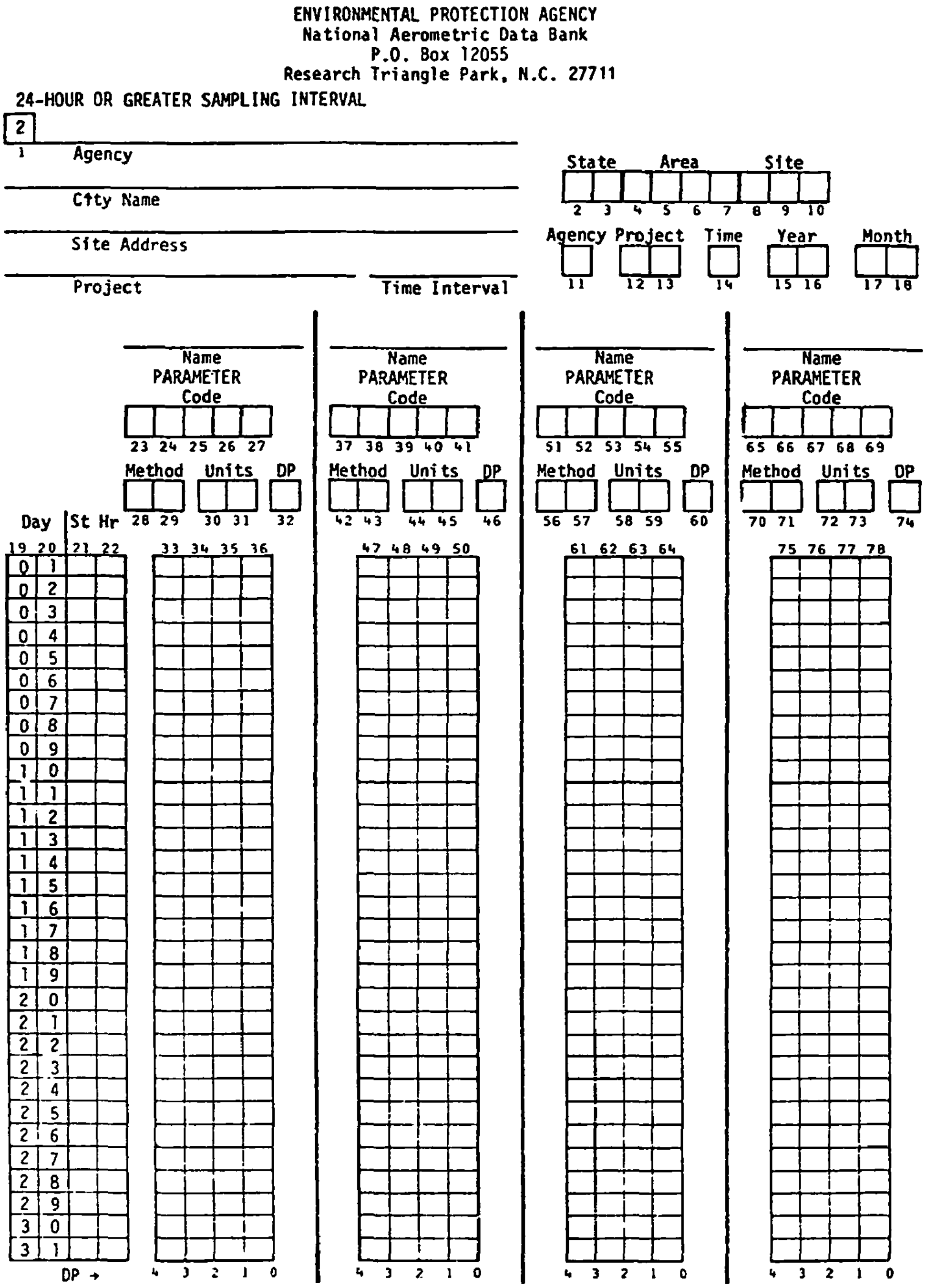
CD No	Pollutant	Method	Total Vol.	Aliquot	Sample Wt.	DP	Blank	%Filter	
(1) 2	(28)								(28-52) (53-77)
(1) 3	(28)								(28-52) (53-77)
(1) 4	(28)								(28-52) (53-77)
(1) 5	(28)								(28-52) (53-77)
(1) 6	(28)								(28-52) (53-77)

Remarks

Final Wt.
Tare Wt. ____________ ____________ ____________ ____________
Sample Wt.

SOURCE: Columbia-Willamette air pollution authority.

Figure 14. Raw sampling and laboratory data coding form.



ENVIRONMENTAL PROTECTION AGENCY
National Aerometric Data Bank
P.O. Box 12055
Research Triangle Park, N.C. 27711

24-HOUR OR GREATER SAMPLING INTERVAL

2
1 Agency

City Name

Site Address

Project

Time Interval

State Area Site
2 3 4 5 6 7 8 9 10

Agency Project Time Year Month
11 12 13 14 15 16 17 18

Name PARAMETER Code	Name PARAMETER Code	Name PARAMETER Code	Name PARAMETER Code
23 24 25 26 27	37 38 39 40 41	51 52 53 54 55	65 66 67 68 69
Method 28 29, Units 30 31, DP 32	Method 42 43, Units 44 45, DP 46	Method 56 57, Units 58 59, DP 60	Method 70 71, Units 72 73, DP 74
33 34 35 36	47 48 49 50	61 62 63 64	75 76 77 78

Day 19 20 | St Hr 21 22

01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31

DP → 4 3 2 1 0 | 4 3 2 1 0 | 4 3 2 1 0 | 4 3 2 1 0

Figure 3. SAROAD Daily Data Form.

Source: Office of Air Programs
Publication No. APTD-0663

SAROAD USERS MANUAL

Figure 15. Card punch format for 24-hour data.

it is necessary to reduce pollutant concentration data from strip charts. Data reduction may be completely manual, in which case a technician visually scans hourly average concentrations and records them on a form similar to that shown in Figure 16. With a form of this type, the 24 one-hour measurements are recorded on two lines. Since this type of data reduction tends to be very tedious for the technician, it is conducive to a high frequency of reading and recording errors.

The reduction of data from strip charts can be expedited through the use of semiautomated chart readers. With a chart reader the technician still visually scans the hourly average concentration but the resultant data is automatically punched onto cards. This eliminates a separate key punch operation, increases the productivity of the technician, and minimizes the error rate in transcribing data on the record form.

7.2.2 Station Operator Logs

When automated data acquisition systems are used to record continuous monitoring data on magnetic tape, it is necessary for the station operator to maintain a daily performance log. An example of such a log is shown in Figure 17. The operator records information about instrument drift and equipment malfunctions. This information is subsequently used by the computer to process and validate the continuous data.

7.2.3 Summary Formats

The kinds of air quality data summaries that are prepared should be determined by the way in which the information is used by management for program evaluation, planning, and decisionmaking. Examples of formats in wide use are presented in this section.

LESS THAN 24-HOUR SAMPLING INTERVAL

1 (1)

Agency

City Name

Site Address

Project

ENVIRONMENTAL PROTECTION AGENCY
National Aerometric Data Bank
P. O. Box 12055
Research Triangle Park
North Carolina 27711

Parameter observed

Method

Time interval of obs.

Units of obs.

State (2 3) Area (4 5 6 7) Site (8 9 10)

Agency (11) Project (12 13) Time (14) Year (15 16) Month (17 18)

Parameter code (23 24 25 26 27) Method (28 29) Units (30 31) DP (32)

Day	St Hr	Rdg 1	Rdg 2	Rdg 3	Rdg 4	Rdg 5	Rdg 6	Rdg 7	Rdg 8	Rdg 9	Rdg 10	Rdg 11	Rdg 12
19 20	21 22	33 34 35 36	37 38 39 40	41 42 43 44	45 46 47 48	49 50 51 52	53 54 55 56	57 58 59 60	61 62 63 64	65 66 67 68	69 70 71 72	73 74 75 76	77 78 79 80

Figure 2. SAROAD Hourly Data Form.

Source: Office of Air Programs
Publication No. APTD-0663, July, 1971.

Figure 16. Card punch format for continuous sampling data.

SEC 468
(REV 10-61)

RECORD OF OPERATOR'S LOG

DATE: ____________ to ____________

OPERATOR ____________

STATION ____________ [1 2 3 4 5]

GAS ____________ [6 7]

MO.		DA.		YR.		D*	ITEM			START				STOP				PURGE				COMMENTS
8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	27	28	29	30	

* Day of Week.

Source: Continuous Air Monitoring Program
OAP-EPA

Figure 17. Station operator's log.

7.2.3.1 Cumulative Frequency Distributions. A summary format which is used extensively to present air quality data is shown in Figure 18. This method of data presentation is ideally suited for 24-hour and continuous monitoring data. Particularly with 24-hour air quality surveillance in which samples are collected on a 6-day basis, the cumulative frequency distribution is most useful. This technique provides an estimate of the overall distribution of air quality for the year.

7.2.3.2 Monthly Summary of Continuous Data. The hourly average pollutant concentration data from a continuous monitoring device can be summarized as shown in Figure 19. This method of presentation provides a means of looking at pollutant concentration trends on individual days. In addition, the table includes daily as well as monthly average concentrations. Finally, the mean hourly concentration at the bottom of the table shows the diurnal pattern.

7.3 Hardware Assistance

The large quantity of data resulting from air quality monitoring activities makes the use of data handling hardware desirable from the standpoints of both efficiency and cost. There are essentially two types of hardware applicable to air quality data handling: (a) data acquisition systems, and (b) computer-oriented data storage and retrieval systems.

A data acquisition system provides an automated method of recording the output from one or more pollutant sensors. The system may record data in the field on paper or magnetic tapes. If the data are recorded on magnetic tape, it is important that the tape format be compatible with the computer to be used in processing the data. Through the use

Table I-7. FREQUENCY DISTRIBUTION OF CONCENTRATION OF GASEOUS ATMOSPHERIC POLLUTANTS

(5-minute values, concentration in parts per million)

City/pollutant	Valid data, %	Minimum	Frequency distribution, percent 10	30	50	70	90	95	98	99	Maximum	Arithmetic mean
CHICAGO												
CARBON MONOXIDE	65	0	1	3	5	7	13	16	20	24	57	6.2
NITRIC OXIDE	79	.00	.01	.03	.06	.09	.15	.18	.23	.28	.66	.071
NITROGEN DIOXIDE	78	.00	.03	.04	.05	.05	.07	.08	.10	.11	.29	.048
SULFUR DIOXIDE	80	.00	.01	.04	.08	.14	.28	.36	.48	.57	1.33	.117
HYDROCARBON	75	.0	1.9	2.3	2.7	3.2	4.1	4.7	5.6	6.6	17.3	2.90
TOTAL OXIDANT	55	.00	.00	.01	.02	.03	.05	.07	.09	.10	.47	.023
CINCINNATI												
CARBON MONOXIDE	57	0	3	4	5	6	9	11	15	31	45	5.6
NITRIC OXIDE	34	.00	.00	.01	.03	.06	.18	.27	.38	.46	1.26	.064
NITROGEN DIOXIDE	73	.00	.02	.02	.03	.04	.05	.06	.07	.08	1.19	.031
SULFUR DIOXIDE	76	.00	.00	.00	.01	.02	.04	.06	.08	.10	1.49	.017
HYDROCARBON	81	.5	1.7	2.0	2.2	2.6	4.0	5.1	6.5	7.4	18.1	2.58
TOTAL OXIDANT	26	.00	.00	.01	.02	.03	.05	.06	.08	.10	.19	.022
DENVER												
CARBON MONOXIDE	71	0	1	3	4	6	11	14	19	24	90	5.3
NITRIC OXIDE	62	.00	.00	.01	.02	.04	.10	.14	.21	.26	.68	.036
NITROGEN DIOXIDE	71	.00	.01	.02	.03	.04	.06	.07	.09	.11	.38	.036
SULFUR DIOXIDE	60	.00	.00	.00	.01	.02	.03	.04	.06	.08	1.81	.012
HYDROCARBON	71	.0	1.7	2.1	2.5	3.1	4.4	5.4	7.0	8.5	18.7	2.89
TOTAL OXIDANT	48	.00	.00	.01	.03	.04	.06	.07	.09	.11	.43	.029
PHILADELPHIA												
CARBON MONIXIDE	48	0	3	6	8	10	15	18	22	25	49	8.5
NITRIC OXIDE	70	.00	.00	.02	.03	.05	.12	.18	.28	.41	1.68	.054
NITROGEN DIOXIDE	77	.00	.02	.03	.03	.04	.07	.08	.10	.12	.22	.039
SULFUR DIOXIDE	89	.00	.01	.03	.05	.08	.19	.28	.40	.48	1.10	.080
HYDROCARBON	60	.0	1.3	1.6	1.9	2.3	3.3	4.1	5.1	5.9	13.3	2.14
TOTAL OXIDANT	42	.00	.00	.01	.02	.03	.05	.06	.08	.10	.31	.022
ST. LOUIS												
CARBON MONOXIDE	86	0	2	3	4	5	8	10	13	16	47	4.6
NITRIC OXIDE	66	.00	.00	.01	.02	.04	.08	.11	.16	.20	.44	.032
NITROGEN DIOXIDE	81	.00	.01	.02	.02	.03	.04	.05	.06	.07	.20	.023
SULFUR DIOXIDE	90	.00	.00	.00	.01	.03	.07	.11	.18	.23	1.33	.028
HYDROCARBON	89	.4	2.0	2.6	3.1	3.7	5.0	6.0	8.0	9.4	17.1	3.40
TOTAL OXIDANT	48	.00	.00	.01	.02	.03	.04	.05	.07	.08	.37	.022
WASHINGTON D.C.												
CARBON MONOXIDE	82	0	1	2	3	4	6	8	11	14	59	3.3
NITRIC OXIDE	71	.00	.00	.01	.01	.03	.08	.13	.23	.33	.76	.035
NITROGEN DIOXIDE	64	.00	.02	.03	.04	.05	.08	.09	.11	.12	[illegible]	.047
SULFUR DIOXIDE	74	.00	.00	.00	.02	.05	.10	.13	.17	.20	.47	.036
HYDROCARBON	82	.0	1.6	1.8	2.0	2.3	3.0	3.6	4.9	6.0	18.6	2.23
TOTAL OXIDANT	59	.00	.00	.01	.02	.03	.06	.08	.10	.12	.29	.027

Table 1-8. FREQUENCY DISTRIBUTION OF SOILING INDEX

(2-hour measurements, concentration in COHS/1000 lineal feet)

(CONCENTRATION IN COHS/1000 LIN. FT.)

CITY	VALID DATA*	MIN	FREQUENCY DISTRIBUTION-PERCENT 10	30	50	70	90	95	98	99	MAX	ARITH MEAN
CHICAGO	100	.0	.5	.9	1.2	1.6	2.3	2.8	3.6	4.1	8.2	1.35
CINCINNATI	95	.0	.2	.5	.7	1.0	1.7	2.2	2.8	3.3	5.6	.87
PHILADELPHIA	100	.0	.3	.6	.8	1.1	1.8	2.2	2.9	3.6	5.6	.95
WASHINGTON, D C	90	.0	.4	.6	.9	1.2	2.0	2.5	3.1	3.6	6.6	1.06
ST LOUIS	80	.0	.2	.4	.6	.8	1.4	1.8	2.3	2.7	4.7	.73
DENVER	75	.0	.2	.4	.6	.9	1.7	2.2	2.9	3.3	6.8	.80

* REPORTED TO NEAREST FIVE PERCENT

VALUES GREATER THAN 6.0 UNDERESTIMATE ACTUAL VALUE

6 Source: National Air Pollution Control Administration Publication No. APTD 69-18, December, 1969.

Figure 18. Cumulative frequency distributions of selected pollutant concentrations.

CONTINUOUS AIR MONITORING PROGRAM

Air Quality Section, Laboratory of Engineering and Physical Sciences
Division of Air Pollution, Public Health Service
U. S. Department of Health, Education and Welfare

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio 45226

HOURLY AVERAGES OF GASEOUS POLLUTANT CONCENTRATIONS

PHILADELPHIA, PA.

CONCENTRATION IN PPM
POTASSIUM IODIDE ANALYSIS

TOTAL OXIDANT
JAN. 1968

DAY OF MONTH	AM 12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	PM 12-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	DAILY MEAN	NO OF HRS	5 MIN MAX
1	.02	.02		.02	.01	.01	.01	.02	.02	.03	.02	.03	.02	.02											.019	13	.03
2											.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.001	14	.02
3	.00	.01		.01	.01	.01	.02	.02	.02	.03	.02	.02	.01				.02	.02	.03	.03	.04	.04	.03	.03	.020	20	.05
4	.04	.04		.03	.02	.03	.03	.05	.04	.03	.04	.04	.03	.03	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.027	23	.07
5	.02	.02		.02	.02	.02	.02	.01	.01	.01	.01	.01	.01	.01	.01	.01	.00	.01	.01	.01	.01	.00	.01	.01	.010	23	.02
6*	.00	.00		.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.01	.01	.02	.03	.02	.02	.03	.05	.05	.011	23	.07
7*	.05	.05		.03	.04	.03	.03	.03	.03	.03	.04	.04	.04	.04											.036	13	.06
8																											
9	.01	.01		.01	.00	.00	.01	.00	.00									.00	.00	.00	.00	.00	.00	.00	.002	15	.01
10	.00	.01		.00	.00	.00	.00	.00	.00									.00	.00	.00	.00	.00	.01	.01	.002	15	.02
11																											
12	.00	.00		.00	.01	.01	.01	.00	.00									.00	.00	.00			.00	.00	.001	13	.01
13*	.00	.00		.00	.00	.00	.00	.00	.00	.00	.00	.01	.02	.02	.02	.02	.02	.03	.02	.03	.03	.02	.02	.03	.012	23	.04
14*	.03	.03		.03	.03	.02	.02	.02	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03	.04	.03	.02	.02	.02	.02	.026	23	.05
15	.01	.02		.02	.02	.02	.02	.02	.02	.02	.01	.01	.01	.01	.02	.01	.01	.01	.01	.01	.02	.02	.02	.02	.016	23	.03
16	.03	.03		.03	.03	.03	.02	.02	.01	.01	.01	.01	.01	.01	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.010	23	.04
17	.00			.01	.01	.01	.00	.01	.00	.00	.00	.00	.00	.00				.01	.02	.02	.01	.02	.01	.03	.008	19	.04
18	.03	.03		.02	.02	.02	.02	.03	.04		.01	.02	.02	.03	.03	.03	.04	.03	.05	.05	.05	.05	.04	.06	.033	22	.08
19	.08	.06		.03	.03	.03	.04	.05	.05	.04	.04	.03	.03	.04	.04	.04	.03	.03	.03	.03	.04	.04	.04	.04	.038	23	.11
20*	.03	.02		.02	.03	.03	.03	.04	.05	.04	.03	.02	.03	.03	.02	.02	.01	.02	.02	.03	.04	.03	.03	.03	.027	23	.06
21*	.03	.03		.03	.02	.02	.02	.03	.02	.03	.03	.04	.05	.05	.05	.03	.03	.02	.03	.04	.03	.03	.03	.03	.030	23	.06
22	.02	.01		.02	.02	.02	.03	.03	.03	.01	.00	.00	.00	.01	.01	.01	.00	.01	.01	.01	.02	.01	.01	.02	.013	23	.06
23	.02	.02		.01	.01	.02	.02	.02	.02	.02	.01	.01	.01	.01	.01	.01	.02	.03	.03	.02	.01	.01	.01	.01	.016	23	.05
24	.02	.02		.03	.03	.02	.02	.02	.01	.00	.00	.00	.00	.00			.00	.00	.00	.01	.01	.01	.01	.02	.010	21	.03
25	.02	.02		.03	.03	.03	.02	.03	.01	.01	.01	.01	.01	.01	.01	.01	.00	.00	.01	.00	.00	.00	.00	.01	.011	23	.04
26	.01	.01		.01	.01	.01	.02	.01	.01	.00	.00	.00	.01					.01	.00	.00	.00	.00	.00	.00	.005	19	.04
27*	.00	.02		.02	.02	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.02	.03	.03	.08		.17	.018	22	.31
28*	.10	.09		.00	.02	.01	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.01	.01	.02	.03	.03	.03	.03	.03	.018	23	.13
29	.02	.01		.01	.02	.02	.03	.04	.04	.04	.02	.03			.04	.03	.04	.03	.01	.01	.01	.01	.01	.02	.023	21	.10
30	.01	.02		.02	.02	.02	.02	.04	.05	.04	.03	.04	.04	.05	.04	.05	.05	.04	.03	.02	.01	.02	.02	.02	.030	23	.07
31	.02	.02		.02	.01	.02	.02	.02	.02	.01	.02	.02	.02	.02			.03	.02	.01	.02	.01	.01	.01	.01	.016	21	.05
MEAN	.02	.02		.02	.02	.02	.02	.02	.02	.02	.01	.02	.02	.02	.02	.02	.02	.01	.02	.02	.02	.02	.02	.03	.018		
NO	28	27		28	28	28	28	28	28	24	26	26	25	23	19	19	22	27	27	27	26	26	26	27		593	
MAX	.10	.09		.03	.04	.03	.04	.05	.05	.04	.04	.04	.05	.05	.05	.05	.05	.04	.05	.05	.05	.08	.05	.17	.038		.31

* Indicates Saturday or Sunday
Local standard time used

TABULATED WED., SEP. 10, 1969

Source: National Air Pollution Control Administration Publication No. APTD 69-18, December, 1969.

Figure 19. Monthly summary of hourly pollutant concentration data.

of telemetry, data may be recorded on tape at a central station or be interfaced directly to a computer.

A computer-oriented data storage and retrieval system, such as the AQDHS, provides a means of processing large quantities of data to obtain tabulations, statistical analyses, or even graphical presentations of data. The data storage and retrieval system utilizes magnetic tape or disk storage devices for maintaining large data files. These files are extremely dynamic, since they are constantly being updated when new data become available. Typically, these files are updated on a weekly or monthly basis.

7.3.1 Current Practices

A wide range of hardware-assisted data handling systems are available today. These systems range from those in which punched cards are used to input data to a computer-oriented data storage and retrieval system, to computer-controlled telemetry systems.

7.3.1.1 Punched Card Data Input. By far the most commonly used hardware-assisted data handling system is based upon the use of punched card input. In this system all data are initially recorded on data load sheets from which punched cards are prepared. The punched cards are read by the computer and magnetic tape files are updated. The primary functions of the computer are file maintenance and retrospective studies of the data. This system is ideally suited to the preparation of monthly, quarterly, and annual data tabulations and reports.

7.3.1.2 Field-Operated Data Acquisition Systems. Included in the equipment specifications for the Continuous Air Monitoring Program (CAMP) were punched paper-tape data-logging devices. Each pollutant sensor was interfaced with its own data logger. At 5-minute intervals the instantaneous position of the pen on the strip chart recorder was digitized and punched onto paper tape. Daily the station operator also recorded pertinent information concerning the sensor and its operation in an Operator's Log. At weekly intervals the strip charts, punched paper tapes, and operator's logs were sent to the data processing center. The punched paper tapes were processed by a computer, which corrected for instrument drift and performed limited data validation. After further data analysis the new information was added to the master files. In addition to preparing listings of the 5-minute data, the computer was used to prepare monthly and annual summaries and detailed statistical analyses.

Systems of this type, which are currently being installed, now record data on magnetic tape. In addition, these newer systems include a programming device which permits the recording of data from a number of sensors on a single magnetic tape. Even though these systems have the capability of recording at a very fast rate, in some instances the practice of recording at 3- to 5-minute intervals is maintained. From a practical standpoint most control agencies are concerned with pollutant concentrations averaged over an hour or more. In essence, the 3- to 5-minute measurements provide a means of integrating to obtain a representative hourly average.

The practice of sending the magnetic tapes to the computer center on a weekly basis is maintained by most agencies. Typically, the computer center prepares listings of the 3- to 5-minute data for use in data validation following which hourly concentrations are computed and stored on the master file. Data summaries are prepared monthly, quarterly, and annually.

7.3.1.3 Telemetered Data Acquisition Systems. The next level of sophistication in a data acquisition systems involves the use of telemetry to transmit data from the monitoring station to a control station. At predetermined intervals the command module at the control station selectively polls the pollutant sensors at each station and records data on tape (usually magnetic) at the control station. Typically, this system includes a teletypewriter which provides a hard copy tabulation of the data as they are received from the field stations. On a daily basis the input tapes are processed by the computer. After validation, the data are entered into the master files of the storage and retrieval system from which all reports and analyses are prepared.

This type of system was first used by the City of Chicago for transmitting data from its eight telemetered air monitoring stations.

7.3.1.4 Computer Controlled Data Acquisition System. The most advanced data acquisition systems now in operation interface the pollutant sensors at the field monitoring station via telemetry, directly to a small dedicated computer at the State (or satellite) location. This system operates in a real-time command and control mode and is ideally suited to the rapid response required of an air pollution emergency operations control center. Systems of this type tend to be very costly and their justification is generally in terms of relatively high frequencies of occurrence of air pollution episode conditions.

The command computer transmits a signal to a remote station, activating a programmer which interrogates each pollutant sensor. After completing the interrogation of all sensors, the computer receives an end-of-message signal which directs the computer to poll the next remote station. Upon receipt of the data, the computer stores the data from each sensor until the end of the hour. Each hour, the computer calculates hourly averages for individual pollutants. These hourly averages are printed through an online printer or teletypewriter and recorded on magnetic tape. The magnetic tape is sent daily to the computer center where the data are entered into the master files of the storage and retrieval system.

The dedicated computer has the ability to compare incoming pollutant concentrations with alert levels specified in the emergency action plan. Whenever an alert level is in danger of being exceeded, the computer will so indicate on the hard copy output.

7.3.2 Advantages

Most State air pollution control agencies will find it increasingly more difficult to operate their air quality surveillance activities without some type of hardware assistance. The type of hardware required will depend upon the volume and types of data being collected. Almost without exception, States will find it necessary to use computer-oriented data storage and retrieval systems. Due to the volume of data generated by continuous monitoring systems, it is advantageous to use data acquisition systems to record data in a computer compatible form. The extent to which a State can justify the use of telemetry systems and online computers will depend a great deal upon its need for rapid response during air pollution episodes.

The advantages of hardware assistance in the handling of air quality data can be summarized as follows:

(a) To provide an effective means of handling large quantities of data,

(b) To relieve staff members from repetitive data manipulations and to make them available for tasks that are more satisfying and productive,

(c) To minimize the proliferation of errors that result in repetitive tasks,

(d) To provide a means for rapid response during air pollution episodes,

(e) To permit retrospective studies which otherwise would not be performed without automated procedures.

7.3.3 Disadvantages

The use of data acquisition systems and computers introduces some problems which cannot be overlooked. Some of the disadvantages of these systems are:

(a) Capital outlay is required to purchase or lease and install the equipment;

(b) Individuals with skills in electronics and computer science must be available on the staff of the agency;

(c) Specialized computer programs must be designed and/or implemented;

(d) Most control agencies must rely on a computer center that is not under their own administration for data processing services (it is very important for the control agency to negotiate a fixed schedule for routine data processing services);

(e) Automated data validation procedures must be developed to the fullest extent possible because people tend to rely too much upon the equipment and may tend to overlook bad data.

7.3.4 Recommended Utilization

All State air pollution control agencies should give serious consideration to the use of a computer-oriented data storage and retrieval system. Additionally, those States with the responsibility of handling data from even a few continuous monitoring stations should investigate the use of data acquisition systems.

The decision of whether or not to use telemetry and/or an online computer should be based upon a cost-benefit type of analysis. There are really two separate situations which must be considered. First of all, the need to have immediate access to air quality data for the emergency action plan must be evaluated. The additional cost of the system may be quite small compared to the cost due to failure to react quickly in averting an episode. Secondly, it is possible that the use of telemetry may so reduce the cost of personnel required to attend the sampling station as to warrant the additional cost of the system.

8.0 LABORATORY QUALITY ASSURANCE PROGRAM

8.1 Introduction

Since air pollution control relies heavily on laboratory support, a real need exists to maintain and document a high level of analytical quality. In the laboratory the quality of the data produced depends on three key considerations: (a) the methodology selected, (b) the reagents, standards, and instruments used, and (c) the operational techniques employed.[42] High quality can be assured, even before the analytical operations are undertaken. Quality assurance begins when the methodology obtains a valid measure of the analytical parameter, when the laboratory tools (reagents, instruments, standards) are of invariant quality, and when the operational techniques insure exacting replication for the entire analytical procedure.

The establishment of quality assurance programs and procedures applicable to the air pollution control (APC) laboratory requires a concerted effort from each of the elements or levels that make up the "national" APC laboratory system, i.e., the Federal sector, such as the National Environmental Research Centers (NERC) and the National Bureau of Standards (NBS), professional associations, State APC laboratories, local APC laboratories, and the private laboratory participating in the APC field. Each of these laboratory elements has a part in the development and utilization of an acceptable laboratory quality assurance program. The implementation of a quality assurance program is dependent on the State and local laboratory managers.

A comprehensive quality assurance program strives to reach, maintain, and assess an acceptable target level of reliability. The development of such a program for the air pollution control laboratory includes several components: (a) uniformity of methodology--methods development, methods standardization (reference methods, equivalent methods); (b) internal laboratory quality control; and (c) interlaboratory testing--collaborative method evaluation studies and round-robin performance evaluation studies. Laboratory accreditation procedures--inspection, proficiency testing, and certification--are expected to follow for an on-going quality assurance program.

Not all of these components are the purview of the State APC laboratory. Methods standardization belongs to EPA's Office of Research and Monitoring and the NERC's, to the National Bureau of Standards, and to certain professional associations and committees. Laboratory accreditation, although presently nonexistent, may be implemented through the EPA Regional Offices. The State APC laboratory will have prime concern for internal laboratory quality control and for participation in interlaboratory quality performance studies.

A viable quality assurance program for the air pollution control laboratory must be based on a framework for uniformity in methodology. The development of sampling-analysis techniques and instrumental applications in the air pollution field is continually progressing. For the most part, standard methods are still under development through the sponsorship of Government, interagency committees, professional associations, and industry-sponsored organizations. Until the standard methods are so designated, the prevailing methods of sampling and analysis will probably be those for which a large amount of data is already available.

Several recent publications refer to the various types of existing and proposed air pollutant reference methods and method classifications.[29,36,43-45] Recommended reference methods for the six pollutants, for which primary and secondary standards have been promulgated, have been designated by the Environmental Protection Agency.[43] Alternative methods may be used in place of certain reference methods if deemed "equivalent" to the reference method. Guidelines for the determination of the equivalence of candidate methods should be determined by the NERC's.

Laboratory quality assurance begins with the basic daily and routine operations in the laboratory. Quality control in analytical work involves the many aspects of administration, personnel training, procurement of materials and supplies, inspections and checks, and statistical calculations. Quality control procedures are designed to remove all unnecessary and controllable sources of variation in method or technique.[46] Thus, analytical procedures are defined in terms of proper conditions or standard operating procedures. Statistical quality control techniques can be used to detect the presence of assignable causes of variation. In sampling and analysis work, basic quality control techniques are calibration to assure accuracy, control samples to determine calibration drift, replication to measure precision, "spiking" to estimate accuracy, and the use of curve-fitting techniques when indicated in the method write-up to provide verification of precision and accuracy.

A laboratory quality assurance program may well include the following areas: evaluation of the present state of the art in methodology; evaluation of equipment; evaluation of expected ranges of normal analytical results; evaluation of methods; selection of methods; setting up quality control charts; setting up appropriate procedures and data sheets for the control of samples; and evaluation of the results of the quality control measures.

8.2 Importance of Laboratory Quality Control

As discussed in Chapters 1 and 3, the role of the technical services function in a statewide air pollution control program emcompasses both field and laboratory operations related to source surveillance, ambient air quality data acquisition, episode criteria monitoring, and a variety of special studies. The function of the technical services group is to provide qualitative and quantitative data to be used at all levels of decisionmaking. Consequently, the air sample procured must be adequately representative of the pollutant source or atmosphere sampled. In addition, the analysis of the sample, carried out in the field or in the laboratory, by automatic instrumentation or by wet chemical means, must provide data that accurately describe the characteristics or the concentration of constituents in the sample. In many instances, an incorrect result will lead to faulty interpretations that may be worse than no result at all.

Far-reaching decisions will be made using air quality and emission data as evidence. The laboratory data will be used to determine whether or not standards are being met. If the results indicate a violation of a standard, action is required on the part of the air pollution control agency. With the current emphasis on legal action and social pressures to abate pollution, the technical services group personnel should be made aware of their responsibility to provide results that are a reliable description of the sample. In addition, the analyst should know that his professional competence, the procedures used, and the reported values may be used and challenged in court. To meet this challenge, the laboratory data must be backed up by an adequate program to document the proper control of all the factors that affect the final result.

The economic implications alone in source testing are sufficient reason for the exercise of extreme care in sampling and analysis. Decisions on process changes, control device installation, and even the construction of new facilities are often based on the results of laboratory analyses.

Special projects and short-range development studies in air pollution control must fall back on a firm base of laboratory data. The value of the development effort will depend on the validity of the laboratory results. The progress of the special study and the alternative experimental pathways are especially evaluated on the basis of accumulated data; the final results and recommendations are presented in numerical terms, i.e., data averages, standard deviations, and confidence limits.

For such reasons as the foregoing, a formal program to assess and document the reliability of the analytical data is essential. Although chemists and technicians practice their own personal quality control, they do so at varying levels and degrees of proficiency, depending on such factors as professional integrity, background and training, and understanding or awareness of the scope and importance of the work they are engaged in. Because of the routine nature of the normal workload and under the pressures of periodic high priority "rush" projects, analytical quality control is easy to neglect. Thus, in order to assure validity and reliability in the final results, it is important to require an established routine control program for every sampling procedure and analytical test.

The quality control program in the laboratory has two major functions: first, the program should be a management tool to monitor the reliability of the results produced in real time; and second, the program should control the analytical quality in order to meet the requirements for reliability. This first function is the measurement of the analytical performance of the laboratory. The second function is the multitude of control measures required to maintain or improve a given level of analytical performance. For example, the sampling, processing, and analysis of standard or reference samples is a measurement of analytical quality; the use of precision glassware, reagent grade chemicals, and optimized instrumentation are control measures to insure analytical quality.

Sampling procedures, operation of automatic and manual instrumentation, and classical analytical methods all utilize a standard protocol or a rigid standard operating procedure (SOP). Likewise, the quality control associated with each protocol should involve definite, required steps to monitor and assure that the data and results are correct.

Quality control aspects vary with the type of sampling-analysis scheme. For instance, in a gravimetric analysis, calibration of the analytical balance with standard weights is an element of quality control. In a titration, frequent standardization of the titrant is an element of quality control. When employing an instrumental method, the check-out of instrument response and the calibration of the instrument is likewise an element of quality control.

Ideally, a quality assurance program should consider and evaluate all the variables that significantly influence the final analytical result and should provide for the control of these factors in order to insure the best possible result. In the air pollution control laboratory, the laboratory quality assurance program should aim at the fourfold objectives: (a) to assure the representative nature of the sampled material, (b) to achieve a high level of reliability in the analytical characteristics reported for the sample, (c) to provide real-time management tools for the laboratory supervisor, and (d) to produce quality control data to document the context of the sample data.

8.3 Proposed Laboratory Quality Assurance Program

Development and operation of an integrated statewide air pollution control technical services system are the direct responsibilities of the State air pollution control agency. State agencies will rely somewhat on the EPA's Regional Offices and National Air Program Laboratories for guidance and assistance. At the same time, the cooperating local air pollution agencies, while serving their own county or municipal jurisdictions, are essential parts or extensions of the State's technical services function.

A laboratory quality assurance program within the statewide air pollution control laboratory system is likewise the direct responsibility of the State air pollution control agency. In addition, the Federal agency can and must provide guidance and technical assistance in this area. The local agencies within the State program should be required to meet a set of quality control standards in order to continue as effective parts of the State laboratory system.

8.3.1 Federal Agency Role in Quality Assurance

EPA will continue to develop, evaluate, and publish air pollution methodology via its own laboratories as well as in cooperation with outside organizations. In its role as overseer and advisor to the State laboratory programs, the following are areas in which the Federal agency can provide valuable guidance and/or assistance to the statewide laboratory quality assurance program.

8.3.1.1 Uniformity of Methodology

8.3.1.1.1 Method Development. With its comprehensive resources and laboratory capabilities in the air pollution control area, the Federal agency is the logical source of new analytical and sampling methods. The need for new methods or method modification may be dictated in part by the quality of the data generated in the measurement of currently defined (by criteria) pollutants. Additional methods will be required for the publication of criteria documents for new pollutants.

8.3.1.1.2 Method Evaluation. The Federal agency will continue to determine the precision and accuracy of new methods through its collaborative testing program. These tests represent the measurement of the best multiple performance characteristics of the method under ideal conditions. In many cases, the analysts participating in the method evaluation study are highly trained specialists or experienced analytical chemists working in research institutes, universities, and private consulting laboratories.[47-49] It is expected, therefore, that as methods are later adopted for use by the State programs, it may be necessary to determine the precision and accuracy, not of the method, but of the application of the method under routine operating conditions, using the analysts and the laboratories that make up the State laboratory system.

In general, the NERC's will standardize the methods and determine their optimal characteristics; the State laboratories should use the methods, document their quality control data, and attempt to reach the same level of performance as attained by the NERC laboratories.

8.3.1.1.3 Method Publication. The Federal agency will participate in and help to coordinate all the on-going method standardization activities that are relevant to a statewide laboratory quality assurance program. The reference methods will continue to be published and guidelines for the determination of "equivalent" methods will be made available to all State laboratory programs on a uniform basis.

8.3.1.2 Technical Assistance

8.3.1.2.1 Training. The Federal agency may develop a prototype training course covering the various elements of a laboratory quality assurance program. This course could be given to representatives of selected State air pollution laboratories in order to refine and revise the course content. Any acceptable training course would be made available to all State air pollution agencies.

8.3.1.2.2 Regional Office Coordination. Each of the EPA Regional Offices has staff members who are concerned with providing technical assistance to State agencies in setting up and maintaining a laboratory quality assurance program. This office, for example, could provide assistance to State agencies that are interested in entering into interstate cooperative agreements in sharing the burden of various laboratory quality assurance program elements.

8.3.2 State Agency Role in Quality Assurance

Chapter 3 describes each of the individual functional elements of a statewide air pollution control technical services group: air quality, monitoring, surveillance monitoring, emergency monitoring, and a variety of support activities. The purpose of a laboratory quality assurance program is to insure that quality control is an integral part of every laboratory operation. The primary State agency objective in this regard is to require uniform and routine acceptance of program elements by State and local laboratories.

The role of the State agency in quality assurance is fivefold: to survey and characterize the laboratory quality control practices of all air pollution agencies within the State; to provide training in quality control to all State and local agency laboratories; to conduct on-site inspections of each agency's technical services facilities on both a set, periodic basis as well as a random, unexpected basis; to set up and operate a statewide laboratory proficiency testing system; and to design and coordinate a statewide interlaboratory collaborative testing mechanism. To do its job well in interlaboratory testing, the State agency's central or coordinating laboratory must have good, internal quality control performance.

8.3.2.1 Statewide Survey of Air Pollution Laboratories. Before introducing a laboratory quality assurance program to each of the regional and local agency laboratories, the State agency must first determine the status of the technical service or laboratory function in each agency. A survey form could be developed to elicit the following information from each agency laboratory: type of samples taken or received; components and/or conditions measured; complete listing and brief description of laboratory apparatus available; description of sampling apparatus, sample containers, sample preservatives, sample collection methods, and sample transfer and labeling procedures; recordkeeping and data handling methods; description of the laboratory, laboratory organization, and laboratory staff; and a description of quality control measures taken and procedures used.

8.3.2.2 Quality Control Training. Just as the Federal agency provides technical assistance and training opportunities to the State agency, the State agency in turn must assist and train local agency laboratory personnel in the elements of analytical and statistical quality control. The development of a formal training course in quality control given at the State level and made available to representatives of the local agency laboratories could be based on the Federal laboratory quality assurance training program. On-the-job training could be provided as part of the State's annual inspection of laboratories.

8.3.2.3 On-site Inspection. The State air pollution control agency might conduct an inspection of every air pollution control laboratory facility within the State at least annually and should periodically spot check laboratory facilities on a random basis. Although the inspection is aimed primarily at assessment of the laboratory's quality control program, general information in such areas as safety, personnel, housekeeping, and recordkeeping will also be acquired.

Inspection forms should be so designed that each checklist item can be scored on a yes/no, met/not met/exceeds, or numerical rating system. It is important to tie in the individual item scores with an overall inspection rating system so that the inspection team has three alternative recommendations: approval, denial, or reinspection required. In this way, the inspection system could be used along with proficiency testing for evaluation within an eventual Federal agency laboratory accreditation system.

8.3.2.4 Proficiency Testing. Proficiency testing is a useful tool in assessing the competency of laboratory staff and the adequacy and quality of facilities, equipment, reagents, working conditions, and procedures. Proficiency testing may be carried on during on-site inspections (in the field and at the bench) or by submittal of "blind" test samples (with known values) to the laboratory for routine examination using regularly assigned personnel and procedures. On-site proficiency testing of ambient sampling operations can be accomplished by splitting the sample stream and conducting side-by-side sampling in the field along with a reference sampling team. Subsequent "spiking" of the sample stream would allow accuracy as well as precision comparisons between the sampling teams. There are, however, inherent problems with the spiking technique, e.g., the spiked ingredient may sometimes react undetected with a constituent(s) of the ambient air sample.

A determination of proficiency in the analytical phases of the laboratory operations can sometimes be distinguished from overall proficiency testing (i.e., sampling and analysis) by using aqueous samples that simulate atmospheric samples collected in liquid media.

8.3.2.5 Collaborative Surveys. Collaborative survey of air pollution measurement methods at the State and local agency or working level gives the "real world" reliability of the method evaluated. The State agency laboratory coordinates the interlaboratory collaborative test program. The local agency laboratories are the so-called cooperating or participating laboratories. Section 8.3.5 describes the makeup and operation of a statewide interlaboratory quality control system.

8.3.3 Local Agency Role in Quality Assurance

Local air pollution control agency laboratories are extensions of the State's technical services function. The local agency laboratory has two major responsibilities in quality assurance: to initiate and maintain internal laboratory quality control and to participate in the statewide interlaboratory quality control program. Once the local agency undertakes the fulfillment of these responsibilities at a high performance level, the other parts of the laboratory standardization program will fall into place. The laboratory will pass inspections, will use the recommended methods, and will maintain its accreditation status.

8.3.4 Internal Laboratory Control of Analytical Performance

A laboratory quality assurance program is contingent on the overall day-to-day operation of the laboratory itself. Does the laboratory use reference methods or their equivalent? Does the laboratory have a check system on its sampling procedures, e.g., maintenance/performance check lists, adequate supplies, etc.? Does the laboratory take adequate measures to preserve sample integrity? Does the laboratory control and assess its analytical processes--calibration, replication, and mathematical evaluation of data? Does the laboratory have a way of monitoring the performance of instrumentation? Is the laboratory committed to the need for quality control--the need for making quality control an inherent part of each laboratory function, the need for allocating funds and manpower to a quality control "overhead" category on the order of 10 percent of its overall effort? This section stresses the importance of each of these quality control areas for the air pollution control laboratory.

Quality control begins with the collection of the sample and should not end until the resultant data are reported.[50,51] Sections 8.3.4.1, 8.3.4.2, and 8.3.4.3 will deal mainly with control of daily performance in the laboratory itself; Section 8.3.4.4 will be devoted primarily to the control of instrument performance, both sampling and analytical instrumentation systems. Section 8.3.4.5 will discuss the more mundane support service requirements of an air pollution control laboratory. Section 8.3.4.6 will rate commonly used air sampling and analytical operations by degree of complexity. The skill-time rating will indicate the level of technical or professional personnel required as well as the manpower requirements related to quality control.

8.3.4.1 Precision and Accuracy. Evaluation of daily performance in the laboratory is essential to document the fact that valid data are being produced and to permit real-time correction of troubles. The quality assurance program requires routine surveillance of the reproducibility or precision and the correctness or accuracy of the measurements.

Systematic (or determinate) errors affect the accuracy of the method because they bias the results. Indeterminate error types affect the precision of the method because they produce random fluctuations in the data. For results to be accurate, the analysis used must give values close to the true values. Precision is the degree of agreement among results obtained by repeated measurements on a single sample under a given set of conditions.

8.3.4.1.1 Determinate Error. A determinate error is one that can be avoided or one for which corrections can be made after the magnitude of the error is determined. Determinate errors may be either constant or inconstant. Constant errors are of the same sign and magnitude, and cause inaccurate results. A buret missing a graduation is an example. Inconstant errors, such as the expansion and contraction of volumetric glassware with temperature, are known errors which can be corrected for but may vary in size and sign.

The sources of determinate errors are method, personal, and instrumental errors. Method errors are inherent in the procedure and are usually, but not always, very serious and the hardest to detect and correct. A common method error is the presence of interfering substances in the sample. To minimize or at least standardize these errors, reference or equivalent methods are recommended. Personal errors are attributable to individual mistakes that are made consistently by an analyst, such as continual carelessness, lack of knowledge, or personal bias. Examples are errors in calculations, use of bad reagents, and poor calibration of standards or instruments. Instrumental errors are caused by an analytical instrument or by the effects of the environment acting on the instrument. Incorrectly labeled volumetric glassware, fluctuating environment temperatures, pickup or "stray" electrical impulses by a spectrophotometer are examples.

The effects of a determinate error may be additive (i.e., the error is constant regardless of the amount of analytically sought constituent in the sample), proportional to the theoretical value, or it may vary with a measurable parameter. Determinate errors can usually be detected by using spiked samples or standard reference materials and obtaining the quantitation of bias by measuring the deviation from the known value. The detection of determinate errors in unknown samples is accomplished by analyzing for the desired constituent by two or more methods that are entirely different in principle, although this may lead to different results from each method, none of which may be correct. Determinate errors can be kept under control if reference or equivalent methods are used intelligently.

Tact should be employed in dealing with personal error. The importance of quality control should be stressed without making the analyst feel that he is being monitored or policed. The quality control program should aim at overall confidence in results; great care must be used to avoid producing a "nonconfidence" attitude in a technician.

For method and instrumental error, blanks can be used to correct for interferences for reagents, sample color, etc. Correction factors, such as extraction recovery factors and chemical yield values in gravimetric analysis, can also be used to eliminate determinate errors.

Sample interferences can be overcome with the standard addition technique by adding equal amounts of unknown sample to a series of standards and determining the concentration of the unknown graphically from a plot of the measured quantity versus the standard concentration. Another approach is to prepare the standard so that its composition resembles that of the sample as closely as possible although this is very difficult for air pollutant samples. The objective of this standard compensation approach is the same as that of the standard addition approach, i.e., to compensate for the presence of interfering substances in the unknown. A well-written analytical method will specify procedures such as these to correct for instrument and method error.

8.3.4.1.2 Indeterminate Error. Even if all determinate errors are eliminated, every replicate analysis will not give the same value. Such variation in results is due to indeterminate error, also called random error. Random error affects the precision or agreement among results and is due to unassignable or chance causes. Since the causes of random error are indeterminate, the statistical measures of precision are used to quantify these errors. Three methods of reporting random error are used: the determination of the range of replicate results, the calculation of standard deviation on the same or different samples, and the calculation of the coefficient of variation.[52-55]

8.3.4.2 Analytical Variability. Statistical measures are needed to express the variability to be expected from an analytical procedure. An analytical procedure is considered reliable if the results are accurate and precise. Several factors determine the reliability of the procedure. When the results of a procedure do not deviate from the known value more than that explainable by the procedure's precision, the procedure is considered accurate. Precision for a procedure involves the variability of the procedure under well-controlled conditions. There are various types of precision. Designation of the context in which precision is used is absolutely necessary for meaningful interpretation. When the conditions involve a single analyst's results, the precision is termed repeatability. The precision of interlaboratory results is often referred to as reproducibility.

Considerable choice exists among the appropriate techniques for measuring precision and accuracy of a method. The conditions under which the laboratory procedure are expected to function will help dictate the classes of variability to be included in an evaluation (e.g., different analysts, instruments, reagents, and laboratories).

8.3.4.2.1 Evaluation of Precision. A reliable method will give results that are predictable within consistent and acceptable limits. These limits will define a band within which results can be expected to fall with calculated probability. A simple way to display and summarize the measures of performance is the control chart. The control chart presents data graphically so that the acceptability of variability developing with time can be seen at a glance.[56]

For example, the analyst might complete a number of duplicate determinations on a few typical samples. The expected standard deviation might be used as a measure of acceptability of observed precision. The control chart technique offers a simple and reliable way of summarizing results to permit convenient and quick judgment of on-going performance. The technique may also be routinely applied to control sample results in real time.

Many analytical procedures are deliberately designed to make use of a linear calibration curve.[57] The proper evaluation of precision in such procedures includes an investigation of the components that contribute to the overall error: replication error, scatter about the calibration line, and the uncertainty of the calibration line itself.

Many laboratories use duplicate or replicate analyses as a routine quality control procedure. The adoption of the procedure using statistical quality control techniques provides a realistic measure of the precision of the analytical procedure. In a typical program, analytical determinations are made on all samples. About 10 percent of these samples are selected randomly for resubmission as a "blind" replication. By comparing the observed value with the calculated theoretical error, it can be determined whether or not the analytical procedure is operating in a state of control, i.e., that the observed values are reproducible within a defined range.

8.3.4.2.2 Evaluation of Sensitivity. Analytical sensitivity is concerned with two problems: the minimum change in true concentration that can be detected, and the minimum detectable concentration. The former problem is the concept of resolution which applies to instruments as well as manual operations.[58] In spectral methods, resolution is of extreme importance when working with multicomponent mixtures. Replication studies are necessary in determining resolution.

Often the analyst can choose a method with a working range that will accomodate the concentration levels to be measured. At other times he must stretch the ultimate capability of the method in order to detect lower and lower values. The National Bureau of Standards has defined a minimum detectable activity (MDA) in terms of the normal variation of the background.[59] The MDA would be that amount of the substance that is different from the blank by three times the standard deviation of the blank. The standard deviation of the blank would have to be evaluated by a series of replicate determinations of the blank value.

A linear calibration line can be fitted to a set of data by application of the least squares method.[57] The a or y-intercept provides a measure of the blank correction of the procedure. The determined value of a and its standard deviation, calculated by the least squares fitting process, provide another means of determining the lower limit of detection or MDA of a procedure.

8.3.4.2.3 Evaluation of Accuracy. Another factor that can affect a procedure or instrument is its linearity. Linearity is a measure of the agreement between the best fit line and the true results. Linearity is generally used as an instrumental performance specification but can be also applied to a procedure. Therefore, linearity is defined as the maximum deviation between an actual instrument reading and the reading predicted by a straight line drawn between the upper and lower calibration points. Accuracy then is determined by the combined errors due to the uncertainties of precision, resolution, and linearity.[58, 60]

To evaluate and control long-term accuracy, the control chart technique provides a very effective technique. The within-sets variability (or range) provides a measure of precision. Any change, either gradually or suddenly, in average value over a period of time would indicate problems regarding accuracy.[46]

8.3.4.3 Evaluation of Analytical Performance. After valid precision and accuracy data on the method and the analyst are made available, systematic daily checks to insure that valid data are consistently being generated should be initiated.[61] For colorimetric analysis, the original standard curve must be verified. (The instrument's filter should be checked quarterly.) Next, at least two standards (a high and a low) should be analyzed daily along with a blank to determine that comparable conditions exist. If the data indicate that the conditions are out of control, tha analyst must troubleshoot the system to find and correct the problem. For gravimetric analysis, the balance should be verified with standard weights prior to weighing.

In order to document the reproducibility or precision of the method, replicate samples are required. Frequency of replicate analyses is dependent on the original precision of the method, the reliability of the instrumentation involved, and the experience of the analyst. The variance of the replicate analyses is calculated and compared with the estimate of variance for the method. A statistical procedure for determining the significance of the difference between the two variance estimates is the F ratio test. If the value of F exceeds a certain value, the system is not under control and the analytical results are subject to question.

One procedure for maintaining acceptable precision of analytical results is to run a duplicate analysis on each set of samples sent to the laboratory. For each set of duplicate analyses, one computes the variance from:

$$\sigma_D^2 = \frac{(X_1 \quad X_2)^2}{2} \qquad (8\text{-}1)$$

where:

σ_D^2 = variance of duplicate,

X_1 and X_2 = duplicate analyses.

This variance of the duplicate analyses is compared with the estimate of variance for the method (as published in the literature or determined experientially in the laboratory). The statistical method of determining whether or not two variance estimates are significantly different is through the _F_ ratio test:

$$F \quad \frac{\sigma_D^2}{\sigma_M^2} \qquad (8\text{-}2)$$

where:

σ_M^2 = variance of method.

If there were no difference between the two variances, the value of _F_ would be unity. Because the value of σ_D^2 is computed from only two analyses (or has one degree of freedom) and the value of σ_M^2 is a pooled variance based on many duplicate analyses (assume the degrees of freedom to be from very large to infinity), some deviation from $F = 1$ must be expected. The analyst may use a nominal risk level. Thus from a table of the _F_ distribution, if the ratio from Eq. 8-2 exceeds 3.84, the variance of the duplicate analyses would be considered unacceptable. Should this situation occur, a new set of duplicate analyses would be run. Should the second set of duplicates also result in a significantly large variance, the analyst would terminate routine analyses and determine the source of error in the procedure.

Quality assurance requires documentation as to the extent to which the method actually measures the content of the sample (i.e., accuracy of the method). Although it is by far preferable to have obtained values that check with known or actual values, it should be recognized that inaccuracy does not destroy the value of data if the degree and precision of the error is known and taken into account. In order to account for background contamination and/or sample interferences, and as a matter of routine practice, spiked samples should be used in addition to standards.

A convenient way of recording the obtained precision and accuracy data is through the preparation of quality control charts. Plotting of the data determines, in a systematic way, whether the laboratory analyses are "in control" and whether trends of positive or negative bias are developing.

When the analytical procedure is appropriate, a known standard is routinely analyzed to insure the accuracy of the results. An acceptable procedure is to run a standard prior to the actual analysis of each lot of samples sent to the laboratory. In addition, if more than 10 individual analyses (i.e., duplicates on five samples) are made, 10 percent of all the individual analyses are run on standards.

Using an estimate of the method variability (i.e., standard deviation) obtained from the literature, or determined by repeated duplicate analyses run in one's laboratory, control charts are prepared (Fig. 20). Each time (t) the analyst runs a standard, the result is entered on the control chart. If the analytical procedure is in control, the estimate of the standard should lie within $\pm 2\sigma$ (standard deviation). Furthermore, the results should be random and tend to fall above and below the true value for the standard. (Fig. 20; left side). If an individual analysis of the standard falls outside the 2σ limits, the analyst is required to repeat the analysis of the standard. Should this second result also fall outside the 2σ limits, the laboratory supervisor must determine the cause of the discrepancy and make the necessary corrections in procedure or technique.

The control chart also provides a means of detecting bias in the results. Evidence of bias is obvious when the individual analyses of the standard all tend to be above (or below) the true value, or begin to show a definite trend in the amount of departure from the true value of the standard (Fig. 20; right side). When this situation occurs, the analyst is instructed to notify the laboratory supervisor even before the 2σ limit is exceeded. Again, routine sample analysis is not continued until the source of bias has been identified and corrected.

A different view of a particular laboratory's performance can be provided by participation in interlaboratory studies. In these cooperative programs, the study samples are treated as part of the regular sample load. Such samples can be regarded as "blind" samples, a very necessary requirement in the quality control of laboratory results. By participating in interlaboratory studies, the analyst is able to compare his individual performance against the personnel from other laboratories. It should be pointed out that these "round-robin" studies are not the same type as those conducted as part of a methods

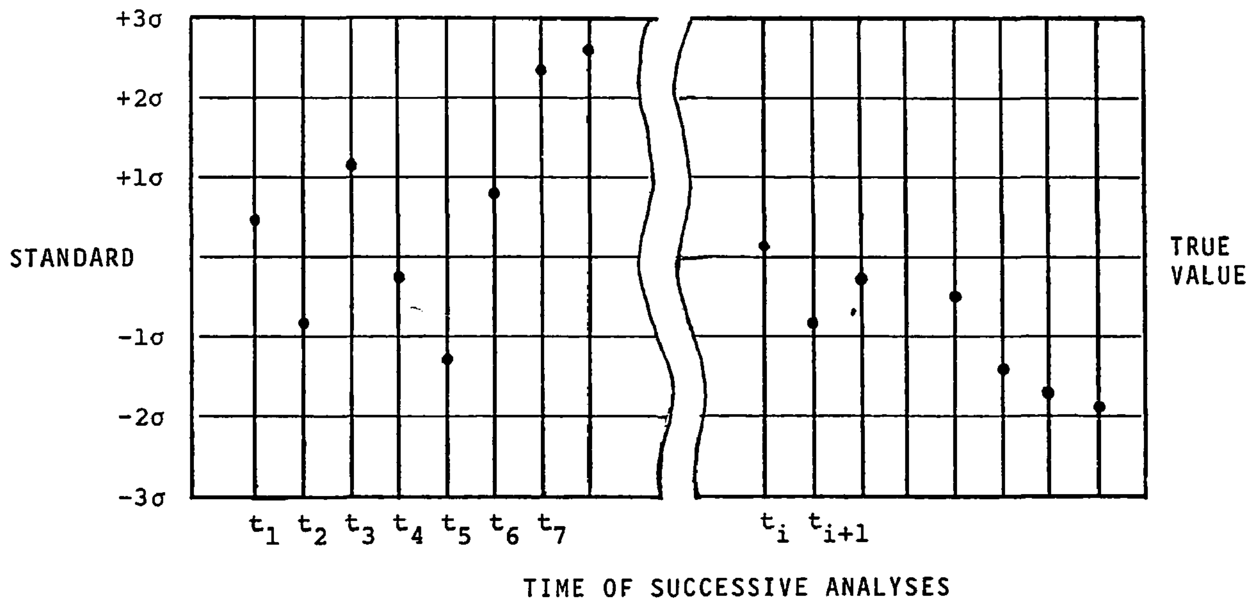


Figure 20. Control chart for analysis of standard.

development program to assess a particular method's capabilities (see Section 8.3.5).

8.3.4.3.1 Control Chart Techniques. One of the most generally used and easily applied quality assurance techniques is the use of quality control charts.[56,61-64] As presented in Figs. 20 and 21, a control chart is a graph with the vertical scale plotted in units of time or sequence of results. The combined use of spiked samples and control charts is an efficient means of keeping routine analyses in control. The control limit is usually set at ± 2σ (standard deviations).[56] Statistically, only 3 in 1000 tests on a spiked sample fall outside this range.[46]

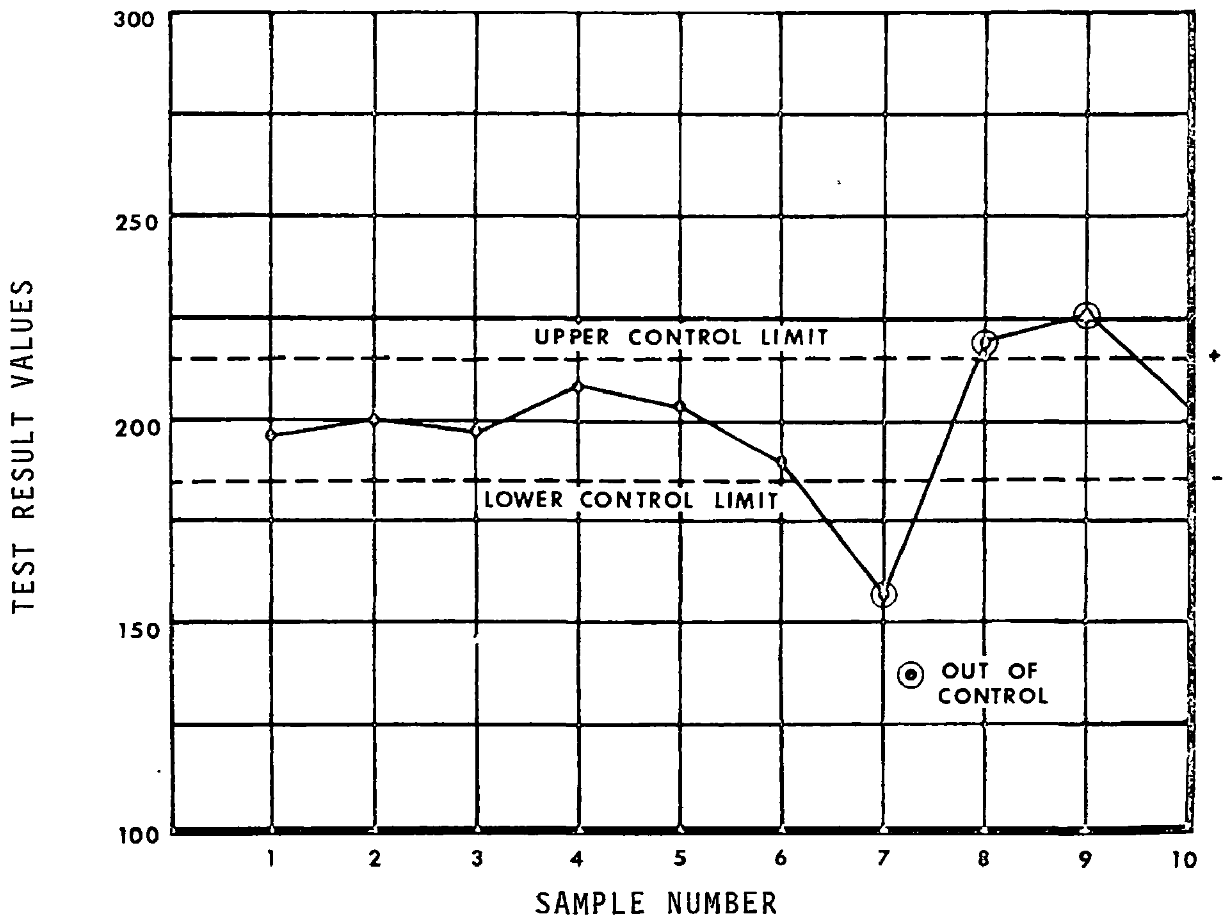


Figure 21. Control chart.

The upper and lower control limits indicate when remedial action is necessary by tagging the significance of variations between replicate samples. The central line represents the average or the standard value of the statistical measure being plotted. Data on both precision and accuracy can be displayed on quality control charts to determine the validity of data being generated on a day-to-day basis.

Although the construction of the control chart can be begun as soon as data are available, at least 10 sets of duplicate or spiked sample data from an in-control method are necessary for meaningful evaluation. A method system is in control when the standard deviation and recovery efficiency data from a given parameter are comparable to those obtained under normal laboratory operation conditions by other recognized, experienced laboratories.

There are several techniques available for constructing quality control charts and plotting the subsequent data. Two popular techniques are the Shewhart Technique[56,61-63] and the Cu Sum technique.[64] In using either of the two techniques, precision control charts are constructed from replicate sample analyses, whereas accuracy control charts are constructed from recovery efficiencies using spiked samples or standard samples.

8.3.4.4 Instrumental Quality Control. The modern air pollution control program depends very much upon instrumentation, from the automatic sampler to the computer. Analytical instrumentation is continually developing, with manufacturers redesigning and improving their products, and with increasing miniaturization, durability, sensitivity, and automation. With the wide-ranging selection of available equipment on the market, the laboratory supervisor and his staff have the difficult task of selecting the most appropriate instrumentation for their needs. Price is only one consideration in purchasing analytical equipment. Ease of operation and maintenance should also be determining factors in the final selection of equipment. Table 15 lists the instruments used in the field and on the bench for ambient air pollution sampling and analysis. The list includes basic equipment used in routine work as well as specialized instrumentation that might

Table 15. INSTRUMENTS USED IN THE AIR POLLUTION CONTROL PROGRAM

A. Manual Laboratory Equipment or Methodology

- Analytical balance
- pH meter (potentiometer)
- Microscope
- Oscilloscope
- Voltmeter
- Spectrophotometers
  - Visible
  - Ultraviolet
  - Infrared
  - Atomic absorption
- Gas chromatography
- Liquid chromatography (paper, thin layer)
- Temperature measurement
- Special methods
  - Carbon-hydrogen combustion analysis
  - Emission spectroscopy
  - Electron microscopy
  - Neutron activation
  - Specific ion electrodes
  - X-ray diffraction
  - Mass spectrometry
  - X-ray fluorescence
  - Fluorescence-phosphorescence

B. Automatic Laboratory Equipment

- Colorimeters (e.g., Technicon Auto Analyzer R)
- Continuous flame ionization detectors (FID)
- Recorders
- Calculators (programable)
- Computer (desk top)

--continued

Table 15 (continued). INSTRUMENTS USED IN THE AIR POLLUTION CONTROL PROGRAM

C. Manual Air Monitoring Equipment

- Hi-Vol sampler
- Gas sampler (24-hour)
- Spot tape sampler
- Membrane filter sampler

D. Automatic Air Monitoring Equipment

- Continuous soiling index (automatic tape)
- Nephelometer
- Mass monitor
- SO_2 gas detectors
  - Colorimetric
  - Coulometric
  - Flame photometric
  - Electrochemical
  - Conductimetric
- NO_2-NO detectors
  - Colorimetric
  - Coulometric
  - Electrochemical
  - Chemiluminescence
- Oxidant detectors
  - Colorimetric
  - Coulometric
  - Chemiluminescence
  - UV absorption
- Carbon monoxide detectors
  - Nondispersive infrared
  - UV mercury displacement
  - Gas chromatography
- Hydrocarbon detectors
  - Flame ionization
  - Infrared
  - Gas chromatography

be needed on occasion. Proper operation and maintenance of each of these devices is a primary consideration in the production of satisfactory data.

Table 16 is a tabulation of selected air pollution laboratory instrumentation and the various parameters that affect their performance and quality control, such as instrument design and instrumental weaknesses. A fundamental understanding of instrument design will assist the analyst in the correct use of the equipment and, in some cases, will aid in detecting instrumental failures.

Table 16. INSTRUMENTAL QUALITY CONTROL

Instrument type	Quality control parameter	References
Analytical balance	Use and maintenance calibration, performance evaluation	A, 65
Spectrophotometer	Instrument specifications	66-68
UV, IR, Visible	Operation & maintenance	3,69
Turbidimeter	Design and operation	22,70
Atomic absorption	Theory & methodology	71-73
Gas chromatograph	Theory & application	74,75
Ion selective electrodes	Theory & application	76
Calorimeter (Bomb)	Theory & application	77
Particle classifier	Theory & application	78
Particle mass monitor	Theory & application	79
Microscope	Operation & application	80-82
Other laboratory instruments	Theory & application	67,68
	Calibration & maintenance	A
Automatic air monitors	Operation & maintenance	2,3
Source sampling equipment	Procedures & errors	22,83,84

A - Use the instrument instruction manual.

8.3.4.5 Ancillary Materials Quality Control. In order to produce high quality analytical data, the quality control program must minimize or eliminate determinate errors. It is not sufficient to minimize personal, operative, and instrumental errors by insuring that the analyst is experienced, careful, and competent and that the equipment is reliable and in optimal operating condition. The proper selection, preparation, and storage of reagents, solvents, and gases and the quality of the glassware, air, water, and electrical services have measurable effect on the analytical results. Special considerations and precautions that the analyst must take in certain cases will depend largely on the individual requirements of the specific method used. In general, however, the laboratory must set basic, routine requirements for the purchase, preparation, purification, calibration, and standardization of chemical reagents, solvents, compressed gases, and glassware. The quality control considerations for the various ancillary laboratory services are listed with references in Table 17.

8.3.4.6 Laboratory Operations Quality Control. Laboratory procedures will vary in terms of frequency, man-hour requirements, and degree of complexity. Certain operations are quite complex but essentially "nonmanual," such as those that are condicted in the field with completely automatic sampling, analysis, and data recording equipment. Sampling operations vary widely in time requirements and complexity. Some analyses require no pretreatment or preservation scheme. Often such samples are measured in just a few minutes using a routine instrumental method. Other sample determinations require very extensive sample preparation prior to complex chemical or

Table 17. ANCILLARY SERVICES QUALITY CONTROL

Ancillary services	Quality control parameter	Reference
Chemical reagents & solvents	Reagent quality	85
	Primary standards	86
	Preparation, standardization, and storage	87
	Errors	88
Gases	Purity	89
Glassware	Cleaning	88,90
	Calibration	90,91
	Specifications	92
Distilled water	Purity	93
	Preparation	94
	Purification	94-96
Compressed air	Purification	89
Electrical services	Voltage regulation	97

instrumental examination.

In addition to these "hardware-type" laboratory operations, a related group of "soft-ware" operations are part of any technical services function. Such operations as sample logging, data logging, data calculations, and statistical quality control techniques range from the self-explanatory to the more time-consuming and more complicated manipulations.

8.3.4.6.1 Analyst Training. In each air pollution control laboratory, work assignments should be clearly defined both in terms of task descriptions and personnel job descriptions. The analyst should undergo a training program including periodic refresher courses as well as training in new areas so that he fully understands the assignments and requirements of his present job before taking on new or added responsibilities.

Besides a planned curriculum of training courses, the novice chemist and technician should receive on-the-job training in many of the basic laboratory operations. Examples of basic operations requiring periodic review with the laboratory personnel are:

(a) Recorder or other readout systems. Check to see whether the individual knows the nominal range of the scale and the principles of interpolation and extrapolation.

(b) Sample log. Emphasize a routine procedure and responsibility assignments for recording and routing of samples entering the laboratory.

(c) Sample handling. Discuss sample transfer (field to laboratory) procedures, sample preservation techniques, sample stability (thermal, photochemical, biological, etc.), and recommended storage procedures. The analyst should also be completely familiar with the procedure for transfer of the sample from the sampling container to the analysis vessel (e.g., pipetted-supernatant only, pipetted after mixing, filter, pour, agitate, heat, cool, etc.).

(d) Volumetric Measurement. Instruction in the use of pipettes, burets, volumetric flasks, and similar graduated glassware.

(e) Gravimetric measurement. Instruction in the proper use of the analytical balance, including periodic standardization and maintenance.

(f) Glassware and equipment maintenance. Glassware must be cleaned and rinsed in accordance with requirements of the analysis. Laboratory personnel should be instructed in the proper cleanliness techniques for both routine as well as special analyses.

(g) Data handling. Instructions in mathematical procedures, statistical methods, control chart techniques, and use of desk top "programmable" calculators.

Quality control is based on a firm foundation of basic laboratory techniques. Error due to the individual analyst as well as the laboratory as a whole can be minimized with the consistent practice of approved, proven techniques. It is the duty of the laboratory supervisor to initiate and to insure the continued use of approved techniques by periodic review and evaluation of each analyst.

8.3.4.6.2 Quality Control Costs. The cost of data production in the analytical laboratory is based largely upon three factors: the pay scale of the analyst, overhead, and the number of data units produced per unit of time. However, estimates of the number of measurements that can be made per unit of time are difficult because of the variety of factors involved. If the analyst is pushed to produce data at a rate beyond his capabilities, unreliable results may be produced. On the other hand, the analyst should be under some pressure to produce a minimum number of measurements per unit of time lest the cost of data production become prohibitive. In order to achieve the maximum number of reliable measurements per unit cost, it is necessary to have operational quality control. Thus, quality control is truly an overhead cost. The level of quality control required should be based on the operational complexity and frequency and the final usage of the data produced.

In the following table (Table 18), examples of sampling and analytical operations required of an air pollution control laboratory are described in terms of skill-time-equipment requirements.[98] The operations are rated in terms of level of personnel and skill required, the overall degree of complexity, and the number or frequency of operations that an analyst is expected to perform on a routine basis. The utility of such a rating system is severalfold. One very important consideration is its usage as a basic tool in determining the quality control requirements of the multitude of air pollution laboratory operations.

A laboratory's quality assurance program should be an integral part of the overall laboratory function, not a separate, add-on segment. Each analyst and technician should continually carry out the operations and procedures designated to measure and improve laboratory performance. The laboratory supervisor or quality control officer will use the quality control data as a real-time management tool to improve laboratory performance.

Quality control does contribute a cost to the laboratory operation. It is estimated that an operating quality assurance program requires 5 to 10 percent of the available manpower for proper implementation. Depending on the individual laboratory's operations, the allocation of this 5 to 10 percent of technical manpower will be distributed in various ways. For the air pollution control laboratory new to the quality assurance field and for the air pollution control laboratory interested in assessing its existing quality assurance program, the

Table 18. QUALITY CONTROL REQUIREMENT BASED ON SKILL-TIME-USE RATING OF AIR POLLUTION LABORATORY OPERATIONS
(Operations selected for illustrative purposes only)

Operation	Complexity requirements						
	Freq. (a)	Man. (b)	Instr. (c)	Skill (d)	Equip. (e)	Data Util. (f)	(QCI) (g)
I. Intermittent							
A. Sampling							
1. Particulate (Hi-Vol)	4*	2	1	4*	3	1 to 4	15 to 19
2. SO_2 (candle)	1	2	1	5*	1	1	11
3. Gases (bubbler)	5	4	2	3*	3	1 to 4	18 to 22
4. Gases (integrated bag)	3*	4	2	3*	3	2 to 4	17 to 19
5. Metals (membrane filter)	3*	3	1	3*	1	1 to 5	12 to 17
6. Fluoride (open tubular column)	3*	3	3	3*	3	1 to 5	16 to 21
B. Analysis							
1. Particulate (gravimetric)	5	2	2	3*	4	1 to 4	17 to 20
2. SO_2 (gravimetric)	1	2	2	3*	4	1 to 2	13 to 15
3. Gases (colorimetric)	5	3	3	3*	4	1 to 4	19 to 23
4. Gases (gas chromotograph)	3*	4	4	2*	4	1 to 4	18 to 22
5. Metals (atomic absorption)	5*	4	4	2*	4	1 to 4	20 to 24
6. Fluoride (specific ion electrode)	3*	1	2	3*	3	1 to 4	13 to 17
II. Continuous							
A. Particulate							
1. Tape	5	1	2	3	4	1 to 5	16 to 20
2. Mass monitor	5	2	4	3	4	1 to 5	19 to 23
B. SO_2							
1. Colorimetric	5	1	1	2	3	1 to 5	13 to 17
2. Coulometric	5	2	5	3	4	1 to 5	20 to 24
C. Oxidant							
1. Colorimetric	5	1	1	2	3	1 to 5	13 to 17
2. Chemiluminesence	5	4	5	3	4	1 to 5	22 to 26
D. CO							
1. NDIR	5	1	1	3	4	1 to 5	15 to 19
2. UV	5	1	2	3	4	1 to 5	16 to 20
E. Hydrocarbon							
1. FID	5	1	2	2	3	1 to 5	14 to 18
F. NO_x							
1. Colorimetric	5	1	1	2	3	1 to 5	13 to 17
2. Coulometric	5	2	5	3	4	1 to 5	20 to 24
G. H_2S							
1. Flame Photometric	5	3	4	2	4	1 to 5	19 to 23
2. Coulometric	5	2	5	3	4	1 to 5	20 to 24
3. Colorimetric	5	1	1	2	3	1 to 5	13 to 17

*A particular laboratory may vary in the frequency and skill categories. A more skilled analyst lessens the external quality control requirements.

Table 18 (continued).

Code:

(a) Frequency

1 = Monthly
2 Biweekly
3 Weekly
4 Two to six times per week
5 Daily (or continuous)

(b) Manual complexity

1 Simple; quick
2 Simple; lengthy
3 Complex; quick
4 = Complex; lengthy
5 - Very difficult

(c) Instrumental complexity

1 Simple principle; minimum downtime
2 Simple principle; periodic downtime
3 - Complex principle; minimum downtime
4 Complex principle; periodic downtime
5 Complex principle; frequent downtime

(d) Skill required (the higher the skill level, the lower the quality control cost)

1 Senior professional or expert specialist
2 Trained professional
3 Skilled technician
4 Semiskilled personnel (sanitarian)
5 Nontechnical personnel (fireman; policeman)

(e) Equipment required

1 Low cost (e.g., dustfall)
2 Low to moderate (e.g., spot tape sampler)
3 Moderate (e.g., HiVol, gas sampler)
4 = Moderate to high (e.g., automatic type, continuous gas monitor)
5 High (e.g., mass spectrometer)

(f) Data utilization

1 Routine ambient network
2 Special studies
3 Source surveillance (enforcement)
4 Routine alert network
5 Episode alert network

(g) Quality Control Index (QCI) equals the Σ a through f

6 to 11	Minimum	12 to 17	Low
18 to 23	Medium	24 to 30	High

method described below is an attempt to allocate costs and distribute quality control effort among the various operations and procedures that make up an air pollution control laboratory program.

The air pollution control laboratory should allocate a certain percentage of available time and resources (man-hours) to the quality assurance program. A technical services function that budgets 10 man-years to its laboratory program might devote 1 man-year (or 10 percent of available manpower) to quality control. This requirement will decrease as better analysts and more reliable methods become available. A tabulation such as illustrated in Table 18 could be used to obtain a further breakdown of the quality control allocation by specific tasks or laboratory operations. Each of the individual operations conducted by the air pollution laboratory could be assigned a rating in several different categories; e.g., frequency of the operation, complexity, personnel skill required, and equipment requirements. The rating system could also incorporate a parameter that considers the utilization and/or immediacy of the data resulting from the operation. The quality control index (QCI) could be represented as the summation of the scores for each of the rating parameters. After each of the laboratory operations has been assigned a quality control index, the amount of time or manpower to be allocated to each of the individual operations can be calculated by multiplying the total quality control manpower allocation by the quality control index divided by the sum of the quality control indexes:

Quality Control Man-Years (Operation #1) =

$$\begin{matrix}\text{Total Quality} \\ \text{Control M-Y}\end{matrix} \times \frac{\text{QC Index}_1}{\sum \text{QCI}} \qquad (8\text{-}3)$$

Quality Control M-Y (Operation #2) =

$$\text{Total QC M-Y} \quad X \quad \frac{\text{QC Index}_2}{\sum \text{QCI}} \; . \qquad (8\text{-}4)$$

The quality control index for a particular laboratory operation would vary from laboratory to laboratory; each of the rating parameters should be developed and tailored for use by the individual laboratory. Factors such as frequency of the operation, the skill level of the personnel used for the operation, and the end use for the data acquired will vary significantly with each laboratory.

A laboratory, for example, that monitors only particulates might have a quality control index (QCI) of 15 for particulate sampling and a (QCI) of 20 for particulate analysis, while devoting 1 man-year of effort to its monitoring activity. The 0.1 man-year for quality control would be distributed as 15/35 or 43 percent for sampling and 20/35 or 57 percent for analysis.

8.3.5 Interlaboratory Quality Control

In addition to intralaboratory control, it is also desirable to control the quality of interlaboratory analyses. More error (both determinate and random) is expected when analyses are performed by different people in different laboratories. Collaborative testing can be conducted to evaluate and control interlaboratory error. The careful design and preparation of the sample is the responsibility of the coordinating or lead laboratory.[99]

The results can be plotted on a control chart or ranked according to the Youden method.[99] Statistical methods can be used to evaluate those laboratories that are out of control.

8.3.5.1 Types of Interlaboratory Studies. Collaborative testing between groups of laboratories are conducted for at least three different purposes: (1) selection of analytical methods, (2) evaluation of analytical methods, and (3) evaluation of laboratory and analyst performance. The first two purposes are part of methods standardization, which determines the accuracy, precision, and bias of a method. The third purpose is part of methods quality control, which determines how well various laboratories are using the methods.

Methods standardization in the air pollution control field is the responsibility of the Federal Environmental Protection Agency.

Collaborative testing of the various methods used in air pollution control is an important part of the Federal EPA laboratory standardization program.[100,101] Interlaboratory studies are necessary to obtain the accuracy and precision of the selected methods used by the participating laboratories. The evaluation of study results also permits a judgment of the relative capabilities of these laboratories performing the sampling and analysis schemes.[50,51]

8.3.5.2 Federal Collaborative Test Program. In defining an interlaboratory method study, it may be well to explain what it is not. It is not an evaluation of reagents, or of materials, or of different test conditions. It is not an initial study of a method nor is it a study to develop a method. An interlaboratory study, in fact, must come after each of these tasks and often depends on their completion. An interlaboratory study is a between-laboratory evaluation of the exact physical, chemical, or biological method that yields a measurement of desired properties.[100-104] An interlaboratory program is usually aimed primarily at one of three objectives: troubleshooting or audit of the comparability of measurements, evaluation of a test method, or extension of a measurement process from a primary laboratory to other laboratories. Depending on the particular objective to be emphasized in the round of tests, the approaches may be somewhat different.

The Youden approach, for example, uses graphical analysis and ranking score procedures that are designed to locate and identify trouble sources.[50,51] In addition, the Youden ruggedness test is a procedure to check out and disclose significant influencing factors that may change from laboratory to laboratory. The Youden emphasis is on troubleshooting through experimental design.

Another approach offered by Mandel and Lashof aims to interpret an established test method through a linear model.[105] The analysis segregates the overall variability into the replication component, the scale or instrument calibration component, and the variability-between-laboratories component. The emphasis of the Mandel-Lashof approach is on the evaluation of the test method and on the quantitative estimation of the effect of these three components.

8.3.5.2.1 General Requirements for a Method Study. Before the State air pollution control program can be part of EPA interlaboratory method studies, the participating laboratories must be "in control." In most cases, this means that between-replicate deviation will be small and uniform in all member laboratories.

Secondly, the method must be written out in detail and followed explicitly.

Thirdly, all laboratories and analysts must be so thoroughly familiar with the method to be tested that any special reagents or equipment required are recognized and made available. If, however, all participating analysts are not acquainted with the method in question, it is quite easy to set up a simplified preliminary study to accomplish this required familiarity.[106]

Fourthly, the method to be evaluated should have been tested for its ruggedness. The developer of the method or another qualified analytical laboratory must determine whether or not the method will be stable under routine analytical conditions, i.e., whether slight variations in time, temperature, pH, reagent, sample volume, interfering substances, etc. give rise to significant deviation effects.

8.3.5.2.2 Testing for Ruggedness. Variation among analysts and among laboratories occurs readily due to differences in reagents used, rate of heating employed, volumes dispensed, temperature reading errors, and the like.[107] After a particular method has been developed for routine use, it is appropriate to deliberately introduce minor deviations from the written procedure into the method and observe the effect of these variations. If, for example, it is determined that a method depends on seven key factors, it is possible to choose, from the 128 (or 2^7) different combinations of nominal and alternative values, a subset of eight of these combinations to determine the effect of each of the seven factors. If one or more of the factors are having an adverse effect, their effect will be substantially larger than that due to the sum of the other factor effects. It should be acknowledged that errors resulting from ruggedness testing must be corrected or minimized before collaborative testing is begun.

8.3.5.2.3 Selection of Laboratories. To provide a statistically valid evaluation, the participating laboratories should be representative of the ultimate users of the method. In a statewide air pollution control program, the users of the method are the State and local agency air pollution control laboratories. The coordinating agency could be the EPA regional office, the State headquarters, or an interstate cooperative. The reference or referee laboratory would be the Federal EPA NERC Center, the National Bureau of Standards laboratory, a university or private institute's laboratory, or a private consulting and testing laboratory. The reference laboratory selected must be proved as competent in the use of the method being tested.

8.3.5.2.4 General Instructions for Methods Study. The inter-laboratory quality control program should be a continuing element of the air pollution control laboratory. It will change and fluctuate in level of effort as existing methods are submitted to evaluation and new methods are developed and compared with existing ones for sensitivity, specificity, and reliability. As part of each method study, specific directions should be prepared and made available to member laboratories prior to study initiation. The following general instructions can be used as a guide in these matters:

(a) Exact method writeups must be provided to each analyst. The technical description of an analytical method is difficult in that the language and organization must be complete, yet unambiguous and easy to understand. Certain requirements in a method may appear trivial. However, if they are not controlled, a methods study can become invalid and useless.

(b) The method must provide explicit directions for sampling, sample preservation and storage, sample makeup and treatment, time and other limitations, sequence of analyses, and so on.

(c) Advance notice of the methods study must be given so that the participating laboratories can integrate the test into their program and realistic deadlines can be established. Scheduled deadlines for agreement to participate and for completion of analyses and reporting must be closely adhered to.

8.3.5.2.5 Providing Test Samples and Containers. A variety of established and new techniques will be used to determine their role and applicability in collaborative testing. Simulated solid, liquid, and gaseous samples will be distributed by the coordinating laboratory to each of the member laboratories to determine the reliability of laboratory (or bench) sampling and analytical procedures. Simultaneous sampling and analysis of various pollutants in the field at the same location and time periods by representatives of each of the cooperating laboratories will be necessary in certain method studies. Another variation of an air pollution method study would include the simultaneous sampling and analysis of replicates by each of the cooperating laboratories both in the field and, at another time, in the control laboratory.

In conducting a methods study in which the sample is either a solid or a liquid (e.g., fuel or solvent analysis), the preparation of test samples is not without problems. However, when the sample is gaseous, vapor, or air-suspended particulate matter, the generation, sampling, and analysis of test or reference atmospheres for collaborative method studies are still in the experimental stages. To this time, no satisfactory particulate matter reference atmosphere has been developed. Preparation of test samples that simulate the gaseous or particulate pollutant, after it has been filtered out or trapped in a bubbler solution, can be more easily accomplished. Collaborative tests based on this type of sample evaluate only the analytical method; evaluation of sampling methods depends on the provision of standard or reference test atmospheres.

8.3.5.2.6 Liquid (or Solid) Reference Samples. The following points relate to the preparation and containerization of liquid (or solid) samples for fuel or solvent analysis or to air samples that have collected in liquid (or solid) media:

(a) The sample should be carefully prepared so as to reflect the composition and concentration level of the test species as it normally occurs and yet to be within the workable portion of the concentration range for the method.

(b) Since precision of almost all methods varies with concentration, a comprehensive study includes several levels of concentration.

(c) Since accuracy of the method is affected by interfering substances, exactly known levels of selected constituents are added to the samples or sampling media.

(d) In some cases, the coordinating laboratory will prepare the samples as "concentrates," ready for final dilution and makeup at each of the individual cooperating testing laboratories (i.e., the local agency air pollution control laboratories).

Advantages are the reduced space requirements and reduced handling and transport costs. By using sealed glass ampoules, preservation of concentrates is maximized by means of steam sterilization. Chemical preservatives can be employed at rather high levels in the concentrate and can be removed later (as interferences) by dilution to the final sample volume.

(e) An alternative to the "concentrate" method of sample preparation is to have the coordinating laboratory prepare and send the dilute simulated samples to the local laboratories. Such standard samples have the advantage that they reach the analyst in the same fashion as does a routine unknown sample. In addition, there is no dilution required so that this source or error or variance is removed. The disadvantages are the higher cost of sample transport, the logistics problems due to storage of large quantities of such samples, the limited choice of sample preservation methods, and the limitations due to the size and composition of the sample container.

8.3.5.2.7 Provision of Test Atmospheres. A serious problem in collaborative testing is the generation and/or selection of test atmospheres. The ideal atmosphere is the real atmosphere with all its interfering substances. Several kinds of approaches are currently available to meet the requirements of interlaboratory method studies;[101] newer and different approaches may be required in some instances.[108] The selection of a particular sample generation procedure should receive a considerable amount of preliminary evaluation by the coordinating laboratory in an attempt to define and compare the selective advantages and disadvantages in each case. The approaches used may include the following:

(a) Permeation tubes. Calibrated standards can be sent to each laboratory to be used in generating the test atmosphere. With the recent availability of permeation tubes for sulfur dioxide, certified by the National Bureau of Standards, the accuracy of this method is further assured. NBS will provide similar standards of certified composition for other pollutants in the near future. These tubes must, however, be constantly monitored to insure consistent permeation rates.

(b) Gas cylinders. Standard gas mixtures can be prepared in large quantities and distributed to participants in individual cylinders. For reactive contaminants that must be measured at fractional-part-per-million levels, such as sulfur dioxide, nitrogen dioxide, or ozone, this procedure cannot be used. For nonreactive contaminants that are measured at parts-per-million levels, such as carbon monoxide, this method has been used when adequate precautions are taken in mixing and calibration.[49] Wall adsorption at low concentrations is a major problem area.

(c) Bag sampler assembly. Duplicate ambient or simulated samples of gaseous pollutants at typical atmospheric concentration levels can be prepared in "bag-box" containers.[109] The containers are composed of Tedlar or Mylar bags enclosed in corrugated boxes so designed that evacuation or pressurization of the box causes filling or emptying of the bag, respectively. One of the replicates is sent to the central or referee laboratory for analysis. The other is analyzed in the field or within the facilities of the cooperating laboratories by their analysts. An additional quality control measure would include the simultaneous analysis of two replicate bag-box samples both in the field and at the bench by the cooperating local control laboratories.

(d) Other approaches used by the coordinating laboratory are to use a mobile van completely equipped with the necessary standards and calibration equipment to visit each member laboratory on a periodic basis and to send representatives from the coordinating laboratory to each of the participant laboratories in order to prepare test atmospheres on a simultaneous basis. This can be done by diluting pure gases into a plastic bag with adequate control of volumes, temperatures, and other operating conditions. If the same technique is used for dilution of each participating laboratory, there can be reasonable assurance that test atmospheres will be very nearly identical throughout the group. However, suitable precautions must be observed to avoid errors due to diffusion of pollutant gases through the plastic, reaction on the surface of the plastic material, or other experimental errors. Sending a representative to each participating laboratory would also impose serious restrictions on the scheduling of collaborative tests by the participants. No single procedure will be satisfactory for all tests. Each method must be evaluated before selecting the best test procedure for each collaborative test series.

(e) Field tests. Instead of generating a test atmosphere, a group of collaborators at a single location can sample a real atmosphere if suitable concentration levels can be found to test the method as desired. The primary disadvantage here is one of statistical validity. Ideally, a collaborative test should indicate what each participant is capable of doing in his own laboratory, not at some central location. The results from this method more nearly indicate an internal laboratory evaluation rather than an interlaboratory evaluation. However, this method does distinguish the analytical differences between laboratory samples and "real" samples.

8.3.5.3 Interlaboratory Testing at the State Level. As described throughout subsection 8.3.5.2, the statewide APC program can participate in the EPA collaborative testing program. Coordination of such Federal-State laboratory method studies will take place through the EPA Regional Offices, from whom more information can be obtained.

Some States may also choose to participate in an interlaboratory quality control program that is not part of methods standardization. Such a program would continually evaluate and rate the performance of each of the cooperating State and local APC laboratories. In certain instances, the place of the central or coordinating agency would be taken by the EPA Regional Office. In other cases, the Regional Office may delegate this responsibility to the State agency or to a laboratory serving a multistate area.

9.0 CONTRACTING CONSIDERATIONS

The statewide air pollution control technical service group provides technical services to the total State air pollution control program. Since these services vary greatly in terms of frequency, manpower, and equipment requirements, level of expertise needed, and immediacy of response required, the technical service group may sometimes have to consider the use of outside contractual assistance. The outside assistance may be from another Government agency, from a university or research institute, or from a private institutional or consulting laboratory.

The need for outside help for short-term projects occurs when specialized equipment or personnel are required or when the increased work load is beyond the capability of in-house resources. Examples of this need are special studies such as a three-month sampling program for a new pollutant, the use of a consultant meteorologist during emergency episode conditions, and training of analysts and technicians in a specialized technical service area.

The utilization of contractual assistance on longer term projects is necessary when the special technical assistance, requiring nonroutine techniques or equipment, is not available in-house. Analysis for metals or pesticides, fuel and solvent analysis, material effects analysis, and the analysis of odorous, nuisance, and hazardous materials are good examples of tasks which could require outside contractual services.

The advantages of using outside contractors may include overall cost savings and/or more immediate availability of results. In addition, the outside laboratory adds a measure of objectivity to data and the resultant recommendations that are used in enforcement activities.

Disadvantages of using the contract mechanism may include the restrictions of State procurement policies and procedures as well as the need to devote time and manpower in keeping abreast with Federal and State contractual guidelines and in monitoring the specific contract for maximum acceptable performance.

To determine whether or not a particular task or study to be undertaken by the State program should be done in-house or on contract, the following considerations should be applied:

(a) Frequency. How often will the task be repeated?

(b) Level of Effort. How many technical operations are conducted per unit time?

(c) Compatibility. How will the task affect the existing program?

(d) Priority. How quickly must the results be ready?

(e) Resource Requirements. Personnel, equipment, other costs.

(f) In-house Capabilities. Current and expected.

(g) Contractor Availability. Location and key performers.

(h) Funding Availability. Current and expected.

The comparative cost between conducting a project in-house and letting a contract can be a secondary consideration when the priority is high and adequate funding is available. Other factors can make the contract mechanism more suitable. The hiring of additional personnel and/or the procurement of additional capital equipment are normally not economically feasible for short-term, relatively infrequent tasks. In other cases, an agency "freeze" on new hiring would postpone an in-house project. Another consideration is the effect of a new project on ongoing laboratory operations. Additional workload from a new project could adversely affect the normal output and quality control of existing programs.

In considering cost alone, personnel additions must be looked at in terms of the continuing program plan. Acquisition of new instrumentation and equipment involves the trade-offs between leasing or buying compared with the costs of an outside contract. A general guideline in this regard can be stated thusly: If the equipment acquisition costs involved in conducting the services in-house are equivalent to the contract cost over a 3-year period, the project should be conducted in-house.

Table 19 lists laboratory functions that can be conducted in-house as well as on a contract basis. The contract areas are elements of the sampling program, of the analysis program, and of the data handling program. In general, statewide laboratory programs can be categorized into three major groups: existing programs with strong technical capabilities, existing programs with lesser developed capabilities, and new or imminent State programs. Table 19 rates each of the program elements for both the central laboratory and the satellite laboratory components of the State program as to the potential for outside contracting. "Remote" (R) indicates that tasks are normally conducted in-house. "Primary" (P) indicates that circumstances will very often warrant an outside contract. "Secondary" (S) indicates that a contractual arrangement will be utilized in some cases, depending largely on the requirements of the individual laboratory.

9.1 Contract Areas

The laboratory program may require contractual services in three areas: sampling and monitoring; analytical characterization of gaseous,

TABLE 19. TYPICAL CONTRACTABLE LABORATORY PROGRAM FUNCTIONS

Contract area	Strongly developed State program		Weakly developed State program		New State program	
	Central Laboratory	Satellite Laboratory	Central Laboratory	Satellite Laboratory	Central Laboratory	Satellite Laboratory
<u>Sampling program</u>						
Air quality monitoring						
Pollutant network	R	R	S	S	P	P
Effects network	R	R	R	R	R	R
Meteorology	R	S	P	S	P	S
Calibration	R	S	P	P	P	P
Training	R	R	S	P	P	P
Surveillance monitoring						
Short-term ambient	S	S	P	S	P	P
Source emissions testing	R	R	P	S	P	P
Emergency monitoring						
Emergency episode	S	R	S	R	P	R
Accidental spill	P	R	P	R	P	R
<u>Analysis program</u>						
Routine analysis	R	R	S	S	P	P
Special analysis						
Fuel	S	P	P	P	P	P
Solvent	S	S	S	P	P	P
Metals	S	S	P	P	P	P
Pesticides	S	P	P	P	P	P
Odor and nuisance	R	S	P	S	P	P
Effects	R	S	S	S	P	P

Table 19(continued). TYPICAL CONTRACTABLE LABORATORY PROGRAM FUNCTIONS

Contract area	Strongly developed State program		Weakly developed State program		New State program	
	Central laboratory	Satellite laboratory	Central laboratory	Satellite laboratory	Central laboratory	Satellite laboratory
Data handling program						
Computer services						
Programming	S	R	P	R	P	R
Time sharing	P	R	P	R	P	R
Modeling	S	R	P	R	P	R
Statistical services	R	S	S	S	P	S
Data acquisition						
Storage and retrieval	S	R	P	R	P	R

Code:

R - remote contract potential.
S - secondary contract area.
P - primary contract area.

liquid, and air samples; and both software and hardware support of the data handling system. Since the technical services group gives technical support services to each of other elements of the State agency, it conducts routine activities on a regular or planned periodic basis. The laboratory is also expected to respond to nonroutine sampling investigations, special analytical studies, and other activities with which it may have little or no familiarity.

9.1.1 Sampling Program

The laboratory sampling program includes the assessment of current air quality, the determination of the degree of improvement required and of the resultant control activities, and the provision of intelligence before, during, and after emergency situations. Although the merits of the air pollution laboratory are based in large measure on its in-house sampling capabilities, there is a real need for contractual assistance in this area with the ever-increasing demands for more data per pollutant and for the measurement of more criteria pollutants.

9.1.1.1 Air Quality Monitoring. The current monitoring activities are devoted in large extent to the measurement of the Set I pollutants (particulate and sulfur dioxide) and, somewhat lesser, to the Set II pollutants (carbon monoxide, hydrocarbons, oxidants, and nitrogen oxides). A recent Federal report[110] discusses the proposed emission standards for three hazardous air pollutants (asbestos, beryllium, and mercury). The resultant accelerated increase in monitoring activities for identified pollutants will bring an additional utilization of the outside contractual agreement.

9.1.1.1.1 Air Quality Network. Technical services tasks that may be accomplished under contract could include the carrying out of a short-term aerometric survey, the development of a monitoring network protocol document, and the selection of air monitoring network sampling sites.

9.1.1.1.2 Meteorology. Most statewide air pollution control agencies require the services of a full-time meteorologist; however, infrequent instances necessitate the availability of multiple staff meteorologists. A consulting firm which provides 24 hours-a-day meteorology services could satisfy the need of most agencies. This service could also be provided for very large metropolitan agencies which need the equivalent service of two or more meteorologists, for large agencies which need the services of a meteorologist on a less than full-time basis, and for small agencies which need a one-time service or service at irregular intervals.

The outside consultant or contractor meteorology firm should be based locally and should be available to the agency on a 24-hour, "on-call" basis. It is suggested that the contract or agreement be written for a definite period of time (such as on an annual basis) and that the projected manpower expenditure be specified in terms of minimum and/or maximum number of service man-days. The types of service rendered under a contract for meteorological assistance could include the following tasks:

(a) Provide consultation and evaluation of urban climatology and microclimatology to aid in determining the conditions under which air pollutants in the particular community atmosphere adversely affect health and property, and the measures necessary to prevent these conditions.

(b) Provide information relative to the relationship between National Weather Service data and locally collected surface meteorological data.

(c) Provide consultation and evaluation of episodic meteorological conditions including adverse surface winds, inversions, and lower atmosphere stagnations.

(d) Provide consultation on the selection and placement of sampling and monitoring equipment for ambient as well as alert stations.

(e) Provide consultation and advice on the development of a simple diffusion model for calculating point concentrations from single and multiple sources and on the use of more sophisticated models employing computers and telemetric data.

9.1.1.1.3 Calibration. An outside contractor can be a very effective agent for field calibration of continuous, automated instrumentation. Periodic dynamic calibration techniques are most effective when used in combination with reference methods. A regular schedule for field calibration at all sampling sites can be set up and carried out by the contractor laboratory team to insure the continued validity of collected data and to permit examination of the possible correlation of data from various sampling locations.

9.1.1.1.4 Training. An outside contractor can be used in developing and carrying out an air pollution training program. The contractor can provide on-the-job training to the technician involved in sampling in the field and to the analyst in the laboratory. The contractor can also prepare and conduct training courses on the various topics related to the sampling, analysis, and data handling activities of the technical services group. Course contents would often be multidisciplinary covering meteorology, chemistry, statistics, electronics, and engineering.

9.1.1.2 Short-Term Ambient Sampling. Short-term ambient sampling may be conducted to further assess the priority rating of the air quality control region in question. Short-term projects are also used to monitor a source's impact on the quality of the ambient air. A private contractor can be used to evaluate the pollutant effect of an existing source on the surrounding community or to conduct before-and-after monitoring on a new facility (or on a new control device for an existing facility).

9.1.1.3 Source Emission Testing. Source sampling is not a full-time activity for the smaller air pollution agency. Since the duties of a source sampling team vary widely, it is difficult for such an activity to be completely self-sufficient. In addition, it is the policy of some agencies to incorporate a level of objectivity into the source testing program by arranging or recommending that compliance testing be conducted by an outside testing team, under the direct supervision of a representative of the cognizant agency.

State agencies will eventually setup and operate a vehicle testing program. The New Jersey automotive inspection project is still in the research phase to determine the effectiveness of engine tuneup and vehicle repair for the reduction of exhaust emissions.[111] The testing, diagnosis, and tuneup or repair is conducted at State laboratories and at private contractor service facilities. Full-scale implementation of similar vehicle source testing programs may require licensing of gasoline stations, car dealers, and maintenance service centers to provide routine testing and repair. Random checking and comprehensive testing of certified vehicles by the State agency will often require assistance from private consulting laboratories.

9.1.1.4 Accidental Spills. Whenever vessel rupture or unplanned spillage represents a significant imminent health hazard (in addition to a local air pollution problem), it is necessary to involve the services of an organization trained in the assessment of occupational health and safety and industrial hygiene problems. This outside organization may be another Government agency specializing in toxic material treatment (such as the local or State equivalent of the Federal National Institute for Occupational Safety and Health), or an agency skilled in handling emergency situations (such as civil defense, highway patrol, fire department), or a private consulting laboratory possessing expertise in the handling and treatment of hazardous and toxic materials.

9.1.2 Analysis Program

The laboratory analysis program includes the characterization of routine ambient and source emission samples as well as special studies requiring nonroutine techniques and equipment. Although the use of an outside contractor is more common for the more specialized, less common analytical measurements, relatively new agencies or small agencies with limited resources may contract out the analytical work to support its routine sampling program.

9.1.2.1 Routine Analysis. Smaller agencies cannot always afford the automatic analytical instrumentation available for routine characterization of air samples. Overall savings in time and cost could be achieved by channeling the analytical work from a group of small satellite agencies to a centralized laboratory. This laboratory could be the State's central laboratory, a neighboring metropolitan agency's laboratory, or a private consulting laboratory. An added benefit in the centralization of laboratory analyses is the facilitation of analytical quality control and consequent ease of validation and correlation of air quality data.

9.1.2.2 Special Analysis. The needs for special analytical services in conjunction with air pollution control activities are quite diversified. Samples submitted for characterization may be solid fuel materials (coal, coke, wood, solid waste), liquid solvents and cleaning compounds, or air-suspended particulates, gases, and vapors. The analysis technique itself may involve physical, chemical, biological, radiochemical, or physiological effects. The capabilities to analyze for the increasing number of potentially detrimental or hazardous pollutants are not readily available in-house to the State or local agency. In the majority of cases, the agency laboratory would do well to provide special analytical services in cooperation with an outside agency or private contractor.

Table 20 lists selected air pollutants whose measurement is related to concern for toxicity levels. In most cases, the instrumentation and expertise required for specific analysis are available in a nearby university's chemistry or environmental engineering department, in a local private consulting laboratory specializing in environmental analytical services, and in the laboratories of Federal agencies engaged in environmental protection research and monitoring projects.

Table 20. MEASUREMENT METHODS FOR SPECIAL AIR POLLUTANTS

Pollutant	Principle sampling technique	Analytical method(s)
Aeroallergens	UD	PA
Anions	High volume; Bubbler	SIE; Colorimetry
Arsenic	High volume	NA; Colorimetry
Asbestos	UD	EM (UD)
Barium	Membrane filter	ES
Beryllium	High volume	ES; AA
Cadmium	High volume	ES; AA
Chromium	High volume	ES; AA
Copper	High volume	ES; AA
Corrosive gases	Bubbler	UD
Fine particles	Impactor	OM; Gravimetry
Hydrocarbons:		
Reactive	UD	GC
Polynuclear	High volume; Bubbler	LC; TLC; F
Hydrogen sulfide	Bubbler; Tape	FP; Coulometry; Colorimetry
Lead	High volume	ES; AA; Colorimetry
Manganese	High volume	ES; AA
Mercury	Gas bubbler	AA; UV
Nickel	High volume	ES; AA
Odor	Grab samples	Scentometer
Organic vapors	Grab samples	GC; MS
Pesticides	UD	GC; Coulometry
Polychlorinated biphenyls (PCB)	UD	GC; Coulometry
Radioactive material	High volume; Bubbler	Counters; β; γ Scanners
Selenium	UD	AA; Colorometry
Tin	High volume	ES; AA
Vanadium	High volume	ES; AA
Zinc	Membrane filter	ES

Code:

AA - Atomic absorption
EM Electron microscopy
ES - Emission spectroscopy
F - Fluorescence; phosphorescence
FP Flame photometry
GC Gas chromatography
IR - Infrared absorption
LC - Liquid chromatography
MS - Mass spectrometer
NA - Neutron activation
OM - Optical microscopy
PA - Protein analysis
SIE - Specific ion electrode
TLC - Thin layer chromatography
UD - Under development
UV - Ultraviolet absorption

9.1.2.2.1 Fuel Analysis. Combustion calorimetry to determine Btu content, sulfur content, ash content, and related parameters is a service rendered by analytical and engineering testing laboratories listed in the yellow pages of the telephone directories of most large metropolitan areas. Elemental analysis is available from several analytical laboratories who advertize their services in most issues of technical journals dealing with pollution control topics (Chemical and Engineering News, Pollution Engineering, Environmental Science and Technology, Journal of the Air Pollution Control Association).

9.1.2.2.2 Solvent Analysis. Process emissions from dry cleaning and degreasing operations and various chemical syntheses cannot be analyzed by routine methods. Gas chromatographic separation and infrared spectroscopic analysis are required in most instances. Smaller agencies can fill their periodic needs in this area by using an outside contractor.

9.1.2.2.3 Metal Analysis. Most analyses for metal air pollutants require expensive instrumentation and an experienced analyst. Until air quality criteria documents are prepared and routine monitoring is called for, most agencies need not develop in-house capabilities in this area. The outside contractor can fill the interim needs.

9.1.2.2.4 Pesticide Analysis. Pesticides are a concern to other Government agencies concerned with pollution control and public health. In circumstances where water pollution, industrial hygiene, or other governmental agencies are conducting routine pesticide analysis, the requirement for periodic laboratory services to the air pollution control agency could be met by interagency agreement.

There are problems, however, with data interpretation related to pesticide levels. Sampling for pesticides in the ambient air has not developed to the stage where sample representativeness is unquestioned. In addition, pesticides are often rather unstable species, with decay factors which vary under different conditions. Pesticide sample integrity presentation is still a research area. In most cases, the private consulting laboratory with capabilities to provide pesticide analysis will conduct the gas chromatographic separation and electron capture or microcoulometric detection only. The sampling operations, data manipulation, and conclusions will be conducted in-house, using state-of-the-art procedures obtained from the appropriate Federal agencies doing pesticides method development.

9.1.2.2.5 Complaint and Nuisance Analysis. Complaints of malodorous gases, corrosive vapors, staining and soiling materials, and dusts that produce allergic reaction are often referred to the technical services group of the air pollution agency. The desirable complaint handling mechanism would involve the agency's enforcement activity with backup technical support from the in-house laboratory program. In cases where this backup expertise is not available internally, a contractual arrangement with a private consultant is an effective alternative.

9.1.2.2.6 Effects Analysis.[112,113] Effects analysis is limited somewhat by the fact that component differences cannot be measured over short time intervals. Corrosion rate, soiling potential, material deterioration, color fading, etc., are determined over exposure periods ranging from a week to a year. Many of the analyses can be handled using ordinary laboratory equipment. In other cases, microscopic examination, reflectance differential measurement, and other specialized techniques are required. Contracted analytical services are employed when the routine effects analyses interfere with other projects and when the specialized effects analysis tools are not available in-house.

9.1.3 Data Handling Program

Only the very large metropolitan and State agencies have complete data handling support facilities. The coupling of telemetry systems and computer technology has revolutionized the field of ambient air monitoring.[114-117] Station interrogation-data transmission techniques have automated air pollution episode alert warning systems. Air quality simulation and dispersion-diffusion modeling is a relatively new technique in air pollution control, dependent upon the development of realistic mathematical programs and the acquisition of valid air quality and meteorological data and reliable emission inventory information. In addition, there is a continual need for various statistical and computational services, data processing and data evaluation services, and data storage and retrieval capabilities. In many cases, some of these data handling requirements cannot be satisfied within the agency itself. Interagency agreements and contracts with outside specialists are very useful in filling the gaps in software and hardware, as well as maintenance and service.

9.2 Contract Mechanisms

The air pollution control agency can enter into a contractual arrangement for various technical services, for equipment maintenance services, and for the leasing of hardware and computer-related software. The contract may be with an individual consultant, a private consulting firm, another Government agency, or a public utility such as the telephone company (e.g., to provide telecommunication lines for transmitting air monitoring data).

9.2.1 Types of Contracts

A contract is any type of agreement or order for the procurement of supplies and services. The contract may be either a fixed-price, actual-cost, cost-plus-a-fixed-fee, or incentive type. It may be a contract providing for the issuance of job orders, task orders, or task letters. It may be a formal contract document, a letter contract, a letter of intent, a purchase order, or a supplemental agreement or amendment to any of the foregoing types. Contracts may also be classified by the method of solicitation and award: sole source, advertised or open bid, or negotiated bid. A negotiated contract is obtained by direct agreement with a contractor, without formal advertising for bids, but after soliciting proposals from qualified sources. Most negotiated contract requirements are for one of four general areas: services, data, material or hardware, or a combination of these three.

9.2.1.1 Service Contracts. This terminology is used to describe contract requirements for certain types of professional, skilled, and unskilled services to be performed over a definite time period. There are usually no deliverable end items required under the contract. The contracts are for janitorial, equipment, maintenance, clerical, training, or similar type services.

9.2.1.2 Data Requirement Contracts. This is a type of contract which calls for some type of data to be delivered as an end item. This could be for research with a report as the end item, which is normally the case on research contracts. Other types of contract requirements which fall into this category are audio-visual aid production and reproduction, preparation of training manuals, and editing and publication of authorized reference material.

9.2.1.3 Material or Hardware Contracts. This includes a variety of requirements, from the standard catalog hardware items (normally purchased by formal advertising) to specialized equipment being developed for research and development purposes (normally handled by negotiations).

9.2.1.4 Combination Requirements. It is quite possible, particularly for research and development procurement, for contracts to require services, data, and hardware. It is important for the project officer to recognize that he has combination requirements, so that in drafting the work statement the required services, data, and hardware can be well defined and separated for pricing and delivery purposes.

9.2.2 Contract Cost Arrangements

The type of contract cost arrangement should be compatible with the technical requirements of the work. Generally, two basic types of contract cost arrangements are the cost-reimbursement and fixed-price types. A third type, the fixed-rate contract, is a combination of these two basic types.

9.2.2.1 Cost-Reimbursement Contracts. There are five kinds of cost reimbursements contracts which would normally be used by the air pollution control agency:

(a) Cost (without fee),

(b) Cost sharing,

(c) Cost-plus-fixed-fee (CPFF),

(d) Cost-plus-incentive-fee (CPIF),

(e) Cost-plus-award-fee (CPAF).

The advantages and appropriate utilization of each of these type contracts are well discussed in a recent EPA publication.[118] For example the cost contract is used principally in contracting with educational and other nonprofit institutions.

9.2.2.2 Fixed-Price Contracts. Fixed-price contracts greatly alleviate the administrative burden to the agency and contractor alike. These contracts can be classified into five categories:

(a) Firm-fixed-price (FFP),

(b) Level-of-effort,

(c) Fixed-price with redetermination provisions,

(d) Fixed-price-incentive,

(e) Fixed-price-with-escalation.

Each of these contract types is covered in a recent EPA publication.[118]

9.2.2.3 Fixed Rate Contracts. This type of contract can be used for services or items for which a fixed price or fixed rate can be established for the labor or for the required items, but for which the amount of labor or quantity of items cannot be determined at the time of contract negotiation. Predetermined rates and/or prices are negotiated in the form of a "basic ordering agreement" (BOA) between the agency and the contractor. The agency will then request the services or items in the form of a "call order" against this basic agreement.

9.2.3 Contract Planning and Management

After the laboratory supervisor or other responsible authority has decided that the project requirement can be best handled by the contract mechanism, there is need to decide if the situation calls for an advertised contract or "invitation for bid" (IFB) or for a negotiated contract or "request for proposal" (RFP). The IFB approach is generally acceptable when the tasks are clearly defined, when the costs are low, and when the award can be easily made to the lowest responsive bidder without need for technical evaluation.

The following subsections outline the duties and responsibilities involved in designing, planning, soliciting, and monitoring a contract in support of an air pollution agency's technical services function. The detailed requirements of each element are fully described in reference.[118]

9.2.3.1 Presolicitation Planning and Determinations. A very important part of the negotiated contract process is the presolicitation phase. It is extremely important for the initiating project officer (usually the laboratory supervisor) to contact and work with the agency's cognizant contracting office immediately upon conception of a contract requirement. The designated project officer should become closely associated with the proposed contract program and should serve as the technical contact for discussions with the agency's contracting officer throughout the process. The following presolicitation elements require frequent and open communication between the project officer and the contracting officer:

(a) Advance procurement planning,

(b) Competitive versus noncompetitive procurements,

(c) The written request for negotiated contract,

(d) Obtaining sources,[119]

  (1) Research and development sources sought,

  (2) Individual synopsis,

  (3) Source files,

(e) Preparation of the request for proposal (RFP),

(1) Scope of work preparation,

(2) Technical proposal requirement of the RFP,

(3) Business proposal requirements of the RFP,

(4) Inclusion of proposal evaluation criteria in RFP.

9.2.3.2 Solicitation, Evaluation, and Contract Award. In general, during the solicitation and contractor/proposal evaluation period, all written and oral communication between the agency and the prospective contractors should be controlled by the contracting officer. The agency's policies and procedures may be more or less formal than those prescribed by the Federal agency;[118] the basic elements are outlined below:

(a) Solicitation,

(1) Relations and communications with prospective contractors,

(2) Safeguarding information received from prospective contractors,

(3) Receipt and handling of proposals,

(b) Evaluation,

(1) Technical evaluation,

(2) Business evaluation,

(c) Negotiation and contract award,

(1) Prenegotiation conference,

(2) Negotiation and contractor selection,

(3) Contract preparation and coordination,

(4) Contract award.

Table 21. TYPICAL ALLOCATION OF RESPONSIBILITIES FOR CONTRACTING AND PROCUREMENT IN STATE AIR POLLUTION CONTROL AGENCIES[118]

Contract function	Responsibility designation	
	Project officer	Contracting officer
<u>Presolicitation</u>		
Advance planning	Develops program plan	Advises as to procurement method
Submission of purchase request	Decision to buy	
Obtaining sources	Recommends & evaluates sources	Establishes source list
Sole source determination	Prepares justification	Final decision
Request for proposal	Develops technical aspects	Responsible for RFP contents and release
<u>Solicitation and evaluation</u>		
Discussions with contractor	Advisory to contracts office	Responsible for all contacts
Technical evaluation	Total responsibility	
Business evaluation		Total responsibility
Selection of competitive range	Advisory	Final decision
<u>Negotiations and award</u>		
Negotiations with contractor(s)	Participant	Responsible for conduct
Selection of contractor	Advisory	Final decision
Contract preparation and award	Scope of work and other technical aspects	Total responsibility
<u>Contract administration</u>		
Technical direction	Within defined limits	
Contract changes and extensions	Initiates to contracts office	Total responsibility
Monitoring performance	Technical performance	Cost performance
Patents	Advisory to general counsel	Coordinates requests
Acceptance of final product	Varies with product	Varies with product
Payment of Vouchers	Advisory	Reviews & certifies
Property administration	Advises and recommends	Final decisions
Administrative close-out		Total responsibility

9.2.3.3 Contract Management Responsibilities. The project officer should insure that the contractor's progress is monitored and properly controlled. If situations arise that would require contract modification or termination, the problem or information should be promptly directed to the attention of the agency's contracting office. The following outlines the duties and responsibilities of the project officer:

(a) Evaluation and control of progress,

  (1) Progress reporting,

  (2) Progress reviews,

(b) Administration required by contract provisions,

  (1) Prior approval items,

  (2) Evaluation of inventions and data rights,

  (3) Handling cost overruns,

(c) Contract modifications,

  (1) Types of contract modifications,

  (2) Modifications within the scope of the contract versus new procurement,

(d) Contract completion.

Table 21 describes the elements of an outside contractual arrangement (from advance planning to contract termination) in terms of the primary and shared responsibilities within the contracting agency. In essence, the project officer handles all technical aspects; the contracting office is charged with all the administrative, fiscal, and legal considerations.

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Appendix A

Sampling Location Guidelines

Appendix A

Sampling Location Guidelines

This report establishes guidelines for installing air monitoring instruments at particular sampling sites, especially those sites located in areas of estimated maximum pollutant concentration. Such sites are established for the purpose of determining compliance with national, primary, ambient air quality standards that protect the public health.

The minimum number of air quality monitoring sites and the minimum frequency of sampling necessary for monitoring compliance with national standards are specified in published Federal rules and regulations.[1] General considerations governing the distribution of air quality monitoring sites within an air quality control region are described in an EPA publication.[2]

Specific guidelines for placing air monitoring instruments in areas of estimated maximum pollutant concentration are given in Table A-1. Guidelines are different for stations defining average 1-hour CO concentrations and for stations defining average 8-hour CO concentrations because people are not ordinarily exposed to CO concentrations occurring over a period of 8 hours in a densely trafficked downtown area. When only one sampling site is used to satisfy the minimum surveillance requirement of the implementation plan, that site must meet the guidelines for averaging over 8 hours. Distance from the street is specified in the location guidelines for stations monitoring for carbon monoxide because the street is the primary location of CO emissions. For the same reason, height of the air inlet from the ground is a more restrictive condition for monitoring for CO than for other

Table A-1. SAMPLING LOCATION GUIDELINES FOR AREAS OF ESTIMATED MAXIMUM POLLUTANT CONCENTRATION

			Position of air inlet		
Pollutant category	Pollutant	Station location	Height from ground, ft	Vertical clearance above supporting structure, ft	Horizontal clearance beyond supporting structure, ft[a]
Primary stationary source pollutant	SO_2	Determined from atmospheric diffusion model, historical data, emission density, or other information; should be representative of population exposure.	<50	>3	>5
	NO_2	Same as above	<50	>3	>5
	Particulates	Same as above.	<50	>3	>5
Primary mobile source pollutant	CO (1-hr averaging time)	Representing area containing dense, slow-moving traffic, obstructions to air flow (tall buildings), and pedestrian population, such as a major downtown traffic intersection (<20 ft from street curb).	<15	>3	>3
	CO (8-hr averaging time)	Representing area of high traffic density in residential area, such as major throughfare in center city or suburban area (<50 ft from street curb).	<15	>3	>3
Secondary pollutant	O_x	Representing residential area downwind of downtown area (5 to 15 miles from downtown and >300 ft from major traffic arteries or parking areas).[b]	<50	>3	>5
	NO_2	Representing residential area downwind of downtown area (<5 miles from downtown).[b]	<50	>3	>5

[a] Not applicable where air inlet is located above supporting structure.

[b] Downwind of prevailing daytime wind direction during the oxidant season.

pollutants. It is desirable whenever practical, however, to sample as close as possible to the breathing zone; sampling height limitations for all pollutants are specified accordingly.

There are no well-established meteorological dispersion models now available to aid in selecting areas where secondary pollutants are expected to reach maximum concentrations. Selection of the high concentration areas described in Table A-1 is based upon information available on the reaction kinetics of atmospheric photochemical reactions involving hydrocarbons, nitrogen oxides, and oxidants; upon atmospheric data on diurnal variations in pollutant concentration; upon distribution of primary mobile sources of pollution; and upon meteorological factors. A minimum distance from major traffic arteries and parking areas is specified for oxidant monitoring sites because NO emissions from motor vehicles consume atmospheric ozone. NO_2 is considered both a primary stationary-source pollutant and a secondary pollutant. Air-monitoring stations for this pollutant should be located according to specific guidelines for NO_2-monitoring stations. Differences in horizontal and vertical clearance distances are based on the increased probability of reaction between reactive gases and vertical surfaces.

Sampling sites in areas of estimated maximum pollutant concentration should be chosen on the bases of actual aerometric and meteorological data, urban and industrial growth and development trends, and other pertinent information. Whenever feasible, a preliminary aerometric survey should be conducted as an aid in selecting sampling locations for maximum pollutant concentration.

General guidelines applicable to sampling station location (in addition to the specific guidelines listed in Table A-1) include the following:

(a) Except for stations that sample 1-hour CO concentrations, avoid locations where there are flow restrictions such as buildings, parapets, or trees in the vicinity of the air inlet.

(b) Avoid sampling locations that are unduly influenced by downwash or by ground dust, such as a roof-top air inlet in proximity to a stack, or a ground-level inlet near an unpaved road. In the latter case, either elevate the sampler intake above the level of maximum ground turbulence effect, or place the sampler intake away from the source of ground dust.

(c) Avoid locations that are inaccessible in adverse weather conditions, prone to vandalism, or otherwise insecure.

It may not be practical to select a sampling site that meets all of the specific and general guidelines. In this case, it is especially important to define the site selected so that the results from the site can be compared with results obtained at other sampling stations that meet these guidelines. Such a definition should include the critical factors of elevation, vertical clearance, horizontal clearance, distance from curb, distance from downtown, distance from major traffic arteries or parking areas, restrictions to air flow in the vicinity of samplers, nearby local sources of pollutants, and meteorological conditions. It is especially important that all samplers of a given kind be located at the same elevation throughout the sampling area.

REFERENCES

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Appendix B

Job Classifications

Materials contained in this Appendix were abstracted in total from the EPA publication entitled "GUIDE CLASS SPECIFICATIONS FOR AIR POLLUTION CONTROL POSITIONS IN STATE AND LOCAL PROGRAMS," July 1971.

Appendix B

Job Classifications

B.0 THE CLASSIFICATION PROCESS

B.1 Using Position Specifications

The basic technique of position classification is the grouping together, in categories or classes, of those positions which are sufficiently similar in duties and responsibilities so that they can be treated alike for various administrative purposes. It provides standard titles and a common language for personnel actions, budgeting, and program planning. The classification plan provides an objective foundation for a compensation plan designed to assure equal pay for equal work. It affords a basis for the systematic recruitment, appointment, and promotion of personnel. Class specifications serve as the basis for development of a practical and normally multi-part examination for assessment of applicant attributes necessary for successful job performance and career development. The validity of the examination depends upon the care with which the skills, knowledges, abilities, and aptitudes sections of the specification are developed. They should reflect the level needed for entrance into the job, since they determine the content of the tests used in the examination process. Depending on the type of position and available manpower resources, work-sample, performance, written or other types of tests may be used to assess the skills, knowledges, abilities and aptitudes needed. Personal qualities necessary for success in the field normally are assessed through an oral examination and evaluation of references. The education and experience requirement provides the basis for a preliminary screening of candidates, admitting to the examination process only those possessing the needed minimum qualifications. In addition, the education and experience requirement also provides a basis for the rating of the quality of the candidates' backgrounds where such a rating is a weighted part of the examination process.

Class specifications help employees and supervisors to understand the duties and responsibilities in job assignments. They are useful in the rating of employee performance and in the development of staff training plans. The classification plan is a valuable tool for encouraging employees to plan a career in the agency by pointing up the opportunities for broader responsibilities and the requirements for advancement.

B.2 Developing and Revising Classification Plans

The development or revision of the classification plan for State or local air pollution control positions should involve the use of a number of resources and techniques in addition to guide specifications. After policy decisions have been made about the organization of the program, job descriptions should be prepared by the employees. Background information, including supervisor's comments, program statements, organization charts, reorganization plans, and other materials should be secured. The development of a workable classification scheme necessarily involves a cooperative effort between the program officials and personnel specialists. The official specifications should conform to the established format used in the jurisdiction and should include all

B.3 Guide Class Specifications for Air Pollution Control Positions

These specifications should be regarded as ***guide or illustrative*** materials to be used in the development of class specifications in State and local air pollution control programs. They are not ready-made substitutes for the careful planning and technical work which must be carried out at the time of installation or revision of a classification structure. Class specifications serve their proper purpose as aids to improved administration when they accurately reflect the program, job content, and organization which exist or have been planned and approved by responsible officials. The classification process should follow, rather than precede, program and organizational decisions.

These specifications should not be interpreted as requiring adherence either to a particular classification structure or to a single type of organization, nor do they represent Federal requirements. They are offered for the assistance of State and local agencies in improving the classification of their jobs. It is possible that some jurisdictions may be able to use the suggested guides without substantial modification, but in many cases adaptation will be necessary. Guide specifications are not to be construed as meaning that each agency should establish positions in all guide classes. No two agencies are identical in their job arrangement. The number of classes necessarily will vary according to the size of the program, the scope of its activities, and other factors. Official State and local specifications should be developed by staff having a comprehensive knowledge of the air pollution control program.

Those State and local programs which find, after investigation, that their needs are different from those envisioned by this publication, can still use the guides as a resource for the needed classification activity.

AIR POLLUTION CONTROL DIRECTOR

DEFINITION

Plans, organizes, and directs the professional, administrative, and technical activities of an air pollution control program; coordinates the program with local, State, regional, Federal, and private agencies and organizations concerned with air pollution and related environmental activities; and evaluates program and personnel effectiveness and initiates improvements.

EXAMPLES OF DUTIES

Plans, organizes, and directs the professional, administrative, and technical activities of the air pollution control program.
Develops, recommends, interprets, and administers air pollution control statutes.
Coordinates a comprehensive air pollution control program with the programs of other governmental organizations concerned with air pollution and related environmental activities at the local, State, Federal and regional levels and of private agencies.
Evaluates air quality control regional plan effectiveness, develops recommendations for plan improvement, and participates in air quality control regional planning.
Evaluates the effectiveness of the air pollution control program and the effectiveness of program personnel and initiates actions to maintain and improve effectiveness.
Insures that air pollution programs, policies, plans, and standards meet applicable laws and regulations.

features which program and personnel specialists in the jurisdiction are accustomed to utilizing. While the merit system agency usually has the final authority for approval of the specifications, in all cases both program and personnel specialists have vital roles to play in the process. They should be cooperatively involved in the process at the earliest possible time.

The guide specifications can be most useful at two points in the development or revision of the agency classification structure. After initial review of the job and program information, program and personnel specialists can consult the guides as one possible approach to setting up a class series — a sequence of related classes which covers all levels in the occupational area and is arranged in order of difficulty and responsibility. Once the basic class structure is decided upon, the guide specifications can be a resource in the preparation of the various sections of the specification and in some instances may provide the actual language used. Caution must be exercised, however, to avoid adopting language from the draft specifications which does not represent the facts concerning the program as it is in the jurisdiction. Most specifications begin with a definition providing a clear, concise statement of the major responsibilities of the positions in the class. In these guide specifications we have used "close supervision", "supervision", "general supervision", and "direction" to show the differences in supervision received. "Close supervision" is defined as receiving detailed instructions with constant review of work; "supervision" as receiving less detailed instructions, except for complex duties, with periodic review of work; "general supervision" as receiving minimal instructions with only results evaluated, and "direction" as receiving very broad guidelines with only results evaluated. The definition should be followed by a sufficient number of examples of work, starting with the more responsible, to cover the range of activities performed. Each example normally is expressed in the same grammatical form.

The last major category in a specification, "minimum qualifications", should include requisites of training, experience, knowledge, skills, abilities, and aptitudes that an employee needs for entrance into the job. Such statements should not include kinds of experience, knowledge, or ability that normally are acquired on the job after appointment. They should not be so narrow as to rule out the recruitment of all except those with an ideal background. They should be reasonably clear from the point of view of prospective applicants. They should be specific enough to be used in reviewing applications of candidates. The establishment of minimum requirements calls for a realistic consideration of the needs of the job and of manpower supply and demand throughout the recruiting area from which most candidates will be drawn. Improperly prepared minimum requirements unnecessarily restrict employees promotability, limit employee reassignments and mobility, and cause employees to seek opportunities elsewhere. In describing the levels of knowledges, a consistent pattern should be followed and the number of levels held to a minimum. Three levels are generally useful. In the guide class specifications presented in this monograph, we have used the terms "thorough knowledge", "knowledge", and "some knowledge"

The administrators of State and local air pollution control programs will find that the time devoted to a better classification plan is a worthwhile investment. Such a plan, reflecting program goals position components, realistic statements of qualifications, will contribute to the achievement of economical and effective program administration.

Directs the development and implementation of a public relations program to educate public and private organizations and individuals to improve air quality.
Represents the air pollution control program at conferences and meetings with public and private officials and organizations.
Develops and presents reports and papers on air pollution control.
Directs the development of the program budget, presents and justifies the budget, and allocates budgeted funds to program activities.
Coordinates and supervises the activities of a staff of professional, administrative, and technical personnel to achieve maximum utilization of manpower, facilities, equipment and material.
Initiates, reviews, approves, and makes recommendations regarding requests for manpower, facilities, equipment, and material.
Develops and administers a personnel program, including manpower planning and the recruitment, orientation, and training of program personnel.
Directs the preparation of program reports and the maintenance of program records.
Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:
Graduation from an accredited college or university and four years of progressively responsible professional experience in air pollution control or a related environmental program which includes at least one year of administrative or supervisory experience,
OR
A combination of education at an accredited college, university, or junior college and progressively responsible professional experience in air pollution control or a related environmental program which totals eight years and includes at least one year of administrative or supervisory experience,
OR
Eight years of progressivley responsible professional experience in air pollution control or a related environmental program which includes at least one year of administrative or supervisory experience.

Substitution:
Successful graduate study in engineering, science, public health or administration, or a related environmental field may be substituted for three of the required four years of progressively responsible experience on a year-for-year basis.
No substitution is permitted for the one year of administrative or supervisory experience.

Knowledges, Skills, and Abilities:
Thorough knowledge of administration, management, supervision, and training.
Thorough knowledge of the principles and practices essential to the identification, control, and reduction of air pollution.
Thorough knowledge of information sources in air pollution control and related environmental programs.
Knowledge of the laws, rules, and regulations applicable in the air pollution control program.
Knowledge of the major types of sources of air pollution.
Skill at analyzing complex documents and technical reports.
Skill at developing and presenting studies and reports orally and in writing.
Skill at establishing and maintaining positive and productive relationships with associates, public and private officials, and the general public.
Ability to plan, organize, and direct the activities of a professional, administrative, and technical staff.

Ability to coordinate the air pollution control program with other air pollution control and related environmental programs.
Ability to evaluate program and personnel effectiveness.
Ability to develop recommendations and to initiate program and personnel improvements.
Ability to represent the air pollution control program to public and private officials, the general public, and to technical and professional organizations.

AIR POLLUTION CONTROL SUPERVISOR

DEFINITION

Under the direction of the Air Pollution Control Director, with broad technical latitude, is responsible for planning a major segment of an air pollution control program; coordinating it with other segments of the program; supervising a professional, administrative, and technical staff; and acting for the Director as designated.

EXAMPLES OF DUTIES

Plans a major segment of an air pollution control program.
Supervises and coordinates as necessary with other segments of the program such functions as:

- Developing, conducting, and maintaining an emission and source inventory;
- Operating and maintaining air monitoring, sampling, and analyzing facilities and equipment;
- Reviewing and acting on requests for new and renewal construction and operation permits;
- Investigating complaints;
- Inspecting facilities and equipment;
- Conducting surveys and special studies.

Develops emergency episode procedures; makes recommendations for invoking the procedures; and may supervise the enforcement of the procedures for the agency.
Develops proposals for needed new standards, regulations, and laws.
Evaluates new local, State, regional, and Federal laws, regulations, and standards for program implications and develops appropriate procedures to carry them out.
Appears at hearings on air pollution violations and presents pertinent data; appears at court actions as an expert witness.
Develops and presents reports and studies on air pollution to management and at conferences and meetings; reviews and evaluates staff reports and studies.
Develops and participates in a public relations program to improve air quality; may carry the responsibility for the program for the agency.
Provides consultative services to public and private agencies and officials on the identification, control, and reduction of air pollution.
Develops the budget for the program segment along with supportive data justifying requests for manpower, facilities, equipment, and material.
Recruits and evaluates candidates for employment, evaluates employees, and makes recommendations to the Director regarding all types of needed personnel actions.
Plans and implements training programs for program staff and for representatives of other public agencies and private organizations interested in air pollution.
May supervise the organization and maintenance of a technical library resource.
Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:
Graduation from an accredited college or university and three years of progressively responsible professional experience in air pollution control or a related environmental program.
OR
Any combination of education at an accredited college, university, or junior college and progressively responsible professional experience in air pollution control or a related environmental program which totals seven years and includes at least three years of progressively responsible professional experience.
OR
Seven years or progressively responsible professional experience in air pollution control or a related environmental program.

Substitution:
Successful graduate study in engineering, science, public health or administration, or a related environmental field may be substituted for the progressively responsible professional experience on a year-for-year basis.

Knowledges, Skills, and Abilities:
Thorough knowledge of the principles and practices essential to the identification, control, and reduction of air pollution.
Thorough knowledge of information sources in air pollution control.
Knowledge of the laws, rules, and regulations applicable in the air pollution control program.
Knowledge of administration, supervision, and training.
Knowledge of the major types of sources of air pollution.
Knowledge of statistical principles and procedures as applied to air pollution programs.
Knowledge of the hazards of and the safeguards essential to a program which: utilizes electrical, mechanical, and chemical equipment and hand and power tools; is performed in shops, laboratories, field installations, and industrial and commercial facilities; and may be carried on under difficult and dangerous conditions.
Skill at analyzing documents and technical reports.
Skill at developing and presenting studies and reports orally and in writing.
Skill at establishing and maintaining positive and productive relationships with associates, public and private officials, and the general public.
Ability to organize and supervise the activities of professional, administrative, and technical staff.
Ability to coordinate the air pollution control program unit with other air pollution control program units.
Ability to evaluate program unit and personnel effectiveness.
Ability to develop recommendations and to initiate unit program and personnel improvements.
Ability to represent the air pollution control program to public and private officials, the general public, and to technical and professional organizations.
Ability to work under difficult and dangerous conditions including temperature extremes, heights, and fumes where necessary.

AIR POLLUTION CONTROL CHEMIST

Air Pollution Control Chemist positions often are included in broad chemist classes which may cover all of a State or local government's chemist positions or those of several programs and agencies. It is generally advantageous to keep to a minimum the number of classes established so long as they adequately reflect for administrative purposes the functions performed in individual positions. These guide class specifications were developed for use by those jurisdictions where a determination is made to establish separate classes for Air Pollution Control Chemists, but the duties described may be useful in preparing job descriptions for Air Pollution Control Chemists where such positions are included in a broader class.

Another pattern of duties and minimum qualifications may be found in the joint Public Health Service and Office of State Merit Systems publication "Guide Class Specifications for State Public Health Laboratories", October 1969.

AIR POLLUTION CONTROL CHEMIST I

DEFINITION

Under close supervision, performs standardized chemical analyses of atmospheric contaminants; assists in the development of analytical procedures and measurement techniques; learns to perform more difficult analyses and to provide professional and technical advice on the chemistry of air pollution; may participate in special studies; may lead and assist in training program personnel.

EXAMPLES OF DUTIES

Performs standardized chemical laboratory and field analyses of atmospheric contaminants.

Assists higher-level staff to develop and standardize new chemical sampling and analyzing procedures.

Meets with public and private officials and assists higher-level staff in providing professional and technical advice.

Gathers, organizes, and develops basic data and information for inclusion in technical reports and studies.

Gathers and assists higher-level staff in the organization, correlation, and preparation of data and exhibits for use in hearings or court cases.

Gathers, organizes, and participates in the evaluation of data and information on the effectiveness and accuracy of air pollution control equipment and instruments and assists higher-level staff in the development of recommendations for improvement.

Prepares for more important assignments by observation, study, on-the-job training, review of reports, and participation in assignments of increasing difficulty and responsibility.

Operates, calibrates, repairs, and assists in the modification of field and laboratory equipment, facilities, and instruments.

Learns to construct special purpose equipment and develop instrumentation by observing and assisting higher-level staff.

EXAMPLES OF DUTIES

May participate in special surveys and studies in the laboratory and in the field.
May appear in hearings or in court actions as a witness.
May participate in the training of program staff and representatives of other public agencies and private organizations.
May lead lower-level employees.
May maintain a technical library resource.
Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:

Graduation from an accredited college or university with a major either in chemistry or biochemistry, or a bachelor's degree in a biological science, physical science, or engineering which includes the equivalent of a minor in chemistry,

OR

Any combination of education at an accredited college, university, or junior college and progressively responsible technical or professional experience performing chemical examinations, tests, and analyses which totals four years.

OR

Four years of progressively responsible technical or professional experience performing chemical examinations, tests, and analyses.

Knowledges, Skills, and Abilities:

Knowledge of the basic principles and laboratory applications of chemistry and biochemistry.
Knowledge of information sources in chemistry and biochemistry.
Some knowledge of scientific methodology.
Some knowledge of current laboratory methods, equipment, facilities, and materials.
Some knowledge of the physical and chemical characteristics of air pollutants.
Some knowledge of the hazards of and the safeguards essential to a program which: utilizes electrical, mechanical, and chemical equipment and hand and power tools; is performed in shops, laboratories, field installations, and industrial and commercial facilities; and may be carried on under difficult and dangerous conditions.
Some skill in the care and use of laboratory equipment.
Ability to make chemical and microscopic analyses of air samples.
Ability to make and record scientific observations accurately.
Ability to analyze and evaluate documents, technical reports, formulae, and data.
Ability to understand and follow complex oral and written instructions.
Ability to perform basic mathematical calculations.
Ability to develop and present studies and reports orally and in writing.
Ability to establish and maintain positive and productive relationships with associates and other public and private individuals.
Ability to evaluate facility and equipment effectiveness.
Ability to understand and implement laws, rules and regulations.
Ability to perceive colors normally and to make olfactory distinctions.
Ability to observe safety precautions and practices.

AIR POLLUTION CONTROL CHEMIST II

DEFINITION

Under general supervision, with technical latitude, performs professional chemical analyses of atmospheric contaminants; develops analytical procedures and measurement techniques for laboratory and field activities; provides professional and technical advice; plans and conducts special studies; assists in planning the air pollution control program; leads and trains program personnel.

EXAMPLES OF DUTIES

Performs laboratory and field analyses of atmospheric contaminants utilizing wet and instrumental chemical methodology.
Develops and standardizes new chemical sampling and analyzing procedures and modifies existing procedures to meet program requirements.
Provides professional and technical advice to public and private officials on the chemistry of air pollution identification, control, and reduction.
Performs special surveys and studies including chemical sampling and analyses in the laboratory and in the field.
Prepares reports and studies for presentation to management and for publication.
Organizes and correlates chemical data and prepares exhibits and presentations for use in hearings and court cases.
Appears in hearings and court cases as an expert witness; and explains and illustrates air pollution data, equipment, instrumentation, and technical processes.
Compiles and evaluates data and information on the effectiveness and accuracy of air pollution control equipment and instruments and develops recommendations for improvement.
Trains program personnel and representatives of other public agencies and private organizations.
Operates, calibrates, repairs, and modifies as necessary field and laboratory facilities, equipment, and instruments used to chemically identify and analyze air pollutants.
Constructs special purpose equipment and develops instrumentation.
Leads, and may supervise, lower-level employees.
Initiates requests for, and makes recommendations regarding, new and additional manpower, facilities, equipment, and material.
Provides basic data for the budget.
Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:

Graduation from an accredited college or university with a major either in chemistry or biochemistry, or a bachelor's degree in a biological science, physical science, or engineering which includes the equivalent of a minor in chemistry, and one year of progressively responsible professional experience performing chemical examinations, tests, and analyses,

OR

Any combination of education at an accredited college, university, or junior college and progressively responsible technical or professional experience performing chemical examinations, tests, and analyses which totals five years and includes at least one year of professional experience, OR

Five years of progressively responsible technical or professional experience performing chemical examinations, tests, and analyses which includes at least one year of professional experience.

Substitution:

Successful completion of one year of full-time graduate study at an accredited college or university in chemistry, a closely related science, or a closely related field or engineering may be substituted for the professional experience.

Knowledges, Skills, and Abilities:

Thorough knowledge of the principles and laboratory applications of chemistry and biochemistry.
Thorough knowledge of information sources in chemistry and biochemistry.
Knowledge of scientific methodology.
Knowledge of current laboratory methods, equipment, facilities, and materials.
Knowledge of the physical and chemical characteristics of air pollutants.
Knowledge of the hazards of, and the safeguards essential to a program which: utilizes electrical, mechanical, and chemical equipment and hand and power tools; is performed in shops, laboratories, field installations, and industrial and commercial facilities; and may be carried on under difficult and dangerous conditions.
Some knowledge of research methods and instrumentation used in the study of air pollution.
Some knowledge of the laws, rules, and regulations applicable in the air pollution control program.
Skill at making chemical and microscopic analyses.
Skill in the care and use of laboratory equipment.
Skill at making and recording scientific observations accurately.
Skill at analyzing documents, technical reports, formulae, and data.
Skill at developing and presenting studies and reports orally and in writing.
Skill at establishing and maintaining positive and productive relationships with associates and other public and private officials.
Skill at performing mathematical calculations.
Skill at observing safety precautions and practices.
Ability to evaluate facility and equipment effectiveness.
Ability to implement and to develop recommendations concerning laws, rules, and regulations.
Ability to represent the air pollution program to public and private officials and to the general public.
Ability to interpret and implement complex oral and written instructions.
Ability to perceive colors normally and to make olfactory distinctions.

AIR POLLUTION CONTROL ENGINEER

Air Pollution Control Engineering positions often are included in broad engineering classes which may cover all of a State or local government's engineering positions or those of several programs and agencies. It is generally advantageous to keep to a minimum the number of classes established so long as they adequately reflect for administrative purposes the functions performed in individual positions. These guide class specifications were developed for use by those jurisdictions where a determination is made to establish separate classes for Air Pollution Control Engineers, but the duties described may be useful in preparing job descriptions for Air Pollution Control Engineers where such positions are included in a broader class.

Another pattern of duties and minimum qualifications may be found in the joint Public Health Service and Office of State Merit Systems publication "Guide Class Specifications for Selected Environmental Engineering Positions in State and Local Health Programs", March 1968.

AIR POLLUTION CONTROL ENGINEER I

DEFINITION

Under close supervision, makes beginning professional engineering analyses and evaluations of air pollution sources, problems, and permit plans; makes basic emission inventory calculations and assists in the development of emission reduction strategies; may assist in provision of professional and technical advice; may participate in special studies; may lead and assist in training program personnel; learns to perform more difficult engineering duties.

EXAMPLES OF DUTIES

Performs beginning professional engineering analyses and evaluations and assists higher-level staff in: the review of plans and specifications for air pollution control devices, systems, and operations; the examination and testing of air pollution control devices, systems, and operations, and the preparation of technical reports thereon.

Reviews, and assists higher-level staff in reviewing, plans and reports related to new construction and changes in air pollution control facilities and equipment.

Compiles air pollution data and prepares charts and graphs for the interpretation of the data with particular reference to the extent, nature, and source of atmospheric contaminants.

Drafts recommendations for the control or reduction of air pollution.

Meets with operators, managers, and owners of facilities which are actual or potential sources of air pollution and assists higher-level staff in providing engineering advice and technical assistance.

Prepares for more important assignments by observation, study, on-the-job training, review of

EXAMPLES OF DUTIES

reports and participation in assignments of increasing difficulty and responsibility.

May, for training purposes, observe and assist more skilled staff in:

- Operating and making minor adjustments to air sampling equipment;
- Collecting samples of air pollutants;
- Patrolling assigned areas to observe and record smoke, fumes, and other undesirable emissions into the atmosphere;
- Making facility and equipment inspections and carrying on complaint investigations.

May participate in the training of program staff and representatives of other public agencies and private organizations.

May participate in special surveys and studies in the office and in the field.

May appear at hearings or in court actions as a witness.

May lead lower-level employees.

May maintain a technical library resource.

Performs related duties as required.

MINIMUM QUALIFICATIONS[1]

Education and Experience:

Graduation from an accredited college or university with a [illegible] engineering or a major in one of the physical sciences and a minor or its equivalent in engineering,

OR

Any combination of education at an accredited college, university, or junior college and progressively responsible technical or professional engineering experience in air pollution control or a related environmental program which totals four years,

OR

Four years of progressively responsible technical or professional engineering experience in air pollution control or a related environmental program.

Knowledges, Skills, and Abilities:

Knowledge of engineering principles relating to air sanitation.
Knowledge of engineering mathematics and statistical techniques.
Knowledge of information sources in air pollution control engineering.
Some knowledge of combustion processes and of elementary thermodynamics.
Some knowledge of the methods used in determining the chemical and physical characteristics of air pollutants.
Some knowledge of the hazards of and the safeguards essential to a program which: utilizes electrical, mechanical, and chemical equipment and hand and power tools; is performed in shops, laboratories, field installations, and industrial and commercial facilities; and may be carried on under difficult and dangerous conditions.
Some skill in the care and use of instruments and equipment.
Ability to analyze and evaluate engineering plans, specifications, technical reports, blueprints, and data.
Ability to understand and follow complex oral and written instructions.
Ability to perform basic mathematical calculations.

Knowledges, Skills, and Abilities:

Ability to develop and present technical studies and reports orally and in writing.
Ability to establish and maintain positive and productive relationships with associates and other public and private individuals.
Ability to evaluate facility and equipment effectiveness.
Ability to understand and implement laws, rules, and regulations.
Ability to observe safety precautions and practices.

AIR POLLUTION CONTROL ENGINEER II

DEFINITION

Under general supervision, with technical latitude, performs professional engineering work in an office or in the field; makes analyses and evaluations of air pollution sources, problems, and permit plans; calculates emission inventories and develops emission control and reduction strategies and emergency episode plans; provides professional and technical advice; plans and conducts special studies; assists in planning the air pollution control program; leads and trains program personnel.

EXAMPLES OF DUTIES

Analyzes and evaluates plans and specifications of air pollution control devices, systems, and operations, and prepares engineering recommendations concerning acceptability or changes needed.
Reviews field reports and compliance schedules and provides engineering analyses for agency personnel and public and private officials
Calculates emission inventories and develops emission control and reduction strategies and emergency episode plans.
Confers with public and private officials, engineering consultants and architects, and the general public to provide engineering advice, technical assistance, and information relative to air pollution control problems.
Reviews plans and specifications of proposed air pollution control facilities and equipment for compliance with laws, rules, and regulations and recommends appropriate action.
Reviews zoning plans, air quality, meteorological and other relevant data and makes recommendations for the location and control of industrial concerns, commercial organizations, and public agencies and facilities with actual and potential air pollution problems.
Provides engineering assistance and technical advice to program staff engaged in air pollution surveillance, inspection, and investigation.
Leads, and may supervise, program personnel.
Provides engineering advice and technical assistance to employees engaged in installing, operating, calibrating, and maintaining air sampling instruments and equipment; initiates, evaluates, and makes recommendations regarding requests for maintenance services; makes recommendations regarding needs for new and additional instruments and equipment.
Trains program staff and representatives of other public agencies and private organizations in the identification, control, and reduction of air pollutants.
Appears at hearings and in court actions as an expert; and explains and illustrates air pollution data, equipment, instrumentation, and technical processes.

EXAMPLES OF DUTIES

Participates in special surveys and studies, prepares charts and graphs, and interprets data.
Analyzes data and makes recommendations as to air sampling site locations, facility types, and necessary equipment and instrumentation.
Develops, adapts, adjusts, and modifies instruments and equipment used in obtaining and analyzing air samples.
Prepares reports and studies for presentation to management and for publication.
Provides basic data for the budget.
Performs related duties as required.

MINIMUM QUALIFICATIONS[1]

Education and Experience:

Graduation from an accredited college or university with a major in engineering or a major in one of the physical sciences and a minor or its equivalent in engineering, and one year of progressively responsible professional engineering experience in air pollution control or a related environmental program,

OR

Any combination of education at an accredited college, university, or junior college and progressively responsible technical or professional engineering experience in air pollution control or a related environmental program which totals five years and includes at least one year of professional experience,

OR

Five years of progressively responsible technical or professional engineering experience in air pollution control or in a related environmental program which includes at least one year of professional experience.

Substitution:

A master's degree from an accredited college or university in engineering, a closely related science, or public or environmental health may be substituted for the professional experience.

Knowledges, Skills, and Abilities:

Thorough knowledge of engineering principles and practices of air quality conservation and of the sources, character, and effect of air pollution.
Thorough knowledge of information sources in air pollution control engineering.
Knowledge of combustion principles in terms of the control of air pollutants.
Knowledge of the physical and chemical characteristics of air pollutants.
Knowledge of the hazards of and the safeguards essential to a program which: utilizes electrical, mechanical, and chemical equipment and hand and power tools; is performed in shops, laboratories, field installations, and industrial and commercial facilities; and may be carried on under difficult and dangerous conditions.
Some knowledge of research and methods and instrumentation used in the study of air pollution.
Some knowledge of the laws, rules, and regulations applicable in the air pollution control program.
Some knowledge of the meteorological factors affecting the development and dispersal of air pollutants.
Skill at analyzing engineering plans, specifications, technical reports, blueprints, and data.

Knowledges, Skills, and Abilities:

Skill in the care and use of air sampling instruments and equipment.
Skill at developing and presenting technical studies and reports orally and in writing.
Skill at establishing and maintaining positive and productive relationships with associates and other public and private officials.
Skill at performing mathematical calculations.
Skill at observing safety precautions and practices.
Ability to evaluate facility and equipment effectiveness.
Ability to implement and to develop recommendations concerning laws, rules, and regulations.
Ability to represent the air pollution program to public and private officials and to the general public.
Ability to interpret and implement complex oral and written instructions.

AIR POLLUTION CONTROL METEOROLOGIST I

DEFINITION

Under close supervision, performs beginning professional meteorological analyses and evaluations of meteorological and air pollution data; assists in the relation of meteorological elements to air pollution problems and preparation of periodic air quality forecasts; may assist in provision of professional and technical advice; may participate in special studies; may lead and assist in the training of program personnel; learns to perform more difficult meteorological duties.

EXAMPLES OF DUTIES

Collects from air monitoring stations and from local, State, and Federal sources meteorological data such as wind velocity and direction, lapse rates, air pressure, temperature, and humidity, and data concerning types and concentrations of air pollutants.
Operates, calibrates, and maintains specialized scientific equipment in meteorological (air monitoring) stations in an assigned area.
Correlates meteorological data with concentrations of air pollutants or the diffusion of contaminants in the atmosphere; and prepares charts and diagrams showing the relationships.
Assists higher-level staff in the preparation of meteorological reports, studies, and recommendations.
Provides routine air pollution and forecast information to the public and to officials of public agencies and private organizations in response to inquiries.
Prepares for more important assignments by observation, study, on-the-job training, review of reports, and participation in assignments of increasing difficulty and responsibility.
May participate in special surveys and studies.
May appear at hearings or in court actions as a witness.
May participate in the training of program staff and representatives of other public agencies and private organizations.
May lead lower-level employees.
May maintain a technical library resource.
Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:

Graduation from an accredited college or university with a major in meteorology or a major in the natural or physical sciences and a minor or its equivalent in meteorology or the atmospheric sciences,

OR

Any combination of education at an accredited college, university, or junior college and progressively responsible technical or professional meteorological experience which totals four years,

OR

Four years of progressively responsible technical or professional meteorological experience.

Knowledges, Skills, and Abilities:

Knowledge of the fundamental physical and mathematical sciences underlying the science of meteorology.

Knowledge of meteorology with emphasis on the relationship of conditions of the atmosphere to air pollution.

Some knowledge of scientific methodology.

Some knowledge of standard meteorological equipment and the method of applying it to meteorological studies.

Some knowledge of statistical principles and procedures.

Some knowledge of the hazards of and the safeguards essential to a program which: utilizes electrical, mechanical, and chemical equipment and hand and power tools; is performed in shops, laboratories, field installations, and industrial and commercial facilities; and may be carried on under difficult and dangerous conditions.

Some knowledge of information sources in meteorology.

Some skill in the care and use of meteorological equipment.

Ability to analyze and evaluate documents, technical reports, and data.

Ability to make and record scientific observations accurately.

Ability to operate and maintain a variety of meteorological measuring instruments.

Ability to develop and present studies and reports orally and in writing.

Ability to establish and maintain positive and productive relationships with associates and other public and private individuals.

Ability to evaluate facility and equipment effectiveness.

Ability to perform mathematical calculations.

Ability to understand and implement laws, rules, and regulations.

Ability to interpret and implement complex oral and written instructions.

Ability to observe safety precautions and practices.

AIR POLLUTION CONTROL METEOROLOGIST II

DEFINITION

Under general supervision, with technical latitude, makes professional meteorological analyses and evaluations of meteorological and air pollution data; relates meteorological elements to air pollution problems in control models; prepares periodic air quality forecasts; recommends implementation and termination of emergency episode plans; provides professional and technical advice; plans and conducts special studies; assists in planning the air pollution control program; leads and trains program personnel.

EXAMPLES OF DUTIES

Plans and conducts meteorological studies using statistical design and air sampling technology.

Operates and supervises the operation of specialized scientific equipment in meteorological observation stations.

Calculates effects of different emission levels using inventories of emission sources, meteorological and topographical data, and population.

Analyzes and evaluates climatological factors in making short-range detailed forecasts of expected air pollution and in forecasting long-range seasonal and annual variations in air pollution measurements.

Advises air pollution control program staff regarding meteorological conditions affecting pollutant measurement and air pollution surveillance.
Conducts and coordinates studies relating meteorological phenomena to the occurrence of airborne wastes in order to devise new, and to refine existing, forecasting techniques regarding air quality trends.
Participates in research projects related to air resource management and land use involving such items as industrial zoning, trends in growth and concentration of industry and population, and public reaction to air pollution standards.
Maintains records of levels of air pollution and meteorological data and advises program officials when appropriate to declare an air pollution emergency episode.
Appears at hearings and in court actions as an expert; and explains and illustrates air pollution data, equipment, instrumentation, and technical processes.
Performs special surveys and studies.
Analyzes data and makes recommendations as to air monitoring site locations, facility type, and necessary equipment and instrumentation.
Develops, adapts, adjusts, and modifies instruments and equipment used in obtaining air samples.
Prepares reports and studies for presentation to management and for publication.
Leads, and may supervise, lower-level employees.
Provides basic data for the budget.
Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:
Graduation from an accredited college or university with a major in meteorology or a major in the natural or physical sciences and a minor or its equivalent in meteorology or the atmospheric sciences, and one year of progressively responsible professional meteorological experience in air pollution control or a related environmental program,
OR
Any combination of education at an accredited college, university, or junior college and progressively responsible technical or professional meteorological experience which totals five years and includes at least one year of professional experience in air pollution control or a related environmental program,
OR
Five years of progressively responsible technical or professional meteorological experience which includes at least one year of professional experience in air pollution control or a related environmental program.

Substitution:
Successful graduate study in engineering, science, public health, or a related environmental field may be substituted for the professional experience.

Knowledges, Skills, and Abilities:
Thorough knowledge of meteorology with emphasis on the relationship of conditio atmosphere to air pollution.
Thorough knowledge of surface and upper air analysis techniques, precipitation forec ,rinciples, and their application to air pollution control.
Thorough knowledge of information sources in meteorology.
Knowledge of standard meteorological equipment and the methods of applying it to meteorological studies.

Knowledge of air pollution control measures and procedures.
Knowledge of the hazards of and the safeguards essential to a program which: utilizes electrical mechanical, and chemical equipment and hand and power tools; is performed in shops, laboratories, field installations, and industrial and commercial facilities, and may be carried on under difficult and dangerous conditions.
Knowledge of scientific methodology.
Some knowledge of the laws, rules, and regulations applicable in the air pollution control program.
Some knowledge of electronic data processing techniques.
Skill in the care and use of meteorological equipment.
Skill at analyzing documents, technical reports, and data.
Skill at making and recording scientific observations accurately.
Skill at developing and presenting studies and reports orally and in writing.
Skill at establishing and maintaining positive and productive relationships with associates and other public and private officials.
Skill at performing mathematical calculations.
Skill at observing safety precautions and practices.
Ability to evaluate facility and equipment effectiveness.
Ability to implement and to develop recommendations concerning laws, rules and regulations.
Ability to represent the air pollution program to public and private officials and to the general public.
Ability to interpret and implement complex oral and written instructions.

AIR POLLUTION CONTROL SPECIALIST I

DEFINITION

Under close supervision, makes beginning professional-level analyses and evaluations of air pollution sources, problems, and permit plans; assists in complex surveillance, inspections, and investigations; assists in the development of recommendations and in the conduct of negotiations for improvement or modification of air pollutant conditions, initiation of enforcement actions, and provision of professional and technical advice; may participate in special studies, may lead and assist in the training of program personnel; learns to perform more difficult professional-level duties.

EXAMPLES OF DUTIES

Gathers and organizes information and data on air pollution sources and emissions and on the effectiveness of program facilities, equipment, instrumentation, and technical processes; and assists higher-level staff in analyzing and evaluating the information and data and in developing recommendations for improving the air pollution control program.
Assists higher-level staff performing complex surveillance, inspections, and investigations.
Assists higher-level staff in evaluating requests for new and renewal operation and construction permits by checking public records, reviewing plans and drawings, inspecting facilities and equipment, and making reports and developing recommendations.
Reinspects public and private facilities and equipment to determine if air pollution operation and construction permit requirements are being met.
Gathers and organizes for presentation basic data on violations of air pollution laws, rules, and regulations and participates with higher-level staff in evaluating and developing recommendations related to the violations.
Meets with public and private officials and assists higher-level staff in conducting negotiations and providing professional and technical advice.
Discusses air pollution control with operators, managers, and owners of facilities which are actual or potential sources of air pollution and seeks to secure voluntary compliance with air pollution laws, rules, and regulations.

Prepares for more responsible assignments by observation, study, on-the-job training, review of reports, and participation in assignments of increasing difficulty.
May participate in special surveys and studies.
May appear at hearings or in court actions as a witness.
May participate in the training or program staff and representatives of other public agencies and private organizations.
May lead lower-level employees.
May maintain a technical library resource.
Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:
Graduation from an accredited college or university with a minor or its equivalent in engineering, chemistry, or the physical or biological sciences,
OR
Any combination of education at an accredited college, university, or junior college and progressively responsible technical or professional experience in air pollution control or a related environmental program which totals four years,
OR
Four years of progressively responsible technical or professional experience in air pollution control or a related environmental program.

Knowledges, Skills, and Abilities:
Some knowledge of the major types of sources of air pollution.
Some knowledge of basic statistical principles and procedures as applied in air pollution control programs.
Some knowledge of information sources in air pollution control.
Some knowledge of the hazards of and the safeguards essential to a program which: utilizes electrical, mechanical, and chemical equipment and hand and power tools; is performed in shops, laboratories, field installations, and industrial and commercial facilities; and may be carried on under difficult and dangerous conditions.
Some skill in the care and use of instruments.
Ability to analyze and evaluate documents, technical reports, and data.
Ability to develop and present studies and reports.
Ability to establish and maintain positive and productive relationships with fellow workers, superiors, and other public and private individuals.
Ability to evaluate facility and equipment effectiveness.
Ability to perform basic mathematical calculations.
Ability to understand and implement laws, rules, and regulations.
Ability to understand and follow complex oral and written instructions.
Ability to work under difficult and dangerous conditions including temperature extremes, heights, and fumes.
Ability to observe safety precautions and practices.

AIR POLLUTION CONTROL SPECIALIST II

DEFINITION

Under general supervision, with technical latitude, functions as a professional-level program representative; conducts complex inspections and investigations of reported violations; analyzes and evaluates air pollution sources, problems, and permit plans; develops recommendations and negotiates improvements or corrective actions; initiates enforcement actions; provides professional and technical advice; plans and conducts special studies; assists in planning the air pollution control program; leads and trains program personnel.

EXAMPLES OF DUTIES

Represents the air pollution control program in discussions and meetings with public and private officials involving the identification, control, and reduction of air pollutants.

Negotiates with operators, managers, and owners of facilities which are actual or potential sources of air pollution to secure voluntary correction or improvement of the pollutant condition; provides technical advice and makes recommendations regarding facilities, equipment, and processes; and issues warnings of possible legal action.

Performs complex or difficult field surveillance, facility and equipment inspection and reinspection, and complaint investigation.

Analyzes and evaluates new or amended laws, rules, and regulations; data on air pollution sources and emissions; and the effectiveness of program facilities, equipment, instrumentation, and technical processes and develops recommendations for improving the air pollution control program.

Analyzes and evaluates requests for new and renewal permits for the construction and operation of pollutant-emitting facilities and equipment and makes recommendations regarding action on the requests.

Gathers, correlates, and evaluates data on violations of air pollution laws, rules, and regulations and provides program management with recommendations on the initiation of legal action.

Implements emergency episode procedures.

Provides technical assistance to employees engaged in installing, operating, calibrating, and performing field maintenance on air sampling instruments and equipment; initiates, evaluates, and makes recommendations regarding requests for maintenance services; makes recommendations regarding needs for new and additional instruments and equipment.

Trains program staff and representatives of other public agencies and private organizations in the identification, control, and reduction of air pollutants.

Appears at hearings and in court actions as an expert; and explains and illustrates air pollution data, equipment, instrumentation, and technical processes.

Performs special surveys and studies.

Analyzes data and makes recommendations as to air sampling site locations, facility type, and necessary equipment and instrumentation.

Prepares reports and studies for presentation to management and for publication.

Leads, and may supervise, lower-level employees.

Provides basic data for the budget.

Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:

Graduation from an accredited college or university with a minor or its equivalent in engineering, chemistry, or the physical or biological sciences, and one year of progressively responsible professional experience in air pollution control or a related environmental program,

OR

Any combination of education at an accredited college, university, or junior college and progressively responsible technical or professional experience in air pollution control or a related environmental program which totals five years and includes at least one year of professional experience,

OR

Five years of progressively responsible technical or professional experience in air pollution control or a related environmental program which includes at least one year of professional experience.

Substitution:

Successful graduate study in engineering, science, public health or administration, or a related environmental field may be substituted for the professional experience.

Knowledges, Skills, and Abilities:

Knowledge of the principles and practices essential to the identification, control and reduction of air pollution.

Knowledge of the hazards of and the safeguards essential to a program which utilizes electrical, chemical, and mechanical equipment and hand and power tools; is performed in shops, laboratories, field installations, and industrial and commercial facilities; and may be carried on under difficult and dangerous conditions.

Knowledge of information sources in air pollution control.

Knowledge of the major types of sources of air pollution.

Some knowledge of the laws, rules, and regulations applicable in the air pollution control program.

Some knowledge of statistical principles and procedures as applied in air pollution programs.

Skill at analyzing documents, technical reports, and data.

Skill at developing and presenting studies and reports orally and in writing.

Skill at establishing and maintaining positive relations with associates and other public and private individuals.

Skill at performing basic mathematical calculations.

Skill at observing safety precautions and practices.

Ability to evaluate facility and equipment effectiveness.

Ability to develop recommendations concerning and to implement laws, rules, and regulations.

Ability to represent the air pollution control program to public and private officials and the general public.

Ability to work under difficult and dangerous conditions including temperature extremes, heights, and fumes.

Ability to interpret and implement complex oral and written instructions.

AIR POLLUTION CONTROL INSPECTOR I (TRAINEE)

DEFINITION

Under close supervision, following detailed directions, performs routine field surveillance, facility and equipment inspection, and complaint investigation and learns to perform more responsible tasks by observing and assisting higher-level staff and participating in training.

EXAMPLES OF DUTIES

Performs routine field surveillance, noting air pollution sources and reporting locations, and observes and assists higher-level staff on complex field surveillance.

Performs routine facility and equipment inspection, reports findings, and observes and assists higher-level staff on complex inspection.

Performs initial complaint investigation of a routine nature, reporting on situational observations and on the statements of complainants and other involved parties, and observes and assists higher-level staff on complex complaint investigation.

Maintains daily records and logs and makes oral and written reports on activities.

Operates vehicles used in field work.

Prepares for higher-level tasks by reading journals, articles, and releases on air pollution control and through participating in training.

Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:

Graduation from high school or the possession of a certificate of high school graduation equivalency,

OR

Three years experience in air pollution control or a related environmental program.

Knowledges, Skills, and Abilities:

Some knowledge of basic chemical, electrical, and mechanical principles.

Ability to understand air pollution control rules and regulations.

Ability to discuss air pollution control problems with fellow workers, superiors, and other public and private individuals.

Ability to maintain positive and productive relationships with associates and other public and private individuals.

Ability to perform arithmetic computations.

Ability to understand and carry out verbal and written directions.

Ability to understand and apply safety precautions.

Ability to work under difficult and dangerous conditions including temperature extremes, heights, and fumes.

Ability to maintain technical and administrative records.

Ability to operate vehicles used for field work.

AIR POLLUTION CONTROL INSPECTOR II

DEFINITION

Under supervision, following general technical directions, performs field surveillance, facility and equipment inspection, and complaint investigation; may assist professional staff conducting special studies; and may lead and assist in the training of lower-level staff.

EXAMPLES OF DUTIES

Performs field surveillance of air pollution and documents the sources, quantity, and density of the air pollution.

Performs facility and equipment inspection, noting level of operational effectiveness of air pollution control devices, recording observations and data, and reporting on inspection findings; may make recommendations for corrective actions.

Investigates complaints through observing air pollution conditions, interviewing complainants and owners and operators of allegedly-polluting equipment and facilities, and inspecting equipment and facility operations.

Develops detailed reports on complaint investigations together with recommendations as to corrective actions needed.

Prepares oral and written reports of activities.

Provides assistance to, and may make work assignments to and lead, lower-level employees.

Operates, and performs the daily maintenance on, vehicles used for field work.

Maintains an effective relationship with representatives of public and private agencies and organizations.

Maintains and improves personal level of technical competence through reading and training.

May attend air pollution control hearings to present data and may be called as a witness in court cases.

May work independently on specialized assignments.

May assist professional staff in conducting special studies.

May assist in the training of lower-level employees.

Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:

Graduation from an accredited junior college,

OR

Graduation from high school or the possession of a certificate of high school graduation equivalency and at least one year of progressively responsible experience in air pollution control or a related environmental program assisting in field surveillance, facility and equipment inspection, and complaint investigation,

OR

Four years of progressively responsible experience in air pollution control or a related environmental program which includes at least one year assisting in field surveillance, facility, and equipment inspection, and complaint investigation.

Knowledges, Skills, and Abilities:

Some knowledge of the principles of operation of air sampling instruments and equipment.

Some knowledge of technical terminology in air pollution and related environmental fields.

Some knowledge of the hazards of and the safeguards essential to using electrical, mechanical, and chemical equipment and hand and power tools.

Skill at performing arithmetic computations.

Ability to operate air sampling instruments and equipment.

Ability to understand and interpret air pollution control laws, rules, and regulations.

Ability to discuss air pollution control problems with fellow workers, superiors, and other public and private individuals.

Ability to maintain positive and productive relationships with associates and other public and private individuals.

Ability to maintain technical and administrative records.

Ability to work under difficult and dangerous conditions including temperature extremes, heights, and fumes.

Ability to operate vehicles used for field work.

Ability to learn to:

- Work independently on specialized assignments;
- Evaluate technical processes and procedures and to develop recommendations for improvement;
- Communicate orally effectively;
- Assist higher-level staff engaged in training activities.

AIR POLLUTION CONTROL INSPECTOR III

DEFINITION

Under general supervision, with technical latitude, performs field surveillance, facility and equipment inspection, and complaint investigation; assists professional staff conducting special studies; and leads and trains lower-level staff.

EXAMPLES OF DUTIES

Performs field surveillance, facility and equipment inspection, and complaint investigation.

Works independently on specialized assignments.

Develops and presents recommendations as to new or different air pollution control processes and procedures.

Maintains files on daily activities including records of surveillances, investigations, and inspections.

Develops and presents oral and written reports together with recommendations.

Leads, and may supervise, lower-level employees.

Attends air pollution control hearings, presents evidence and data, and testifies as a witness in court cases.

Assists in the training of lower-level employees and other personnel.

Assists professional staff conducting special studies.

Maintains and promotes effective personal relationships with public and private officials, agencies, and organizations.

Discusses air pollution — its causes, impact, and control — with public and private officials, agencies, and organizations in the course of field activities.

Operates, is responsible for the daily maintenance of, and initiates requests for repair and maintenance of vehicles used for field work.

May make recommendations regarding new and additional equipment.

Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:
Graduation from an accredited junior college and one year of progressively responsible experience in air pollution control or a related environmental program performing field surveillance, facility and equipment inspection, and complaint investigation,
OR
Graduation from high school or the possession of a certificate of high school graduation equivalency and at least two years of progressively responsible experience in air pollution control or a related environmental program performing field surveillance, facility and equipment inspection, and complaint investigation,
OR
Five years of progressively responsible experience in air pollution control or a related environmental program which includes at least two years performing field surveillance, facility and equipment inspection, and complaint investigation.

Knowledges, Skills, and Abilities:
Knowledge of the principles of operation of air sampling instruments and equipment.
Knowledge of technical terminology in air pollution and related environmental fields.
Knowledge of the hazards of and the safeguards essential to using electrical, mechanical, and chemical equipment and hand and power tools.
Knowledge of air pollution control laws, rules, and regulations which affect field surveillance, facility and equipment inspection, and complaint investigation.
Some knowledge of administrative principles and practices.
Some knowledge of training principles.
Some knowledge of basic principles of leadership and supervision.
Skill at performing surveillance, inspection, and investigation activities.
Skill at operating air sampling instruments and equipment.
Skill in maintaining positive and productive relationships with associates and other public and private individuals.
Skill at performing arithmetic computations.
Skill at communicating orally.
Ability to evaluate technical processes and procedures and to develop recommendations for improvement.
Ability to analyze documents, reports, and plans.
Ability to discuss air pollution control problems with fellow workers, superiors, and other public and private individuals.
Ability to present evidence and data and to testify as a witness in court cases.
Ability to work independently on specialized assignments.
Ability to assist higher-level staff engaged in training activities.
Ability to work under difficult and dangerous conditions including temperature extremes, heights, and fumes.
Ability to maintain technical and administrative records.
Ability to operate vehicles used for field work.

AIR POLLUTION CONTROL TECHNICIAN I (TRAINEE)

DEFINITION

Under close supervision, following detailed directions, performs routine technical tasks in the laboratory, field, and shop; assists higher-level staff installing, operating, calibrating, modifying, maintaining, and repairing a variety of equipment and instruments used in the air pollution control program; and participates in training.

EXAMPLES OF DUTIES

Performs routine technical tasks in support of higher-level staff in the laboratory, field, and shop.
Observes and assists higher-level staff in laboratory, field, and shop:

- Installing, operating, calibrating, modifying, maintaining, and repairing air sampling, meteorological, and laboratory equipment and instruments;
- Measuring, testing, and analyzing air pollutants;
- Stack sampling;
- Source and emission inventorying;
- Recording, tabulating, charting, and graphing data;
- Fabricating field shelters for equipment;
- Keeping files and records on activities;
- Operating and maintaining field vehicles.

Drives, loads, and unloads vehicles used in field work.
Performs related duties as required.
Prepares for higher-level technical tasks by reading journals, articles, and releases on air pollution control and through participation in technical training.

MINIMUM QUALIFICATIONS

Education and Experience:
Graduation from high school or the possession of a certificate of high school graduation equivalency,
OR
Three years of experience in air pollution control or a related environmental program.

Knowledges, Skills, and Abilities:
Some knowledge of basic chemical, electrical, and mechanical principles.
Some knowledge of the kinds and uses of hand and power tools.
Ability to operate and perform routine field maintenance of air sampling equipment and instruments.
Ability to discuss technical problems with fellow workers, superiors, and other public and private individuals.
Ability to maintain positive and productive relationships with associates and other public and private individuals.

Ability to perform arithmetic computations.
Ability to understand air pollution control laws, rules, and regulations.
Ability to understand and carry out verbal and written directions.
Ability to maintain technical and administrative records.
Ability to work under difficult and dangerous conditions including temperature extremes, heights, and fumes.
Ability to understand and apply safety precautions.
Ability to operate vehicles used for field work.

AIR POLLUTION CONTROL TECHNICIAN II

DEFINITION

Under supervision, following general directions, installs, operates, calibrates, modifies, maintains, and repairs a variety of equipment and instruments used in the air pollution control program; and may lead and assist professional staff conducting special studies; and may lead and assist in the training of lower-level staff.

EXAMPLES OF DUTIES

Installs, operates, calibrates, modifies, maintains, and repairs air sampling equipment.
Conducts stack sampling activities and gathers data for source and emission inventories.
Performs routine tests and measurements including standardized analyses of air pollutants.
Records, tabulates, charts and graphs data obtained from air sampling equipment, meteorological instruments, and laboratory analyses.
Assists higher-level staff designing or modifying instruments and equipment.
Fabricates field shelters and facilities and assists in the placement of air sampling and meteorological instruments and equipment.
Assists higher-level staff reviewing and evaluating engineering proposals and drawings for new and modified industrial processes and facilities as actual or potential sources of air pollution.
Assists higher-level staff conducting the more complex tests, measurements, and analyses.
Prepares oral and written reports of activities.
Provides technical assistance to, and may make work assignments to and lead, lower-level employees.
Operates, and is responsible for the daily maintenance on, vehicles used for field work.
Maintains an effective relationship with representatives of public and private agencies and organizations.
Maintains and improves personal level of technical competence through reading and training.
May work independently on specialized assignments.

EXAMPLES OF DUTIES

May assist professional staff conducting special studies.
May attend air pollution control hearings to present data and may be called as a witness in court cases.
May assist in the training of lower-level employees.
Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:

Graduation from an accredited junior college with at least 12 semester hours in engineering, chemistry, or the physical or biological sciences,

OR

Graduation from high school or the possession of a certificate of high school graduation equivalency and at least one year of progressively responsible experience in air pollution control or a related environmental or other program assisting in the installation, operation, calibration, modification, maintenance, and repair of equipment and instruments,

OR

Four years of progressively responsible experience in air pollution control or a related environmental or other program which includes at least one year assisting in the installation, operation, calibration, modification, maintenance, and repair of equipment and instruments.

Knowledges, Skills, and Abilities:

Knowledge of technical terminology in air pollution and related environmental fields.
Knowledge of basic chemical, electrical, and mechanical principles.
Knowledge of the kinds and uses of hand and power tools.
Some knowledge of the basic technical practices and standized procedures utilized in stack sampling and source and emission inventorying.
Some knowledge of the principles of operation and repair of air sampling instruments and equipment.
Skill at performing arithmetic computations.
Some knowledge of the hazards of and the safeguards essential to using chemical, electrical, and mechanical equipment and hand and power tools.
Ability to operate and repair air sampling instruments and equipment.
Ability to discuss technical problems with fellow workers, superiors, and other public and private individuals.
Ability to maintain positive and productive relationships with associates and other public and private individuals.
Ability to understand and interpret air pollution control laws, rules, and regulations.
Ability to work under difficult and dangerous conditions including temperature extremes, heights, and fumes.
Ability to maintain technical and administrative records.
Ability to operate vehicles used for field work.
Ability to learn to:

- Work independently on specialized assignments;
- Evaluate technical processes and procedures and to make recommendations for improvement;
- Assist higher-level staff engaged in training activities.

AIR POLLUTION CONTROL TECHNICIAN III

DEFINITION

Under general supervision, with technical latitude, performs a broad range of technical duties of varying complexity in laboratory, shop, and field; assists professional staff conducting special studies; and leads and trains lower-level staff.

EXAMPLES OF DUTIES

Performs complex installations, operations, calibration, maintenance, and repair of air sampling equipment.
Performs stack sampling and the gathering of data for source and emission inventories.
Performs complex tests, measurements, and analyses of air pollutants using standardized procedures.
Fabricates field shelters and facilities for air sampling equipment.
Sites and places air sampling and meteorological instruments and equipment as directed.
Assists in the review of engineering proposals and drawings for new or modified industrial processes and facilities and may develop recommendations.
Works independently on specialized assignments.
Leads, and may supervise, lower-level employees.
Prepares oral and written reports of activities and makes recommendations.
Assists in the training of lower-level employees and other personnel.
Assists professional staff conducting special studies.
Attends air pollution control hearings, presents evidence and data, and testifies as a witness in court cases.
Maintains and promotes effective personal relationships with associates and other public and private individuals.
Operates, is responsible for the daily maintenance of, and initiates requests for repair and maintenance of vehicles, instruments, and equipment.
Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:

Graduation from an accredited junior college with at least 12 semester hours in engineering, chemistry, or the physical or biological sciences and at least one year of progressively responsible experience in air pollution control or a related environmental or other program installing, operating, calibrating, modifying, maintaining, and repairing equipment and instruments,

OR

Graduation from high school or the possession of a certificate of high school graduation equivalency and at least two years of progressively responsible experience in air pollution control or a related environmental or other program installing, operating, calibrating, modifying, maintaining, and repairing equipment and instruments,

OR

Five years of progressively responsible experience in air pollution control or a related environmental or other program which includes at least two years installing, operating, calibratiang, modifying, maintaining, and repairing equipment and instruments.

Knowledges, Skills, and Abilities:

Knowledge of technical terminology used in air pollution and related environmental fields.
Knowledge of basic chemical, electrical, and mechanical principles.
Knowledge of the air pollution control laws, rules, and regulations which affect stack sampling and source and emission inventorying.
Knowledge of the kinds and uses of hand and power tools.
Knowledge of the basic technical practices and standardized procedures utilized in stack sampling and source and emission inventorying.
Knowledge of the principles of operation and repair of air sampling instruments and equipment.
Knowledge of the hazards of and the safeguards essential to using chemical, electrical, and mechanical equipment and hand and power tools.
Some knowledge of administrative principles and practices.
Some knowledge of training principles.
Some knowledge of basic principles of leadership and supervision.
Skill at stack sampling and gathering data for source and emission inventorying.
Skill at performing arithmetic computations.
Skill at working with hand and power tools.
Skill at operating and repairing air sampling instruments and equipment.
Ability to evaluate technical processes and procedures and to develop recommendations for improvement.
Ability to analyze documents, reports, and plans.
Ability to discuss technical problems with fellow workers, superiors, and other public and private individuals.
Ability to maintain positive and productive relationships with associates and other public and private individuals.
Ability to present evidence and data and to testify as a witness in court cases.
Ability to work independently on specialized assignments.
Ability to assist higher-level staff engaged in training activities.
Ability to work under difficult and dangerous conditions including temperature extremes, heights, and fumes.
Ability to maintain technical and administrative records.
Ability to operate vehicles used for field work.

AIR POLLUTION CONTROL AIDE 1

DEFINITION

Under close supervision, following detailed instructions, serves as a helper to a higher-level employee and learns to perform routine tasks.

EXAMPLES OF DUTIES

Observes and helps a higher-level employee working on a task such as:

- Analyzing air pollutants;
- Calibrating air sampling equipment;
- Keeping daily records;
- Maintaining vehicles.

Loads, unloads, and moves equipment, instruments, and supplies.
Unpacks and stores equipment, instruments, and supplies.
Collects, cleans, and distributes laboratory glassware.
Keeps working areas neat and clean.
Through training, observation of higher-level employees, and practice, develops a basic knowledge and understanding of procedures for the tasks to which assigned.
Learns safe practices.
Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:
None

Knowledges, Skills, and Abilities:
Ability to help higher-level employees performing various laboratory, shop, and office tasks.
Ability to learn to perform routine and repetitive tasks.
Ability to learn to use basic hand and power tools.
Ability to work cooperatively and productively with fellow workers.
Ability to follow safety precautions.
Ability to understand and follow simple written and oral directions.
Ability to read and write at the eighth grade level.
Ability to perform addition and subtraction.
Ability to communicate orally.

AIR POLLUTION CONTROL AIDE II

DEFINITION
Under close supervision, performs routine tasks as a helper to higher-level employees and learns to perform more difficult tasks requiring some technical knowledge and skill.

EXAMPLES OF DUTIES
Observes and helps higher-level employees performing a variety of air pollution control duties in laboratory, shop, field, and office, such as:

- Surveillance, inspection, and complaint investigation;
- Testing and analyzing air pollutants;
- Stack sampling;
- Source and emission inventorying;
- Installing, operating, and maintaining air sampling equipment;
- Operating and maintaining field vehicles;
- Keeping files and records on activities.

Loads, unloads, and moves equipment, instruments, and supplies.
Records receipt of, unpacks, and stores equipment, instruments, and supplies.
Decontaminates and sterilizes laboratory glassware.
Maintains working areas in a safe, neat, and clean condition.
Through training, observation of higher-level employees, and practice, develops a basic technical knowledge, understanding of practices and procedures, and some skill in performing the routine types of duties to which assigned.
Learns safe practices and safety principles.
Performs related duties as required.

MINIMUM QUALIFICATIONS

Education and Experience:
One year of experience in air pollution control or a related environmental program.

Knowledges, Skills, and Abilities:
Ability to perform routine and repetitive tasks as assigned.
Ability to learn to assist professional, administrative, and technical staff as needed.
Ability to acquire a basic technical vocabulary and understanding of basic technical practices and procedures.
Ability to learn to use hand and power tools.
Ability to develop skill in performing assigned tasks.
Ability to work cooperatively and productively with fellow workers.
Ability to learn and apply safety precautions.
Ability to understand and follow simple written and oral directions.
Ability to read and write at the eighth grade level.
Ability to perform addition and subtraction.
Ability to communicate orally and in writing.

Appendix C

Summary of the NY/NJ Air Pollution Abatement Activity Monitoring Program

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Summary of the NY/NJ Air Pollution Abatement Activity Monitoring Program

The objectives of the New York-New Jersey project were to demonstrate the geographical distribution of sulfur dioxide and carbon monoxide, to document interstate transport of pollutants, to compare observed concentrations with levels having an impact on health and welfare, and to delineate probable sources. Principal phases of the project were the air-quality-meteorological network and the emissions inventory.

The emissions inventory estimated emissions from a few large sources and from a host of small sources. Sources were characterized as fossil-fuel combustion for power generation and space heating, vehicles, refuse disposal by open burning or incineration, and industrial processes. The emissions were located and source types described as points or areas. They were summarized by political divisions, census tracts, and grids.

The agreements among the agencies, unilateral actions already taken by the agencies, and the Federal procedures to gather manpower and to procure equipment placed restraints upon the network design. The more significant factors were:

(a) An abatement conference would be convened in late 1966,

(b) The initial actions would concern carbon monoxide and sulfur compounds,

(c) New York had several sampling sites in operation,

(d) New Jersey had already negotiated for most of its sites,

(e) Sampling equipment to be used by the Federal personnel would not be available before April, and some not before June 1966.

From these factors, additional and necessary considerations became apparent:

(f) The time schedule confined the sampling to the summer months;

(g) Industrial activities were the predominant sulfur dioxide sources in summer--sulfur dioxide emissions from residential space heating being at a minimum;

(h) Most sulfur dioxide would be emitted from stationary sources whose locations were fixed and generally known; most carbon monoxide would be emitted from automobiles, a mobile source;

(i) Interstate transport of emissions could be demonstrated and its rate ascertained more readily, if the sampling network were:

  (1) Oriented so as to be consistent with the prevailing direction of air flow during the summer;

  (2) Oriented with respect to the sulfur dioxide sources whose locations were known; and

  (3) Designed to be compatible with existing sampling locations.

An analysis of wind directions at the four New York area weather-observing sites of the U.S. Weather Bureau indicated that summertime air flow was from the southwest more than one-third of the time with no other direction being more frequent.

From a map of the 17-county metropolitan area, an estimate of the major centers of sulfur dioxide emissions, and the locations of existing sampling stations, it was apparent that the axis of a sampling network could be placed parallel to the prevailing summertime air flow, through several established sampling sites, and through the area where most of the sulfur dioxide was emitted.

For convenience in analyzing data when winds were not precisely parallel to the axis of the network, radials with their origin near Raritan Bay were constructed 22-1/2° from the axis. Additional sampling stations were placed on the radials. Preferred locations were at the intersections of radials and minor axes constructed normal to the primary axis and through established sampling stations.

The resultant aerometric surveillance network is described in the following text extracted from Air Quality Monitoring Protocol for the New York-New Jersey Air Pollution Abatement Activity:

"Air Quality Monitoring Network

"The United States Public Health Service proposed a design of air quality monitoring equipment to study interstate pollutants between New York and New Jersey. The design consists of an inner portion (or core network) ringed by two concentric arcs of lead peroxide sulfation candles. [Figure C-1 shows geographical location.]

"Air Monitoring Stations

"The core network will be oriented on a 45°-225° axis through a monitoring station in Bayonne, New Jersey. This axis also passes through the monitoring stations in Central Park on Manhattan Island, and near the centers of gravity of the two largest industrial pollution regions in the study area, i.e., the north-eastern New Jersey (Arthur Kill) and East River regions of New York. Assuming the areas of major industrial pollution are located along the East River and west of Arthur Kill, the sampling station in Bayonne is approximately midway between the two. The distance from Bayonne to Central Park is considered a unit distance. Two additional stations will be located on the axis, one at three unit distances 'downwind' from Bayonne (New Rochelle, N. Y.), and another 'upwind' three unit distances from Bayonne (Raritan Depot, N. J.). Automatic stations will be placed on either side of the axis, located insofar as practicable, to form with stations on the axis, three lines perpendicular to the axis. The stations west of the axis from north to south are Fair Ridge, Neward, and Roselle. East of the

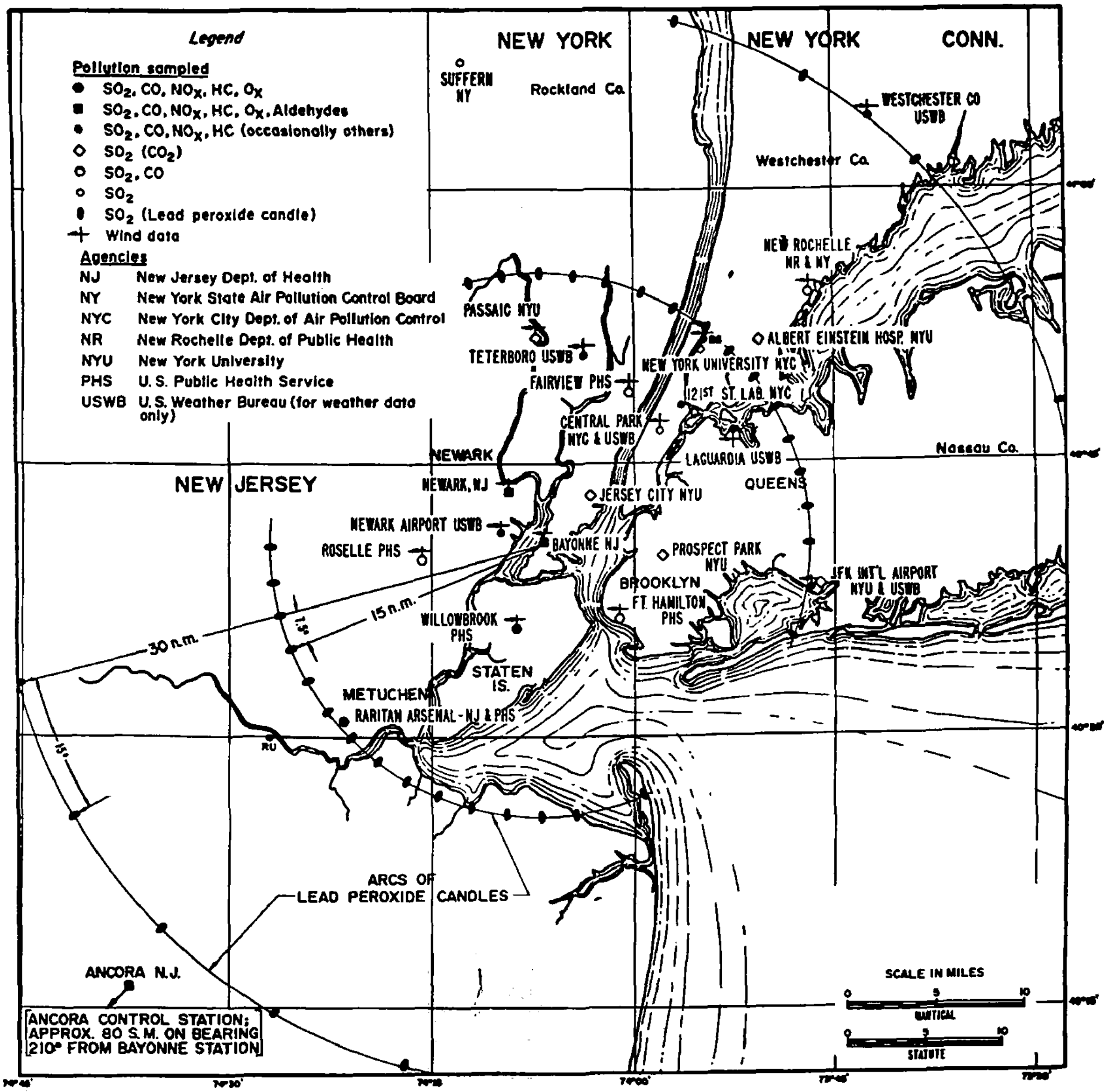

Figure C-1. Location of air monitoring sites in the N.Y.-N.J. Abatement Activity.

axis are 121st Street Lab., Fort Hamilton, and Willowbrook. A station at Ancora, N. J., would serve as a control background station. Five additional New York University stations will provide sulfur dioxide data. They are Passaic, Albert Einstein, Jersey City, Prospect Park, and JFK Airport. This deployment provides a reasonably wide sector coverage when air flow is from southwest and northeast quadrants, and provides data on variations in concentrations with distance when winds are from southeast and northwest quadrants.

"Lead Peroxide Sulfation Candles

"Two arcs of lead peroxide sulfation candles will ring this core network and will be centered on the Bayonne station. The inner arc will have a radius of 15 miles and will have lead candles stationed every 7-1/2° or about 2 miles. The outer arc will have a radius of 30 miles and will have its candles located every 15° or about 8 miles. In addition, each station in the core network will have a lead candle to provide correlation information between continuous automative analyzers, sequential samplers, and candle sampling. A total of 70 candles will be utilized; 54 in the two arcs and 16 at the air monitoring stations."

Appendix D

Air Pollution Control Agency Manpower Model

Appendix D

Air Pollution Control Agency Manpower Model

The APCA Manpower Model has 14 sets of basic predictors and manpower factors to be used in estimating the manpower needs for 14 designated agency functions (see Table D-1). Several of these functions directly involve the technical services group: operation of the monitoring network, special studies, data processing, source testing, instrument calibration and maintenance, and analytical laboratory operations. Other functions are indirectly related such as staff training, agency policy, public relations, administration, and clerical support. The number of man-years required for a given function is the product of the basic predictor times the particular manpower factor. For example, the basic predictor for operation of the monitoring network is the number of monitors required, based on Federal Register specifications. The manpower factor is 0.1 man-year per unit predictor. The basic predictor for operation of the laboratory is equivalent to the sum of the manpower required for ambient monitoring, source testing, and special studies. The laboratory manpower factor is 0.35 man-year per unit predictor. The manpower required to conduct special studies is equivalent to the manpower needed for the four key agency functions times 0.06; the manpower required for source testing is equivalent to the sum of the manpower needs for scheduled inspections and permit-system operation times 0.10.

To demonstrate the use of the model, the manpower requirements will be determined below for a region with the following characteristics:

Table D-1. BASIC PREDICTORS AND MANPOWER FACTORS FOR MANPOWER ESTIMATES

Function	Predictor	Manpower factor
1. Operation of monitoring network	No. of instruments (from Federal Register	0.1 MY/unit predictor
2. Scheduled inspections	$\frac{\text{No. of manufacturing establishments}}{1000}$	2.8 MY/unit predictor
3. Complaints and field patrol	$\frac{\text{Population}}{100{,}000}$	0.7 MY/unit predictor
4. Operation of permit system	$\frac{\text{Capital expenditures for new plants}}{100{,}000{,}000}$	9.7 MY/unit predictor
5. Policy, public relations, etc.	MY 1,2,3,4	0.22
6. Staff training	MY 1,2,3,4	0.12
7. Special field studies	MY 1,2,3,4	0.06
8. Emission estimates	MY 1,2,3,4	0.05
9. Special engineering activities	MY 1,2,3,4	0.06
10. Administrative and clerical support	MY 1,2,3,4	0.50
11. Data processing	MY 1,2,3,4	0.09
12. Source testing	MY 2,4	0.10
13. Instrument calibration and maintenance	MY 1,7	0.25
14. Laboratory operations	MY 1,7,12	0.35

Code: MY - Man-year.

Table D-2. SUMMARY OF MAN-YEAR ESTIMATES FOR EXAMPLE AGENCY

Function	Predictor	Manpower factor	Calculated man-years
1. Operation of monitoring network	74.	0.1	7.4
2. Schedule inspections	7.15	2.8	20.0
3. Complaints and field patrol	24.43	0.7	17.1
4. Operation of permit system	2.46	9.7	23.8
Subtotal			(68.3)
5. Policy, public relations,etc.	68.3	0.22	15.0
6. Staff training	68.3	0.12	8.2
7. Special field studies	68.3	0.06	4.1
8. Emission estimates	68.3	0.05	3.4
9. Special engineering activities	68.3	0.06	4.1
10. Administrative and clerical support	68.3	0.50	34.1
11. Data processing	68.3	0.09	6.1
12. Source testing	43.8	0.10	4.4
13. Instrument calibration and maintenance	11.5	0.25	2.9
14. Laboratory operations	15.9	0.35	5.6
Total			156.2

(a) Number of monitors: 74;

(b) Population: 24.43 x 10^5;

(c) Number of manufacturing establishments: 7.15 x 10^3;

(d) Capital expenditures: \$2.46 x 10^8.

Direct application of the predictors listed above and the predictors and manpower factors listed in Table D-1 results in a total estimated staff of 156.2 man-years as detailed in Table D-2. When compared to the population served, this estimated calls for a staff of 6.3 man-years/100,000 population.

Appendix E

Interagency Contracts for Technical Services--A Checklist

Appendix E

Interagency Contracts for Technical Services--A Checklist

E.1 Introduction

Types of agreements can range from a simple agreement to provide technical services for five or six specific hi-vols to a complex arrangement whereby a complete program including day-to-day monitoring, episode monitoring, data handling, and input and source testing is contemplated. This checklist, coupled with the text in the body of this report, will provide the reader with sufficient information to insure that the agency's attorney can draw up a workable agreement. The agency will benefit if its attorney is knowledgable of the workings of an air pollution control agency.

Since agency personnel often work out preliminary agreements prior to involving an attorney, this checklist also covers facets of contracting common to all agreements. This enables preliminary agreements to be made in a manner that enables the parties to know where they stand. For this reason, two checklists are provided--one "legal" and one "technical."

E.2 Legal Checklist

(a) Authority to Contract. Since a technical services contract involves governmental entities, it is important to verify that both parties are authorized by the State constitution, statutes, and/or local ordinances to enter into the contract. Note that there is a difference between providing a service and receiving a service. It is not uncommon for a governmental agency to have the authority to contract to receive services but lack authority to provide services.

(b) Consideration. An agreement is not binding unless there is consideration. Both parties must be obligated to give something. If the agreement merely provides that one agency is to provide services to another without any kind of recompense, there is no binding contract.

(c) Term of Contract. The agreement must be specific as to its term. Is it to run from year to year? Is it to be automatically renewable? Is its term indefinite as to termination? The agencies' contract-making authority may also limit the term of the agreement.

(d) Termination. Do the parties want a provision for orderly unilateral termination? What happens to the equipment upon termination? If unilateral termination is desirable, how much notice should be given?

E.3 Technical Checklist

(a) Operations (Refer to Chapter 3.0). Are the services to cover ambient monitoring? Source testing? For what pollutants? Does it matter which sampling and analytical methods are used? If so, specify method. (See also Chapter 8.0 in this regard.) Who supplies the equipment? If both parties are to supply equipment, list the equipment. Who maintains the equipment? Who insures the equipment? How many tests are to be made during a specific time period?

(b) Partition and Location (Refer to Chapter 4.0). Where are the laboratory facilities to be located? May they be moved at the discretion of only one party? Is work to be shared? If so, how? Is one party to pay the other for the services? Who pays rent and utilities?

(c) Legal Considerations (Refer to Chapter 5.0). Is the testing agency to furnish enforcement support? If so, specify that proper methods shall be used to insure usefulness of a sample as evidence. Testing agency should supply the report and expert testimony to support tests if required. How is the agency to be paid for this service?

(d) Management (Refer to Chapter 6.0). To render services, an agency must have adequate manpower. Personnel must be qualified. (See also Chapter 5.0 in this regard.) What are test priorities, if any? Will recipient agency have voice in determining priorities? Are tests to be made only upon issuance of work order? May the laboratory subcontract work to private firms? Such subcontracts may void contract if the recipient agency lacks authority to contract with private firms directly. (See also Chapter 9.0 in this regard.)

(e) Data Handling (Refer to Chapter 7.0). Are test results to be used in a computer program? In what format? Is one party to provide hardware for the other? Will technical services include episode monitoring? How often is data to be reported?

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