United States
Environmental Protection
Agency

Technology Transfer

EPA

Handbook

Industrial Guide for Air Pollution Control

EPA-625/6-78-004

INDUSTRIAL GUIDE FOR AIR POLLUTION CONTROL

U.S. ENVIRONMENTAL PROTECTION AGENCY
Technology Transfer

June 1978

ACKNOWLEDGMENTS

This handbook was prepared for the Environmental Research Information Center by PEDCo Environmental, Inc., under EPA Contract No. 68-01-4147. Alsid, Snowden and Associates and York Research Corporation were technical reviewers of the handbook. EPA reviewers were Robert Walsh of the Office of Air Quality Planning and Standards, and Francis Biros, Stationary Source Enforcement Division.

NOTICE

The mention of trade names of commercial products in this publication is for illustration purposes and does not constitute endorsement or recommendation for use by the U.S. Environmental Protection Agency. This manual is presented as a helpful guide to the user and should in no way be construed as a regulatory document. For legislative or enforcement assistance, the user should contact air pollution personnel in either EPA regional offices or the appropriate state agency.

CONTENTS

CONTENTS – Continued

LIST OF FIGURES

FIGURES – Continued

FIGURES – Continued

LIST OF TABLES

CHAPTER 1

INTRODUCTION

The information presented in this manual is intended for plant managers, engineers, and other industrial personnel responsible for plant compliance with air pollution control regulations. It is intended as a set of guidelines and is oriented to companies that are not yet fully involved in a corporate program of environmental control. Some of the tasks involved in achieving and maintaining compliance with regulations require expertise that is beyond the usual range of skills and experience of industrial plant personnel; the manual therefore presents criteria for evaluation of outside firms or consultants who offer specialized environmental services.

The question may arise, "Why should we as an industry read and do what this guide describes?" Certainly legislation and enforcement action by cognizant regulatory authorities will force industry to comply with pollution regulations or face severe penalties.

Perhaps another factor as important as the mandating aspect is the social awareness of protecting the community from the harmful effects of air pollution. A well-conceived pollution abatement program is important to those residing close to the plant. Industries that maintain a good relationship with the surrounding community may recognize benefits such as assistance in zoning changes and less vandalism.

Since this manual is designed for use in industry-at-large, much of the discussion is general. The discussions are illustrated with examples that are industry-specific such as flowsheets, survey forms, checklists, maintenance schedules, and similar materials currently used in compliance programs of individual industrial plants. The example illustrations typify the tools available to the corporate compliance planner.

The manual is designed to be used in different ways by personnel performing diverse functions within the company structure. The plant executive will wish to know what this document provides and how it can best be used by the responsible persons on his staff. He may have no personal need for details of procedures for shutdown, maintenance, and start-up of an electrostatic precipitator; he should, however, be aware of the degree of technical knowledge and skill that is required to perform these tasks efficiently. In some instances, sample detailed checklists are provided within the text with additional detailed procedures included in the appendix. Not everyone will read or use all portions of this manual. Some portions may be excerpted for distribution to the responsible staff.

As closely as possible, the structure of the manual corresponds to the structure of an industrial compliance program, consisting of three major phases:

1. Achieving compliance,
2. Demonstrating compliance, and
3. Maintaining compliance.

It is difficult to determine whether emission sources or emission regulations should be discussed first. It was decided to place the Plant Emission Survey (Chapter 3) ahead of Emission Regulations (Chapter 4). It is suggested that the reader refer to Chapter 4 prior to conducting an emission survey in order to become familiar with the regulations that apply to specific processes or operations.

The relationship of chapters in this manual to the three-phase, overall compliance program is delineated in Figure 1-1 and is discussed below.

Achieving Compliance

Chapter 2: Compliance Program Planning – Intended primarily for industrial managers with highest-level responsibility for the compliance program, this chapter introduces the basic steps involved in tailoring the program to the company's needs. It outlines departmental functions, as exemplified in typical organizational options for large and small industries.

Chapter 3: Plant Emission Survey – The emission survey identifies all sources of air pollutant emissions within an industrial plant. This chapter, directed to the plant engineer or process engineer, describes how to conduct the survey, quantify pollutant emissions, and prepare a source identification file.

Chapter 4: Emission Regulations – Having determined the plant's specific pollution problems, the industrial manager, possibly with consultation of the corporation's legal counsel, can review in this chapter the requirements applicable to the company under current and anticipated air pollution control regulations. The chapter outlines salient provisions of the Clean Air Act of 1970; requirements for inspection, monitoring, recordkeeping, and data reporting; legal considerations for confidentiality of proprietary information; and the major implications for industry of State Implementation Plans under the Clean Air Act, including registration/permit programs.

Demonstrating Compliance

When the industrial plant manager has reviewed the available options for air pollution

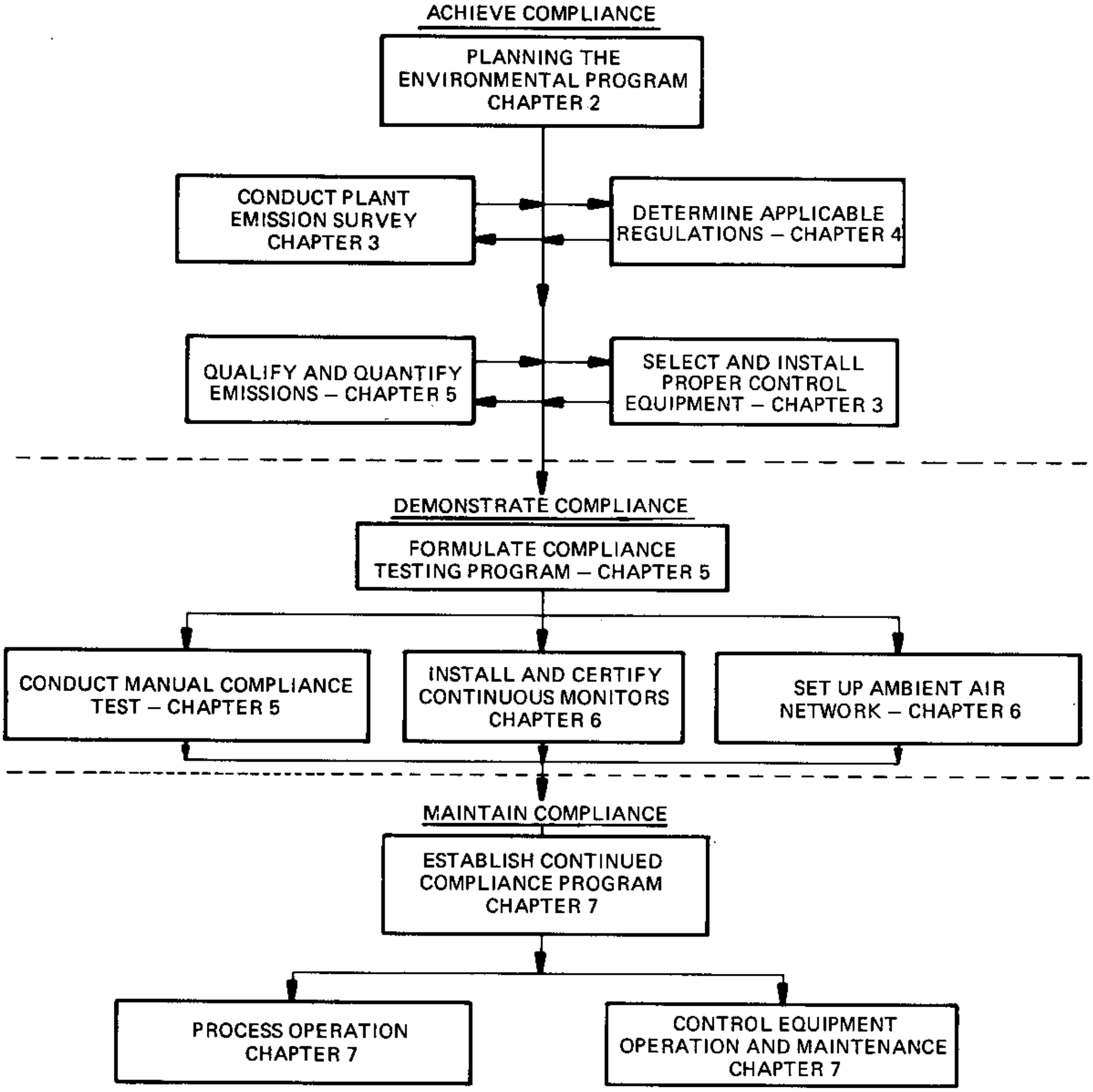


FIGURE 1-1
A THREE-PHASE COMPLIANCE PROGRAM

control and has conducted the modifications/installations that will bring the plant into compliance with applicable regulations, compliance must be demonstrated to control agency representatives by measurement of pollutant emissions in a series of compliance tests during representative plant operations. Information on compliance testing and monitoring, as well as continuing compliance efforts, includes approximate costs of equipment, labor, and other expenditures; these estimates are based on 1977 costs.

Chapter 5: Stack Emission Measurements – This chapter presents the basic concepts of emission testing, with detailed consideration of the planning, testing, and reporting phases of an emission test program. It provides criteria for determining whether the tests should be performed by in-house technical staff or by contract for the services of a professional emissions testing team. Section 5.3 briefly describes the sampling methods specified by control agencies for each of the regulated pollutants.

Chapter 6: Ambient Air Monitoring/Continuous Stack Monitoring – In conjunction with measurements of emissions in the stack, industrial plant operators may wish to conduct a program of ambient air monitoring (i.e., measuring specific pollutants in the atmosphere near the plant). Monitoring is done for a variety of reasons, often in conjunction with planning of new plants or expansion of facilities. Continuous monitoring of plant emissions for specified pollutants is required in certain industries under the U.S. EPA's New Source Performance Standards. Chapter 6 describes the fundamentals of ambient air monitoring and continuous stack monitoring, including selection of monitoring sites, instrumentation, and data reporting.

Maintaining Compliance

Chapter 7: The Continuing Program – This chapter presents the elements of an industry's continuing program to maintain compliance status when that status has been achieved. It considers the effects of changes in raw materials and in-process operations, malfunctions of process or control equipment, start-up and shutdown, maintenance and troubleshooting. Three major particulate control system are considered in detail: the fabric filter, venturi scrubber, and electrostatic precipitator. Each system is analyzed in terms of inspection/maintenance/troubleshooting, spare parts inventory, and manpower requirements.

In presenting this manual for use by managerial and technical staff of diverse United States industries, it is recognized that not all specific needs can be addressed. The information presented here should, however, provide for industrial personnel an insight into the probable scope of a company's compliance program and the methods by which the plant can achieve and maintain compliance status.

CHAPTER 2

COMPLIANCE PROGRAM PLANNING

2.1 Environmental Assessment and Planning

Environmental assessment and planning can be integrated into a company's corporate structure in several ways. The company can manage and operate its own program with in-house personnel, hire a consulting firm to outline and implement the environmental program, or utilize some combination of in-house staff and consultants. The exact mechanisms for carrying out these responsibilities will vary with each company, depending on its size, staff, potential environmental problems, and its dedication to solving these problems. This chapter discusses only the aspects of environmental planning related to atmospheric emissions. A full-scale environmental program will also consider water, solid wastes, and noise pollutants and will be coordinated with plant programs for occupational safety, health, and energy conservation. In addition, other aspects of environmental planning such as plant siting, assessment and impact studies, and nondegradation should be considered but are beyond the scope of these guidelines.

2.1.1 Corporate Planning of the Environmental Program

Each company must define its objectives as they relate, for example, to legal requirements, emission assessment, emission control plans, expansion plans, and corporate responsibility. As these objectives are explored and defined, an awareness of the overall environmental situation will develop and will provide a basis for planning. In determining specific objectives and the tasks required to carry them out, the company must conduct a preliminary assessment of process emissions at each operating location that could constitute an emission source. This assessment will determine the number and complexity of the subsequent steps required to fulfill the desired objectives.

Corporate objectives must be defined to develop a corporate environmental program. Table 2-1 lists sample objectives as well as program elements and results which aid in achieving those sample objectives. The extent and complexity of the program will depend largely on specific objectives and on the number and type of processes involved.

2.1.2 Locate and Describe Atmospheric Emission Sources

A first step in any program is to determine what processes emit atmospheric pollutants and are subject to a pollution control regulation, or could cause a public nuisance or an adverse health effect. This inventory of sources provides the comprehensive basis for many subsequent planning steps and thus should be as complete as possible.

TABLE 2-1

SAMPLE CORPORATE OBJECTIVES, PROGRAM ELEMENTS, AND RESULTS

Objective	Program elements	Result
Locate and describe atmospheric emission sources	Survey all processes	Inventory of all emission sources and vents
Assess emissions	Make estimates and measurements	Definition of emission parameters
Determine compliance with applicable regulations	Review regulations Determine emissions Compare values with those cited in applicable regulations	Listing of sources not in compliance
Obtain required operating permits	Determine permit requirements Obtain data Complete and submit forms	Operating permits for all required sources
Prepare and implement compliance action	Assign priorities to noncomplying sources Perform control feasibility studies Allocate resources	Agency-approved compliance plan and eventual compliance with regulation
Obtain engineering design data	Perform source testing Determine emission factors	Quantitative data for selecting new control equipment
Determine product losses	Perform source testing Make engineering estimates	Economics of further control
Establish surveillance program	Up-date source inventory Review new regulations Renew permits Monitor emissions	Maintaining compliance with applicable regulations

As described in Chapter 3, a comprehensive survey of each process should identify vents and emission parameters. In an initial survey, only individual sources such as boilers, incinerators, and manufacturing processes must be identified. In subsequent, more-detailed surveys, all individual vents and stacks serving the processes should be identified.

2.1.3 Emission Assessment

Having determined what processes emit pollutants to the atmosphere and what regulatory requirements apply to these processes, a preliminary assessment of their emissions is made by applying emission factors, making material balances and measurements, and estimating engineering requirements. Emission tests may be required for compliance with regulations or when emission estimates are not adequate for inventory purposes.

2.1.4 Regulatory Requirements

Atmospheric emissions are regulated at local, state, and federal levels. All of these regulations must be searched, with notation of sections applicable to the various plant processes. The compliance status of each process must then be determined by comparing actual emissions with allowable emissions.

Enforcement personel from state or local agencies will contact those industries which are thought to be violating emission standards. The industry is then responsible for either proving they are in compliance or implementing control systems to comply with standards.

2.1.5 Permit Requirements

Since the early 1970's, and in many jurisdictions well before that, operating permits have been required for various processes that are vented to the atmosphere. A thorough review of regulations applicable to each plant site is required to determine precisely the processes for which permits are required.* Copies of permit application forms can be obtained from the appropriate agency. Example forms are shown in Figures 2-1 and 2-2 for an oil-fired boiler (Figure 2-3) and a spray booth (Figure 2-4). These forms should be completed by persons with understanding of the regulations and of the process involved. Air pollution control agencies will explain any ambiguous wording or interpretation regarding processes requiring permits.

Permit applications provide the basis for a control agency's decision to grant or deny a permit to operate. Most agencies require process flow diagrams, composition and feed rates of raw materials, production rates, operating schedules, exhaust rates, and related information characterizing the process. The information required on these forms is largely

---

*See Chapter 4.

FUEL BURNING EQUIPMENT

(Boilers, Heaters, and Steam Generators)

1. Manufacturer____________________ Model No. __________

2. Your identification ____________________ Year installed __________

3. Input capacities (10^6 BTU/hr): Rated ______ Max. ______ Normal ______
   Output capacities (lb–steam/hr): Rated ______ Max. ______ Normal ______
   Note: Indicate units if different from above.

4. Percent used for: Space heat _____ % Process _____ % Power _____ %

5. Normal Operating schedule: _____ hr/day, _____ day/wk, _____ wk/yr

6. Type of fuel fired: ☐ Coal ☐ Oil ☐ Natural gas
   ☐ Wood ☐ LPG ☐ Other, specify __________

7. Type of draft: ☐ Natural ☐ Induced ☐ Forced

8. Combustion monitoring: ☐ Fuel/air ratio ☐ O_2 ☐ Smoke
   ☐ Other, specify ____________________

COAL-FIRED UNITS

9. Type of firing: ☐ Hand-fired ☐ Underfeed stoker ☐ Traveling grate
   ☐ Chain grate ☐ Spreader stoker ☐ Cyclones
   ☐ Pulverized, dry bottom ☐ Vibrating grates
   ☐ Pulverized, wet bottom
   ☐ Other, specify ____________________

10. Fly ash reinjection: ☐ Yes ☐ No

OIL-FIRED UNITS

11. Type of oil: ☐ No. 2 ☐ No. 6 ☐ Other, specify __________

12. Atomization: ☐ Oil pressure ☐ Steam pressure ☐ Compressed air
    ☐ Rotary cup ☐ Other, specify ____________________

13. Oil preheater: ☐ Yes, temp. _____ °F ☐ No

FIGURE 2-1

EXAMPLE PERMIT APPLICATION FORM FOR FUEL BURNING EQUIPMENT

FUEL DATA

14. Complete the following tables for each type of fuel:*

Type of fuel	Heat content (BTU/unit)	Percent		Quantity of fuel used		
		Ash	Sulfur	Per year	Normal/hr	Maximum/hr
Coal	BTU/lb			ton	lb	lb
Oil	BTU/gal			gal	gal	gal
Gas	BTU/cu ft			cu ft	cu ft	cu ft
Wood	BTU/lb			ton	lb	lb
LPG	BTU/gal			gal	gal	gal
Other						

Type of fuel	Percent annual use			
	Winter	Spring	Summer	Fall
Coal				
Oil				
Gas				
Wood				
LPG				
Other				

*Obtain fuel analysis from vendor(s) and report on an as-received basis. Use weighted annual averages.

CONTROL EQUIPMENT

Control equipment code:

(A) Settling chamber
(B) Cyclone
(C) Multiple cyclone
(D) Electrostatic precipitator
(E) Fabric collector (baghouse)
(F) Spray chamber
(G) Cyclonic scrubber
(H) Packed tower
(I) Venturi
(J) Other ________________

15. Control equipment data:

Item	Primary collector	Secondary collector
(a) Type (see above code)		
(b) Manufacturer		
(c) Model No.		
(d) Year installed		
(e) Your identification		
(f) Pollutant controlled		
(g) Controlled pollutant emission rate (if known)		
(h) Pressure drop		
(i) Design efficiency		
(j) Operating efficiency		

FIGURE 2-1 (Cont.)
EXAMPLE PERMIT APPLICATION FORM FOR FUEL BURNING EQUIPMENT

EMISSION POINT DATA

16. Your emission point identification ______________________

17. Are other sources vented to this stack? ☐ Yes ☐ No
If yes, identify sources ______________________

18. Type: ☐ Round, top inside diameter dimension ____________
☐ Rectangular, top inside dimensions (L)________ x (W)________

19. Height: Above roof ________ ft, above ground ________ ft

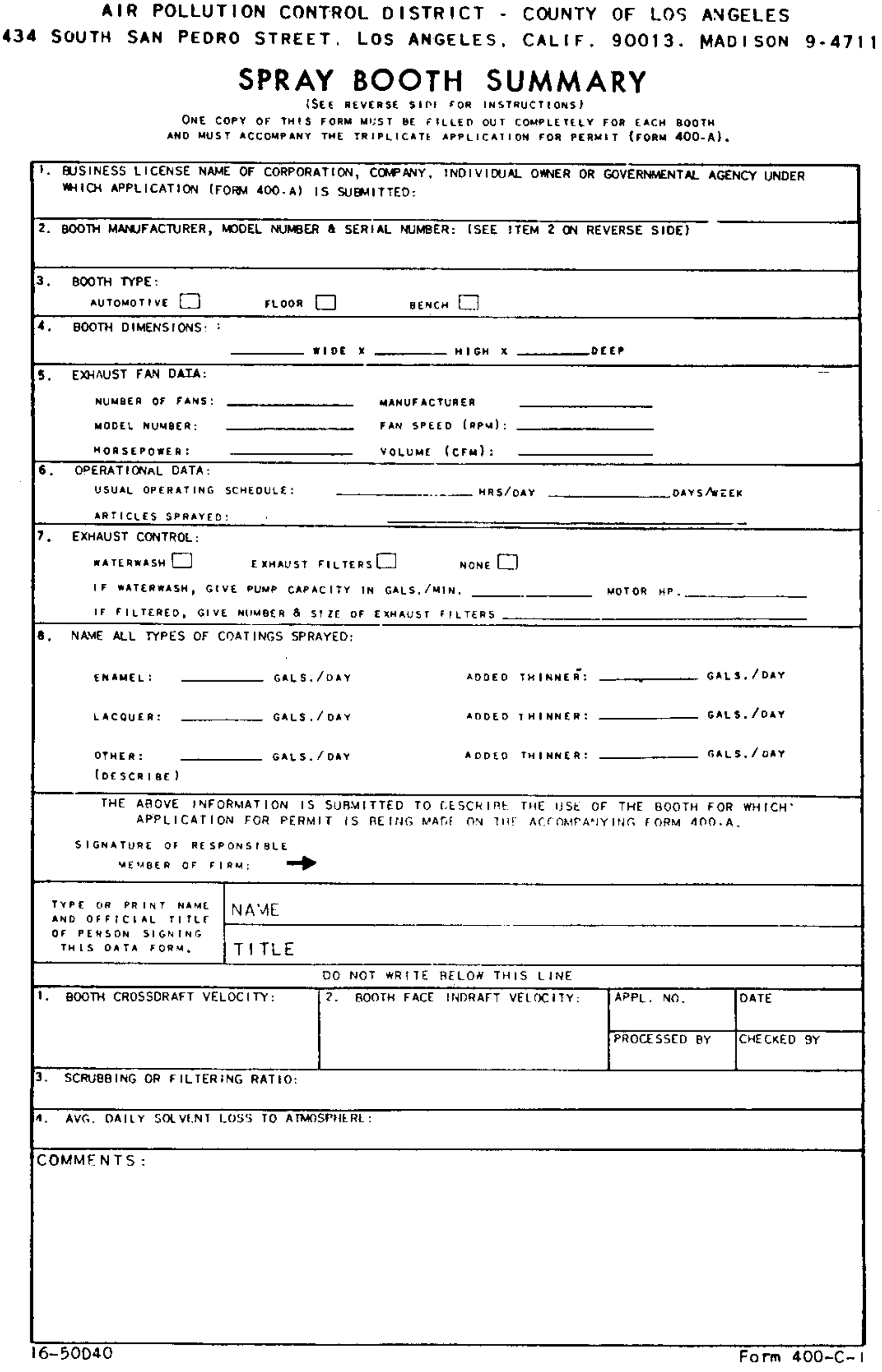
20. Exit gas: Temp. ______°F, Volume ______ acfm, Velocity ______ ft/min

21. Continuous monitoring equipment: ☐ Yes ☐ No
If yes, indicate type ______________, Manufacturer ______________
Make or model ______________, Pollutant(s) monitored ______________

22. Emission data: Emissions from this source have been determined and such data are included with this appendix: ☐ Yes ☐ No
If yes, check method: ☐ *Emission test* ☐ *Emission factor*

Completed by ______________, Date ______

FIGURE 2-1 (Cont.)
EXAMPLE PERMIT APPLICATION FORM FOR FUEL BURNING EQUIPMENT



AIR POLLUTION CONTROL DISTRICT - COUNTY OF LOS ANGELES
434 SOUTH SAN PEDRO STREET, LOS ANGELES, CALIF. 90013. MADISON 9-4711

SPRAY BOOTH SUMMARY

(SEE REVERSE SIDE FOR INSTRUCTIONS)

ONE COPY OF THIS FORM MUST BE FILLED OUT COMPLETELY FOR EACH BOOTH AND MUST ACCOMPANY THE TRIPLICATE APPLICATION FOR PERMIT (FORM 400-A).

1. BUSINESS LICENSE NAME OF CORPORATION, COMPANY, INDIVIDUAL OWNER OR GOVERNMENTAL AGENCY UNDER WHICH APPLICATION (FORM 400-A) IS SUBMITTED:

2. BOOTH MANUFACTURER, MODEL NUMBER & SERIAL NUMBER: (SEE ITEM 2 ON REVERSE SIDE)

3. BOOTH TYPE:
AUTOMOTIVE ☐ FLOOR ☐ BENCH ☐

4. BOOTH DIMENSIONS:
________ WIDE X ________ HIGH X ________ DEEP

5. EXHAUST FAN DATA:
NUMBER OF FANS: ________ MANUFACTURER ________
MODEL NUMBER: ________ FAN SPEED (RPM): ________
HORSEPOWER: ________ VOLUME (CFM): ________

6. OPERATIONAL DATA:
USUAL OPERATING SCHEDULE: ________ HRS/DAY ________ DAYS/WEEK
ARTICLES SPRAYED: ________

7. EXHAUST CONTROL:
WATERWASH ☐ EXHAUST FILTERS ☐ NONE ☐
IF WATERWASH, GIVE PUMP CAPACITY IN GALS./MIN. ________ MOTOR HP. ________
IF FILTERED, GIVE NUMBER & SIZE OF EXHAUST FILTERS ________

8. NAME ALL TYPES OF COATINGS SPRAYED:
ENAMEL: ________ GALS./DAY ADDED THINNER: ________ GALS./DAY
LACQUER: ________ GALS./DAY ADDED THINNER: ________ GALS./DAY
OTHER: ________ GALS./DAY ADDED THINNER: ________ GALS./DAY
(DESCRIBE)

THE ABOVE INFORMATION IS SUBMITTED TO DESCRIBE THE USE OF THE BOOTH FOR WHICH APPLICATION FOR PERMIT IS BEING MADE ON THE ACCOMPANYING FORM 400-A.

SIGNATURE OF RESPONSIBLE MEMBER OF FIRM: →

TYPE OR PRINT NAME AND OFFICIAL TITLE OF PERSON SIGNING THIS DATA FORM.	NAME
	TITLE

DO NOT WRITE BELOW THIS LINE

1. BOOTH CROSSDRAFT VELOCITY:	2. BOOTH FACE INDRAFT VELOCITY:	APPL. NO.	DATE
		PROCESSED BY	CHECKED BY

3. SCRUBBING OR FILTERING RATIO:

4. AVG. DAILY SOLVENT LOSS TO ATMOSPHERE:

COMMENTS:

16-50040 Form 400-C-1

FIGURE 2-2
EXAMPLE PORTION OF APPLICATION FORM FOR A SPRAY BOOTH

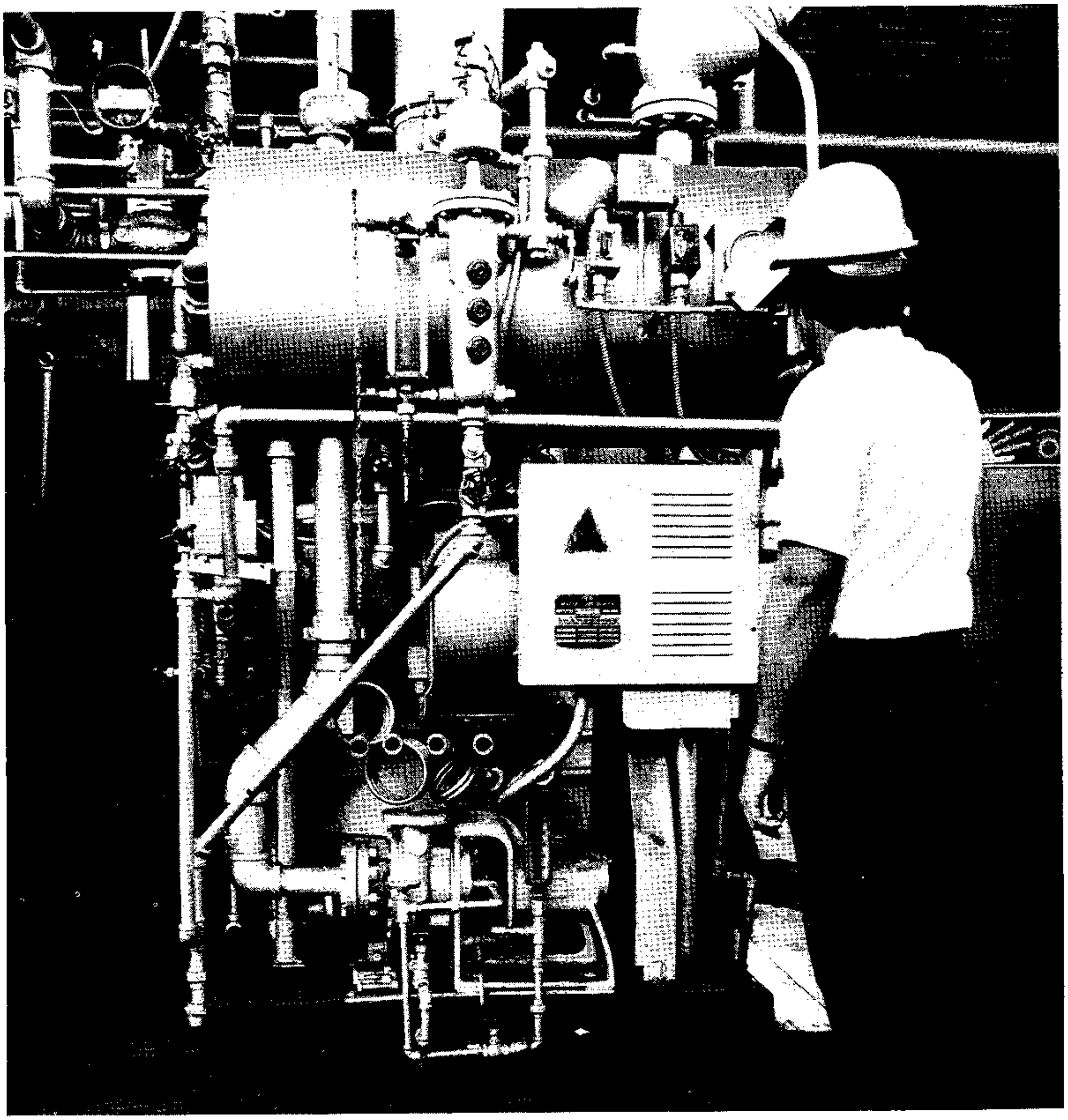


FIGURE 2-3
SMALL OIL-FIRED BOILER

self-explanatory. Units of measurement must be carefully observed, e.g., an entry may be in actual cubic feet per minute (acfm) or in standard cubic feet per minute (scfm, corrected to a temperature and pressure specified in the regulations). Estimation of emission rates is discussed in Chapter 3. If emission data are unknown, no value should be inserted.

In some jurisdictions, the law requires that permits be obtained before a new source of atmospheric emission is constructed or an existing source is modified. Permit forms for

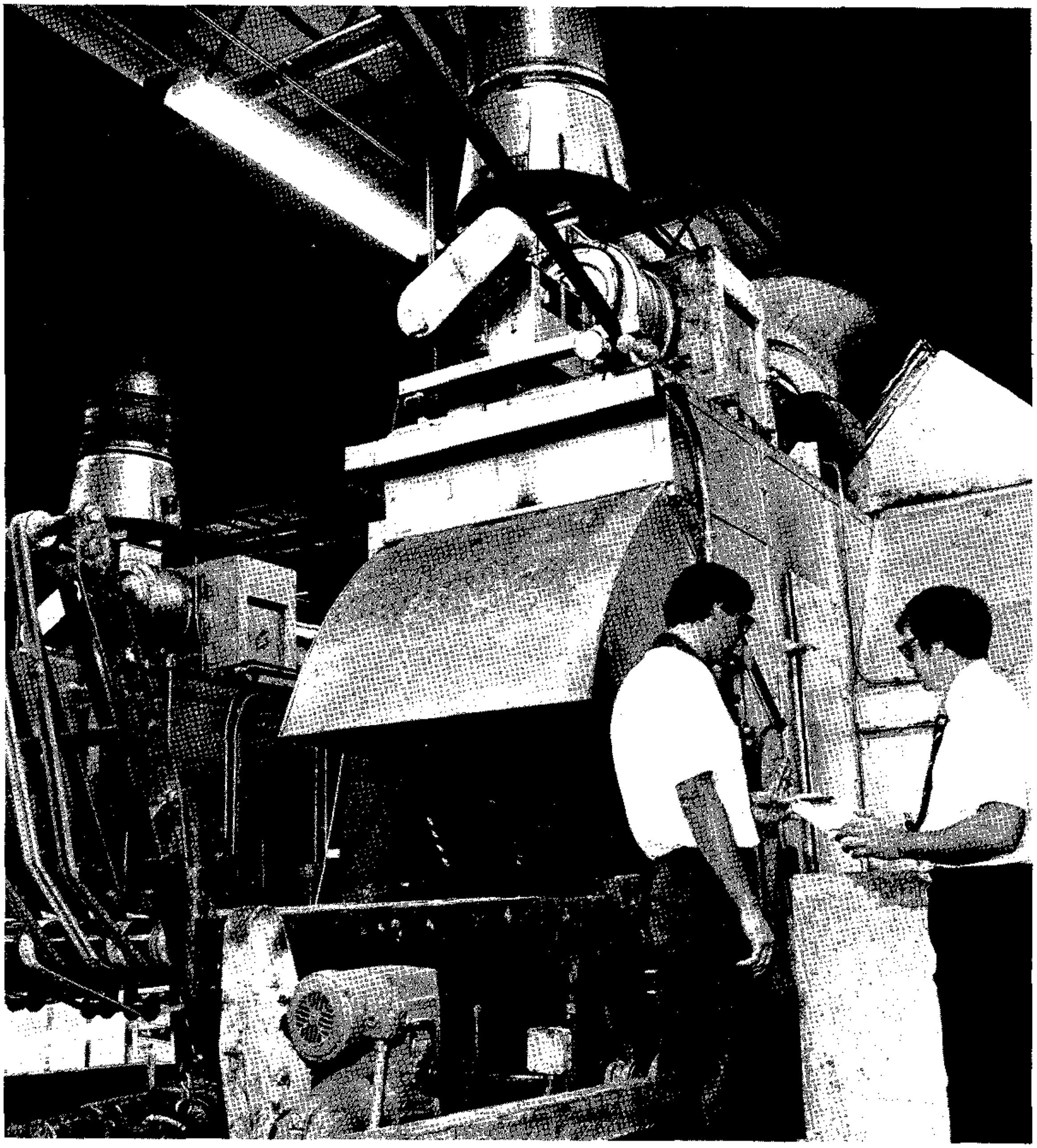


FIGURE 2-4
SPRAY BOOTH WITH DRIER DUCT IN BACKGROUND

these operations allow the control agency to evaluate the emission control equipment that is planned and to assess potential compliance with applicable regulations. If the agency judges that the source as planned will not operate in compliance with regulations, agency officials may require changes in the design of the process or installation.

Only processes operating in compliance with the applicable regulations can receive permits.

2.1.6 Control Requirements and Compliance Programs

The preliminary emission assessment will indicate potential problems concerning regulatory violations, product loss, or public nuisance. For those sources that are shown to require control, a compliance plan must be developed; this plan will be based on detailed emission estimates and engineering feasibility studies. The compliance program must state how processes will be brought into compliance with regulations and when compliance will be achieved.

Corporate planning may require determination of detailed emission data such as gas composition, particulate loading, particle size, and emission rates. This information may be required for designing a new control device or process, or for obtaining bids from vendors of control systems.

Product losses through process vents must be determined when material cannot be accounted for in a materials balance (that is, a balance in quantities of input/output materials). Product losses can occur in both gaseous and solid forms; depending on their value, recovery of these losses could be economical.

A final step in the corporate plan is developing a system for maintaining compliance of all emission sources. This system will include a program for updating the inventory of existing and new sources and for obtaining the various construction and operating permits that are required periodically. New regulations must be studied and the impacts appraised.

New federal regulations are published in the *Federal Register.* Large utility and industrial companies have adequate staff to review these regulations. Smaller companies that do not have the time or manpower to scan the *Federal Register* must keep in touch with local agencies or trade associations for the latest regulatory changes.

2.2 Implementing the Environmental Program

Structuring of the various program functions can be accomplished in a number of ways depending on availability and expertise of the corporation's staff. Advantages and disadvantages of several functional plans are described here.

2.2.1 Corporate Responsibility

One senior person or a small committee of senior corporate officials should have full responsibility for implementing the corporate atmospheric emission compliance program. This person or group will serve in a staff capacity and will be directly responsible to the president of the corporation. When a program is implemented and operating, this person or group can provide continuing internal review. In smaller companies, they may direct all environmental activities. This group can initially perform or take responsibility for completing the objectives described in Table 2-1. If engineering personnel are available, this work can be started internally. If knowledgeable staff personnel are not available, the assistance of consulting engineers will be required.

2.2.2 Sources of Information and Assistance

Many publications are available concerning technical aspects of atmospheric emission measurement and control. Sources of this information include the environmental committees of various technical trade associations such as the following:

1. American Iron and Steel Institute,
2. American Petroleum Institute,
3. American Institute of Plant Engineers,
4. American Mining Congress,
5. Graphic Arts Technical Foundation, Inc.,
6. National Coal Association,
7. National Oil Fuel Institute,
8. National Asphalt Pavement Association
9. Technical Association for the Pulp and Paper Industry,
10. Portland Cement Association,
11. Manufacturing Chemists Association, and
12. Incinerator Institute of America.

Complete listings of organizations and their addresses are given in References 1 and 2. Technical societies can also provide background information and guidance to a corporate staff in assessing emissions; membership of one or two key employees should be encouraged. These societies include:

1. Air Pollution Control Association,
2. American Society of Mechanical Engineers,

3. American Institute of Chemical Engineers,
4. American Chemical Society, and
5. Source Evaluation Society.

A primary source of information on environmental subjects is the U.S. EPA and its regional offices.

If in-house capability is not available, a consultant or engineering firm may be engaged to assist in defining objectives and initial functions, to identify the required subsequent functions, and to provide continuity in the corporate environmental program (see Section 5.2). The Air Pollution Control Association publishes annually a listing of consultants and companies that specialize in air pollution control services.

Reports of governmental research and grant activities also provide a valuable source of information on specific processes and control systems. Federal organizations active in atmospheric emission control programs include:

1. Environmental Protection Agency – all sources of air and water emissions, solid wastes management;
2. U.S. Bureau of Mines – combustion and metallurgical processing;
3. Energy Research and Development Administration – energy resources; and
4. Tennessee Valley Authority (TVA) – fertilizers and coal combustion.

2.2.3 Departmental Functions

After preliminary information has been assembled, various functions must be defined more exactly, the format depending on size of the corporation and its manufacturing processes. Some industries face significant potential emission problems. These include most of the heavy industries such as ore refining and metallurgical processing, large combustion sources, chemical manufacturing, pulp and paper manufacturing, and processing of mineral products such as cement and asphaltic concrete. Companies engaged in these types of industries and having more than two or three manufacturing locations will, at least initially, require an internal staff to handle environmental planning. The size of the staff can be minimized by use of consultants and outside engineering services.

Engineering – A corporation's engineering department usually handles all tasks pertaining to plant and process construction and operation. Frequently, that department also handles major maintenance projects. Because emissions result from process operations, the engineering department generally has initial prime responsibility for evaluating emissions, completing permit application forms, and developing compliance plans.

The engineering department should thus be responsible for the following activities:

1. Process and Vent Inventories – As mentioned previously, an early step in any environmental program is to inventory all processes that vent to the atmosphere. Individual vents and their emission parameters should also be inventoried as described in Chapter 3. This information will be useful from an air pollution control standpoint and also in determinations of product loss, heat loss, and building air balance.

   In large firms this effort should be planned at the corporate level to ensure completeness and uniformity, and should be carried out by the plant engineering staff.

2. Emission Assessment – A critical and potentially time-consuming task is determining the rate of emission from all process vents. These emissions can sometimes be estimated from material balances, equipment design and operating data, or published emission factors. The use of experienced consultants in this phase of the work can save a great deal of time. Where the estimated emissions approach or exceed emission regulations, the values should be confirmed by a measurement program; if the source is obviously in violation, a compliance plan may be based on experience with similar processes. Specific plans for complying with applicable regulations should be developed by the engineering department. Contact with engineering firms specializing in this type of work and with control equipment suppliers is recommended. Smaller firms having few if any environmental experts should hire a consulting firm rather than working initially with control equipment suppliers. Some control equipment suppliers may tend to endorse their own hardware even if another control system is better for a specific application. The engineering department should also develop equipment operating and maintenance procedures.

3. Compliance Plans – The engineering department usually is responsible for development of control plans and schedules or process modifications for reducing emissions. The magnitude of this task depends on the number of sources not in compliance and the modifications required.

4. Inspection and Maintenance of Process and Control Equipment – As part of a continuing compliance program, the operation and maintenance of the process and any pollution control equipment must be checked routinely. This effort should be coordinated with the maintenance department. Key items to be

observed include leaks in hoods and control device housings, operation of instruments and records of values read, disposal of collected material, visible plume from discharge vents, corrosion, and adherence to a maintenance schedule.

Legal Activities – The legal staff should undertake a thorough review of federal, state, and local regulations pertaining to operating and planned processes. This review will enable management to determine what sources are subject to the regulations, details of these regulations, and what permits are required. The legal staff should also review tax laws pertaining to pollution control equipment. They should also keep abreast of current regulations pertaining to wastewaters, solid residues, noise pollution, industrial hygiene, and energy resource management, since regulations applicable to one environmental problem will frequently affect another. The company's legal staff can usually provide contact with outside legal counsel knowledgeable in environmental matters.

Budget Department (Comptroller's Office) – The corporation's budget group will probably enter the environmental planning phase at the point of preliminary cost estimates for control of processes that do not comply with regulations. Further studies of control may not be warranted in marginal operations for which compliance would require major expenditures.

Initial funding requirements for emission assessments, tests, and compliance plans could be incorporated into routine operating or engineering budgets. A single member of the accounting staff should be assigned to the budgeting and recording of environmental program costs.

Research and Development – Initiation of new processes or process changes may affect pollutant emissions. The research and development group should therefore be aware of potential problems in manufacturing and also in product use and eventual disposal. R&D departments frequently have a laboratory that can assist in making preliminary routine measurements.

2.3 Related Responsibilities

In addition to the atmospheric emission aspects of environmental planning, a corporate staff must consider other environmental aspects of their manufacturing operations:

1. Liquid discharge,
2. Sludge or solid waste discharge,
3. Product use and eventual disposal,

4. Accidental spills or emissions, and

5. Industrial hygiene.

Although some of these do not directly affect atmospheric emissions, many environmental problems are interrelated. As examples, resolving an industrial hygiene problem by ventilation of a workroom may create a new emission source, and installing a scrubber system to remove atmospheric contaminants may introduce new problems of wastewater discharge or sludge disposal. Potential atmospheric emissions from the use or eventual disposal of a product (such as spray cans, reactive solvents, pesticides) must also be considered.

Again, the nature of these related environmental responsibilities will vary widely for specific companies and for specific products. Early consideration of potentially related problems could save effort and expense in subsequent control plans.

2.4 Examples of Corporate Environmental Programs

Each company must decide how to integrate an environmental program into its corporate structure. Examples are presented here to illustrate several practical arrangements.

2.4.1 Large Environmental Staff

Figure 2-5 illustrates how environmental control functions may be integrated into a fairly large organization. This chart shows the environmental control group in a large company with responsibility for control of air and water quality and for industrial hygiene activities. The director of the environmental control group would report to the vice president of operations and would have full responsibility for corporate activities in environmental matters. This group will provide direction to plant managers in complying with environmental requirements. A person or persons at the plant or division level should also be responsible for handling day-to-day activities and carrying out the corporate program. Figure 2-6 presents an alternative for a similar organization; here the environmental functions are made part of the corporate engineering operations. This organizational structure might be appropriate for a large company with relatively minor environmental problems.

Figure 2-7 shows an example organizational chart for an electric utility company. Utilities generally face significant potential environmental problems affecting air and water quality and land use. Therefore a post at the senior level is generally established to direct environmental efforts. Depending on the atmospheric emission problems, another assistant could be assigned solely to this area. Utilities make extensive use of outside engineering companies to assess and solve atmospheric emission problems.

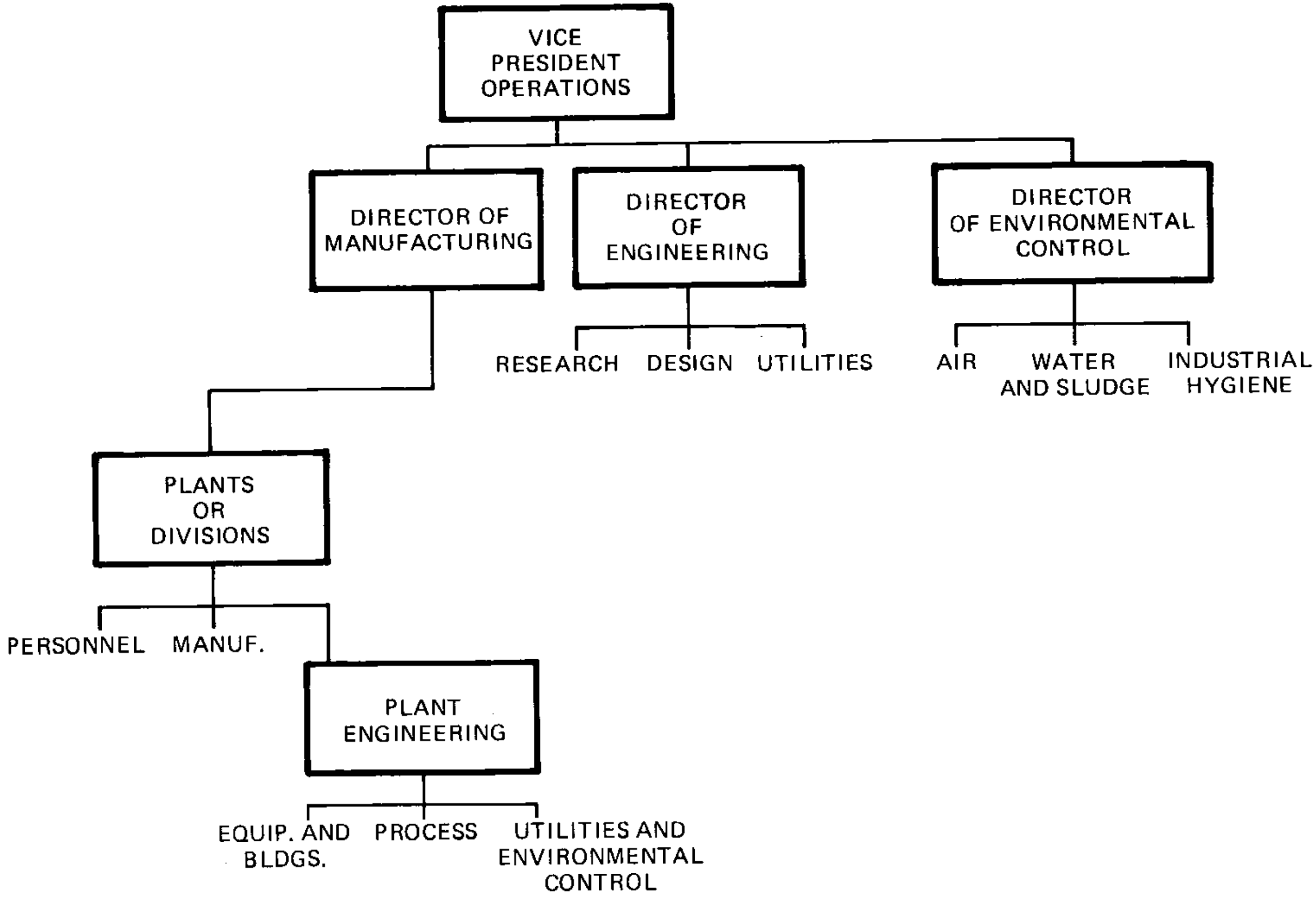


FIGURE 2-5

EXAMPLE PARTIAL ORGANIZATION CHART
FOR LARGE MANUFACTURING COMPANY

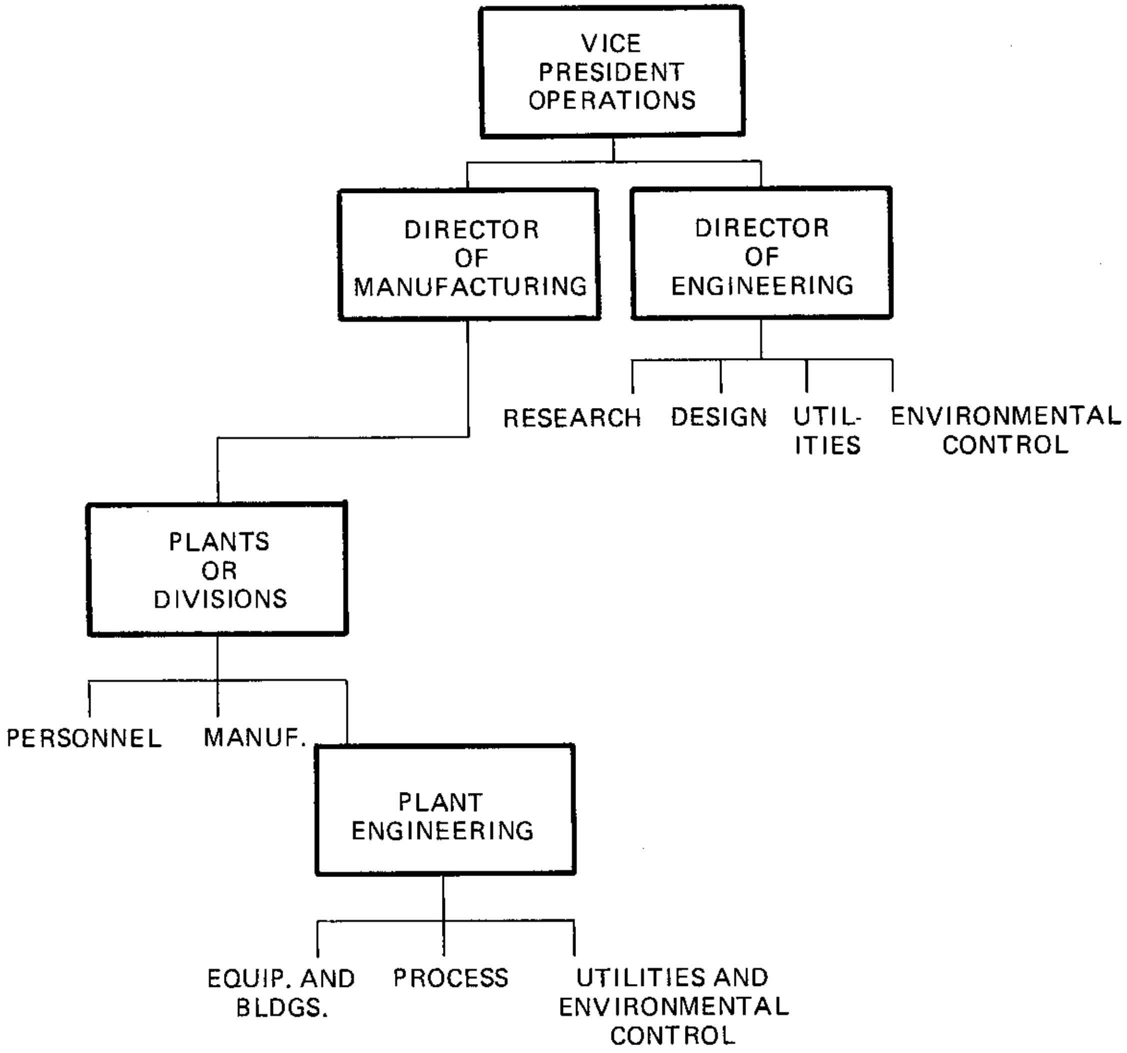


FIGURE 2-6
ALTERNATIVE PARTIAL ORGANIZATION

2.4.2 Small to Medium Environmental Corporate Staff

A corporate ad hoc staff of one to about five persons could handle most of the environmental planning functions of a multiplant corporation with relatively few emission problems. After an initial peak workload, this staff could be reduced to one or two. The degree of utilization of outside help will greatly affect the corporate staff requirements. The environmental group is generally assigned to the engineering department. Individuals at each plant location are then assigned tasks as required by the corporate staff. The engineering department at each plant can exercise the option of requesting assistance from consultants if the current workload is too great. A company may elect to request a variance from the control agency which will enable them to have more time to evaluate their environmental needs.

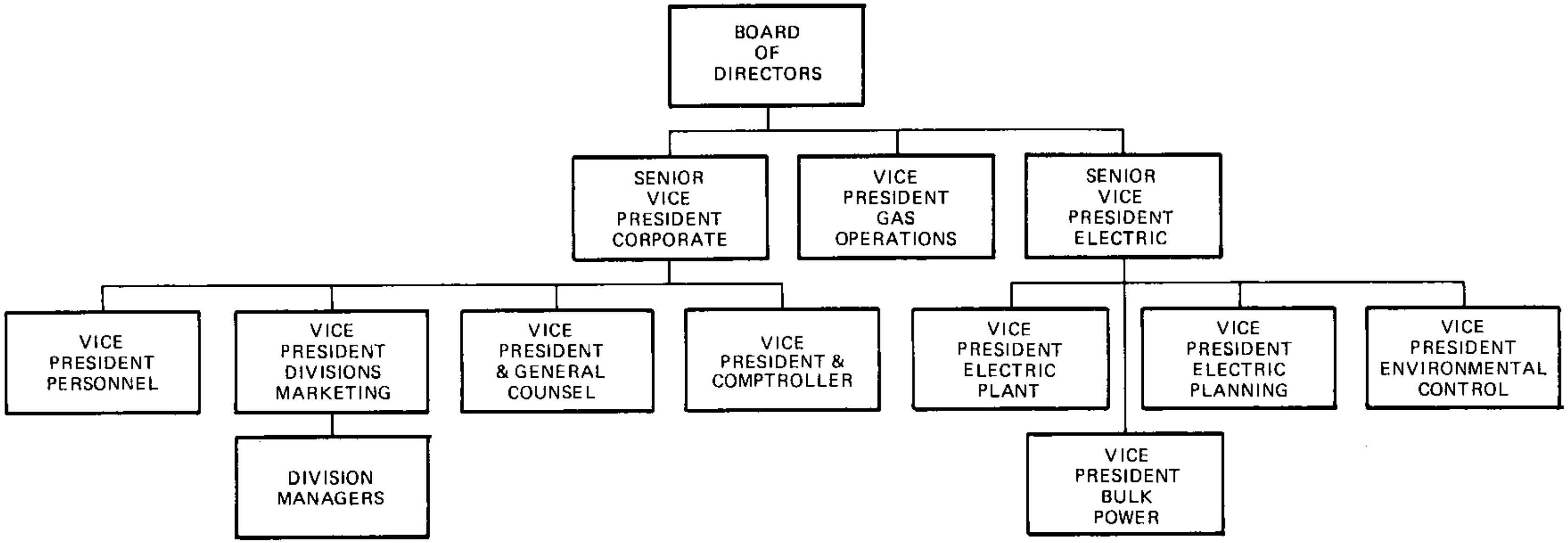


FIGURE 2-7
EXAMPLE ORGANIZATION OF A LARGE UTILITY

Figure 2-8 shows integration of environmental tasks into the corporate structure of a small company.

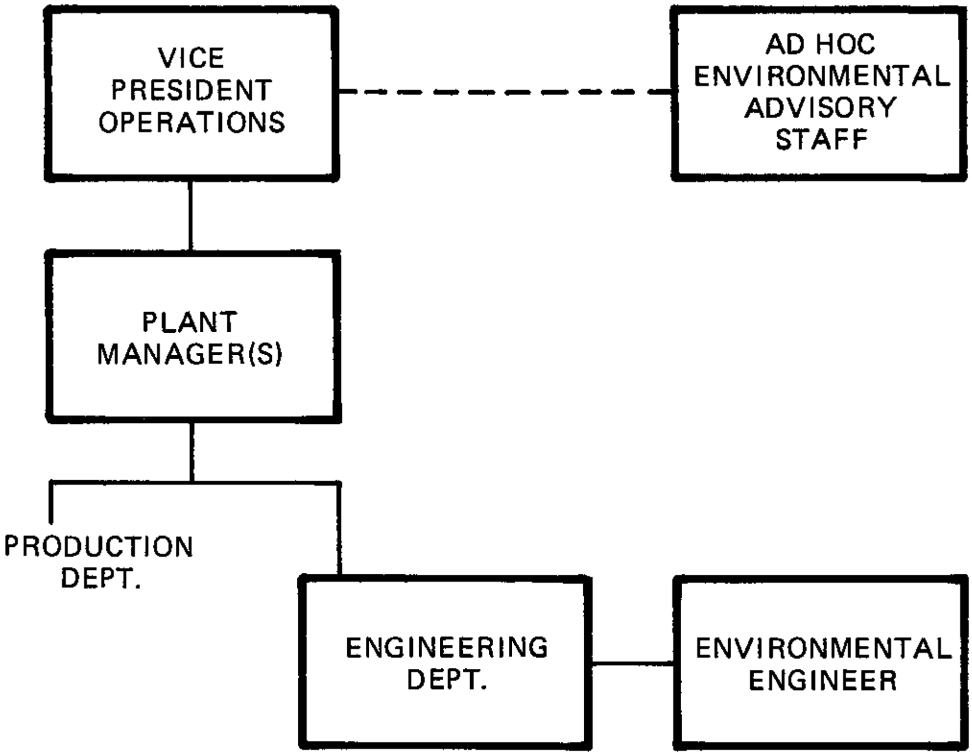


FIGURE 2-8
EXAMPLE PARTIAL ORGANIZATION FOR A SMALL COMPANY

2.5 References

1. *The Encyclopedia of Associations,* published yearly by Gale Research, Detroit, Michigan.

2. *National Trade and Professional Associations,* published yearly by Columbia Books, Inc., Washington, D.C.

CHAPTER 3

PLANT EMISSION SURVEY

3.1 Introduction

The initial step in a plant program for monitoring and controlling atmospheric emissions is an emission survey. In this survey, all of the pollutant sources are identified and the quantities of emissions from each source are determined, as shown in Figure 3-1. Results of the survey will provide management personnel with a comprehensive overview and will also provide enough detail from which to formulate plans for abatement and monitoring programs. The eventual cost of a poorly executed survey will almost always exceed the initially higher cost for a well-executed survey.

This section describes survey procedures, from planning through data reporting, and provides examples of survey forms and checklists. Methods for conducting such surveys efficiently have been developed over the years. In every case, three fundamental steps are involved:

1. Identifying and cataloguing the emission sources,

2. Identifying and quantifying the emissions, and

3. Preparing a source identification file.

These procedures are described in the sections that follow.

3.2 Identifying and Cataloguing Emission Sources

Identification of pollutant sources within an industrial operation is accomplished in two steps: analysis of process flow sheets and tour of plant facilities. The process flow sheets serve essentially as a map, indicating points at which emissions are known to occur or are possible. In the subsequent plant tour, the emission surveyor then verifies these sources and possibly identifies others. In these efforts he will require assistance from process supervisors and engineers and will also rely on his own observations.

3.2.1 Process Flow Sheets

A flow sheet of each process within the facility should be presented in sufficient detail to indicate the flow of all raw materials, additives, end products, by-products, and wastes. A simple process flow sheet is shown in Figure 3-2. The flow sheet should identify all

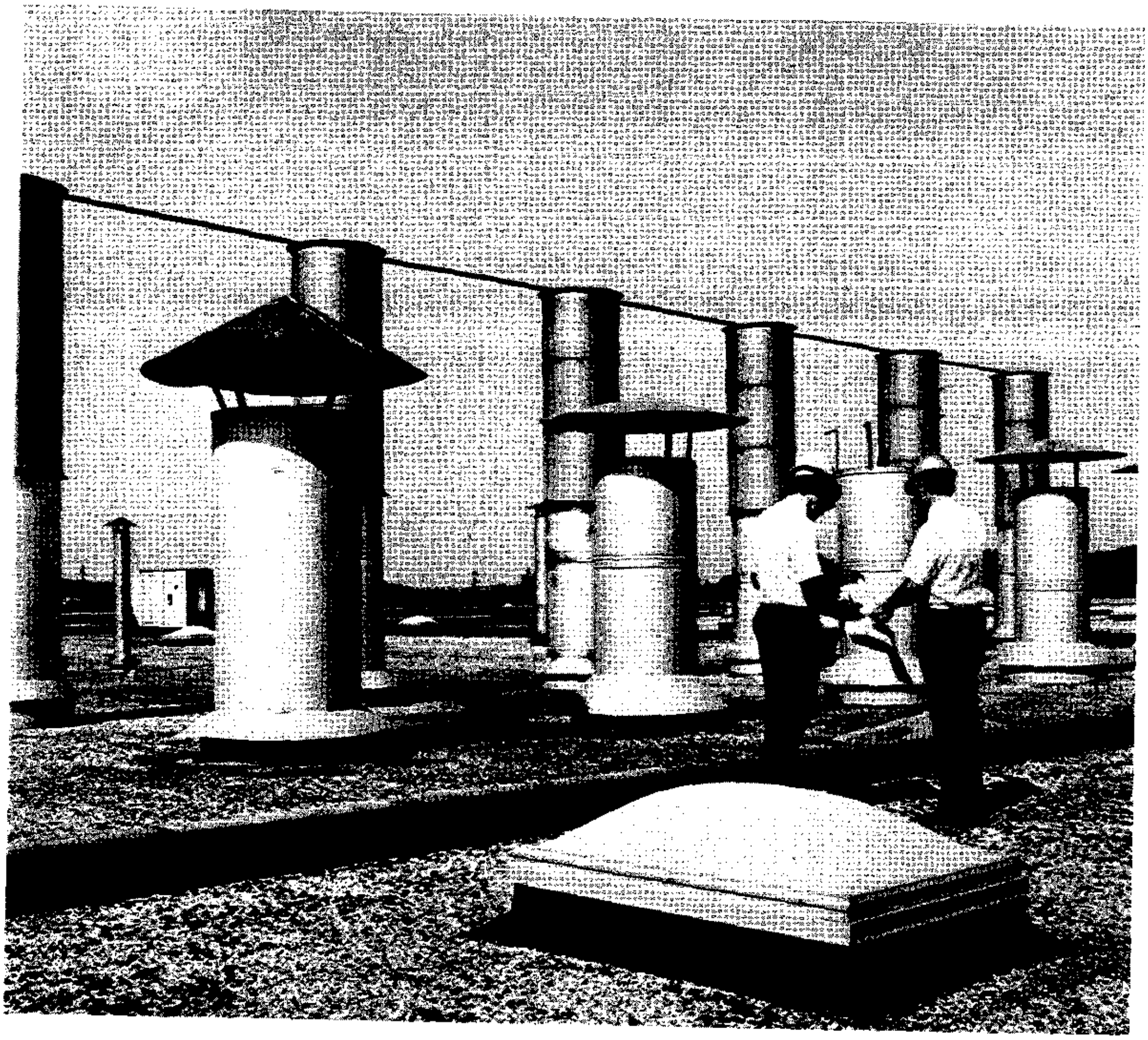


FIGURE 3-1

PLANT PERSONNEL VERIFYING EMISSION SOURCES DURING EMISSION SURVEY

points of feed input and all points at which atmospheric, liquid, and solid wastes are discharged. The engineer or foreman responsible for each process should verify that the flow sheets identify all sources. Many plants, as shown in Figure 3-3, have numerous sources that must be identified correctly for identification purposes.

Analysis of process flow sheets can be further verified by review of permit applications, process blueprints, photographs, and inspection manuals. With the aid of these and any other resources available, the emissions surveyor can then develop checklists in the form of survey data sheets that will be used in the plant tour to ensure complete and efficient gathering of pertinent data. These survey data sheets will pertain chiefly to two categories: (1) process and feed data, and (2) control equipment and emissions data. An

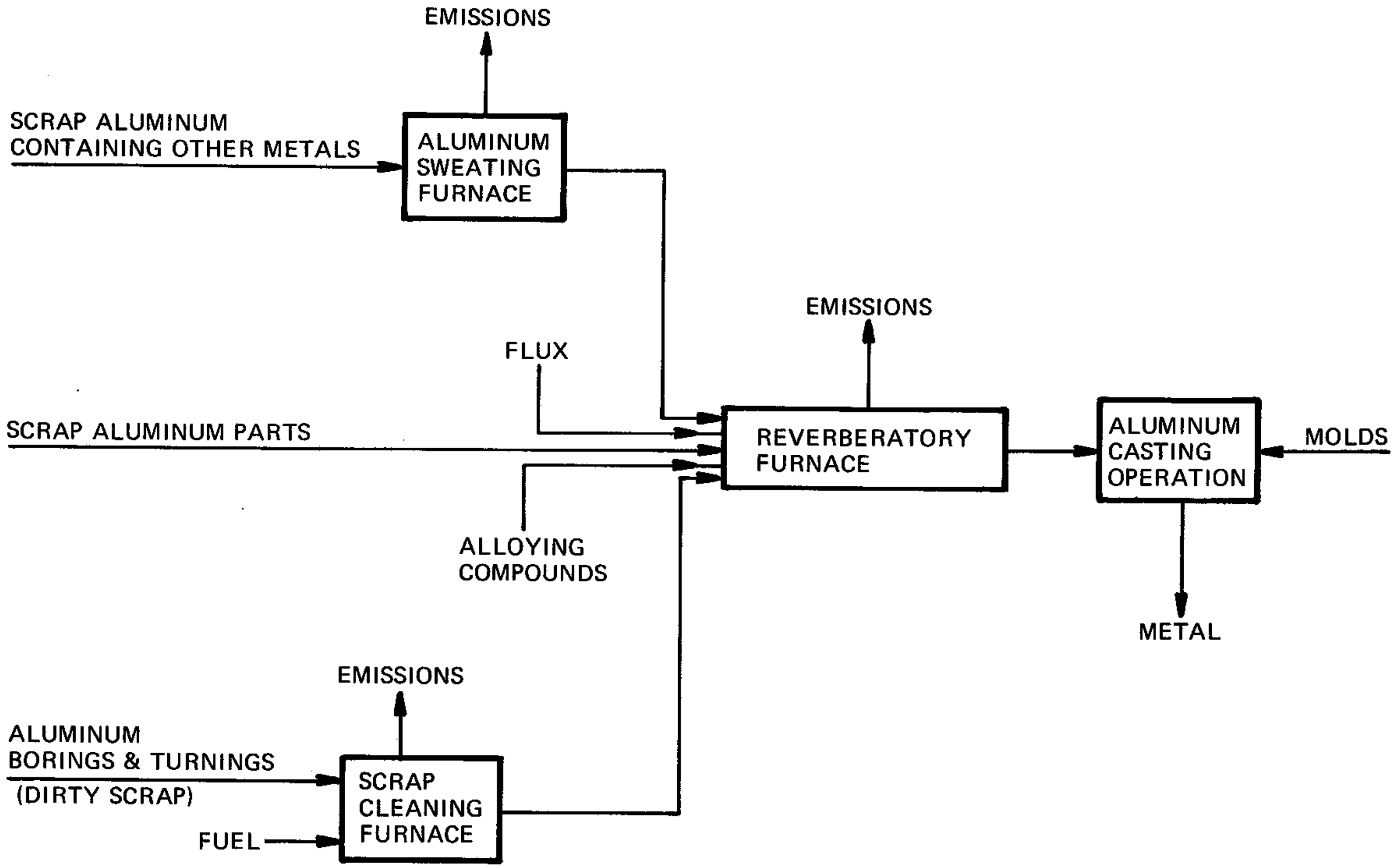


FIGURE 3-2

EXAMPLE PROCESS FLOW DIAGRAM

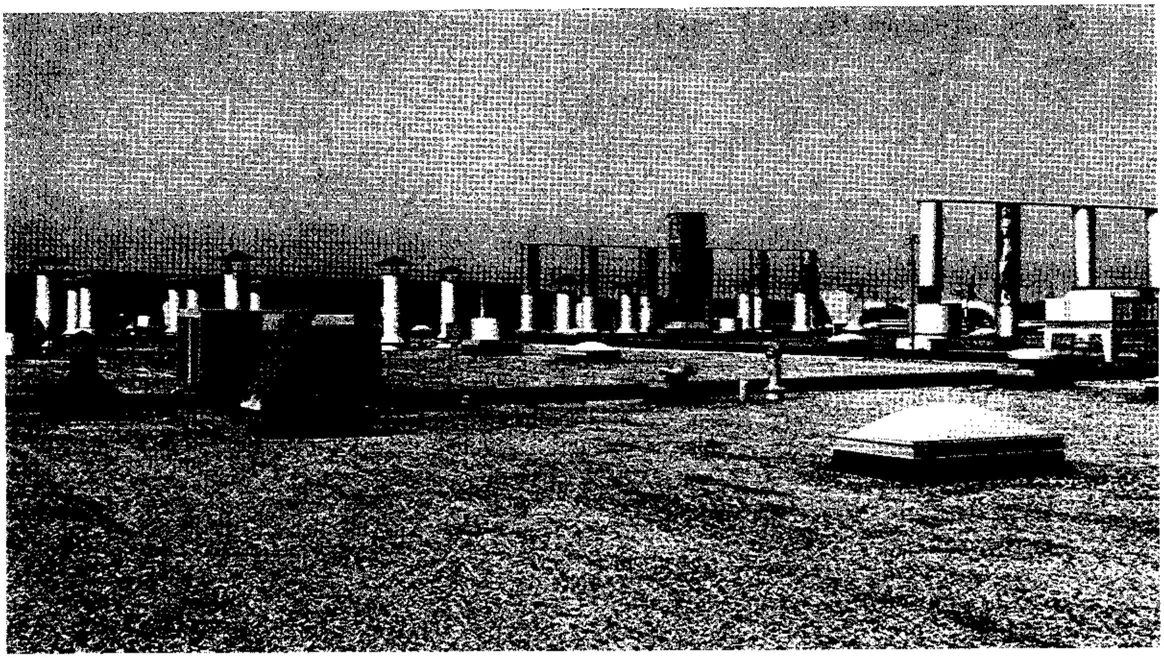


FIGURE 3-3

ROOF OF A TYPICAL CHEMICAL PLANT WITH NUMEROUS EMISSION SOURCES

example process survey data sheet is shown in Figure 3-4, representing presurvey evaluation of a fuel-fired combustion source. These examples can be modified to apply to most types of control equipment now in operation.

The process survey data sheet should include the following:

1. Detailed information on operating conditions for the process as designed;
2. Identification of normal operation as continuous, batch, or intermittent, with frequency of emission discharges for each operation;
3. Description of raw materials, products, and wastes; and
4. Values for normal operating temperature, equipment performance ratings, flows, pressures, and similar data that are routinely monitored and/or recorded.

A blueprint of the exit stack should be obtained for use on the plant tour. If a blueprint is not available, a sketch of the exit stack, with accurate measurements, can be made during the tour. Examples of stack survey data sheets are presented for electrostatic precipitators, baghouses, and scrubbers in Figures 3-5, 3-6, and 3-7.

POWER PLANT SURVEY FORM

TYPE OF HEAT EXCHANGER

	PRIMARY	STANDBY
Coal-fired	☐	☐
Oil-fired	☐	☐
Gas-fired	☐	☐

If multiple-fired, check appropriate boxes

RATED INPUT CAPACITY ____________ BTU/hr

MAXIMUM OPERATING RATE ________ BTU/hr

RATED STEAM OUTPUT ____________ lb/hr (a) ______________ BTU/lb steam

MAXIMUM STEAM OUTPUT __________ lb/hr (a) ______________ BTU/lb steam

FURNACE VOLUME width _____ ft x depth _______ ft x height __ ft = ______ ft^3

OPERATING SCHEDULE ________ hr/day ________ day/wk ________ wk/yr

COAL FIRING

TYPE OF FIRING

☐ Grate Type ____________________

☐ Spreader stoker

☐ Pulverized coal ☐ Dry bottom ☐ Wet bottom

☐ Cyclone

FLY ASH REINJECTION ☐ YES ☐ NO

SOOT BLOWING

☐ Continuous

☐ Intermittent

TIME INTERVAL BETWEEN BLOWING ________ minutes

DURATION ________ minutes

OUTSIDE COAL STORAGE ☐ YES ☐ NO

MAXIMUM AMOUNT STORED OUTSIDE ______________ tons

FIGURE 3-4

EXAMPLE PRESURVEY DATA SHEET FOR FOSSIL-FUEL-FIRED STEAM GENERATORS

POWER PLANT SURVEY FORM

IS OUTSIDE STORAGE SPRAYED ☐ YES ☐ NO

COAL COMPOSITION	Range		Average
Ash	_______%	to _______%	_______%
Sulfur	_______%	to _______%	_______%
BTU/lb as fired	_______	to _______	_______

ARE FUEL CONSUMPTION RECORDS KEPT ☐ YES ☐ NO

FOR STOKER SYSTEM,

Coal size __________

FOR PULVERIZED COAL AND CYCLONE SYSTEM

FIRING METHOD
- ☐ Front wall
- ☐ Front wall – rear wall
- ☐ All wall
- ☐ Tangential
- ☐ Other Type _______

OIL FIRING

FIRING METHOD
- ☐ Front wall
- ☐ Front wall – rear wall
- ☐ All wall
- ☐ Tangential
- ☐ Cyclone
- ☐ Other Type _______

TYPE OF FUEL
- ☐ No. 1
- ☐ No. 2
- ☐ No. 4
- ☐ No. 5
- ☐ No. 6
- ☐ Other Type _______

FIGURE 3-4 (Cont.)

EXAMPLE PRESURVEY DATA SHEET FOR FOSSIL-FUEL-FIRED STEAM GENERATORS

ELECTROSTATIC PRECIPITATOR

Manufacturer's name ______________________________, Model No. __________

Date of start up ____________________

Design efficiency ________________ %

Number of electrical fields in direction of flow ______________________________

Total plate area ____________________

Methods for cleaning plates

Normal rapping sequence, Plates ______________________ Wires ____________

Preconditioning or dilution air __________

Gas conditions	Design	Normal
volume, acfm	_____	_____
temperature, °F	_____	_____
fan motor amperes	_____	_____

Rectifier No.	Operating condition	Rectifier power output		Sparking rate sparks/min
		Voltage kilovolts	Current milliamps	
1	design normal			
2	design normal			
3	design normal			
4	design normal			
5	design normal			
6	design normal			

FIGURE 3-5
EXAMPLE PRECIPITATOR SURVEY DATA SHEET

FABRIC FILTER COLLECTOR

Manufacturer's name ______________________________________

Make or model number ______________

Date of start up ______________

Design efficiency ______________%

Number of compartments ______________

Number and size of bags ______________

Type of filter material ______________

Average bag life ______________

Pressure drop across collector, inches of water	Design	Normal
just prior to bag cleaning	______	______
just after bag cleaning	______	______
Gas Conditions		
volume, acfm	______	______
temperature, °F	______	______
dew point	______	______
fan motor amperes	______	______
Air to cloth ratio	______	______

Type of cleaning

- ☐ shaking – number of compartments ______________________
- ☐ reverse air flow – number of compartments ______________________
- ☐ repressing – number of compartments ______________________
- ☐ pulse jet (cleaned while on stream) ______________________
- ☐ other ______________________

Normal cleaning cycle ______________________________________

Normal particulate removal sequence ______________________________

Preconditioning of dilution air ______________________________

FIGURE 3-6
EXAMPLE FABRIC FILTER SURVEY DATA SHEET

SCRUBBER OR CYCLONE

Manufacturer's name ______________________________

Make or model number ________________________

Date of start up _____________________________

Design efficiency ____________________%

Type of collector

☐ cyclone
☐ venturi scrubber
☐ turbulent bed
☐ other _____________

☐ multicyclone
☐ variable throat
☐ plate

☐ fixed throat
☐ spray

Operating conditions	Design	Normal
pressure drop across collector, in. H_2O	_____	______
gas volume out of collector, acfm	_____	______
gas temperature to collector, °F	_____	______
gas temperature out of collector, °F	_____	______
fan motor, amperes	_____	______
liquid flow rate to scrubber, gpm	_____	______
recirculation of scrubbing liquid, %	_____	______

Type of liquid used in scrubbing ____________________________________

Liquid and/or particulate removal sequence ____________________________

Preconditioning of dilution air ______________________________________

FIGURE 3-7
EXAMPLE SCRUBBER OR CYCLONE SURVEY DATA SHEET

In further preparation for the plant tour, a tentative filing or catalog system will be helpful. For ease of data handling, each process can be assigned a unique name or letter, and emission points for each process can be numbered as shown in Figure 3-8. If the tour discloses an additional process or emission point, it can be easily logged into the system.

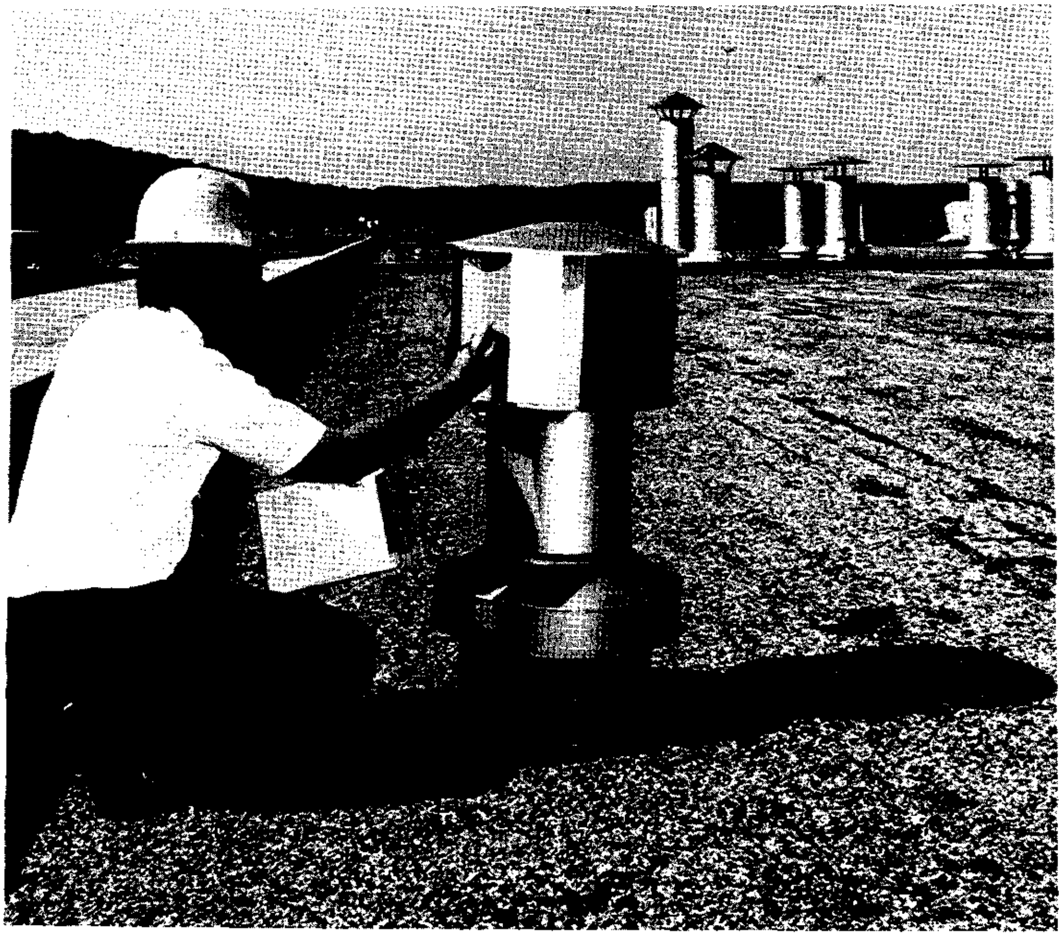


FIGURE 3-8
TECHNICIAN IDENTIFYING PROCESS STACK

3.2.2 Plant Tour

A tour of the plant facilities, including discussions with the person responsible for each process, is the most productive means of identifying all sources and verifying the process flow sheets. Enough data should be gathered from the files and by on-site inspection to allow calculation of a material balance as a basis for qualifying and quantifying each emission source.

The plant tour starts at the files. There the surveyor will gather design specifications for each process and control device. Correspondence may also yield pertinent information relating to operation and maintenance of process and control equipment, current status of compliance, comments of control agencies, public complaints, and the like. This kind of background information can enhance the understanding needed for a meaningful onsite inspection of each process and control device.

Each air contaminant source has a duct that vents from the process to an outside chimney or stack. The exhaust gas is moved by a fan, or in some instances where heat is applied, by natural draft. For each operation, the ducting should be followed from the process to the point of entry to the atmosphere. In some instances, the exhaust gas stream is difficult to follow. Introduction of make-up air, split gas streams, and ducting of several operations to a common stack complicate the overall exhaust system and require careful tracing to ensure that exhaust gas paths are properly defined. Placement of fans and control devices must be noted. Air conditioning, heating, and make-up vents, as shown in Figure 3-9, must not be mistaken for process stacks.

After defining all process systems, the surveyor should check the roof to identify any emission points that are "left over." The check ensures that all egress points are accounted for.

Equipment requirements for an onsite survey depend largely on the processes surveyed. Following is a partial list of basic equipment:

1. 50° to 1200°F dial thermometer (12-inch stem),
2. Velocity measuring device (Velometer),
3. 50-foot tape measure,
4. Set of basic shop tools,
5. Camera,
6. Detector tube samplers (for measuring gas concentrations),
7. Survey data forms, and
8. Safety equipment (hard hat, safety shoes, goggles).

Obtaining accurate stack information during the tour, as shown in Figure 3-10, is a prerequisite to effective stack sampling, since the configuration of sampling sites and the characteristics of the exhaust gases will affect the quality of samples that may be

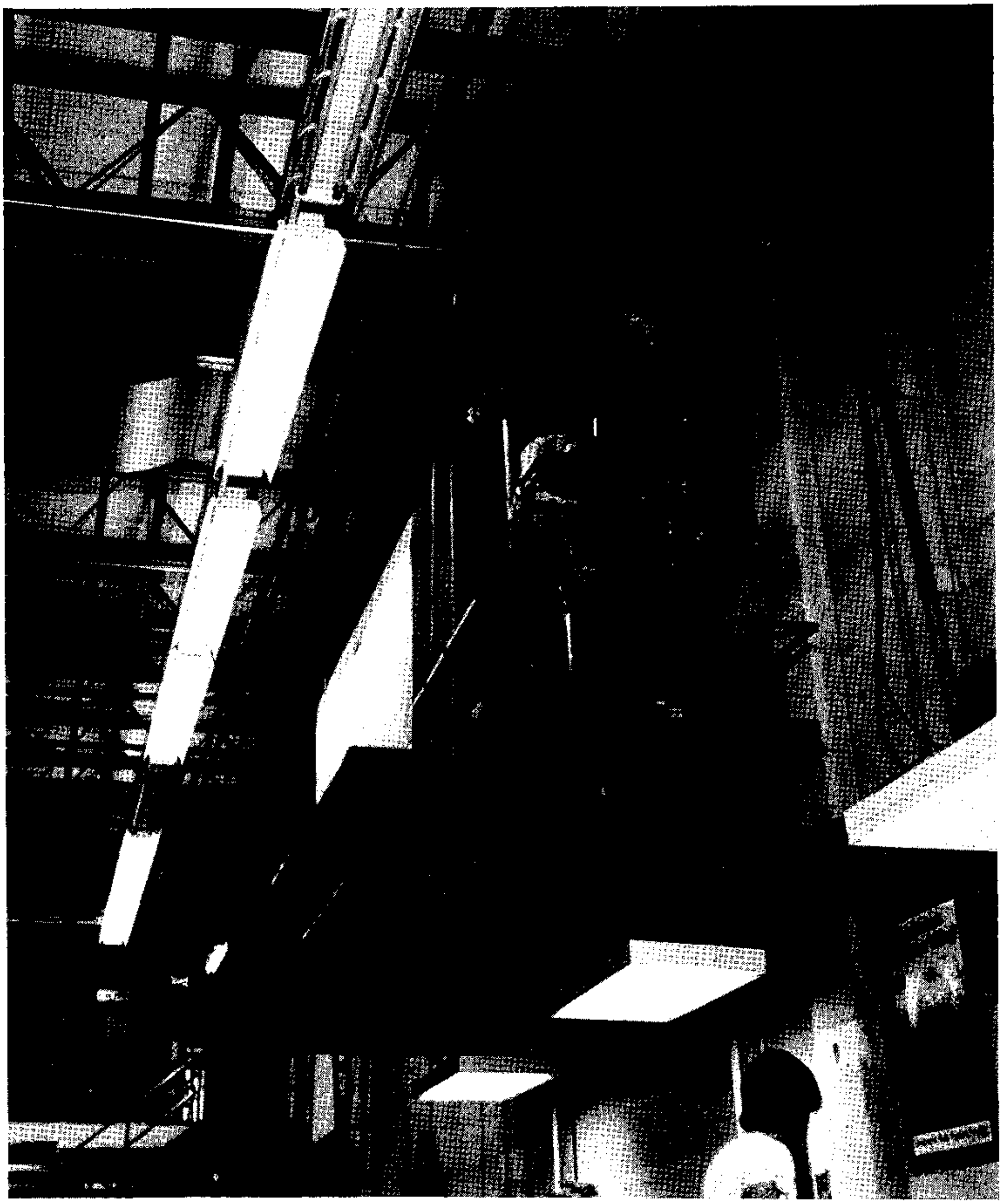


FIGURE 3-9

AIR CONDITIONING SYSTEM AND DUCT TO ROOF OF BUILDING

extracted. In addition to flow considerations, the factors of accessibility and safety are important to emission testing. Clearance for probes and sampling apparatus, availability of electricity, potential for exposure of personnel and equipment to weather or excessive heat, presence of toxic or explosive gases, and other safety factors should be noted and recorded during the plant tour. Outlet ducts must be examined to ensure proper

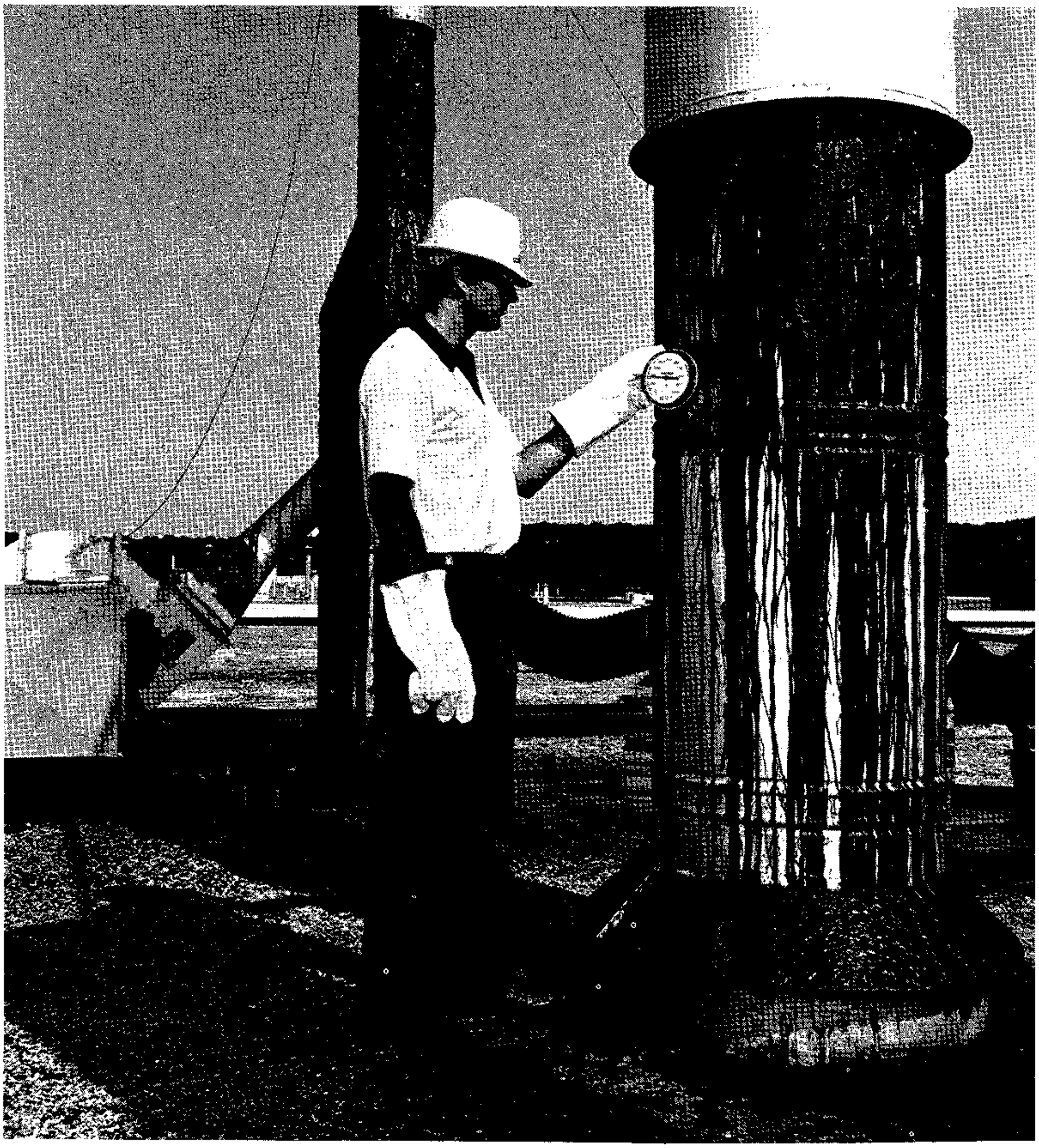


FIGURE 3-10
OBTAINING ACCURATE STACK INFORMATION DURING THE PLANT TOUR

sampling. In most states, a stack as shown in Figure 3-11 requires an extension to meet emission testing requirements. However, some states have adopted a procedure for sampling cyclone outlet elbows with a Hi-Vol Sampler. Stack data should be recorded on a form as shown in Figure 3-12.

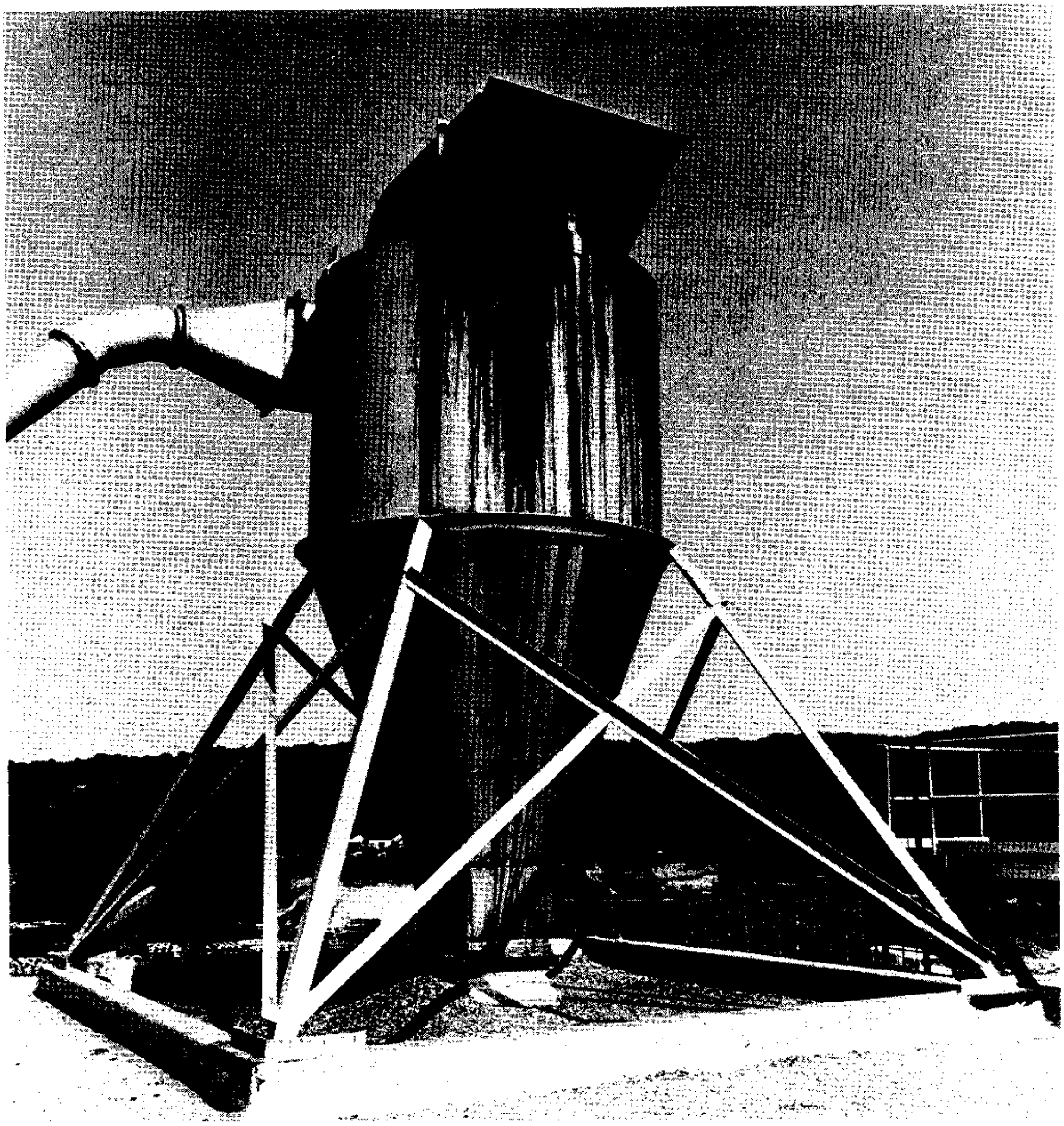


FIGURE 3-11
CYCLONE OUTLET REQUIRING MODIFICATION BY MOST STATES PRIOR TO PERFORMING EMISSION TEST

3.3 Identifying and Quantifying Emissions

All of the data obtained thus far from the process flow sheets, process survey forms, control equipment survey forms, stack survey form, photographs, correspondence, discussions, and the plant tour can now be organized for development of an emission survey plan. This plan will indicate the quantity of emissions to be expected from each source, with possible variations due to season, time of day, feed materials, and similar

	Stack or vent number	
Sampling location parameters		
Process vented		
Platform height, ft		
Platform width, ft		
Platform length, ft		
Inside diameter, in. at port		
Wall thickness, in. at port		
Material of construction		
Ports: a. Existing		
b. Size opening		
c. Distance from platform		
Straight distance before ports, ft		
Type of restriction before ports		
Straight distance after ports, ft		
Type of restriction after ports		
Environment at sampling site		
Work space area		
Ambient temperature, °F		
Average pitot reading, in. H_2O		
Stack gas velocity, ft/min		
Stack gas flow, acfm		
Moisture, % by volume		
Stack gas temperature, °F		
Particulate loading, gr/scf		
Particle size		
Gases present		
Stack pressure, in. H_2O		
Water sprays prior to site		
Dilution air prior to site		
Elevator to site?		
Available electricity and distance		

FIGURE 3-12
STACK DATA REQUIREMENTS

variables. The emissions characterization should identify all important parameters affecting control of the pollutants and possible sampling techniques. These data will be used to establish a compliance program for each source. These programs will describe the plans that will be implemented by the company to achieve compliance and should contain the following increments of progress or milestones (1):

1. Date of submittal of the final control plan to the appropriate air pollution control agency;

2. Date by which contracts for emission control systems or process modifications will be awarded; or date by which orders will be issued for purchase of component parts to accomplish emission control or process modification;

3. Date of initiation of onsite construction or installation of emission control equipment or process change;

4. Date by which onsite construction or installation of emission control equipment or process modification is to be completed; and

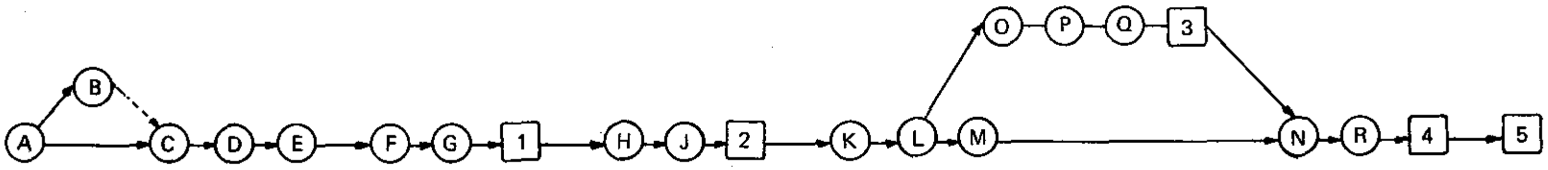
5. Date by which final compliance is to be achieved.

Figure 3-13 presents an example of the activities that must be completed before compliance can be achieved. Depending on the nature of the emission source and the complexity and size of the modifications required, the time requirements for compliance can range from a few months to several years (2).

3.3.1 Data Usage

Emissions from each source will be identified and quantified as part of the compliance program throughout each of the major phases: achieving, demonstrating, and maintaining the company's compliance status. The compliance status of each source determines the type of data that must be collected.

Achieving Compliance – The first step in the compliance program is to bring all emissions within the allowable limits established by the control agency. This phase of the compliance program usually involves the purchasing of control equipment. Because of the high initial costs of current control equipment, as well as operating and maintenance costs, the gathering of process data for equipment selection is of utmost importance. Most vendors of control equipment base their guarantee on process data presented to them before the equipment is installed. If the installed control equipment does not enable the plant to comply with the allowable emission rate and the process parameters are different from those specified to the control vendor, then the plant must alter the process or provide additional control equipment at its own expense.



☐ = Milestones

2 = Activity and duration in weeks

MILESTONES		ELAPSED TIME (WEEKS)
1	Date of submittal of final control plan to appropriate agency.	______
2	Date of award of control device contract.	______
3	Date of initiation of onsite construction or installation of emission control equipment.	______
4	Date by which onsite construction or installation of emission control equipment is completed.	______
5	Date by which final compliance is achieved.	______

ACTIVITIES

Designation		Designation	
A-C	Preliminary investigation	K-L	Review and approval of assembly drawings
A-B	Source tests	L-M	Vendor prepares fabrication drawings
C-D	Evaluate control alternatives	M-N	Fabricate control device
D-E	Commit funds for total program	L-O	Prepare engineering drawings
E-F	Prepare preliminary control plan and compliance schedule for agency	O-P	Procure construction bids
F-G	Agency review and approval	P-Q	Evaluate construction bids
G-1	Finalize plans and specifications	Q-3	Award construction contract
1-H	Procure control device bids	3-N	Onsite construction
H-J	Evaluate control device bids	N-R	Install control device
J-2	Award control device contract	R-4	Complete construction (system tie-in)
2-K	Vendor prepares assembly drawings	4-5	Start up, shakedown, preliminary source test

FIGURE 3-13
COMPLIANCE SCHEDULE CHART

Detailed procedures for selecting the proper type and size of control equipment are beyond the scope of this manual. The basis for selection changes continually with changes in cost of materials and with development of new technology. When a company is uninformed regarding control equipment, the best method of selection is usually through an evironmental consulting group that is not affiliated with a control equipment vendor.

The most important process parameters that must be collected for selection of control equipment are the following:

Flue gas characteristics (from emission test)

1. Total flue gas flow rate,
2. Flue gas temperature,
3. Control efficiency required,
4. Particle size distribution,
5. Particle resistivity,
6. Composition of emissions,
7. Corrosiveness of flue gas over operating range,
8. Moisture content, and
9. Stack pressure.

Process or site characteristics (field survey)

1. Reuse/recycling of collected emissions,
2. Availability of space,
3. Availability of additional electrical power,
4. Availability of water,
5. Availability of wastewater treatment facilities,
6. Frequency of startup and shutdown,

7. Environmental conditions (e.g., extremely low ambient temperatures),
8. Anticipated changes in control regulations,
9. Anticipated changes in raw materials, and
10. Plant type (stationary or mobile).

Demonstrating Compliance – The second phase of the compliance program is providing proof that all emissions are within the specified limits. This involves a compliance test using a specified or reference test method. The test is usually witnessed by control agency officials. During the compliance test, enough process and emission data must be recorded to satisfy the control agency's requirements and to confirm the control equipment vendor's guarantee. If the process data indicate operation within the design range specified by the plant to the vendor but compliance is still not achieved, documentation of process and emission parameters will demonstrate failure of the vendors to meet their guarantee. If the process data recorded during the test are different from or are not within the range earlier specified by the facility, failure to achieve compliance cannot be attributed to the control equipment vendor.

Control agency requirements for process parameters that must be collected during a compliance test are variable. If any of the requirements concern process data that are considered confidential, operators of the facility should so inform the agency by registered mail. Most control agencies follow specific guidelines regarding confidentiality. These matters and other aspects of compliance testing are discussed more fully in Chapter 5.

Continuing Compliance – After compliance of each source has been demonstrated, compliance status must be maintained. Chapter 7 describes in detail the procedures that will provide a continuing compliance program.

3.3.2 Quantification Techniques

The emission survey can be developed by applying a combination of techniques: calculation of mass balance, application of emission factors, review of permit applications, analysis of fuels, and source emission tests. These techniques are described in more detail below.

Mass Balance – When the throughputs and composition of raw materials are known, a mass balance usually can be established around each process. The materials balance will indicate the extent of solid, liquid, and gaseous wastes. A materials balance for the entire facility will also indicate the amounts of wastes generated, a value obtained by subtracting the amounts of material shipped from the amounts purchased. Much of the waste generated is, of course, not airborne.

A search of applicable air pollution control regulations will provide the basis for the mass balance. The control regulations state what pollutants are regulated and define each pollutant. The definition of each pollutant determines the conditions under which the pollutant is sampled and its chemical or physical makeup. For instance, because water vapor is not considered an air pollutant, it need not be accurately accounted for in the mass balance. Emissions of sulfur dioxide or organic substances are usually regulated and must be estimated in the materials balance.

A materials balance for gaseous pollutants can be determined by analysis of raw materials, fuels, and products to give the gaseous pollutant potential of many of the compounds liberated during a combustion or chemical process.

Fuel Analysis – Knowledge of fuel composition is especially useful in estimating emissions, since many gaseous compounds in the fuel become airborne after combustion (e.g., sulfur in fuel oil exhausts as sulfur dioxide). Other constituents, such as ash and volatile matter, directly affect the quantity of particulate emissions.

Permit Applications – A completed copy of the facility's current permit application should provide information on equipment, input materials, and potential emissions. Permit applications that are no longer current can be used for background information and reference.

Visible Emissions – State regulations emphasize visible emissions except for water vapor. Training and certification are required for a compliance determination of visible emissions. Although an untrained observer cannot make an official determination, he can attempt to estimate the percent obscuration of an object viewed through the stack discharge plume. If no emissions are visible, emissions would be judged to be in compliance with visible emission regulations. The percent of visible opacity is not an accurate indication of total mass emissions but can indicate trouble areas.

Emission Factors – Publications listing emission factors (3) provide a range of emissions to be expected from specific processes. These values, which are based on uncontrolled process operations, can be factored with the expected collection efficiency of the facility's air pollution control equipment to yield an estimated pollutant emission rate. For example, where the emission factor for a process is 10 pounds of particulate per ton of product and the process is equipped with a particulate control device that is 90 percent efficient, the emissions would be:

$$10 \text{ lb/ton} \times \left(\frac{100\text{-}90}{100}\right) = 1.0 \text{ lb/ton}$$

Emission Testing – Emission testing is usually the most accurate method of determining emissions. Specific emission testing procedures are usually prescribed for each pollutant from each process. Emission testing by these prescribed methods, however, is also the most expensive technique of emissions survey. An emission testing program may include ambient sampling, a series of stack tests over a period of several hours, continuous monitoring, or a combination of these, as described more fully in Chapters 5 and 6. Detailed sampling procedures have been published for various pollutant compounds (4), (5).

Even if it is determined that emission testing of all sources is required for a comprehensive emission survey, data gathering by the methods described earlier will establish the normal operating conditions for processes and control equipment and will provide a check on values obtained in emission tests. Data from earlier emission tests of a process or a similar process are also helpful.

Testing methods other than those prescribed (such as use of a velometer or vane anometer to determine stack gas velocity and of detector tube concentrations for gaseous pollutants) can provide approximate engineering data in a rapid and relatively inexpensive manner.

3.4 Preparing a Source Identification File

A source identification file provides a means of standardizing data for the emission survey. For each pollutant source, a standard identification form gives a description of the process, a summary of emission data, the current compliance status, and proposed actions, if any are intended. A basic source identification form is shown in Figure 3-14. Some sources involve several emission points with more than one pollutant at each point.

The source identification file should be indexed to provide easy access by any concerned party. The index should list all sources and identify each emission point for each source. Assignment of a number for each emission point, as discussed earlier, will facilitate an alphanumeric search for emission points in the source identification file. A facility cover sheet, as shown in Figure 3-15, should precede the index. As an aid to management personnel in tracking and holding large numbers of sources, a corporate environmental management information system has been developed (6).

The source identification file should provide sufficient information to enable control agency staff to complete an appropriate form for entry of data into the National Environmental Data Systems (NEDS). Appendix A contains an appropriate form.

3.5 References

1. Code of Federal Regulations, Vol. 40, Part 51, August 14, 1971.

Emission point no. ______________________________

Emission point name ______________________________

Date of record ______________________________

Source name ______________________________

Description of source ______________________________

Type of permit ______________________________

Date of permit ______________________________

Applicable regulation(s) ______________________________

Particulate emissions ____________________ units __________

Allowable emissions ____________________ units __________

Method of determination ______________________________

Gaseous emissions ______________________________
    type ____________________ units __________
Allowable emissions ____________________ units __________

Method of determination ______________________________

Compliance status ______________________________

Date contact awarded ______________________________

Date construction began ______________________________

Monitoring ______________________________
    ambient ______________________________
    stack ______________________________

FIGURE 3-14
SOURCE IDENTIFICATION FORM

Plant name ______________________________

Address ______________________________

City, state ______________________________

County ______________________________

AQCR ______________________________

Telephone number ______________________________

Environmental project director ______________________________

Official local control agency

Name ______________________________

Address ______________________________

City ______________________________

Telephone number ______________________________

State control agency

Name ______________________________

Address ______________________________

City ______________________________

Telephone number ______________________________

Corporate office

Name ______________________________

Address ______________________________

City, state ______________________________

Telephone number ______________________________

Environmental director ______________________________

FIGURE 3-15
FACILITY COVER SHEET

2. *Technical Guide for Review and Evaluation of Compliance Schedules,* U.S. Environmental Protection Agency, EPA-340/1-73-001a, Washington, D.C., July 1973.

3. *Compilation of Air Pollutant Emission Factors,* U.S. Environmental Protection Agency, EPA AP-42, Research Triangle Park, North Carolina, April 1973.

4. *Federal Register,* Vol. 36, No. 247, December 23, 1971.

5. *Federal Register,* Vol. 39, No. 47, March 8, 1974.

6. *Corporate Environmental Management Information Systems Users Guide,* PEDCo. Environmental Specialists, Cincinnati, Ohio, 1972.

CHAPTER 4

EMISSION REGULATIONS

4.1 Legal Requirements Under the Clean Air Act Relative to Testing

4.1.1 The Clean Air Act – General

The Clean Air Act of 1970 was structured by Congress to channel regulatory action in a well-planned manner. Basically, two types of pollutant sources are regulated: stationary and mobile. This industrial guide pertains only to stationary source pollutants. Congress meant to control both new and existing stationary sources as follows:

1. The regulatory agency (now the U.S. EPA) is charged with the task of setting National Ambient Air Quality Standards for nonhazardous pollutants. Once a standard is set, each state must develop a plan for achieving and maintaining the prescribed ambient air quality. Pollutants so controlled are known as criteria pollutants.

2. New or modified sources of air pollutants are to be regulated to a greater degree. The rationale here is that newer technology can be utilized and pollutants better controlled for a new source where the control is part of the original process design.

3. Certain air pollutants may directly or indirectly cause an increase in mortality, illness, or discomfort. These are termed hazardous pollutants. These pollutants are first identified by U.S. EPA, whereupon a standard is proposed within 180 days for that hazardous pollutant. Test procedures are defined for the pollutants and published in the *Federal Register.*

The Clean Air Act Amendments of 1977 (Public Law 95-95) made significant changes in the Clean Air Act of 1970. A summary of major provisions related to industrial sources follows:

1. A new short-term nitrogen dioxide standard will be promulgated unless there is evidence that the standard is not necessary to protect public health.

2. A new system is implemented to prevent significant deterioration of ambient air quality. The country will be divided into three classes, each allowing a different amount of industrial activity.

3. The new act now allows the agency to assess non-compliance sources with a penalty equal to the cost of complying with regulations, rather than a maximum fine.

4. Procedures are outlined for new industries that desire to locate in "non-attainment" areas, i.e., areas where national health standards are exceeded.

All stationary source regulations are addressed in Title I, Sections 101 through 119 of the Act. A very brief outline of these sections follows:

Sections 101 through 106 – Defines purpose of the law; establishes research and training means; provides for planning and control program grants.

Section 107 – Mechanism for naming Air Quality Control Regions; assigns environmental responsibility to state governments.

Section 108 – Provides for background studies to establish air quality standards; basic data to include control technology costs, energy requirements, emission reduction benefits, and environmental impacts.

Section 109 – Mandates the EPA Administrator to promulgate national ambient air quality standards (AQS) based on the information gathered pursuant to Section 108.

Section 110 – Directs each state to develop a plan (State Implementation Plan, or SIP) to achieve and maintain the AQS set pursuant to Section 109.

Section 111 – Establishes new source performance standards (NSPS). Authority may be delegated to states to implement and enforce standards.

Section 112 – Establishes national standards for hazardous air pollutants; applies to both new and existing sources.

Section 113 – Outlines mechanisms for federal enforcement; authorizes federal endorcement of standards.

Section 114 – Authorizes U.S. EPA to require record-keeping and monitoring; authorizes inspections and test requirements.

Sections 115 through 119 – Provides for administrative means of abatement; certain state authority is specifically retained; establishes a Presidential Advisory Board; mandates federal facilities to comply with air pollutant regulations; defines procedures pertaining to fossil-fuel-fired units during periods of fuel switching, fuel unavailability, and fuel stipulations as defined by the Energy Supply and Environmental Coordination Act.

Table 4-1 lists the entities affected by the three different types of regulatory schemes and the citations wherein the various emission limitations and test procedures are given.

4.1.2 Criteria Pollutants

Criteria pollutants are promulgated pursuant to Sections 108 and 109. Particulate matter, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide were defined as criteria pollutants when the 1970 CAA was promulgated. On March 31, 1976, lead was added to the list of criteria pollutants.* Each state has promulgated regulations to control these pollutants such that the national ambient air quality standards (AQS) are achieved. These regulations, part of each SIP, may vary from state to state. The regulations cover both existing and new sources and may be thought of as basic regulations. Determining whether sources meet these regulations may require source tests. Although the U.S. EPA has promulgated test procedures, tests prescribed by state regulatory agencies for criteria pollutants vary. For example, one state may measure the amount of condensible pollutants whereas another state may count only the "front end" of the sampling train (filterable particulate matter).

Not only may the test method vary, but process monitoring can affect the emission regulation. Whether a regulation limits a pollutant in terms of parts per million (ppm) or pounds per ton of raw material throughput determines the process monitoring requirements.

4.1.3 New Source Performance Standards

It is recognized that some processes emit greater quantities of pollutants than others. Section 111 of the Act requires U.S. EPA to single out certain processes for new source performance standards (NSPS). Generally, such standards are more stringent than those applicable to existing sources that emit criteria pollutants. Congress intended for such new sources to employ the best technology in controlling pollutants. Should an NSPS apply to a criteria pollutant, a newly built facility must comply with the NSPS limitation for that pollutant or with the SIP regulation, whichever is more stringent.

Since these standards are national in scope, the test methods do not vary by state. Specific test methods are promulgated with the NSPS. Although in general the NSPS do not apply to existing facilities that emit pollutants, there are two exceptions. The first exception relates to emitters of noncriteria pollutants. Such existing facilities must meet a state-promulgated standard, which the states are required to adopt under Section 111(d). These

---

*EPA has proposed an ambient air quality standard for lead of 1.5 micrograms per cubic meter, figured on a monthly average. Issuance of a final standard by EPA is scheduled for June, 1978.

TABLE 4-1
REGULATIONS UNDER THE CLEAN AIR ACT

Type of emission standard	Affected entities*	Source of emission limitations and prescribed test procedures
Criteria Pollutant Standards – Standard set for the pollutant; applies to all sources of such pollutant; standards for emissions and source testing vary among the states.	All facilities which emit particulate matter, sulfur oxides, nitrogen oxides, hydrocarbons, carbon monoxide.	State Implementation Plans and local ordinances (whichever are more stringent).
New Source Performance Standards – Standard set for the specific process; applies to all new processes of that type; nationwide test standards apply; existing sources are amenable to NSPS if such sources are substantially modified or rebuilt.	New facilities: fossil-fuel steam generators, incinerators, portland cement plants, nitric acid plants, sulfuric acid plants, asphalt concrete plants, petroleum refineries, storage vessels for petroleum liquids, secondary lead smelters, secondary brass and bronze ingot production plants, iron and steel plants, sewage treatment plants, primary aluminum industry, primary copper, zinc, and lead smelters, phosphate fertilizer industry operations, coal preparation plants. Existing facilities: 1) Any of the above which exist prior to an NSPS but are subsequently modified. 2) Any of the above which emit a pollutant limited by the NSPS other than particulate, SO_x, NO_x, HC, and CO. The particular limitation is set by the state and may be less stringent than that applicable to new facilities.	Title 40, Code of Federal Regulations, Part 60 (40 CFR 60).
Hazardous Pollutant Standards – Standard set for specific pollutant; applies to all sources of such pollutant; emission and test standards are nationwide in scope; no variation among state and local jurisdictions.	Specified facilities which emit asbestos, beryllium, mercury, benzene.	Title 40, Code of Federal Regulations, Part 61 (40 CFR 61).

*Through March 1976.

state-promulgated standards may be less stringent than the NSPS. The other exception concerns modification of existing sources. Should an existing source be modified or reconstructed to the degree that it may be deemed a new source, it is subject to the NSPS.

4.1.4 Hazardous Pollutants

The Clean Air Act differentiates nonhazardous and hazardous pollutants. The U.S. EPA Administrator is charged with promulgation of standards for hazardous pollutants regardless of whether they emanate from new or existing sources. At the state's option, implementation plans may be submitted to U.S. EPA. Upon U.S. EPA approval, the states are authorized to enforce the hazardous pollutant standards within their jurisdiction. Should the state fail to implement such a plan, however, U.S. EPA will enforce standards for hazardous pollutants against both existing and new sources.

Source test methods are promulgated with the hazardous pollutant standards. These test methods are the only approved means by which compliance may be determined.

4.2 Inspection and Data Requirements Under the Clean Air Act

Section 114 of the Act gives the U.S. EPA Administrator broad powers to inspect, monitor, and test pollutant-emitting facilities and to require record-keeping, monitoring, and testing by the regulated source. The 1977 Clean Air Act Amendments have significantly changed permit requirements. It is recommended that the reader contact an EPA Region office or a state agency to obtain requirements on permits. Section 4.4.3 of this publication will be revised at a later date.

4.2.1 Sources of Criteria Pollutants

In general, reporting requirements for sources of criteria pollutants are minimal. These requirements are set forth in the applicable SIP. Most of the reporting is in the form of use permit applications, which provide information on process throughput, control facilities, stack gas temperatures, and the like. This information is very useful to state and local air pollution control agencies because it allows them to inventory total pollutants over large areas and thereby to formulate large-scale control strategies.

On occasion, the source must verify its claim of compliance with applicable emission limitations by providing source test data. Most monitoring and reporting requirements for existing large sources are formulated for the individual source as a result of compliance negotiations. For small sources, such as small incinerators used by grocery stores and grain-conveying cyclones used by small feed and grain stores, the reporting or monitoring requirements usually are not extensive.

4.2.2 Sources Subject to New Source Performance Standards

Requirements for testing and reporting under an NSPS are usually extensive. Within 6 months of startup, performance tests must be conducted in accordance with EPA-promulgated methodology. All new sources subject to an NSPS must provide test ports and facilities adequate for performing source tests as required by the regulations. This is a national regulation, and variations from the test requirements are not permitted. Prior to performance testing, the source must notify the U.S. EPA. Generally, observers from EPA or from the state or local agency are present to ensure that proper test methods are used. All new sources subject to an NSPS are required to have performance tests.

The individual NSPS regulations specify monitoring and reporting requirements. Logs showing startup, shutdown, and malfunctions must be kept for 2 years. Quarterly reports of excess emissions must be submitted to the Administrator.

4.2.3 Sources of Hazardous Pollutants

Hazardous pollutant regulations apply to both new and existing sources. The regulations specify reporting requirements for the source. Not only must operational data be maintained, but application must also be made to EPA prior to any modification of existing sources. This application may be denied. No new or modified source of a hazardous pollutant may start operation without prior notification of EPA.

Source testing facilities are required for both new and existing sources. Testing, monitoring, and reporting requirements for sources of hazardous pollutants are set forth in the individual regulations for each pollutant.

4.3 Confidentiality of Data — The Freedom of Information Act

4.3.1 General Business Information

It is the general policy of U.S. EPA to make the fullest possible disclosure of information to the public. In carrying out this policy, the U.S. EPA has devised a procedure intended to protect both the interests of businesses that furnish information to the U.S. EPA and the interests of the public. This procedure is designed to afford business a fair opportunity to assert a confidentiality claim and to substantiate the claim prior to any U.S. EPA ruling on the claim.

Certain types of business information gained by the U.S. EPA are entitled to be treated as confidential and are protected from disclosure to the public. Generally this includes any information concerning which a business has a legal right to limit disclosure to others. For example, proprietary information and commercial or financial information that is privileged or confidential are specifically exempted from the mandatory disclosure requirements of the Freedom of Information Act.

Information supplied to the U.S. EPA is entitled to confidential treatment if:

1. The business has asserted a business confidentiality claim,
2. The business has taken reasonable measures to protect the confidentiality of the information,
3. The information has not been reasonably obtainable by others without consent of the business,
4. No statute requires disclosure of the information, and
5. Either
    a. Disclosure of the information is likely to cause substantial harm to the firm's competitive position, or
    b. The information was voluntarily submitted, but its disclosure would impair the Government's ability to obtain necessary information in the future.

4.3.2 Special Rules Governing the Clean Air Act

Generally, the procedures and substantive rules for maintaining and claiming the confidentiality of business information also apply to data provided to the U.S. EPA under Section 114 of the Clean Air Act. Information is eligible for confidential treatment in these circumstances:

1. It was provided in response to a request by the U.S. EPA made for any of the purposes stated in Section 114; or
2. It could have been required under Section 114.

Emission data, however, are not eligible for confidential treatment. Ineligible information includes:

1. Information necessary to determine the characteristics of an emission by a source, and

2. General descriptions of the location and/or nature of a source to the extent necessary to identify the source and to distinguish it from other sources.

Under certain circumstances, this category may also include data relating to:

1. The manner and rate of operation of a source, and

2. The device, installation, or operation constituting a source.

As a result of this broad exclusion, much of the information gathered in inspections and source tests of facilities under Section 114 of the Act is available to the public. This information may include such items as process throughput, stack gas temperatures, and the like.

Certain limitations, however, are applied to disclosure of information relating to research and commercial facilities. The following information is considered emission data:

1. That concerning research on any project, method, device, or installation that was produced, developed, installed, or used only for research, and

2. That concerning any product, method, device, or installation designed and intended to be marketed or used commercially but not yet so marketed or used.

Such emission data are therefore available to the public only insofar as it is necessary to disclose whether a source is in compliance with an applicable standard and to demonstrate the feasibility, practicability, or attainability of an existing or proposed standard.

4.3.3 Asserting a Confidentiality Claim

A business that submits information to U.S. EPA may initially assert that the information is entitled to confidential treatment by attaching a notice or legend to the information at the time it is submitted, employing language such as "trade secret," "proprietary," or "company confidential." Although confidentiality of information previously submitted may be claimed, the U.S. EPA is obligated only to use such efforts as are practicable to associate the claim with the previously submitted information; consequently, such efforts may be ineffective. If a business fails to assert a confidentiality claim, the information will not be entitled to confidential treatment.

If U.S. EPA determines that information may be entitled to confidential treatment, each business asserting such a claim is asked to comment. In other words, the burden of proof of confidentiality is on the claimant. These comments must address the following matters:

1. The portions of the information entitled to confidential treatment,

2. The period of time for which confidential treatment is desired,

3. The purpose for which information was furnished to the U.S. EPA,

4. Whether business confidentiality claim accompanied the information,

5. Measures taken to prevent undesired disclosure,

6. Extent to which the information has been disclosed to others,

7. Pertinent confidentiality determinations,

8. Whether disclosure would likely result in substantial harm to the company's competitive position, and

9. Whether information was voluntarily submitted.

The legal office of U.S. EPA is responsible for making the final determination whether business information is entitled to confidential treatment. If a business fails to submit its comments in the time permitted, the confidentiality claim is waived and the information is not entitled to confidential treatment. In all other cases, the legal office will evaluate the claim and comments and determine whether the information is in fact entitled to confidential treatment.

A notice of denial is provided to a business whenever U.S. EPA determines that the information is not entitled to confidential treatment. Public disclosure of the information is then automatic unless the business commences action in a federal court to obtain judicial review of the determination and to obtain a preliminary injunction prior to such disclosure.

4.4 State Implementation Plans

4.4.1 Emissions Regulations

Each state is required to develop and implement a plan whereby it will achieve the federal ambient air quality standards set for criteria pollutants (Sections 109 and 110 of the Act). This plan is known as the SIP. The cardinal part of an SIP is the emission regulation scheme. For a given pollutant, a state may adopt many regulations. This is true of particulate matter, for example, where it is not uncommon for an SIP to include separate particulate emission regulations for indirect-fired heat exchangers, incinerators, cement kilns, asphalt batching plants, and catalytic cracking units, with a general regulation for all other sources of particulate emissions. Further, the units of various emission regulations may be different, taking the following forms:

1. Pounds of particulate per hour per pound of process throughput,
2. Grains per standard cubic foot of exhaust gas,
3. Pounds of particulate per million BTU heat input, and
4. Pounds of particulate per ton of refuse burned.

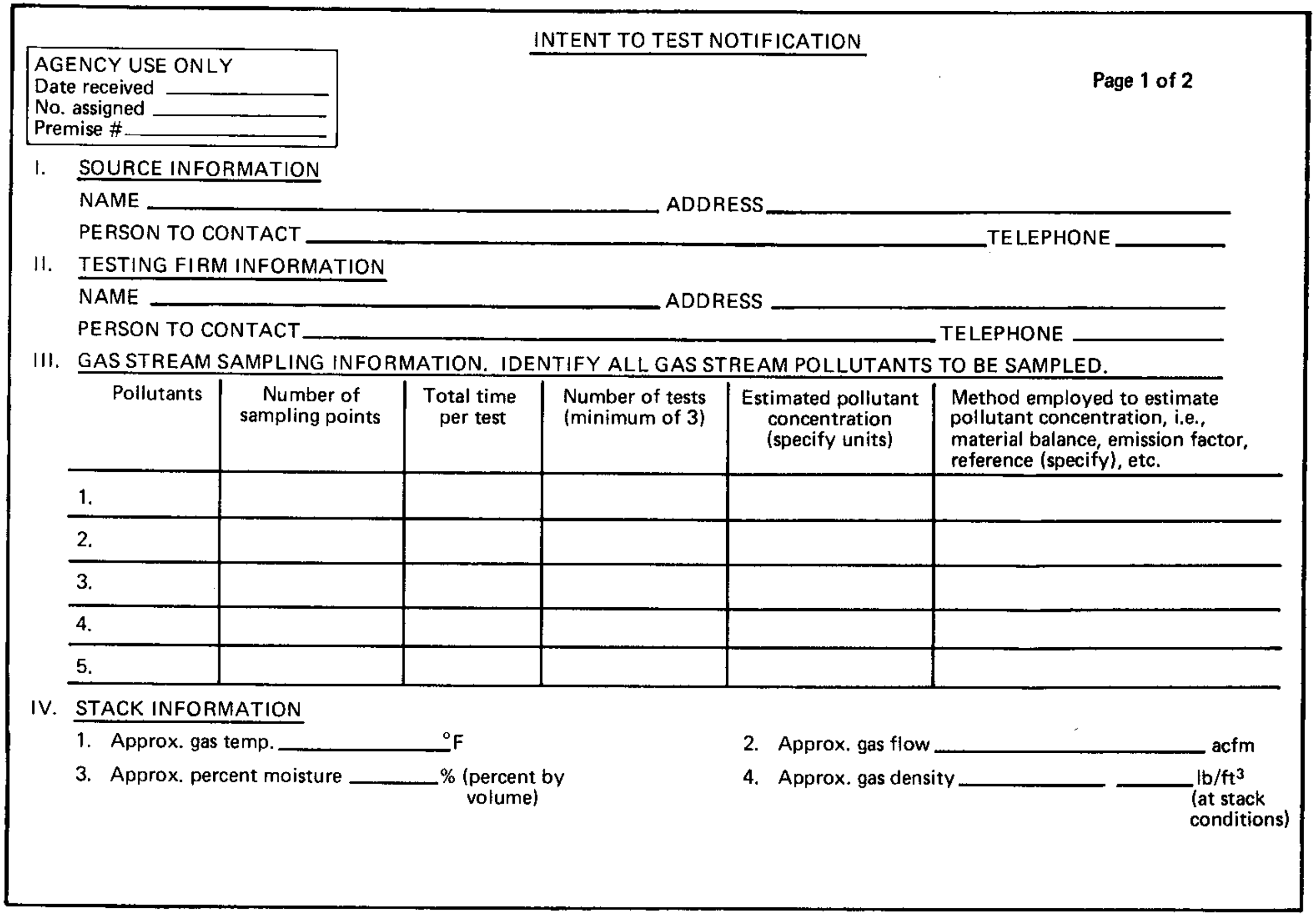
Persons monitoring a process during performance of a source test must be cognizant of these units, since they directly affect the monitoring requirements. For example, much more detailed process monitoring and recording are needed to determine compliance with a standard expressed in pounds of particulate per ton of throughput than with a standard expressed in grains per standard cubic foot.

4.4.2 Source Test Regulations

Each SIP provides a regulatory scheme for source testing. Some of these schemes require continuous monitoring in addition to periodic testing. It is stressed that each state may have different requirements; no industry should assume that requirements of any specific state are similar to those of its neighboring states or of the federal government. Almost all states specify the test method to be used. All but four states, however, further provide that the source may utilize a nonspecified test method if prior approval is obtained. Most of the SIP's require the use of EPA's Test Method 5 for particulate source tests. A substantial number specify the ASME-PTC27 method, and two jurisdictions (Connecticut and the District of Columbia) also require use of the ASME-PTC21 method for certain sources. Since source tests are expensive, it is important that approval of any proposed test method be obtained from appropriate authorities in advance. Additionally, the test must be performed in such a way as to determine compliance. Not only must the facility be operating normally during the test, but a knowledgeable and reliable person must monitor and record the production operations to assure that the extracted sample can be gauged in terms of the emission standard.

With regard to obtaining prior approval of a proposed test method, at least 13 states require prenotification of a proposed source test. Failure to comply with this regulation in a timely manner may negate any test data obtained. Since costs of many compliance tests exceed $5,000, this could be an expensive mistake.

As the results of source tests are being used more and more as proof of compliance, the requirements for pretest preparation and post-test reporting are becoming more sophisticated. Figures 4-1 and 4-2 show the "Intent to Test Notification" form and "Statement of Process Rate" form used by the Ohio EPA. In addition, that agency requires that the following guidelines be observed in preparation of test reports:



AGENCY USE ONLY
Date received ____________
No. assigned ____________
Premise # ____________

INTENT TO TEST NOTIFICATION

Page 1 of 2

I. SOURCE INFORMATION

NAME ____________ ADDRESS ____________

PERSON TO CONTACT ____________ TELEPHONE ____________

II. TESTING FIRM INFORMATION

NAME ____________ ADDRESS ____________

PERSON TO CONTACT ____________ TELEPHONE ____________

III. GAS STREAM SAMPLING INFORMATION. IDENTIFY ALL GAS STREAM POLLUTANTS TO BE SAMPLED.

Pollutants	Number of sampling points	Total time per test	Number of tests (minimum of 3)	Estimated pollutant concentration (specify units)	Method employed to estimate pollutant concentration, i.e., material balance, emission factor, reference (specify), etc.
1.					
2.					
3.					
4.					
5.					

IV. STACK INFORMATION

1. Approx. gas temp. ____________ °F
2. Approx. gas flow ____________ acfm
3. Approx. percent moisture ________ % (percent by volume)
4. Approx. gas density ____________ ________ lb/ft³ (at stack conditions)

FIGURE 4-1
PRE-TEST FORM USED BY OHIO EPA

Page 2 of 2

THE FOLLOWING ADDITIONAL INFORMATION SHALL BE SUBMITTED AS ATTACHMENTS:

V. DATE OF LAST CALIBRATION

1. Velocity measuring equipment ____________________
2. Gas volume metering equipment ____________________
3. Gas flow rate metering equipment ____________________
4. Gas temperature measuring equipment ____________________

VI. SAMPLING TRAIN INFORMATION

1. A schematic diagram of each sampling train. The name, model number, and date of purchase of commercially manufactured trains should be included with the diagram.
2. The type or types of capture media to be used to collect each gas stream pollutant.
3. Sample tube type, i.e., glass, teflon, stainless steel, etc.
4. Probe cleaning method and solvent to be used, if applicable.

VII. LABORATORY ANALYSIS

A description of the laboratory analysis methods to be used to determine the concentration of each pollutant.

VIII. DATA SHEETS

A sample of all field data sheets to be used in the-test or tests.

IX. DESCRIPTION OF OPERATIONS

A description of any operation, process, or activity that could vent exhaust gases to the test stack. This shall include the description and feed rate of all materials capable of producing pollutant emissions used in each separate operation.

Note: All testing shall be performed at maximum rate capacity as specified by the equipment manufacturer or at the maximum rate actually used in the source operation, whichever is greater.

X. STACK AND VENT DESCRIPTION

A dimensional sketch or sketches showing the plan and elevation view of the entire ducting and stack arrangement. The sketch should include the relative position of all processes or operations venting to the stack or vent to be tested. It should also include the position of the sampling ports relative to the nearest upstream and downstream gas flow directional or duct dimensional change. The sketches should include the relative position, type, and manufacturer's claimed efficiency of all gas cleaning equipment.

A cross sectional dimensional sketch of the stack or duct at the sampling ports, showing position of sampling points. In the case of a rectangular duct, show division of duct into equal areas.

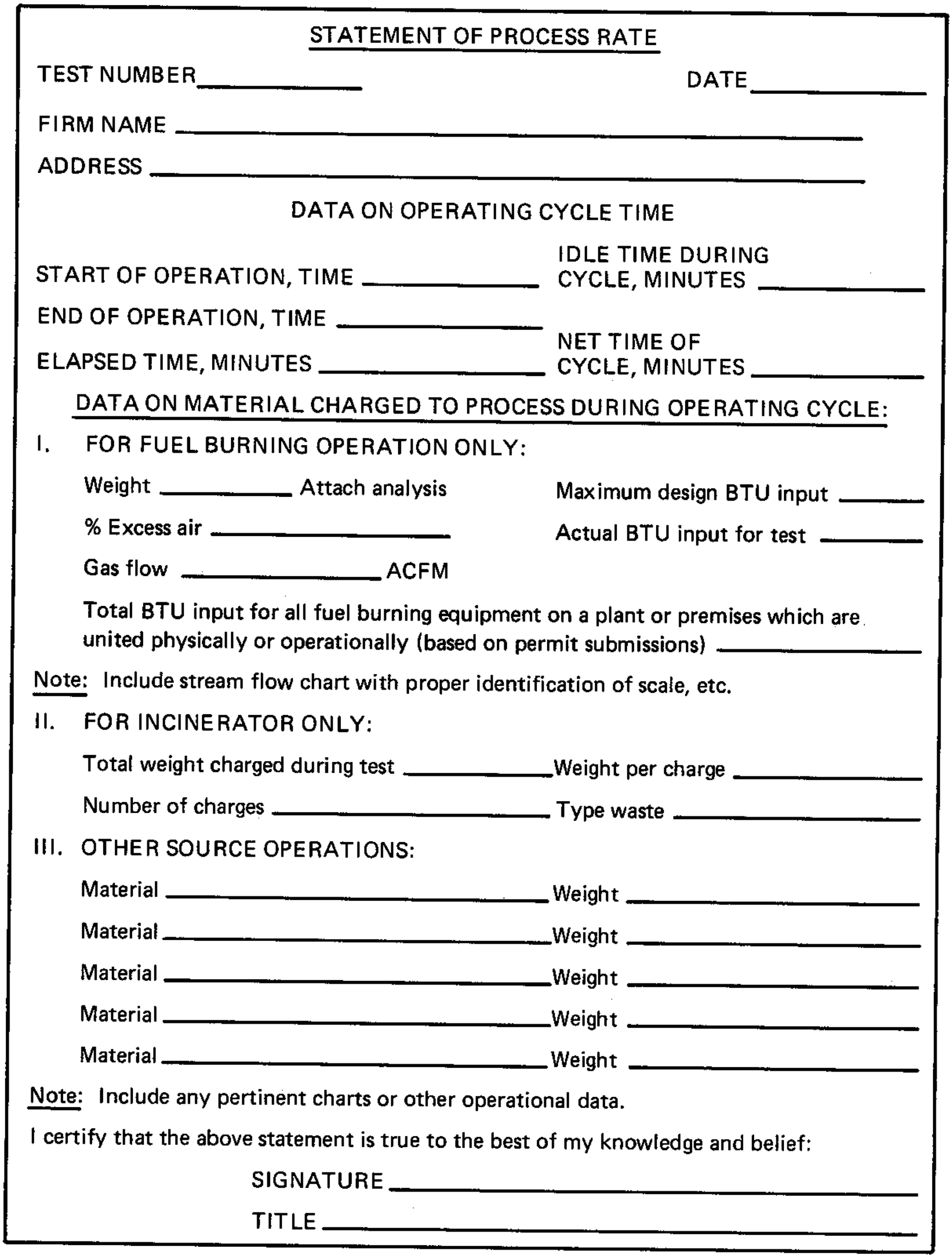
XI. SAFETY

Describe all possible safety hazards including such items as weak roofs, low railings, toxic fumes, hot items, electrical power lines, nearby by-pass vents, unguarded ladders, etc.

List all safety warning signals such as fire alarms, sirens, etc.

Note: Conditions considered unsafe at the time of the test will cause postponement.

FIGURE 4-1 (Cont.)
PRE-TEST FORM USED BY OHIO EPA



STATEMENT OF PROCESS RATE

TEST NUMBER ____________ DATE ____________

FIRM NAME ____________

ADDRESS ____________

DATA ON OPERATING CYCLE TIME

START OF OPERATION, TIME ____________ IDLE TIME DURING CYCLE, MINUTES ____________

END OF OPERATION, TIME ____________

ELAPSED TIME, MINUTES ____________ NET TIME OF CYCLE, MINUTES ____________

DATA ON MATERIAL CHARGED TO PROCESS DURING OPERATING CYCLE:

I. FOR FUEL BURNING OPERATION ONLY:

Weight ____________ Attach analysis Maximum design BTU input ____________

% Excess air ____________ Actual BTU input for test ____________

Gas flow ____________ ACFM

Total BTU input for all fuel burning equipment on a plant or premises which are united physically or operationally (based on permit submissions) ____________

Note: Include stream flow chart with proper identification of scale, etc.

II. FOR INCINERATOR ONLY:

Total weight charged during test ____________ Weight per charge ____________

Number of charges ____________ Type waste ____________

III. OTHER SOURCE OPERATIONS:

Material ____________ Weight ____________

Material ____________ Weight ____________

Material ____________ Weight ____________

Material ____________ Weight ____________

Material ____________ Weight ____________

Note: Include any pertinent charts or other operational data.

I certify that the above statement is true to the best of my knowledge and belief:

SIGNATURE ____________

TITLE ____________

FIGURE 4-2
PROCESS INFORMATION FORM USED BY OHIO EPA

1. Display test results in tabular form (the units of measurement shall be consistent with units in the applicable regulations),
2. Include a copy of all field data sheets completed during testing,
3. Include information required by Item IX of the "Intent to Test Notification,"
4. Include a completed "Statement of Process Rate" form for each test, and
5. Include a sample of all formulas used in calculating results.

Many states that do not require a formal notification of an intent to test do require that a state representative be present during the test. Again, failure to notify may invalidate the test results.

In addition to requiring the source to provide test data, many state agencies are empowered to perform source tests. Although most states do not maintain an extensive test program because of the great expense, the authority to test is a powerful tool for enforcement of state regulations. As is the case with industry, the state agency can hurt its case through use of improper testing methods. Full cooperation must be given with regard to unit operations during an agency-conducted test.

4.4.3 Permit System Review Requirements

Permit systems of most air pollution control programs at the state and local level require the following:

1. Source registration data (identify type and location of source),
2. Information on the process employed and control devices installed, and
3. Emission inventory data (emission information for comparison with regulations and as input for air impact analysis through modeling).

Construction and Operating Permits – The permit system is the main mechanism by which industrial emissions are controlled.

Before a facility can be constructed, a permit to construct must be issued by the state and/or local regulatory agency. As illustrated in Figure 4-3, a permit application may include the following:

1. Application forms, including process description,

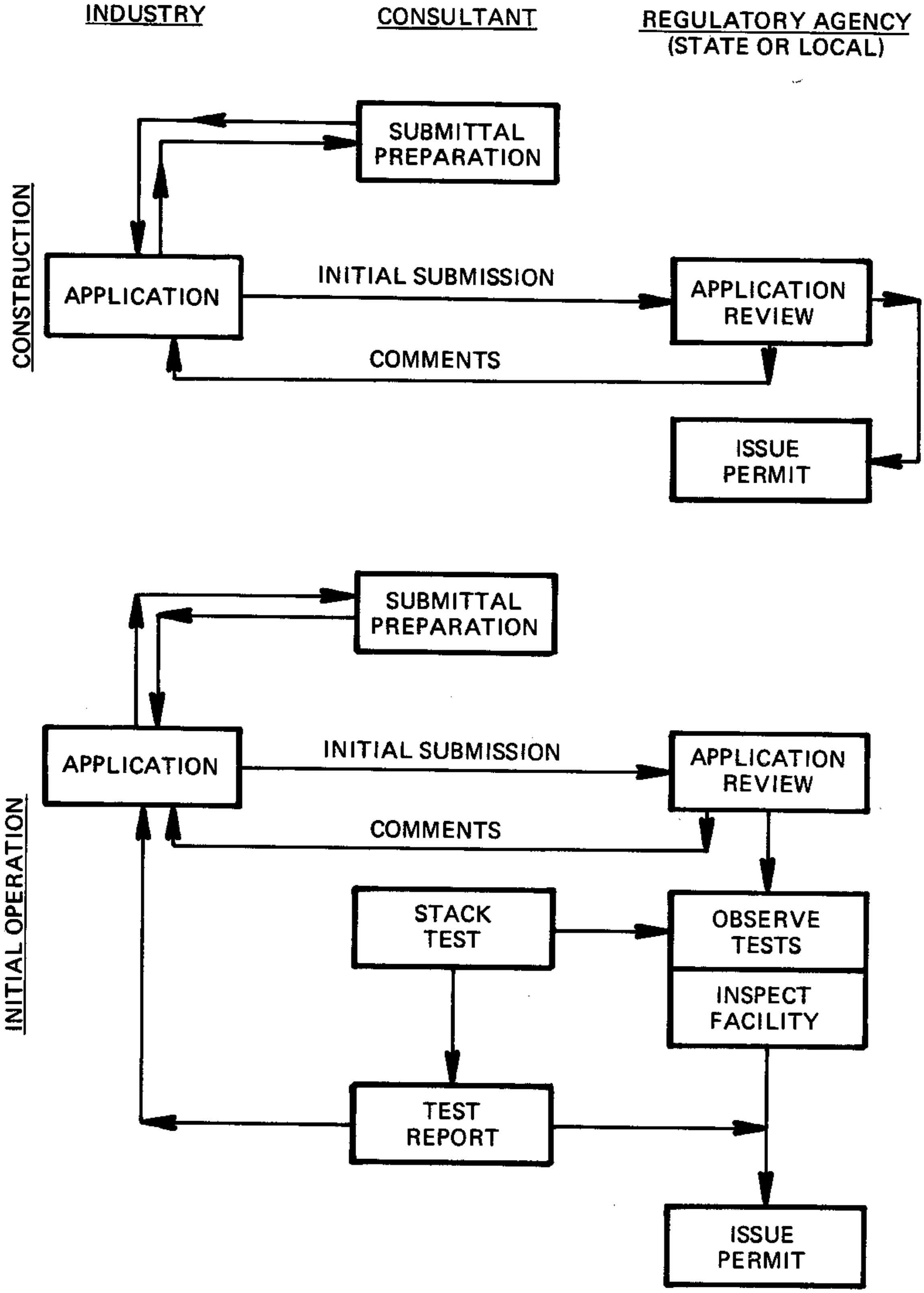


FIGURE 4-3
TYPICAL PERMIT SYSTEM FLOW DIAGRAM

2. Area map showing surrounding structures,

3. Site plan showing building/process, and

4. Equipment specifications.

Larger industries having an environmental engineering staff prepare these documents in-house whereas smaller industries usually retain consultants to help with this activity. In some states, applications must be signed and sealed by a registered professional engineer. The regulatory agency reviews the application package and after any questions are resolved, issues a permit to construct a facility and/or control device. After the facility is constructed, the industry or consultant submits as-built plans to the regulatory agency indicating any changes from the original plans.

Once the facility has been placed in operation, it is usual for the agency to inspect the facility to determine whether the plant is built in accordance with approved plans and to perform stack and/or visible emissions tests at all emission sources. An operations permit is applied for after the shakedown period; if the inspection(s) and tests indicate compliance with applicable regulations and standards, an operations permit is issued. The permit usually incorporates (1) limitations on production rate, and (2) monitoring requirements such as type of monitoring (continuous or manual), frequency of sampling, and reporting frequency.

If the facility comes under the New Source Performance Standards, it must comply with federal as well as state and local requirements.

Testing of new or modified sources must be performed no later than 60 days after achieving maximum production rate, but no longer than 180 days after initial startup. The tests must be conducted during representative performance, with fuels and raw materials representative of those used during normal operation.

The owner or operator has the following responsibilities:

1. To give a minimum of 30 days notification of scheduled tests.

2. To give a minimum of 30 days notice of anticipated startup. U.S. EPA must be notified of actual startup within 15 days after startup.

3. To provide adequate sampling ports, safe sampling platforms, safe access to the platforms, and utilities for sampling and testing equipment.

4. To perform emission tests and furnish a written report of test results to the Administrator.

Testing methods are specified in 40 CFR 60.

Permit Renewal – The permit system within a state or local program is operated under the combined direction of the engineering services and field enforcement services departments. A typical organizational chart for a local governmental air pollution agency is shown in Figure 4-4.

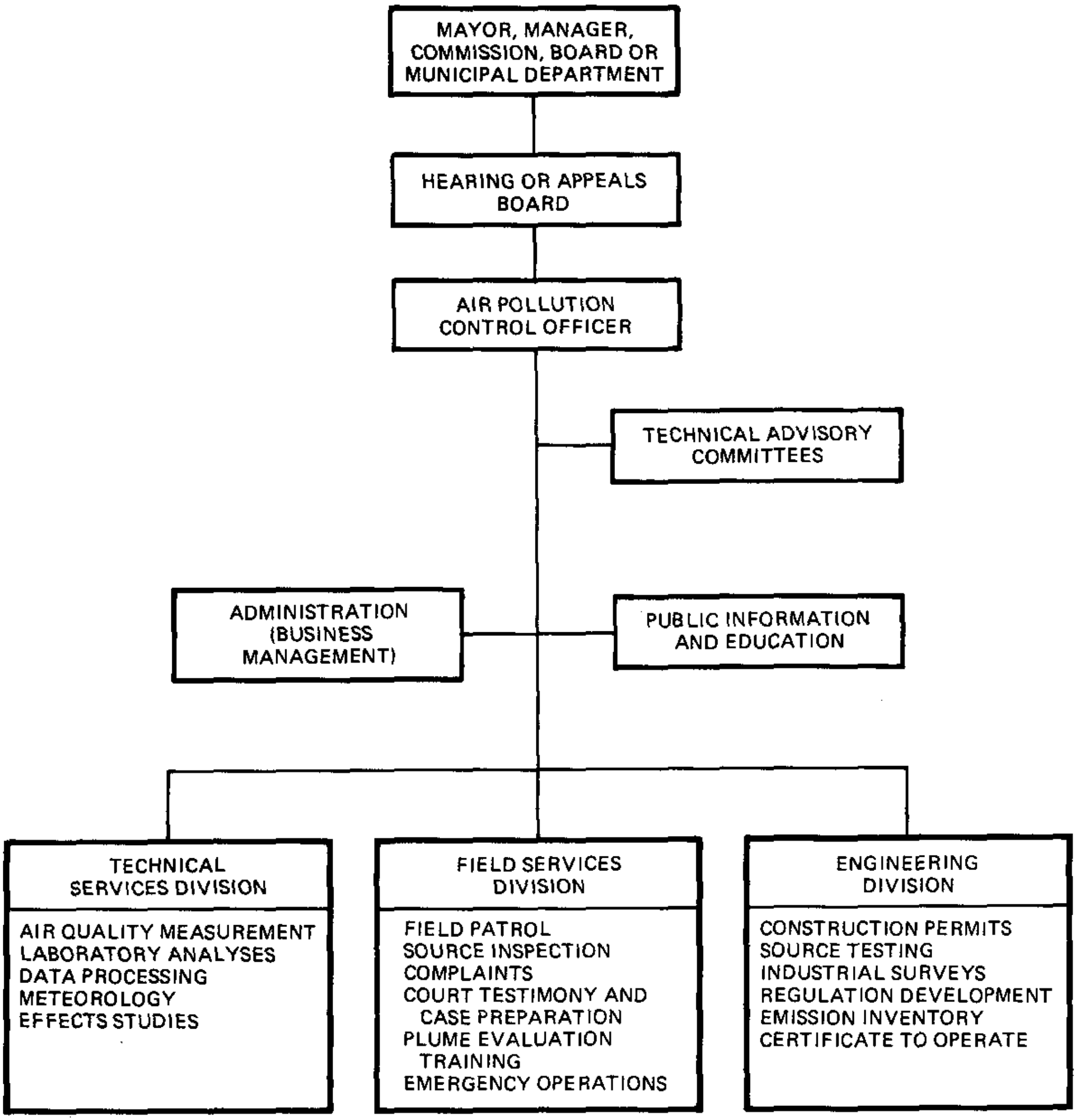


FIGURE 4-4
TYPICAL ORGANIZATIONAL CHART FOR A LOCAL GOVERNMENTAL AIR POLLUTION AGENCY

A large part of the activity of a state or local air pollution control agency is permit-related. Figure 4-5 shows that of the 23 percent (23.3) of time spent in engineering services, 15 percent (14.8) is spent in operation of the permit system. Field enforcement services consume up to 8 percent (7.9) of the agency's time. Almost 13 percent (12.9) of the field services consist of scheduled inspections for permit renewals.

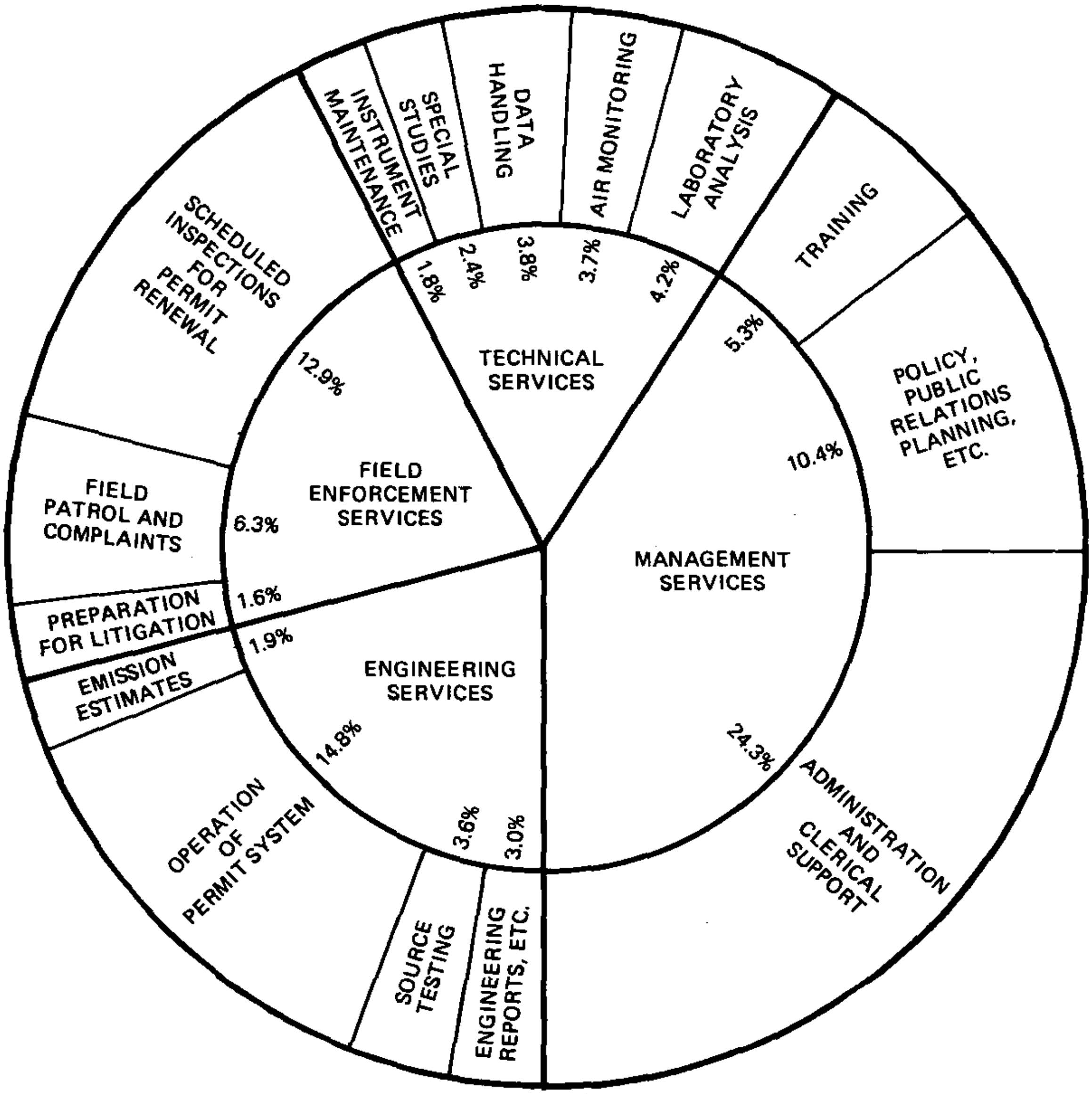


FIGURE 4-5
GENERALIZED DISTRIBUTION OF FUNCTIONAL ACTIVITIES
FOR REGULATORY AGENCIES ANTICIPATED FOR 1974

The reinspection procedure for permit renewals entails a number of functions:

1. Processing data for determining whether to issue or deny a certificate to operate,
2. Processing data for determining the need for source testing,
3. Verifying data for source registration,
4. Verifying data for emission inventory,
5. Procuring data for court or appeals board action,
6. Procuring data for evaluation of operating procedures relative to compliance with current standards,
7. Procuring data for evaluation of possible nuisance problems, and
8. Verifying operating schedules of equipment.

Reinspections are done primarily in connection with permit renewal but may also be done in response to citizen complaints (which require about 6 percent (6.3) of an agency's time) or in connection with a periodic (usually annual) compliance test and/or inspection. A continuing permit system operation is illustrated in Figure 4-6.

Typical of the forms used by inspectors in these surveillance activities are those of the Los Angeles County Air Pollution Control District for field inspection reporting (Figures 4-7 and 4-8).

4.4.4 Reporting Requirements During Violations

Industrial plants are normally considered in violation of regulations when a process or control device emits pollutants in excess of the rate cited in the applicable regulation or standard. Excessive emissions could occur because of poor operation and maintenance or a malfunction in the process.

The *Federal Register* defines malfunctions as follows:

> "Malfunctions are sudden and unavoidable failures of control or process equipment, or processes that do not operate in a normal or usual manner. Failures that are caused entirely or in part by poor maintenance, careless operation, or any other preventable condition shall not be considered malfunctions." (2)

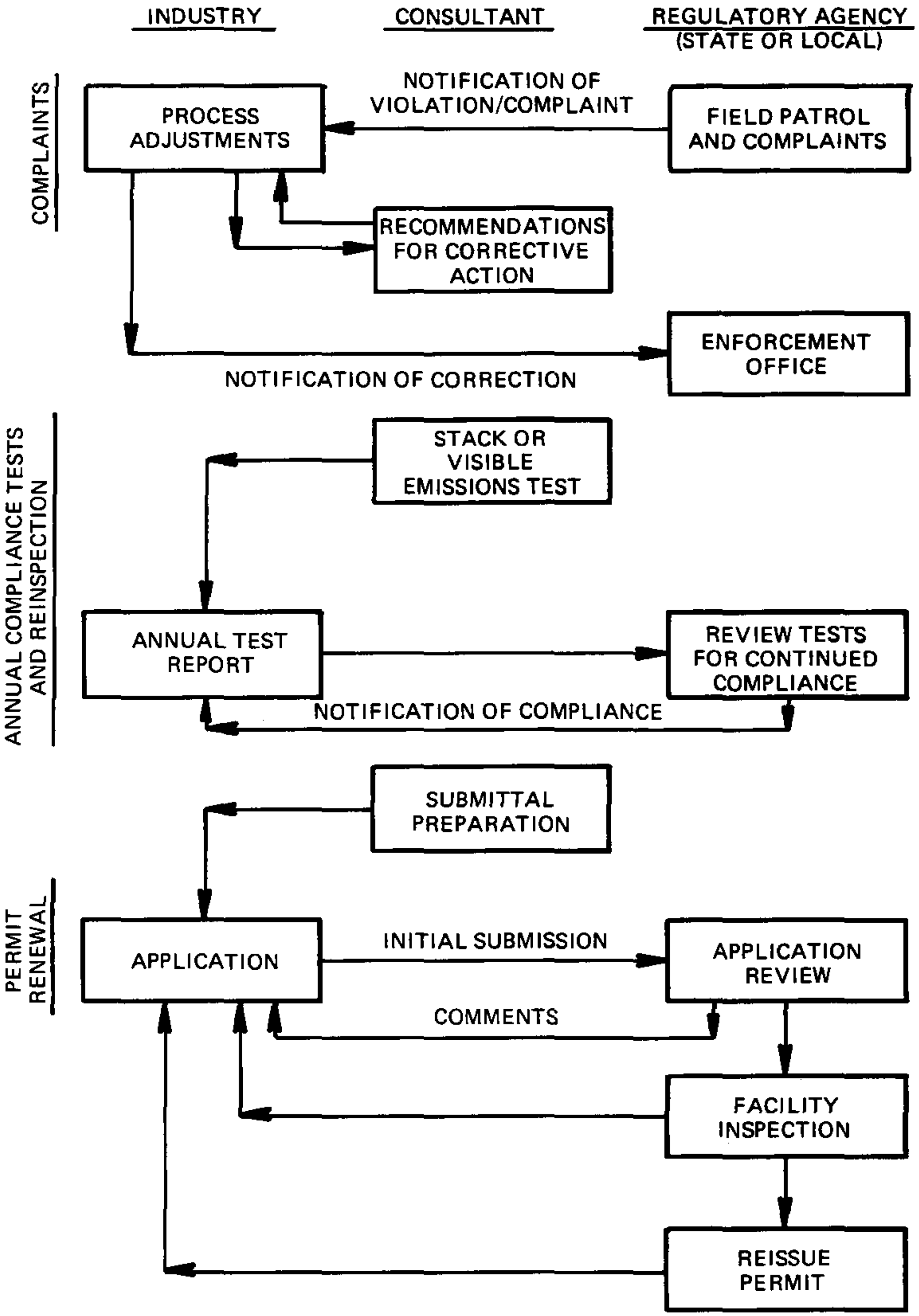
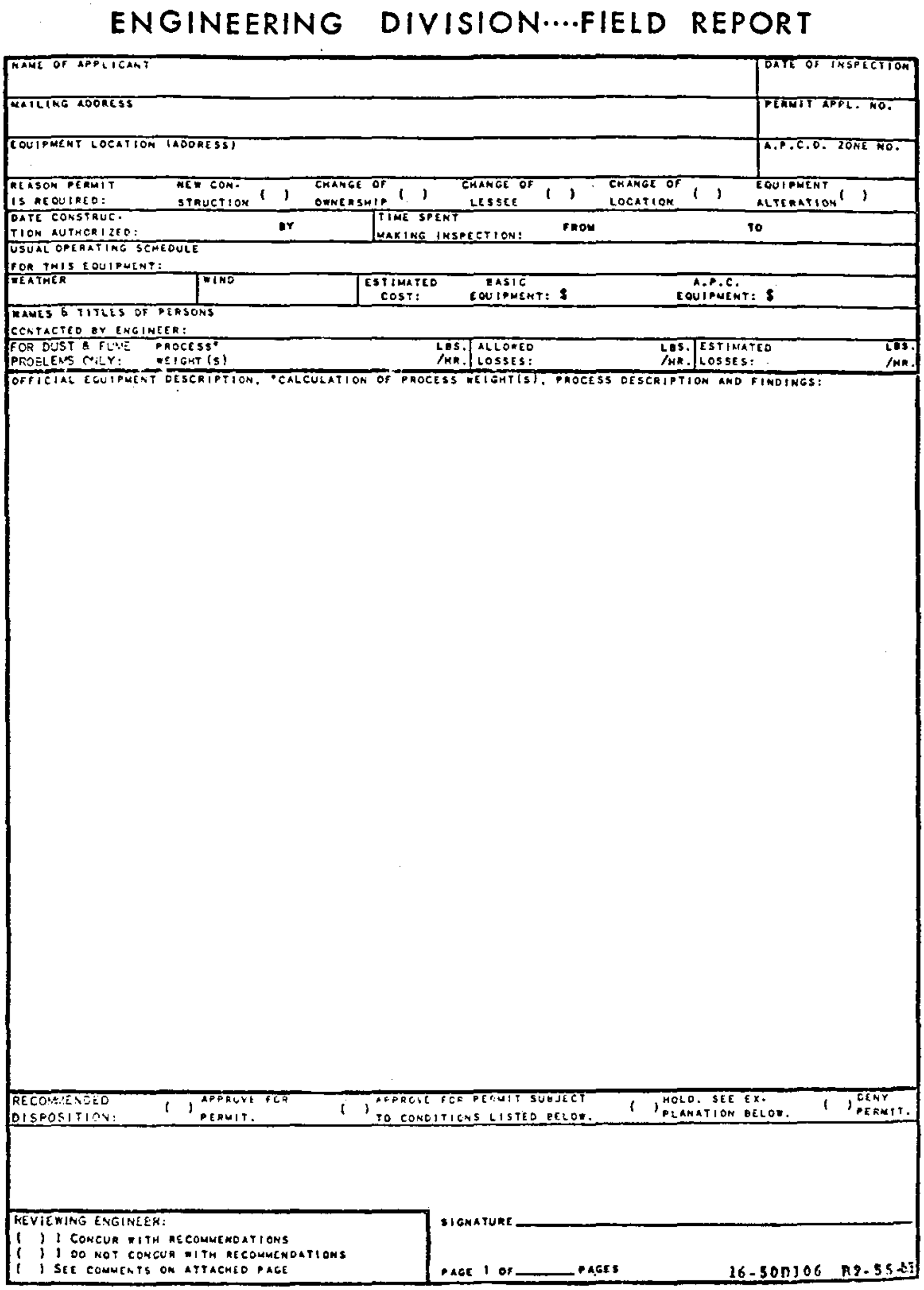


FIGURE 4-6
CONTINUATION OF PERMIT SYSTEM



ENGINEERING DIVISION····FIELD REPORT

NAME OF APPLICANT
DATE OF INSPECTION
MAILING ADDRESS
PERMIT APPL. NO.
EQUIPMENT LOCATION (ADDRESS)
A.P.C.D. ZONE NO.

REASON PERMIT IS REQUIRED: NEW CONSTRUCTION ( ) CHANGE OF OWNERSHIP ( ) CHANGE OF LESSEE ( ) CHANGE OF LOCATION ( ) EQUIPMENT ALTERATION ( )

DATE CONSTRUCTION AUTHORIZED: BY

TIME SPENT MAKING INSPECTION: FROM TO

USUAL OPERATING SCHEDULE FOR THIS EQUIPMENT:

WEATHER

WIND

ESTIMATED COST: BASIC EQUIPMENT: $ A.P.C. EQUIPMENT: $

NAMES & TITLES OF PERSONS CONTACTED BY ENGINEER:

FOR DUST & FUME PROBLEMS ONLY: PROCESS* WEIGHT (S) LBS./HR. ALLOWED LOSSES: LBS./HR. ESTIMATED LOSSES: LBS./HR.

OFFICIAL EQUIPMENT DESCRIPTION, *CALCULATION OF PROCESS WEIGHT(S), PROCESS DESCRIPTION AND FINDINGS:

RECOMMENDED DISPOSITION: ( ) APPROVE FOR PERMIT. ( ) APPROVE FOR PERMIT SUBJECT TO CONDITIONS LISTED BELOW. ( ) HOLD. SEE EXPLANATION BELOW. ( ) DENY PERMIT.

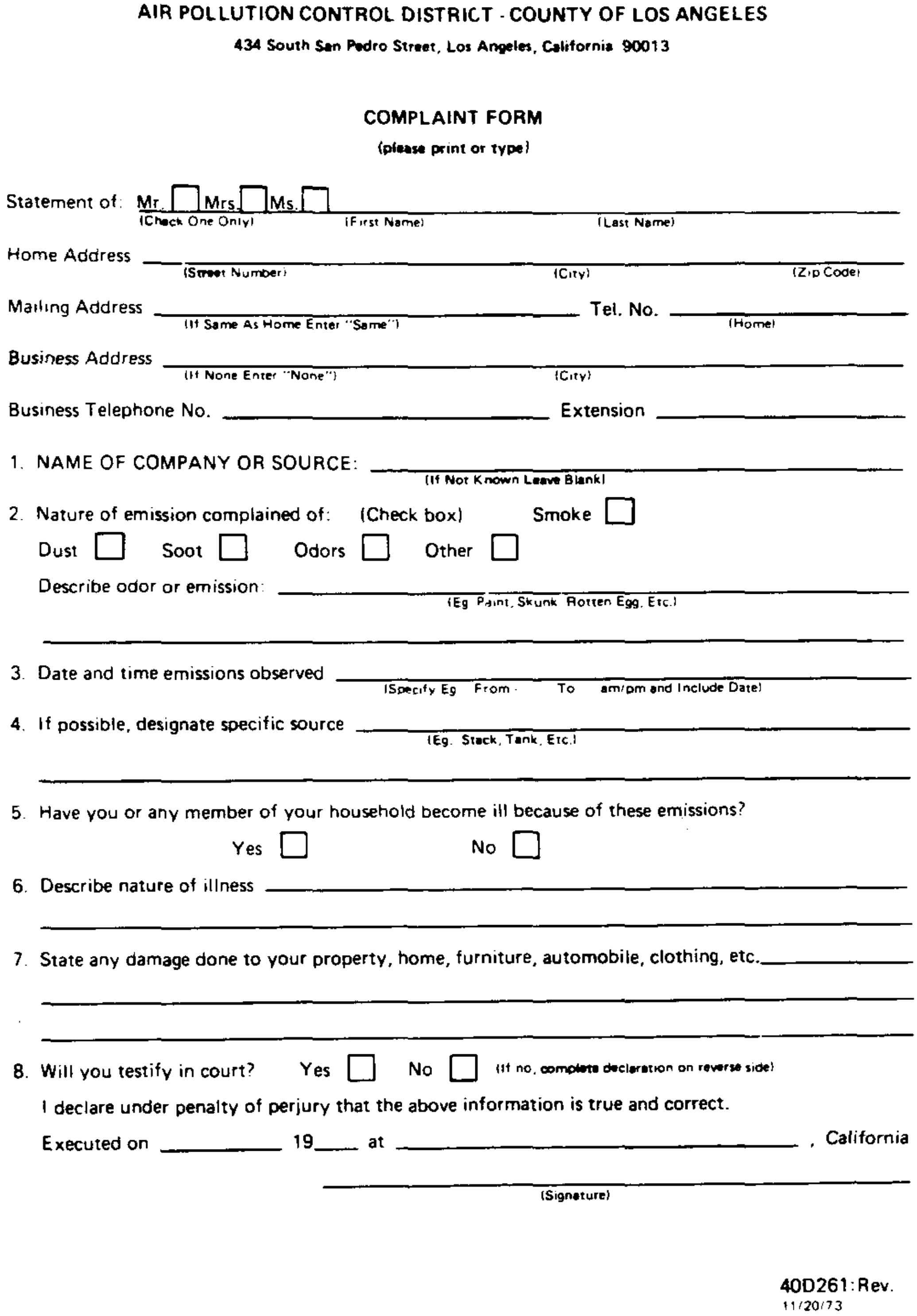
REVIEWING ENGINEER:
( ) I CONCUR WITH RECOMMENDATIONS
( ) I DO NOT CONCUR WITH RECOMMENDATIONS
( ) SEE COMMENTS ON ATTACHED PAGE

SIGNATURE ______

PAGE 1 OF ______ PAGES

16-50D106 R9-55-63

FIGURE 4-7
FIELD REPORT FORM, DUST AND FUMES, LOS ANGELES COUNTY AIR POLLUTION CONTROL DISTRICT (1)



AIR POLLUTION CONTROL DISTRICT - COUNTY OF LOS ANGELES

434 South San Pedro Street, Los Angeles, California 90013

COMPLAINT FORM

(please print or type)

Statement of: Mr. ☐ Mrs. ☐ Ms. ☐ ____________________
(Check One Only) (First Name) (Last Name)

Home Address ____________________
(Street Number) (City) (Zip Code)

Mailing Address ____________________ Tel. No. ____________________
(If Same As Home Enter "Same") (Home)

Business Address ____________________
(If None Enter "None") (City)

Business Telephone No. ____________________ Extension ____________________

1. NAME OF COMPANY OR SOURCE: ____________________
(If Not Known Leave Blank)

2. Nature of emission complained of: (Check box) Smoke ☐
Dust ☐ Soot ☐ Odors ☐ Other ☐
Describe odor or emission: ____________________
(Eg Paint, Skunk, Rotten Egg, Etc.)
____

3. Date and time emissions observed ____________________
(Specify Eg From - To am/pm and Include Date)

4. If possible, designate specific source ____________________
(Eg. Stack, Tank, Etc.)
____

5. Have you or any member of your household become ill because of these emissions?
Yes ☐ No ☐

6. Describe nature of illness ____________________
____

7. State any damage done to your property, home, furniture, automobile, clothing, etc. ____________________
____
____

8. Will you testify in court? Yes ☐ No ☐ (If no, complete declaration on reverse side)

I declare under penalty of perjury that the above information is true and correct.

Executed on ____________ 19____ at ____________________, California

____
(Signature)

40D261:Rev.
11/20/73

FIGURE 4-8
AGENCY INSPECTION COMPLAINT FORM (1)

COUNTY OF LOS ANGELES
AIR POLLUTION CONTROL DISTRICT

Declaration of ____
(Full Name)

Address ____
(Street and Number) (City) (Zip Code)

I, ______________________________, declare that:
(Name)

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

I have read the foregoing declaration and I declare under penalty of perjury that the information is to the best of my knowledge true and correct.

Executed on ______________, 19____, at ______________________________,
(Date) (City or Community)

California. ____
(Signature)

APCD USE ONLY

No. ______________________
(FA or Complaint)

Complaint and/or declaration received by ______________________________
(Inspectors Name - Print)

on ______________, 19 ______ ______________________________
(Date) (Inspectors Signature)

Verified source ____
(Name)

Address ____
(Street and Number) (City) (Sector)

FIGURE 4-8 (Cont.)
AGENCY INSPECTION COMPLAINT FORM (1)

Therefore, a violation can occur in a plant whether the problem results from poor operation/maintenance or from a malfunction. Technically, a malfunction is considered legitimate, whereas a violation caused by an operation/ maintenance problem could result in prosecution.

Most agencies require the reporting of violations in accordance with the SIP. Some agencies request notification by phone, and others use a more formal reporting system.

Because companies often do not call the regulatory agencies when violations occur, complaints by affected citizens provide a method for detection of violation. Some plants subject to NSPS must operate continuous monitors; for such plants, an inspector can readily check the records on the stack monitors to document a violation. For compliance with the NSPS, the owner or operator of a plant is required to record any emissions resulting from malfunctions of startups that are measured or estimated to be greater than those allowed by NSPS. A report of such emissions must be submitted to the Administrator on the 15th day following the end of each calender quarter. Figure 4-9 illustrates the violation notification process.

Violation Notices – Although procedures for notification and correction of violations vary among state and local agencies, many of them simulate U.S. EPA procedures. The procedures discussed in this section are typical; however, each industry should check with the appropriate regulatory agency to determine specifics and deviations.

The following groups are usually involved in a violation notice:

1. Regulatory agency personnel,
2. Industry consultant,
3. Industry attorney, and
4. Industry management.

Figure 4-10 illustrates interaction of these groups during the procedure for violation correction. The individual agency functions are shown in Figure 4-11.

The regulatory agency determines a violation and issues a violation notice. The industry must respond to the notice within a specific period of time. The regulatory agency and the industry confer to discuss the problem, the intent of the industry to correct the problem, and the corrective alternatives that are available.

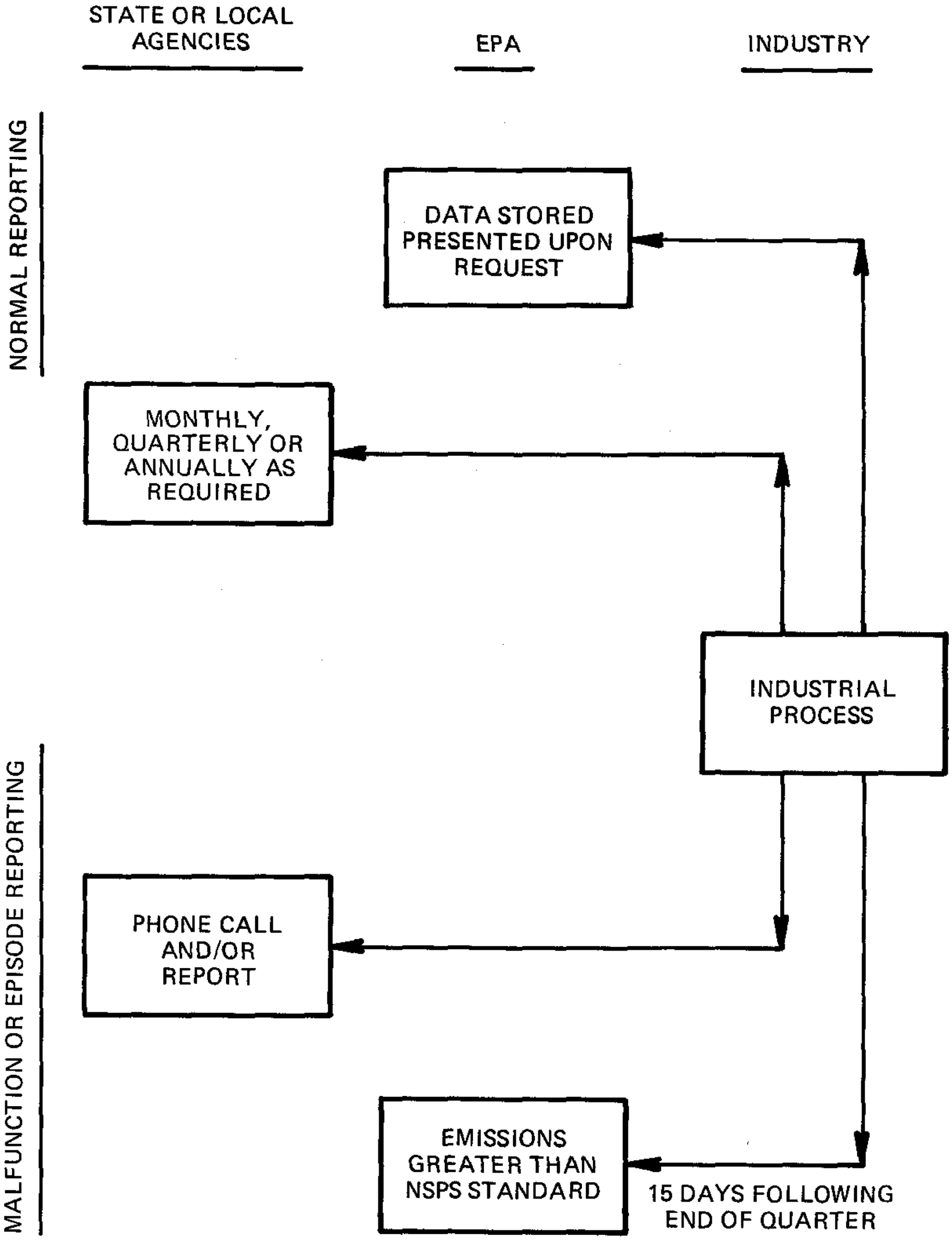


FIGURE 4-9
REPORTING OF VIOLATIONS

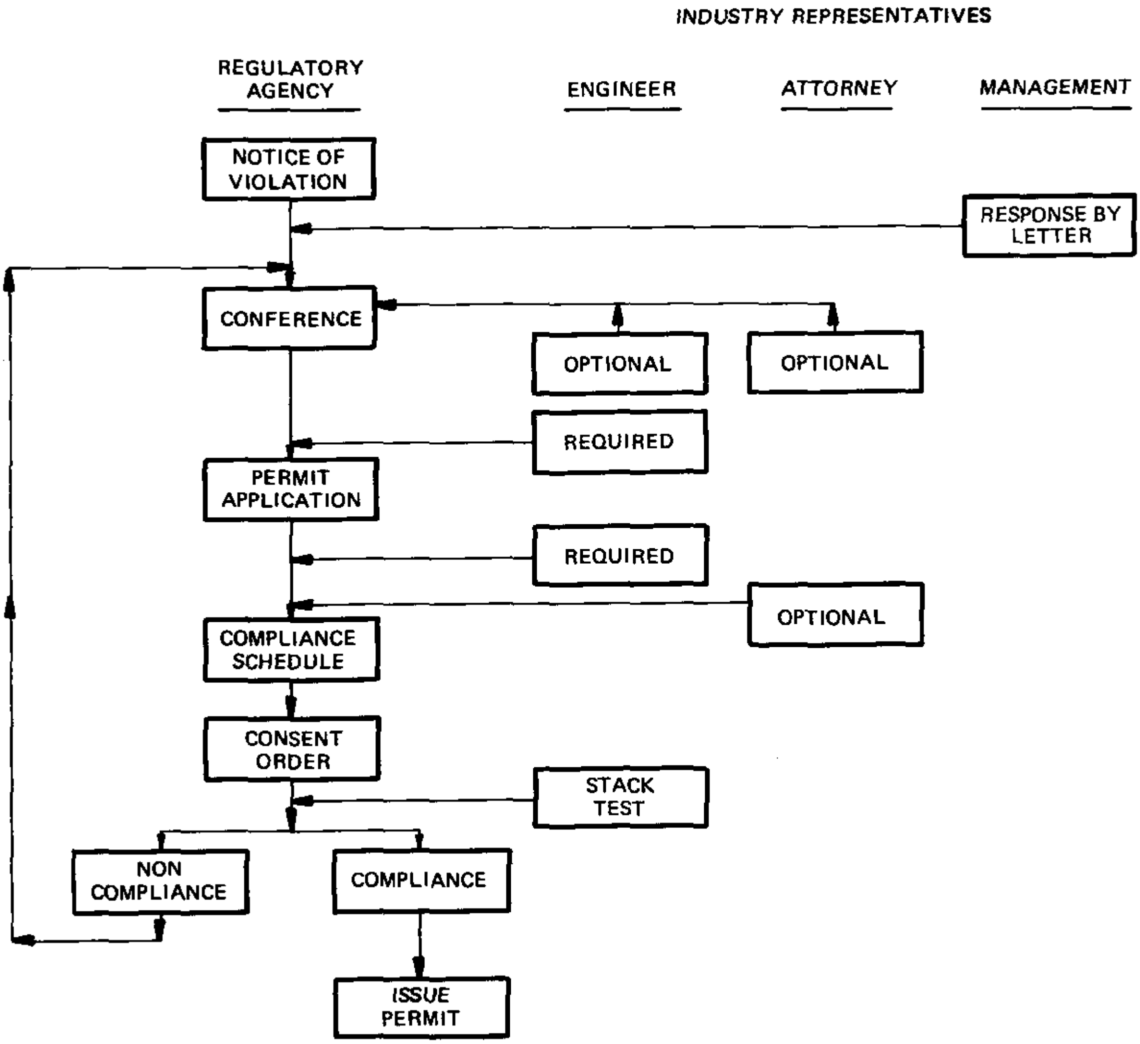


FIGURE 4-10
GROUP INTERACTIONS FOR VIOLATION CORRECTION

A permit application is generally filed by a registered engineer. The control agency determines the compliance status of the process or operation for which the application has been filed. If the operation is not in compliance, then a compliance schedule is filed, which is the basis for a consent order. The compliance schedule is a timetable or milestone chart indicating when certain increments of progress toward correction of the violation will be completed. The consent order is a formal agreement to complete the engineering indicated in the permit application according to the compliance schedule. When changes have been made to correct the violation, a stack test is performed to indicate whether the plant is in compliance or in violation. If the plant is in compliance, the regulatory agency issues a permit.

If compliance is not reached in the first attempt, the process is repeated with a new consent order.

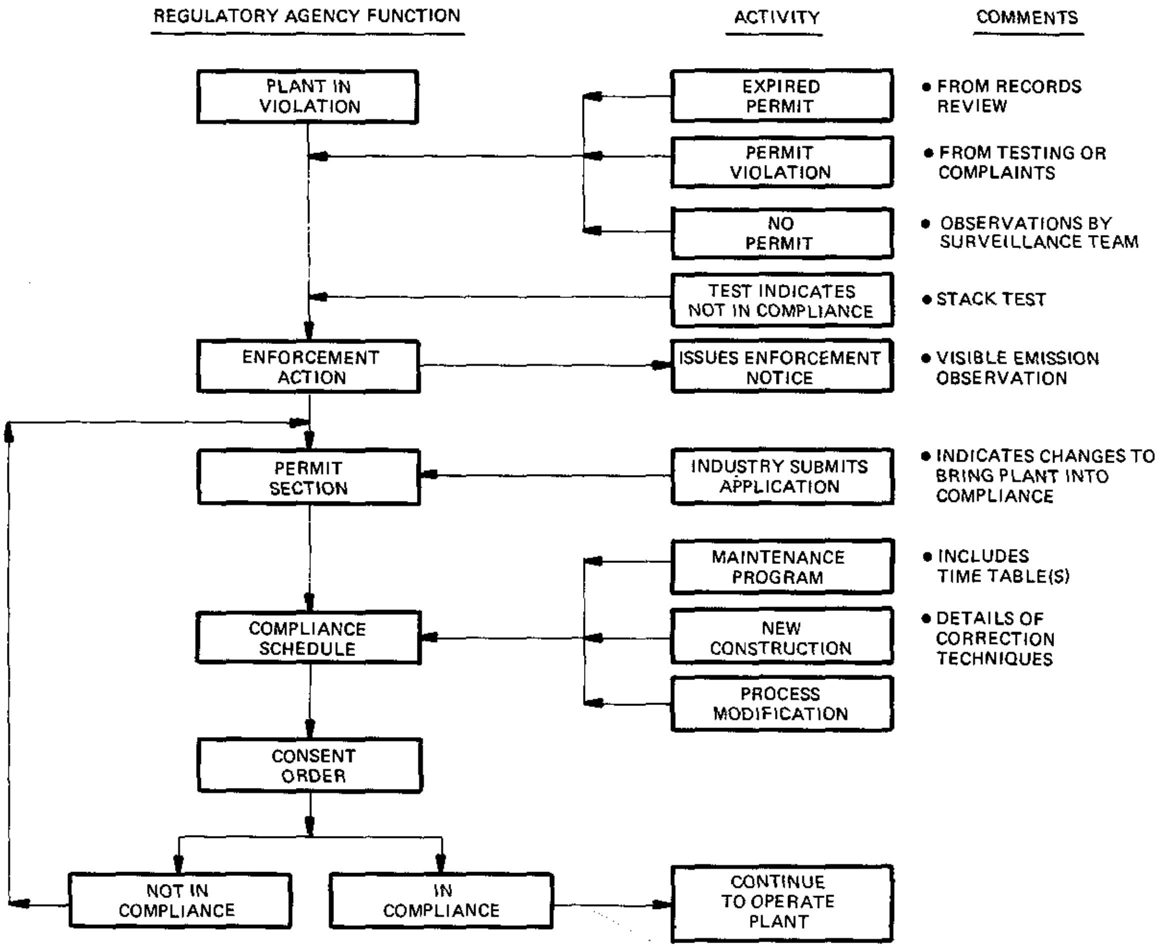


FIGURE 4-11
REGULATORY AGENCY FUNCTIONS FOR HANDLING VIOLATION

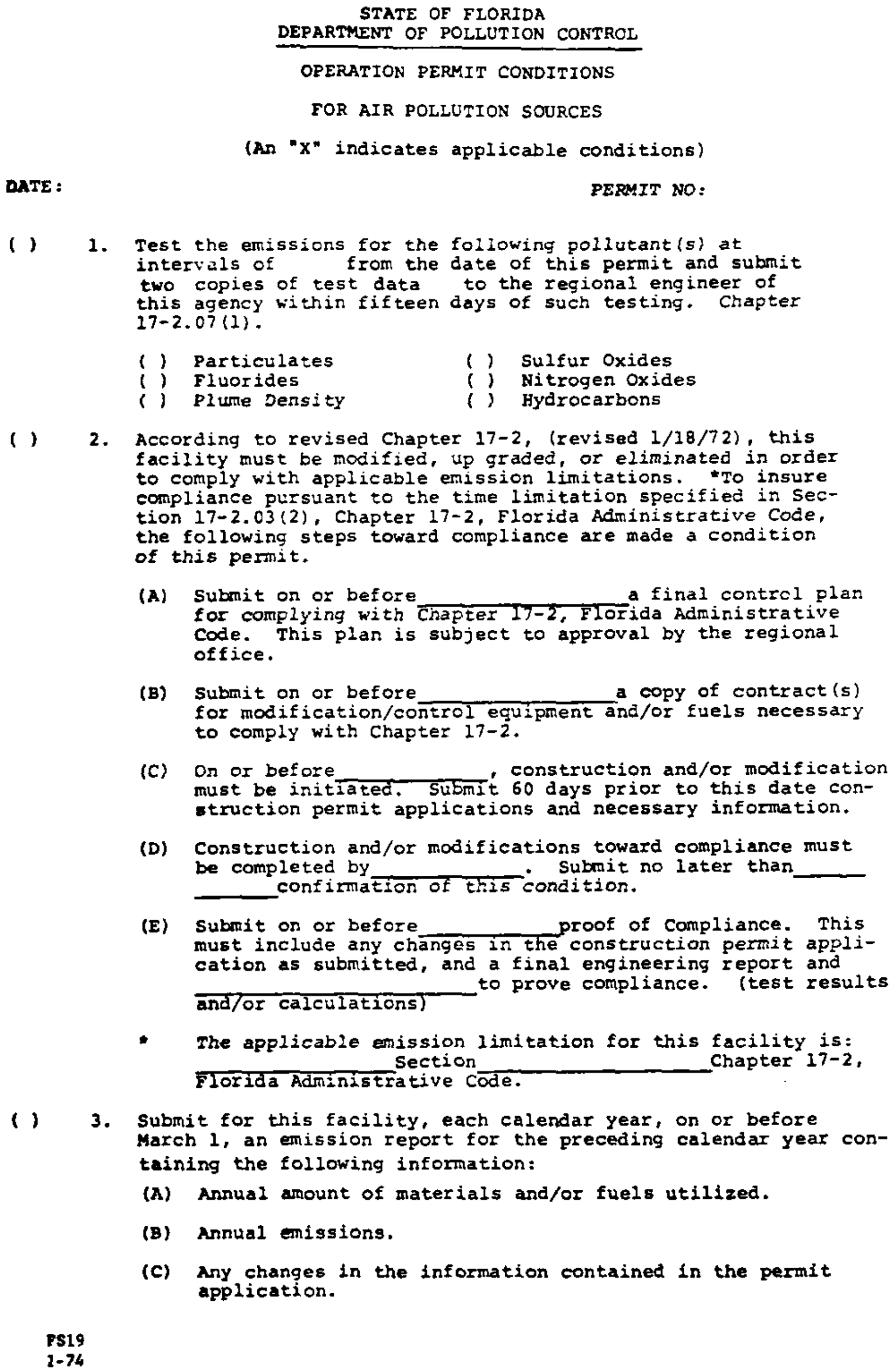
Compliance Schedules – When a plant is in violation, an enforcement notice is issued that leads to the formation of a compliance schedule and eventual correction of the problem. Figure 4-12 illustrates the steps involved in the establishment of a compliance schedule.

The compliance schedule is a timetable under which certain corrective measures will be accomplished. Figure 4-12 is a typical form used as the basis of a compliance schedule. Note that the compliance schedule conditions are made a part of the permit that, in this case, the State of Florida would issue.

4.5 References

1. *Guide to Engineering Permit Processing,* U.S. Environmental Protection Agency, EPA APTD-1164, July 1972.

2. *Federal Register,* Vol. 38, No. 84.



STATE OF FLORIDA
DEPARTMENT OF POLLUTION CONTROL

OPERATION PERMIT CONDITIONS

FOR AIR POLLUTION SOURCES

(An "X" indicates applicable conditions)

DATE: *PERMIT NO:*

( ) 1. Test the emissions for the following pollutant(s) at intervals of from the date of this permit and submit two copies of test data to the regional engineer of this agency within fifteen days of such testing. Chapter 17-2.07(1).

( ) Particulates
( ) Fluorides
( ) Plume Density
( ) Sulfur Oxides
( ) Nitrogen Oxides
( ) Hydrocarbons

( ) 2. According to revised Chapter 17-2, (revised 1/18/72), this facility must be modified, up graded, or eliminated in order to comply with applicable emission limitations. *To insure compliance pursuant to the time limitation specified in Section 17-2.03(2), Chapter 17-2, Florida Administrative Code, the following steps toward compliance are made a condition of this permit.

(A) Submit on or before ____________ a final control plan for complying with Chapter 17-2, Florida Administrative Code. This plan is subject to approval by the regional office.

(B) Submit on or before ____________ a copy of contract(s) for modification/control equipment and/or fuels necessary to comply with Chapter 17-2.

(C) On or before __________, construction and/or modification must be initiated. Submit 60 days prior to this date construction permit applications and necessary information.

(D) Construction and/or modifications toward compliance must be completed by __________. Submit no later than ________ confirmation of this condition.

(E) Submit on or before __________ proof of Compliance. This must include any changes in the construction permit application as submitted, and a final engineering report and ________________ to prove compliance. (test results and/or calculations)

* The applicable emission limitation for this facility is: __________ Section ______________ Chapter 17-2, Florida Administrative Code.

( ) 3. Submit for this facility, each calendar year, on or before March 1, an emission report for the preceding calendar year containing the following information:

(A) Annual amount of materials and/or fuels utilized.

(B) Annual emissions.

(C) Any changes in the information contained in the permit application.

FS19
1-74

FIGURE 4-12
TYPICAL FORM FOR COMPLIANCE SCHEDULE

CHAPTER 5

STACK EMISSION MEASUREMENTS

5.1 Introduction

Measurement of pollutant emissions in the stack of an industrial process, often called "stack testing," "source sampling," or "emissions testing," provides for industry management the data required for several determinations:

1. Losses of product through the stack,
2. Efficiency of control equipment, and
3. Compliance/noncompliance with emission regulations.

Methods for manual measurement of emissions from point sources are becoming increasingly sophisticated, although such practices still remain an art rather than a science. Requirements for emissions testing are becoming more stringent, and quality assurance programs are being initiated at all levels of government to ensure control of testing procedures, transport of samples, and laboratory analysis.

This chapter provides background information on the concepts, techniques, and quality control requirements involved in an industrial emissions sampling program. Although no attempt is made in this guide to provide a training manual on emissions testing, these discussions should provide the knowledge that is needed to formulate an industrial testing program, secure the services of a professional test team when one is required, and obtain the data needed to determine a plant's compliance status.

Each industry produces an identifiable "fingerprint" in the air pollutant spectrum, emitting particulates, gases, or both in characteristic combinations. The experienced observer is aware, for example, that an asphalt plant emits particulates of a certain type, and that a paint spray booth emits hydrocarbons in the form of solvent vapors. He also recognizes that certain sources may produce major emissions of specific pollutants and only minor emissions of others. The principal emissions from a phosphate chemical processing plant, for example, are particulates, sulfur dioxide, and fluorides; minor emissions from the same plant will include ammonia and sulfuric acid mist, which are of secondary concern.

In formulating an emissions testing program and determining what emissions should be measured, the industrial planner must consider these factors:

1. The plant's major emissions sources,
2. Sources having an impact on sensitive receptors,

3. Local, state, and federal regulations, and

4. Community environmental concerns.

A basic concept of manual emissions testing is that a representative portion (sample) is taken from a pollutant-laden gas stream being exhausted from a stack or other duct to the atmosphere. The purpose is to determine the total mass emission rate or concentration of a pollutant in a form dictated by the applicable emission regulations. Regulations limiting emissions to a specified value in parts per million (ppm) or grains per standard cubic foot (gr/scf) require that the concentration of the pollutant be determined. Regulations limiting emissions to a specified value in pounds per hour or total mass emissions require that the concentration and the total flue gas volumetric flow rate be determined.

In obtaining the sample, a sampling tube or probe is placed in the stack and the sample is extracted. This sample is then subjected to analysis, usually in a laboratory. Analysis of the sample gives the concentration of the pollutant in the gas stream. Calculating the total mass emission rate requires measurement of the volumetric flow rate, which can be expressed by:

$$\text{pmr} = C_s \times Q_s$$

where:

pmr = the total pollutant mass emission rate

C_s = concentration of the pollutant in the gas stream

Q_s = volumetric flow rate of the entire gas stream out of the stack to the atmosphere.

A sampling apparatus is designed for a specific sampling method to provide data that display the test results in the desired form.

Throughout the discussion of emissions testing, the concept of representativeness is emphasized repeatedly. For an emissions test to be representative, the following criteria must be met:

1. Process and control equipment must be operated in such a manner as to produce representative emissions. Many regulatory agencies require that the process be run at the "maximum normal production rate" during the emission tests.

2. Locations of the sampling site and sampling points must provide samples representative of the emissions.

3. The sample collected in the sampling apparatus must be representative of the sampling points.

4. The sample recovered and analyzed must be representative of the sample collected in the sampling apparatus.

5. The reported results must be representative of the sample recovered and analyzed.

A sample obtained in an emissions test represents a very small fraction of the total gas stream exhausted to the atmosphere; sample volumes may be as small as 0.002 cubic meter. Since only a very small portion of the total pollutant is collected during a test, a high degree of skill and knowledge is required to obtain a representative sample. Complex sampling and analytical procedures also require competent and experienced personnel, since any error in the sample is multiplied many times when related to the total exhaust flow. Recognizing the need for skills and experience in an emissions test team, the industry planner is faced with an important decision: whether the test should be conducted by in-house personnel or by a consultant testing group. Following are some considerations affecting this decision.

5.2 Utilizing Consultants and Testing Service Organizations

Many companies engage consultants or service organizations to supplement their own staff in such specialized areas as law, advertising, and accounting. Consultant groups are also available to assist in an environmental program by performing emission tests, evaluating emission control systems, determining environmental impacts, and related services. Depending on their experience and capabilities, such firms can provide a variety of services on an intermittent or continuing basis (1). A service that should be strongly considered for contracting to an outside firm is emission testing, especially for initial or intermittent test work.

5.2.1 Contract or In-House Testing Considerations

In considering the use of an outside testing service, a company must evaluate the following factors:

1. Availability and experience of in-house staff,

2. Availability of test and analytical equipment and work area in-house,

3. Utilization of test data,

4. Estimated cost of in-house versus outside service,

5. Estimated total amount of testing (number of sources and repetitions),

6. Restrictions imposed by labor unions,

7. Safety and employee insurance,

8. Proprietary nature of processes to be tested, and

9. Plant security.

Any one of these factors (and possibly others) could be decisive in the choice of in-house versus outside services; a combination of factors usually affects the final decision.

Availability and experience of in-house staff are two primary factors. Personnel with chemistry or engineering backgrounds could be trained in a 4-day introductory course, for a fee of approximately $500 (plus salary of personnel), together with participation in preliminary or practice runs to gain experience. In-house staff could also gain experience by working closely with a service company for a few initial test series. "Hands-on" testing should be supported by a thorough understanding of the principles involved in obtaining a representative sample. An alternative to training staff personnel is to hire personnel experienced in emission testing, however, such personnel are not easily found.

Availability of testing and analytical equipment also takes high priority in the decision to stay in-house or go outside for emission testing. The cost of particulate and gaseous sampling trains, calibration devices, and analytical equipment is approximately $12,000. If an in-house laboratory already is equipped with basic analytical tools, such as a balance, dessicator, and colorimeter, and with a suitable work area, the cost of sampling equipment would be about $7,000. The availability of staff members with skills and experience in sample analysis must also be considered.

Utilization of test data is sometimes ignored in the planning of emission tests. For approximate data-gathering functions with a flexible schedule, a relatively inexperienced staff may be adequate. Only an experienced test team can provide precise engineering data or perform compliance testing. Testing by a third-party team often satisfies the needs of both the plant owner and the control agency for impartial, accurate emission test data.

The cost of emission testing is always an important consideration. Unfortunately, a direct cost comparison of in-house and outside testing is difficult. Many costs, such as those for equipment, space, and fringe benefits, must be added to direct salaries to arrive at estimated testing costs. Also, costs per test vary widely with the number and type of tests and with accessibility of the test site. A 1973 article summarizing costs for emission testing services states the following conclusions (2):

1. A firm doing more than $60,000/yr of testing per location with an environmental testing firm should consider performing most of the tests in-house and using the test consultant as an auditor.

2. A firm doing $20,000 to $60,000/yr of testing work should investigate in-house testing, particularly if it has idle or under-used man-hours.

3. A firm doing less than $20,000/yr of testing will find that the use of testing services is almost invariably more economical than in-house testing.

A key factor in assessing cost is the number of tests to be performed over a given time period. For a long-term program that involves frequent testing, the use of in-house personnel is usually more cost-effective.

Employee job functions or descriptions and applicable labor union rules also affect decisions regarding test work. Emission testing is not usually covered in descriptions of routine job or trade functions. Although job functions are negotiable, such negotiations can be time-consuming and, for a brief test series, not worth the potential problems. Employee safety and possible insurance problems must also be considered. Personnel performing emission testing are required to use safety gear; they also must carry heavy equipment and often must work from platforms above ground or at roof level. Exposure to toxic fumes, electrical wires, and inclement weather may add to the hazards of testing. Special safety precautions and great care are required to prevent serious injury (3).

Testing of highly proprietary processes may necessitate the use of in-plant personnel to maintain confidentiality of the process or the emission data. Although this problem may be overcome by requiring secrecy agreements with outside testing personnel, some risk is still incurred. Plant security procedures that restrict the admittance of outside personnel could present a problem in gaining entrance for contractor personnel into some areas of a plant, especially where classified governmental work is performed.

Some less tangible considerations are also involved in deciding whether to engage an outside test consultant:

1. A consultant organization might act as a third party in negotiations with a state, local, or federal air pollution control agency.

2. Where the company has poor rapport with control agency personnel, an outside test firm could be used to advantage.

3. A consultant firm would provide assistance in related environmental matters concerning, for example, potential regulatory actions, evaluation of control systems, occupational safety and hygiene problems, and water pollution aspects of emission controls.

5.2.2 Selecting Consultants and Testing Services

Selection of a consulting firm requires that the industry specify exactly what is to be done and determine what specific applicable experience is offered by various consulting firms. The effort expended in selection of a consultant varies with the amount and nature of the work to be performed. For short-term, relatively simple tasks, selection may be based upon phone contact and a review of capabilities. For more extensive and complex tasks, a carefully prepared bid solicitation is desirable.

Recommendations of business associates, trade and technical associations, and past clients of a consulting firm can influence the selection. A firm's promotional literature usually describes facilities, capabilities, and experience. Written responses from prospective consultants should include:

1. A statement of the objective of the study or task,
2. The procedures to be followed,
3. A schedule for completing these procedures,
4. An estimate of effort and costs, and
5. Specific capabilities or staff experience.

The hiring firm can require that all test methods, equipment, and test reports be acceptable to and approved by the responsible air pollution control agency. Such requirements would cover equipment calibration, use of the test methods required by the agency, test program preparation, quality control, chain of custody of samples, calculation procedures, and report format and content. Ideally, a prospective contractor will provide for review an earlier test report prepared by the firm. Control agency personnel usually can assist in procuring an emission testing service by listing a number of capable companies in the local area. It is advisable to visit the prospective test company to inspect the equipment calibration area and laboratory.

Suppliers of pollution control and related equipment sometimes offer consulting and testing services. Although these companies may offer extensive experience, they may not be completely objective in recommending a method of control or in evaluating an existing device. In addition, if confidentiality is involved, it may not be prudent to divulge process information to a company that also deals with competitors.

5.2.3 Obtaining Emission Testing Services

Written requests for emission testing services should be submitted to candidate companies. These written requests should specify:

1. What is to be tested, i.e., boiler, process, or other;
2. Plant location;
3. Purpose of test;
4. Compounds to be measured (if known);
5. Details of the test site, such as height of test ports, stack diameter, platform dimensions, approximate gas temperature, and other details of the work area; and
6. Desired test and report dates.

On the basis of specifications, the testing firms will submit proposals and specific qualifications.

Purchase of emission testing services can be accomplished on a fixed-cost basis for a well-defined task, or on a man-hour basis for a task whose scope is not yet defined. Estimated total costs or average hourly rates will allow comparison of bids from various respondents. Cost estimates for a given task do not usually vary widely among competent testing consultants, since the same amount of work is required by persons with similar salaries.

To ensure that estimated costs are not exceeded, the plant officials must assume certain responsibilities:

1. Maintenance of constant process operation for the duration of each test.
2. Provision of unobstructed sampling ports for access to the gas ducts. A minimum 3-inch opening is required at the locations requested by the test engineer.
3. Provision of 110-volt, 25-ampere electrical supply at the sampling site.
4. Provision for access to the sampling site and safe working conditions.
5. Prompt clearance of personnel, vehicles, and equipment through plant security.

5.3 Planning and Conducting the Emission Test

5.3.1 Sequence of Events in an Emissions Test

Three groups are involved in the planning and execution of a compliance test: representatives of the plant whose emissions are being tested, the testing team (consultant or in-house), and the responsible control agency. Each of these groups has specific responsibilities in performance of the test. The plant representative is responsible for monitoring and recording facility operations and for collecting process samples, such as samples of feed materials used during the test. The test team sets up the sampling equipment, performs preliminary measurements, conducts the sampling runs, recovers collected samples, and disassembles the equipment. The test group is also responsible for analysis of samples and reporting of results. The control agency representative is responsible for guidance before and during the test, for evaluation of sampling procedures, and for taking readings of visible emissions during the test. The usual sequence of events is described briefly in the remainder of this section.

Before the compliance test, representatives of each group conduct a pretest meeting to develop testing procedures, establish conditions of facility operation, determine data requirements, and formulate a test schedule. All responsibilities for specific tasks are determined in detail at this meeting. A test program detailing the elements discussed at the meeting should be prepared by the test group.

A compliance test consists of three sampling runs, preceded by preliminary measurements to check the test equipment. The normal time requirements for each phase of the test are shown in Table 5-1. A usual sequence of events would be completion of tasks 1, 2, 3, and 4A or 4B for the first run; task 2 (optional), 3, and 4A or 4B for the second run; and task 2 (optional), 3, 4A or 4B, and 5 for the third run. If the test team is well-equipped, it will not be necessary to recover the collected samples until all runs are completed.

TABLE 5-1
TIME REQUIREMENTS FOR COMPLIANCE
TEST EXECUTION

Task No.	Task	Time required
1	Set up equipment	2-4 hr
2	Make preliminary measurements	1 hr
3	Conduct one sample run	1-4 hr
4A	Recover sample and set up for next run	1-3 hr
4B	Set up for next run without sample recovery	1-2 hr
5	Disassemble and pack equipment	1-2 hr

Under ideal conditions, it is possible to set up the equipment and make all three runs in one day. A more usual sequence, however, is to set up the equipment on the morning of the first day and perform one sample run in the afternoon. The test team then can review the data from the first run that night to determine whether the tests are yielding valid data. The second run is then made on the morning of the second day, and the last run in the afternoon.

When all testing is completed, the sampling equipment is disassembled and removed from the site. The equipment is carefully repacked to ensure safe transport. Transport is especially critical if the collected samples are not recovered on site. A professional testing firm will usually provide preliminary test results in about 1 week and a final report in 2 to 3 weeks.

The emission test procedures are described in detail in the following sections.

5.3.2 Developing the Test Program

At the outset, all of the groups involved in emission testing should understand the potential legal implications of the compliance test. Because of the possibility that test results or the control agency's decision might be challenged, full understanding among the concerned parties should be achieved and documented before the test is performed.

Upon notice from the plant representative that a compliance test is intended, the control agency will prepare written guidelines that clearly delineate the acceptable sampling procedures. These guidelines will inform the test team and the plant representative of all baseline or minimum conditions to be met in the test and will indicate procedures for calculation and reporting of test data. The requirements may be part of an overall regional compliance schedule or they may be stipulated in a Federal Standard for New Source Performance (NSPS).

On the basis of specified requirements, the plant representative and test consultant will develop a proposed compliance test program, which will be discussed with an agency official in one or more pretest meetings. One of the most significant items to be determined is what constitutes representative facility operation.

Determining Representative Facility Operation – Representative facility operation must be specified in detail before the test, for the protection of both the facility and the control agency. Facility operations are defined to include the key process operating parameters and the operation of air pollution control equipment. An emissions test can be set up both to determine the plant's compliance status and to verify the efficiency of control equipment in fulfillment of the vendor's guarantee. If the latter is part of the test program, samples sometimes must be taken both before and after the control equipment. In any case, the test team must be apprised of all criteria to which the test data will be applied.

Where the facility is new or is a modified older facility, the plant operators must provide for the control agency the anticipated facility operating conditions in order to obtain a permit to construct and/or operate. The specified facility operations will then be monitored and recorded during the compliance test and later will be routinely monitored as part of the continuing compliance program.

Most control agencies have developed standard facility checklists for each of the major industrial processes and pollution control systems. Figure 5-1 is a standard cover sheet identifying the persons who will represent the plant, the test team, and the control agency. It also identifies the persons in each group who have senior responsibility and authority in matters pertaining to the compliance test. Most communications regarding the test will be among the representatives; higher authority is usually sought only in the event of disagreement regarding validity of the test or in other special circumstances.

Figure 5-2 is a general "Test Program Agreement on Continuing Compliance Conditions" form, setting forth the operating conditions that must be met in the future for the plant to maintain compliance. This information provides the basis on which to establish the representative facility operations for the test, as shown in Figure 5-3, "Test Program Agreement on Facility Operation". A specialized checklist series for coal-fired boilers is presented in Appendix B.

In determining representative facility operation, the plant representative has several important responsibilities. He should know all aspects of plant operation well enough to

TEST PROGRAM MEETING REPRESENTATIVES

Plant Name ______________________ Date ____________

Plant Address ______________________

Source to be Tested ______________________

Plant Representative ______________________ Phone ____________

Plant Manager ______________________ Phone ____________

Test Team Company Name ______________________

Team Representative ______________________ Phone ____________

Responsible Person ______________________ Phone ____________

Members of Test Team	Title

Agency(s) ______________________

Agency Representative ______________________ Phone ____________

Responsible Person ______________________ Phone ____________

Agency Observers	Affiliation and Tasks

FIGURE 5-1
TEST PROGRAM MEETING REPRESENTATIVES

TEST PROGRAM AGREEMENT ON CONTINUING COMPLIANCE CONDITIONS

Process

1) Process parameters that must be recorded and submitted to agency or kept on file for later inspection

2) Percentage by which each process parameter can exceed the tested rate and on what time-weighted average

3) Future operating procedures

Control Equipment

4) Control equipment parameters that must be recorded and submitted to the agency or kept on file for later inspections

5) Normal operating procedures

6) Normal maintenance schedule

7) Frequency of scheduled inspections by agency

Reviewed and approved by:

Agency____________________Facility____________________Tester____________

FIGURE 5-2
TEST PROGRAM AGREEMENT ON CONTINUING COMPLIANCE CONDITIONS

anticipate any potential problems. He should make sure that all values specified for operations that could cause upset conditions are outside the acceptable values. If these operations then should cause upset conditions during the test, the test data cannot be used against the plant in any future litigation. Documentation of upset conditions during testing is important, since a control agency's compliance test report can be used as evidence by any public or private group or individual at a later date.

TEST PROGRAM AGREEMENT ON FACILITY OPERATION

Process

1) Method of process weight or rate determination

2) Process parameters to be monitored and recorded, and their acceptable limits to document process operation

3) Raw material feed and/or fuel acceptable analyzed values

4) Normal operating cycle or procedures

5) Portions of the operating cycle or procedure that will be represented by each run

Control Equipment

6) Control equipment and effluent parameters to be monitored and recorded, and their acceptable limits to document control equipment operations

7) Normal operating cycle (cleaning, dust removal, etc.)

8) Normal maintenance schedule

9) Manner in which the control equipment will be operated during test

FIGURE 5-3
TEST PROGRAM AGREEMENT ON FACILITY OPERATION

Although some control agencies have the authority to establish unilaterally the operating conditions for a compliance test, the agency representative usually seeks input and agreement from the plant representative. If the agency does not, and the plant representative believes that the stipulated operating conditions are unjust, then the company should notify the agency of its objection by registered letter. Although the test may be conducted under the disputed conditions notwithstanding the objection, the plant would then have the right to contest the results in court if the agency has been notified prior to testing.

Another point of significance to the industry being tested is that the agency should not require the monitoring and recording of any parameter of process operation unless that parameter has a direct bearing on process rate or on atmospheric emissions. If the agency representative proposes the monitoring of parameters that seem not directly related to process rate or emissions, it is appropriate to ask how the resulting data will be used and what values would be considered unacceptable.

Future Facility Operations – Future operations of the plant must be factored into the determination of representative conditions. If the plant has been operating for some time and significant changes are anticipated, the compliance test should be geared to future operations. For example, a plant that has been firing high-sulfur coal may plan to switch to using low-sulfur coal as part of a compliance program. The agency will allow firing of the low-sulfur coal during the compliance test if assurance is provided that this coal will be representative of the plant's future operations. Similarly, use of a new type of solvent could be introduced into plant operations to reduce hydrocarbon emissions. Use of the new solvent in the compliance test would be allowed if the plant then continued its use in regular operations. A statement of future operations is included in the "Test Program Agreement on Continuity Compliance" form (Figure 5-2). Failure of the plant officials to consider such potential changes in operation could lead to significant expenditures of time, money, and effort in the event that retesting is required because of such a change.

At the conclusion of the final test program meeting, all of the parties involved should clearly understand how the test will be conducted, the sampling procedures to be used, the operating parameters to be monitored and recorded, the raw materials to be fed to the process, and any conditions that would invalidate the test. With the testing program agreed upon and defined in detail, the compliance test should proceed smoothly and should yield valid results.

Measurement Errors – In further preparation for the compliance test, the plant representative should understand the significance of measurement errors that might occur. Although such errors can be minimized by selection of an experienced testing firm, they rarely can be eliminated entirely. Determining pollutant emission rates by stack sampling involves measurement of a number of parameters. Errors of measurement associated with each parameter combine to produce an error in the calculated emission rate. Measurement errors are of three types: bias, blunders, and random errors.

Bias errors, usually resulting from poor technique, cause the measured value to differ from the true value in one direction. This operator error often can be minimized by proper calibration of instruments and by adequate training in instrument operation. Most bias errors can be eliminated if the testing supervisor provides documentation of the calibration of equipment at the pretest meeting. A one-point field check of calibration is sometimes warranted.

Most blunder errors occur during collection, recovery, or transportation of the sample or during analysis. Unfortunately, such errors are difficult to observe, and the total effect cannot be calculated. Elimination of blunders should be a main concern of the testing supervisor. The plant representative also should be alert to possible blunders.

Random errors, which result from a variety of factors, cause a measured value to be either higher or lower than the true value. Such errors are caused by inability of sampling personnel to read scales precisely, poor performance of equipment indicators, and lack of sensitivity in measurement devices. The usual assumption is that random errors are normally distributed about a mean or true value and can be represented statistically in terms of probabilities. Determining the maximum expected error, however, does not require a strict statistical approach. Total maximum error can be estimated by summing the maximum expected errors for each factor.

The impacts of measurement errors on test results can vary greatly. With some parameters, such as static pressure of the stack gas, the error may be ±100 percent and still not affect the results appreciably. Conversely, a blunder error that might seem insignificant, such as bumping the sampling apparatus against the inner stack wall, could produce emission values that are 10 times higher than the true emissions.

In an effort to minimize errors, the sampling procedures prepared by control agencies include quality controls. Most of these quality controls, however, are designed to eliminate only the errors that produce a value lower than the true one, giving a low bias. It is the responsibility of the testing team to eliminate errors or procedures that produce results higher than the true value, giving a high bias.

5.3.3 Sample Site Requirements

The sampling site designated for an emissions test can affect the quality of the sample extracted. Site selection should be simple at new installations, since most states require installation of an acceptable sampling site as a condition for obtaining a construction permit. Acceptability is generally determined with reference to the distance from the nearest upstream and downstream disturbance to gas flow by an obstruction or change in direction. More sampling points are required for each test the closer it is to a disturbance, as shown in Figure 5-4.

In addition to flow considerations, accessibility and safety are important. Clearance for the probe and sampling apparatus, availability of electricity, exposure of personnel and equipment to weather or excessive heat, presence of toxic or explosive gases, and other safety factors must be considered. The following guidelines constitute minimum requirements for safe and accessible stack sampling facilities:

Sampling Ports –

1. Port location – Ports should be located at least eight stack diameters downstream of any bends, inlets, constrictions, abatement equipment, or other flow disturbances and at least two stack diameters upstream of the stack exit or other flow disturbances. Where these

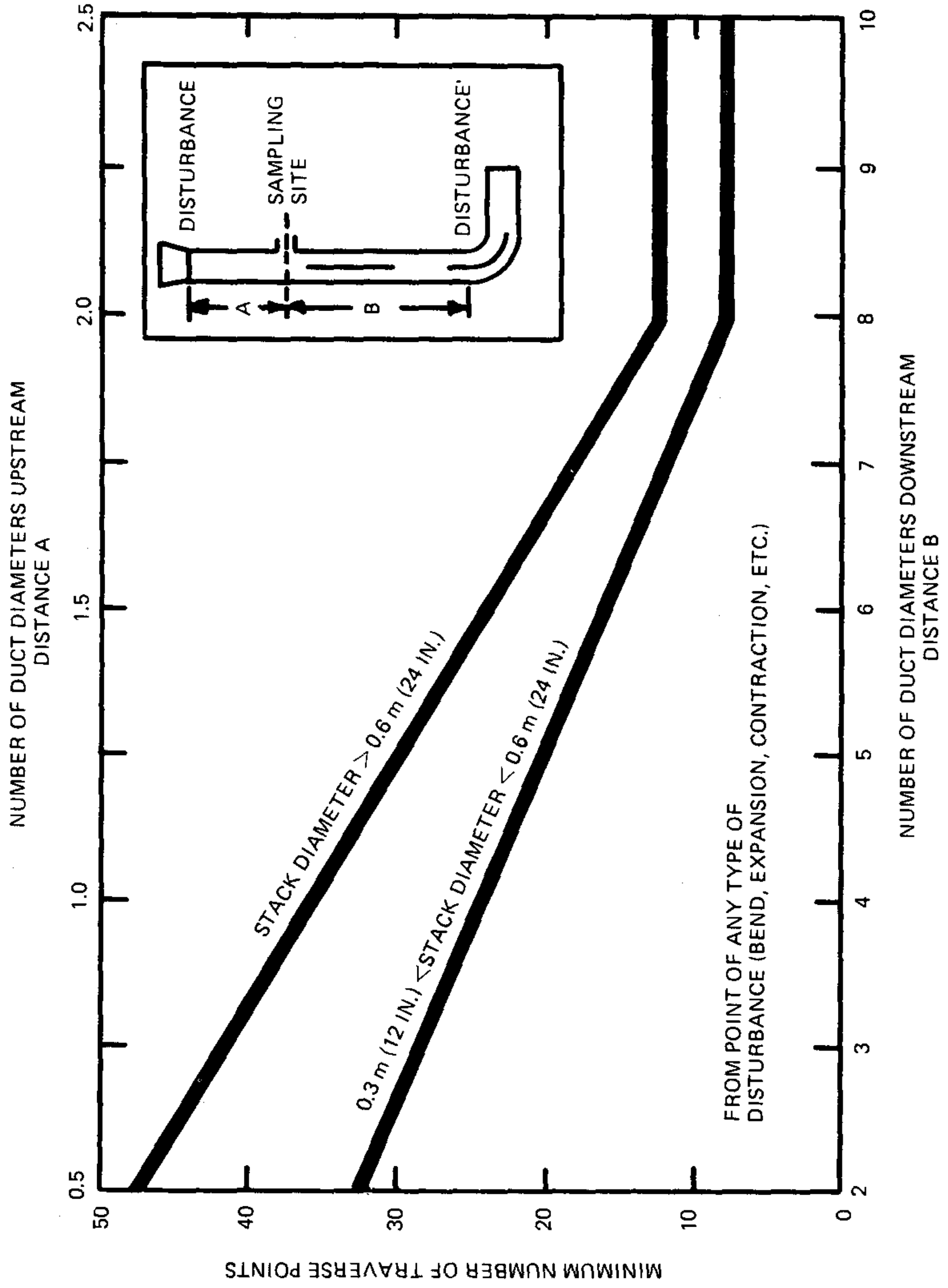


FIGURE 5-4
MINIMUM NUMBER OF SAMPLE POINTS

criteria are not met, a stack extension may be required unless the plant representative can demonstrate that this remedy is not feasible. In such a case, an alternative port location must be approved by the control agency.

2. Port type – A sampling port should be a standard industrial flanged pipe of 3-inch inside diameter (ID) with a 6-inch bolt circle diameter. An easily removable blind flange should be provided to close the port when not in use. Ports larger than 3-inches ID are permissible and even desirable on large-diameter, double-walled stacks, which necessitate use of longer probes. These ports also should be equipped with a standard industrial flange of the same ID as the port. Gate valves should be installed only when unusual stack conditions or the presence of hazardous materials require such devices to ensure safety.

3. Port installation – Ports should be installed flush with the interior stack wall. Ports should extend outward from the exterior stack wall no less than 2 inches nor more than 8 inches, unless additional length is required for gate valve installation. Ports should be installed no less than 2 feet nor more than 6 feet above the floor of the platform. Ports should be installed with respect to the limitations of the clearance zone, described later.

4. Number of ports required – If the sum of the stack ID plus one port length (stack inside wall to end of port extension) is less than 10 feet, two ports should be installed on diameters 90 degrees apart. Proposed U.S. EPA guidelines for continuous monitoring of certain categories of sources may necessitate the installation of four ports on diameters 90 degrees apart for stacks in this size range. If the sum of the stack ID plus one port length (stack inside wall to end of port extension) is equal to or greater than 10 feet, four ports should be installed on diameters 90 degrees apart.

5. Port loading – The port installations should be capable of supporting the following loads:

a. Vertical shear of 200 pounds,

b. Horizontal shear of 50 pounds, and

c. Radial tension of 50 pounds (along stack diameter).

Work Platform –

1. Size and extent of platform – If two ports are required at 90 degrees, the work platform should serve that quarter of the stack circumference between the ports and extend at least 3 feet beyond each port. Minimum platform width is 3 feet. If four ports are required at 90 degrees, the work platform should serve the entire circumference of the stack. Minimum platform width is 4 feet unless the sum of the stack ID plus one port length (stack inside wall to end of port extension) is less than 10 feet, in which case the minimum platform width is 3 feet.

2. Platform access – Safe and easy access to the work platform should be provided via caged ladder, stairway, or other suitable means.

3. Guardrails, latterwells, and stairwells – A safe guardrail should be provided on the platform. Angular rather than round rail members should be used if possible. No ladderwell, stairwell, or other such opening should be located within 3 feet of any port. Ladderwells should be covered at the platform and any stairwell leading directly to the platform should be equipped with a safety bar (or the equivalent) at the opening.

4. Platform loading – The work platform should be able to support at least three men and 200 pounds of test equipment (at least 800 pounds total). If the stack exits through a building roof, the roof may suffice as the work platform, provided the minimum test site requirements are still met. In such cases, all other requirements are the same as for a remote stack.

Clearance Zone – A three-dimensional, obstruction-free clearance zone should be provided around each port. The zone should extend 1 foot above the port, 2 feet below the port, and 2 feet to either side of the port. The zone should extend outward from the exterior wall of the stack to a distance of at least one stack ID plus one port length (inside wall to end of port extension) plus 3 feet. The clearance zone is illustrated in Figure 5-5.

Power Supply – Power sources shall be as follows:

1. Platform – One 115-volt, 15-amp, single-phase, 60-Hz AC circuit with a grounded, two-receptacle weatherproof outlet. Receptacles should accept standard, three-prong, grounded, household-type plugs, or else suitable adapters shall be provided.

2. Stack base – One 115-volt, 30-amp, single-phase, 60-Hz AC circuit with a grounded, two-receptacle weatherproof outlet. Receptacles should accept standard, three-prong, grounded, household-type plugs, or suitable adapters shall be provided.

Vehicle Access and Parking – Except for situations in which sampling operations must be conducted from a rooftop or similar structure, stack sampling is sometimes coordinated and controlled from a cargo van or trailer, which is parked near the base of the stack for the duration of the sampling period. Vehicle access and parking space must be provided, since various umbilical, communications, and equipment transport lines will be strung from the van or trailer to the stack platform and will remain in position during the operations.

Compliance With Safety Standards – Stack sampling facilities must meet all applicable Occupational Safety and Health Administration (OSHA) requirements and must conform to any other relevant safety guidelines.

Optional Permanent Monorail System – Some plants may wish to install a permanent monorail system to facilitate self-monitoring. Persons considering such installations should be aware that commercially available test equipment varies in size and configuration and will not necessarily operate on a permanent monorail system as shown in Figure 5-6.

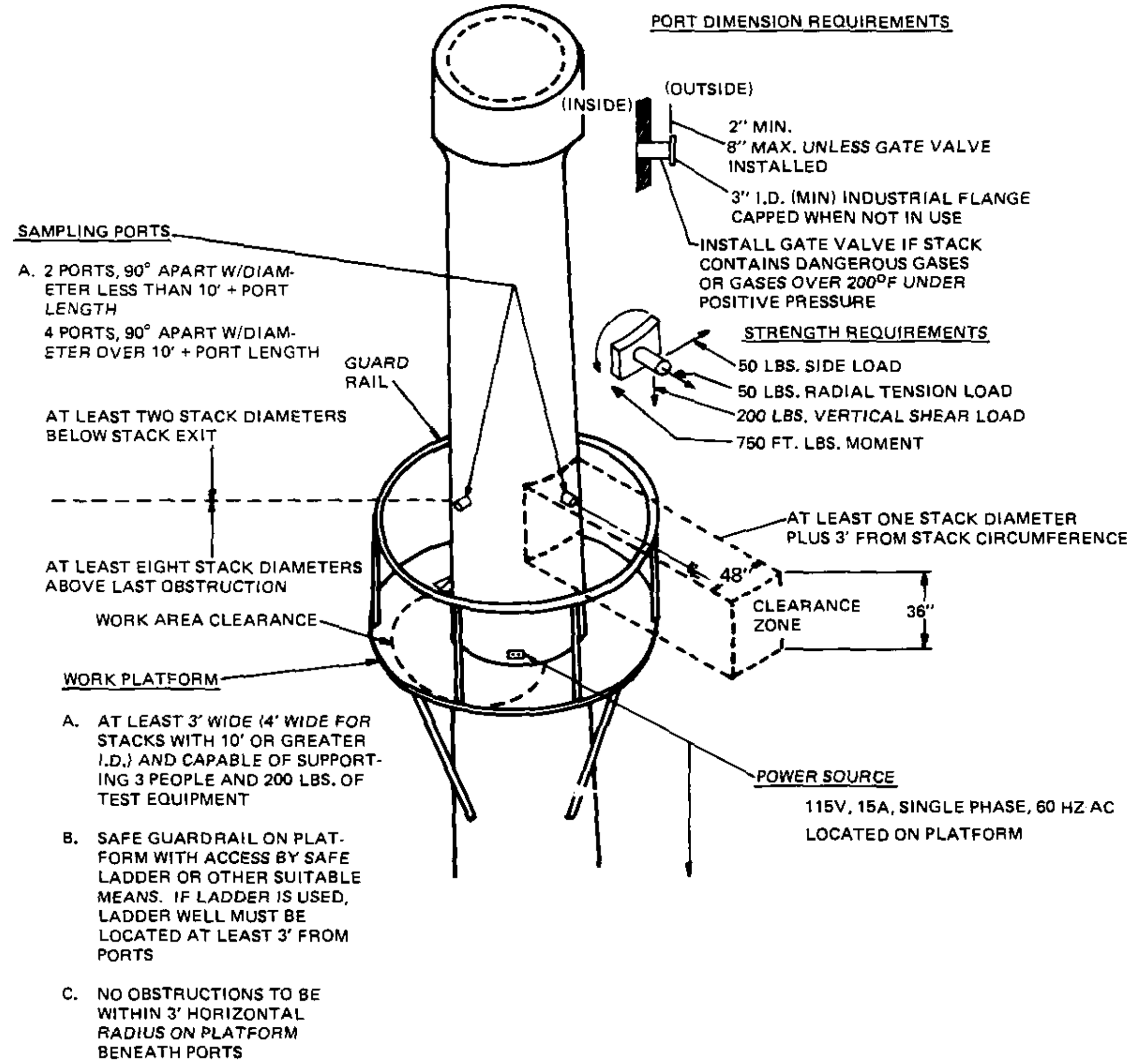


FIGURE 5-5
TYPICAL SAMPLING PROVISION

Miscellaneous Requirements – In addition to the specific requirements described in this section, other requirements may be specified for sources with very large stacks or nonstandard sampling locations. Examples of such requirements are:

1. Power hoists for sampling equipment when the platform is in excess of 200 feet above ground level.

2. Additional attachment points above and to each side of the ports for supporting very long monorails.

3. Provisions for sampling vertically in horizontal ducts.

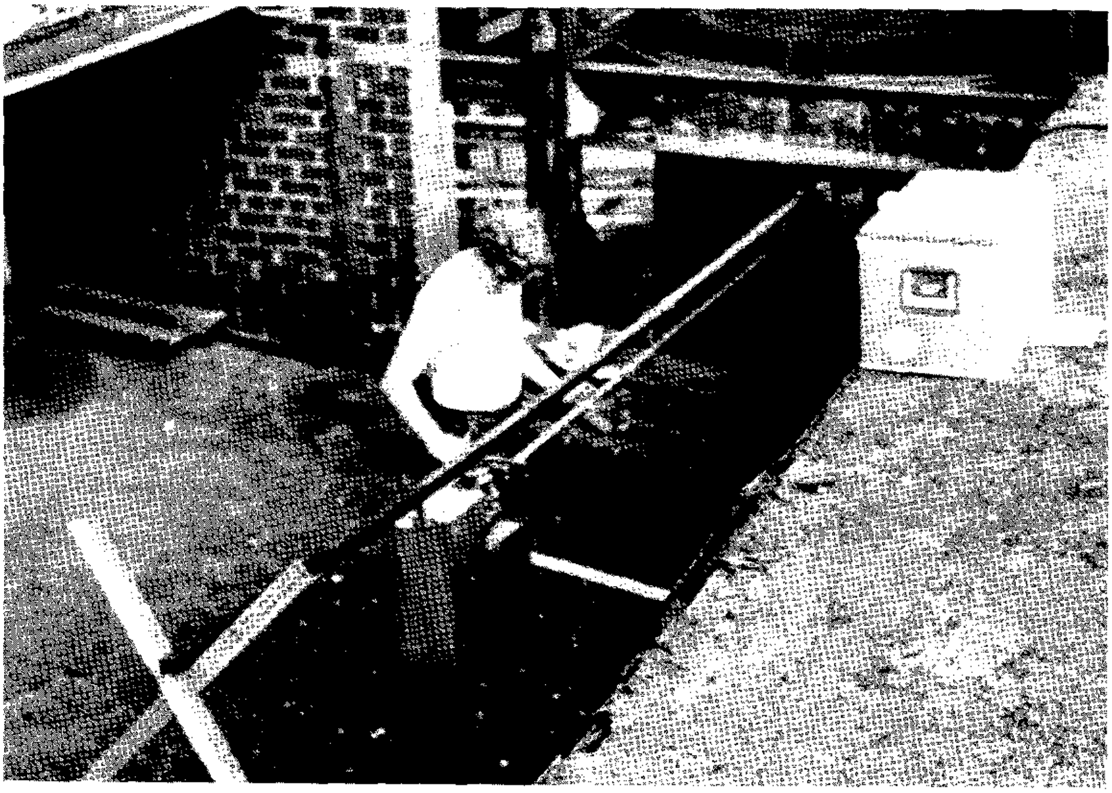


FIGURE 5-6
MONORAIL SYSTEM

Excess Air – In addition to the above requirements, certain processes (such as sulfur recovery units) may require provisions for determining the composition and flow rates of feedstock streams. This information, taken at the time of sampling, is needed to determine the amount of excess air in the stack effluent.

Stack Extensions – Many times the maximum straight run of stack is not sufficient to meet the agency requirements or the stack is lined and ports cannot be cut into the stack. A simple solution applicable to some smaller-diameter stacks is the use of a stack extension as shown in Figure 5-7. Stack extensions need not be permanent and can be made out of sheet metal or plywood for testing purposes only.

5.3.4 Conducting the Emissions Tests

At the time of the compliance test, the plant representative has two major responsibilities: (1) to ensure that process operations are in accordance with the representative conditions established in the test program, and (2) to ensure that the emissions sampling is performed as planned. Although the latter is the direct responsibility of the test team supervisor, the plant representative should observe these sampling operations closely enough to be confident that the specified procedures are followed. Again, the use of checklists is advised; these can be used by an in-house test team for quality control.

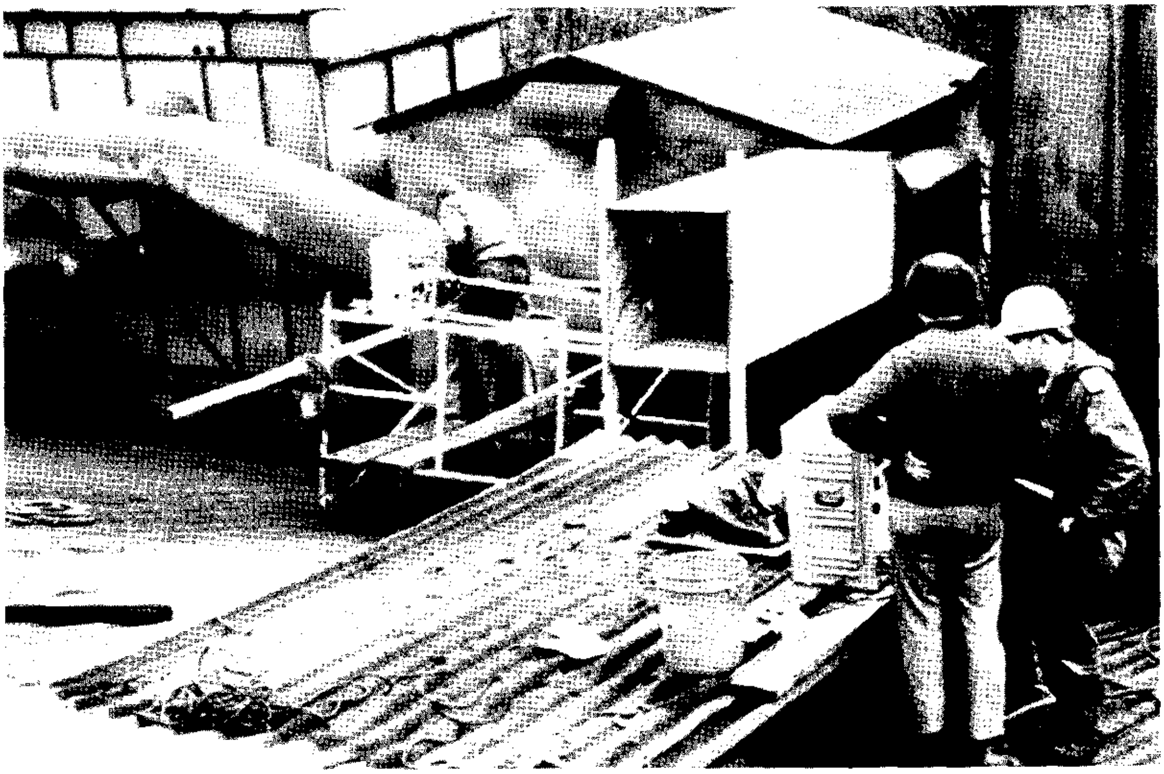


FIGURE 5-7
STACK EXTENSION

Starting the Test – The plant representative should be present when the test team starts preparations. They will unpack the test equipment, check for possible damage, set up the sample recovery lab, and assemble the sampling train. If an agency observer is present, he will give close attention to these initial operations. His monitoring of test procedures protects the interests of both the agency and the operating facility. If the test team requires considerable direction and assistance from their supervisor, this is an indication of inexperience and a signal to the plant representative to observe test operations as well as process operations. In such a case, he may request the assistance of another plant official during the test. A standard test team and equipment for particulate sampling is shown in Figure 5-8. A checklist for observation of calibration, sample apparatus assembly, and final checks is shown in Appendix B. If testing is performed improperly, the agency observer may require performance of another sample run. Any additional sampling necessitated by improper sampling techniques should be performed at the expense of the testing firm as part of the contract agreement. Any responsible testing firm will be willing to guarantee that all sampling procedures will be acceptable to the control agency.

In the course of the test, all parties are expected to perform their duties quietly and thoroughly, with as little conversation as possible. The plant representative should instruct all process operators to deal solely through him during the test and to discourage queries or comments from any of the nonplant personnel. In particular, the operators should make no

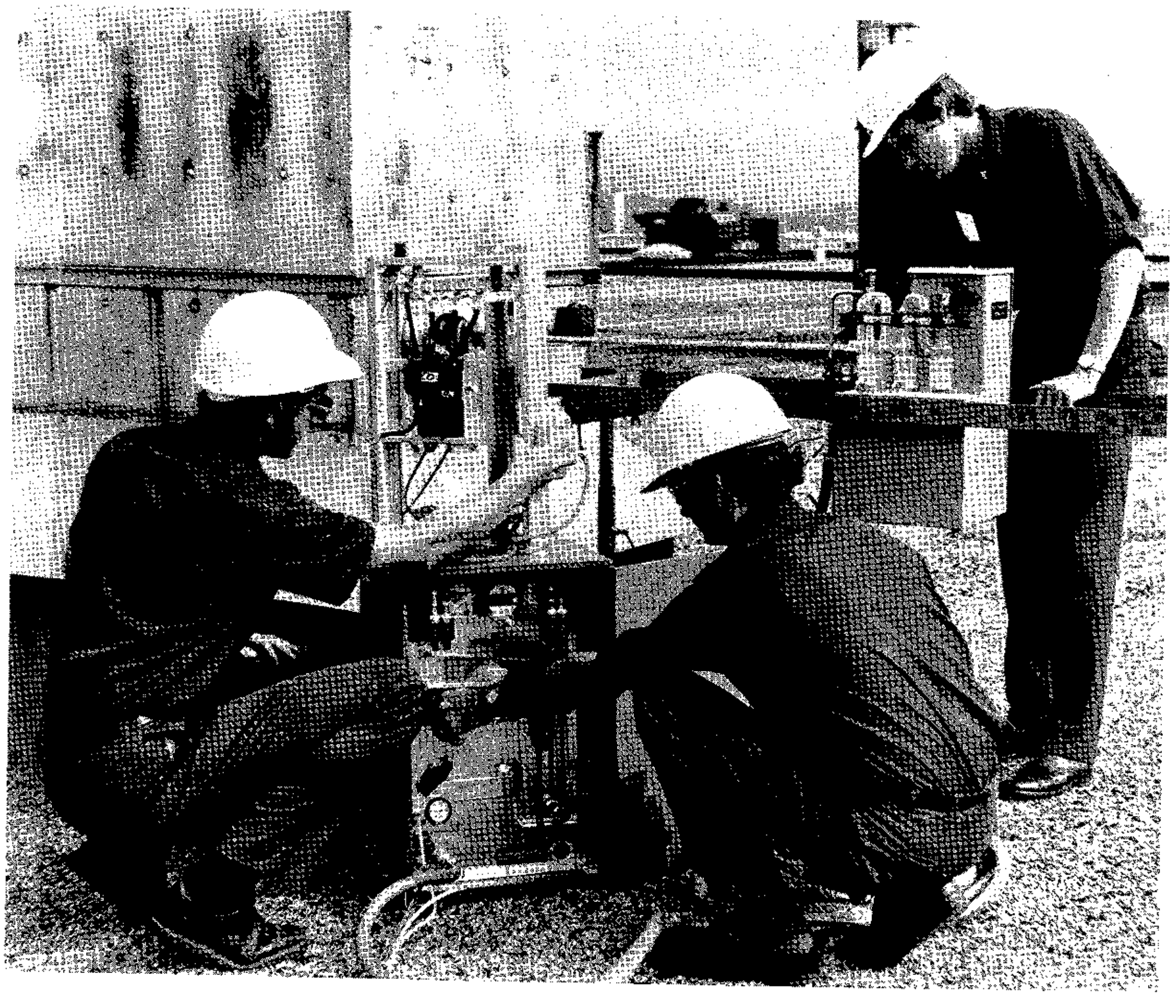


FIGURE 5-8
TEST TEAM AND EQUIPMENT

process change, even at the request of the agency observer or test team supervisor, without approval of the plant representative. The same courtesy should be extended to the test team, who should not be questioned or instructed by any person except their supervisor.

Monitoring Facility Operations – With some assurance that the test team is functioning as planned, the plant representative will give his major attention to facility operations during the test. Plant personnel are responsible for these functions: (1) monitoring and recording the process parameters as specified in the test program, (2) collecting process raw materials for subsequent analysis, and (3) monitoring the operation of control equipment. Functions of the test team are clearly defined and should not interfere with process operation. The chief responsibilities of the agency representative are to observe and to record data.

It is not possible to formulate for all industrial operations a general checklist of process parameters. These are highly particular to the plant process and are dictated also by the applicable control regulations. One can, however, consider examples of process data checklists for specific industries. The process parameters that are monitored and recorded should demonstrate whether the facility is operating in a manner that is considered normal for future operations.

If an equipment malfunction or upset should occur, the agency observer and test team leader should be notified immediately. The resulting sample run should be invalidated and no analysis performed. A charge of noncompliance could result from use of data taken during upset conditions. For this reason, the plant representative should in no circumstances allow the subsequent analysis of samples obtained during malfunction or upset. The cost of performing an additional sample run while the test team and sampling gear are on site is small compared with the cost of retesting at a later date.

Monitoring Control Equipment – Plant personnel are responsible for monitoring and recording control equipment parameters during the compliance test. Because of the broad range of control devices and techniques that are applied to industrial operations, the discussion and examples given here are directed toward particulate sampling only. Particulate control equipment can be categorized in several groups, based on similarities in the several types of equipment within each group. Typical checklists for basic categories of particulate control equipment are given in Appendix C, covering electrostatic precipitators, fabric filters, centrifugal collectors (dry mechanical collectors), and scrubbers (wet mechanical collectors), respectively. These checklists include most of the control equipment parameters that should be monitored and recorded during a compliance test.

Completing the Compliance Test – At the conclusion of each test run, the sample is recovered for laboratory analysis. Several types of errors can occur during sample recovery. The plant representative may refer to a sample recovery checklist (Appendix B) as a guide to evaluating the performance of the test team in these critical operations.

Many errors can be detected by simple observation. Spillage during sample removal, use of solvents in plastic containers, and handling of samples in an improper environment are examples of unacceptable procedures. A filter from a particulate sampling device should be dry. Where a control device is used and is operating properly, the filter should contain no distinct particles that are visible to the eye. The color of the sample catch should be approximately the same in each test run.

During recovery of samples from a compliance test, a chain of custody should be established and recorded. An example chain of custody sheet is shown in Appendix B. Such a sheet documents the events of sample recovery and can be used if litigation arises.

Transport of the samples from test site to the laboratory is also documented. A checklist for the purpose is shown in Appendix B. Except when the plant undergoing the compliance test is equipped with a suitable analytical laboratory, the plant representative usually does not observe the analytical procedures. An analysis checklist, which appears in Appendix B, shows the types of quality controls that are applied to analytical procedures by a professional testing team.

Before the test team leaves the site, the plant representative should obtain copies of all emission data sheets that have been filled out during the test runs. Similarly, he should if possible obtain a copy of data records and notes made by the agency observer; if copies are not available, he should review the observer's notes and data, and initial them. In reviewing these materials, the plant representative will check for any unusual data values or comments and for possible inclusion of confidential data. The agency observer is responsible for maintaining the confidentiality of the emissions values and process operating data, subject to the possibility of fines or other punitive measures in the event that confidentiality is violated. In summary, the plant representative should obtain copies of all data, logs, or comment sheets that will leave the premises. Alternatively, he should be given the opportunity to examine all such records, to designate any portions considered confidential, and to initial the records.

Compliance Test Report – The final step in compliance testing is preparation of the test report. This is the official record of the test, which can become a legal business record admissible in court. Many control agencies provide a standard report format such as that shown in Figure 5-9.

After the testing firm completes the test report, copies are forwarded to the client who requested the tests. The client is usually an industry, although enforcement agencies also engage consultants to perform emission tests. The industry funding the tests will have representatives review the report prior to submission to the control agency. The plant representative should review these reports closely and perform data validation checks as appropriate. These would include the same elements that are involved in a preliminary emission estimate: calculation of mass balances, process temperatures and pressures, fan curves, design parameters, and stoichiometry. Review of these elements will indicate any significant discrepancy in the test report data.

5.4 Specified Methods for Measurement of Pollutants

This section deals with the methods specified for sampling of particulates, sulfur dioxide, nitrogen oxides, fluorides, carbon monoxide, and hydrocarbons. It also briefly describes determination of velocity and volumetric flow rate, moisture content, and molecular weight of a gas stream. In all sampling procedures, the main concern is to obtain a representative sample; the U.S. EPA has published reference sampling methods for all of these pollutants except hydrocarbons so that uniform procedures can be applied in testing to obtain a representative sample.

Each sampling method requires the use of complex sampling equipment which must be calibrated and operated in accordance with specified reference methods. Additionally the process or source that is being tested must be operated in a specified manner, usually at rated capacity, under normal procedures. Calibration/operation of equipment and process operation are not considered in the brief descriptions that follow; they are nonetheless important in the emissions test.

SOURCE TESTING REPORT FORMAT

Cover

1. Plant name and location
2. Source sampled
3. Testing company or agency, name and address.

Certification

1. Certification by team leader
2. Certification by reviewer (e.g., P.E.).

Introduction

1. Test purpose
2. Test location, type of process
3. Test dates
4. Pollutants tested
5. Observers' names (industry and agency)
6. Any other important background information.

Summary of Results

1. Emission results
2. Process data, as related to determination of compliance
3. Allowable emissions
4. Description of collected samples
5. Visible emissions summary
6. Discussion of errors, both real and apparent.

Source Operation

1. Description of process and control devices
2. Process and control equipment flow diagram
3. Process data and results, with example calculations
4. Representativeness of raw materials and products
5. Any specially required operation demonstrated.

Sampling and Analysis Procedures

1. Sampling port location and dimensioned cross section
2. Sampling point description, including labeling system
3. Sampling train description
4. Brief description of sampling procedures, with discussion of deviations from standard methods
5. Brief description of analytical procedures, with discussion of deviations from standard methods.

Appendix

1. Complete results with example calculations
2. Raw field data (original, not computer printouts)
3. Laboratory report, with chain of custody
4. Raw production data, signed by plant official
5. Test log
6. Calibration procedures and results
7. Project participants and titles
8. Related correspondence
9. Standard procedures.

FIGURE 5-9

SOURCE TESTING REPORT FORMAT

5.4.1 Velocity and Volumetric Flow Rate

The U.S. EPA has published Method 2 as a reference method for determining stack gas velocity and volumetric flow rate. At several designated sampling points, which represent equal portions of the stack volume (areas in the stack), the velocity and temperature are measured with instrumentation shown in Figure 5-10.

Measurements to determine volumetric flow rate usually require approximately 30 minutes. Sampling rates are dependent on stack gas velocity. A preliminary velocity check is usually made prior to testing to aid in selection of the proper equipment and in determining the approximate sampling rate for the test.

The volumetric flow rate determined by this method is usually within ± 10 percent of the true volumetric flow rate. Collaborative tests have shown that skilled test teams using Method 2 can achieve accuracies within ± 4 percent.

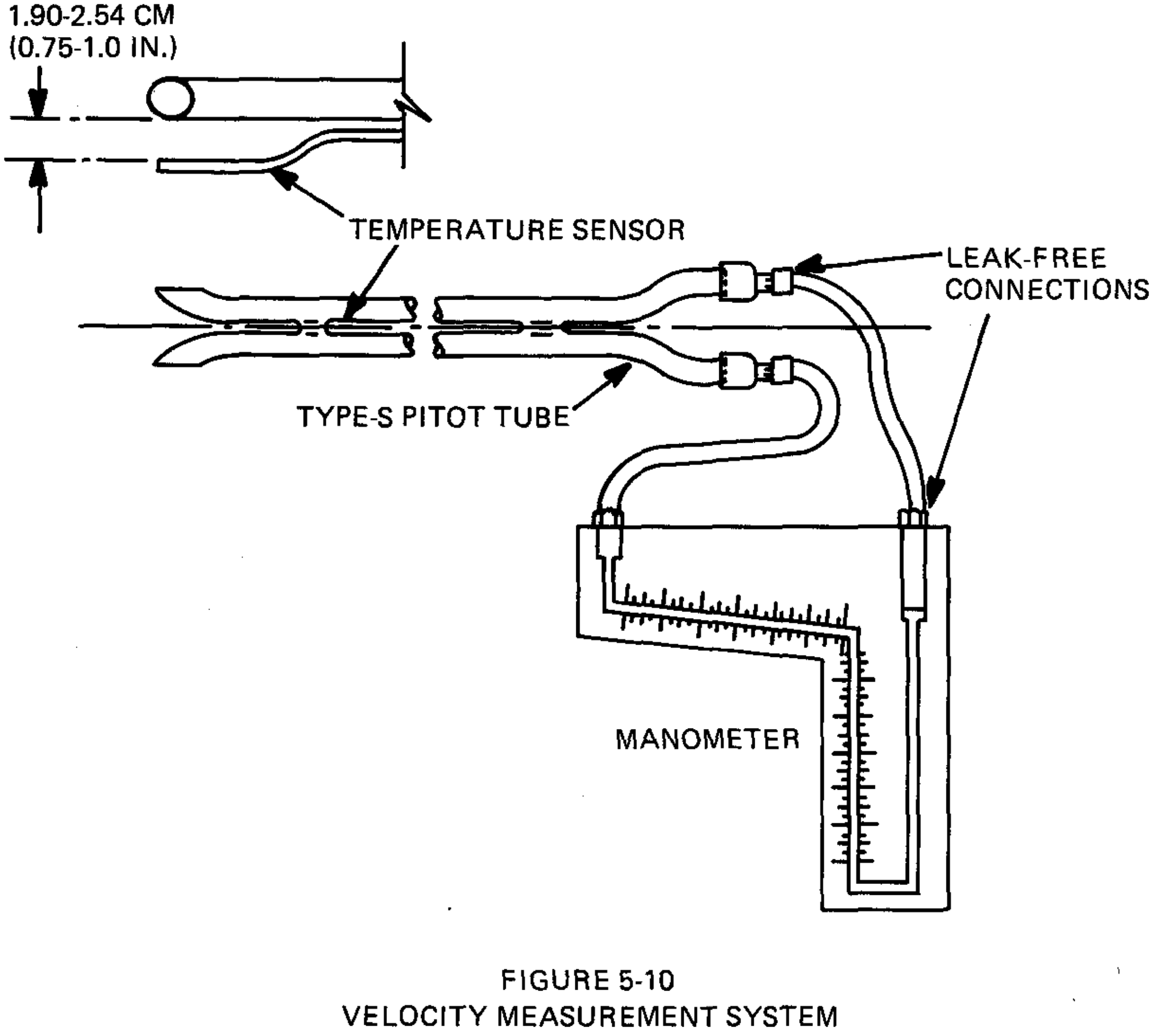


FIGURE 5-10
VELOCITY MEASUREMENT SYSTEM

Total cost of the equipment for measuring volumetric flow rate is approximately $4,500; this cost represents the equipment specified in EPA Methods 2, 3 (molecular weight determination), and 4 (moisture determination).

An alternative method for determining volumetric flow rate is to use data describing the exhaust fan. A plot of fan performance (fan curve) provided by the manufacturer can be used to determine approximate volumetric flow rate. This procedure should be used only as a check to validate the data obtained by use of Method 2. If a combustion source is being tested, a stoichiometric calculation can be performed to determine the stack gas flow rate.

A technician could perform this procedure by reading the method description and the available manuals. It is advisable, however, that the technician attend a training course if possible.

5.4.2 Molecular Weight and CO_2 or O_2

The EPA Method 3 is used to determine carbon dioxide or oxygen content and molecular weight of the stack gas stream. Depending on the intended use of the data, these values also can be obtained with an integrated or grab sample. Both methods are discussed here.

Grab sampling is used primarily to determine the molecular weight of the gas stream. A sampling probe is placed at the center of the stack or no closer to the wall than 3.28 feet, and a sample is drawn directly into an Orsat analyzer or Fyrite-type combustion gas analyzer. The sample is then analyzed for carbon dioxide and oxygen content. With these data, the dry molecular weight of the gas stream can then be calculated.

Figure 5-11 shows the equipment used to obtain a grab sample. Total cost of the equipment for this method is approximately $400.

An integrated sample is required when the analytical results will be used to calculate a correction factor for pollutant emission rate, such as percent excess air or the "F" factor (for combustion sources). For an integrated sample, sampling probes are located at several designated points in the stack, which represent equal areas, and a sample is extracted at a constant rate. As the gas passes through the sampling apparatus, the moisture is removed and the sample is collected in a flexible bag. The sample is then analyzed by use of the Orsat analyzer.

The minimum detectable limit for this method is 0.1 percent. No collaborative tests have been performed.

Figure 5-12 is a schematic of an assembled apparatus for collection of an integrated stack gas sample. In addition to this equipment, an Orsat analyzer is required. Total cost for this equipment is approximately $1,000.

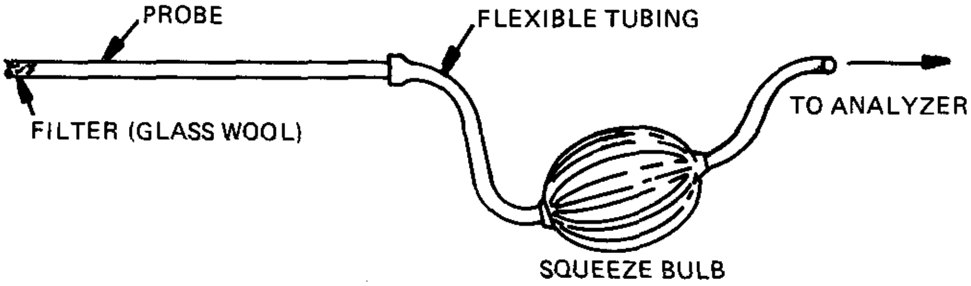


FIGURE 5-11
GRAB SAMPLE SETUP FOR MOLECULAR WEIGHT DETERMINATION

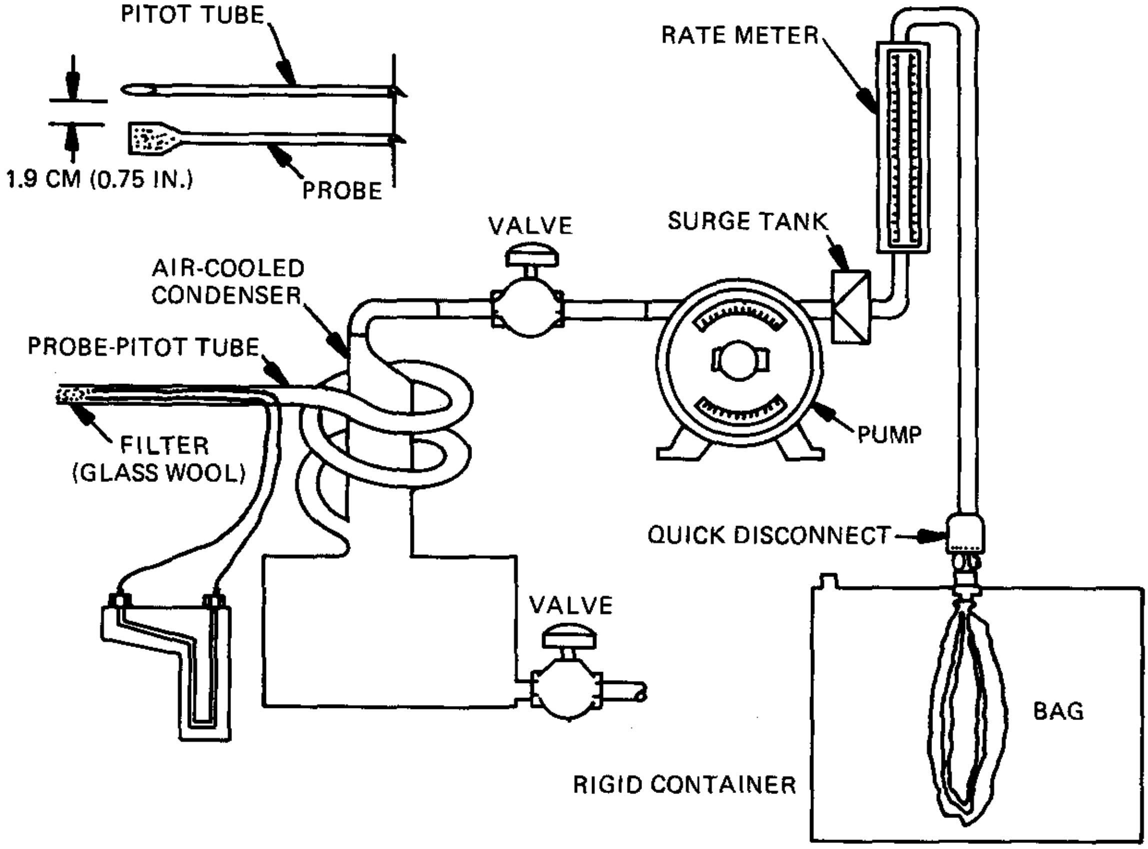


FIGURE 5-12
INTEGRATED SAMPLE SETUP FOR MOLECULAR WEIGHT DETERMINATION

5.4.3 Moisture Content

EPA Method 4 is the reference method for determining the moisture content of the stack gas. A value for moisture content is needed in some of the calculations for determining pollutant emission rates.

A sample is taken at several designated sampling points in the stack, which represent equal areas. The sampling probe is placed at each sampling point, and the apparatus is adjusted to take a sample at a constant rate. As the gas passes through the apparatus, a filter collects the particulate matter, the moisture is removed, and the sample volume is measured. The collected moisture is then measured, and moisture content of the gas stream is calculated.

No collaborative tests have been conducted on this method, and no minimum detection limits have been established. This method should not be used if the gas stream contains liquid droplets since it will produce erroneously high results.

A schematic of the sampling apparatus used in this reference method is shown in Figure 5-13. In addition to this equipment, the following field equipment and supplies are required:

1. Balance to measure within 1 gram, and

2. Thermocouple and potentiometer or equivalent.

Commercial units are available at a cost of approximately $3,000. Total cost of equipment for moisture determination is approximately $4,000.

Method 4 also provides an alternative procedure, which is an approximate method for determining moisture content of a gas stream. Figure 5-14 shows a schematic of the sampling apparatus used in the approximate method. The probe is placed in the stack, and a sample of approximately 30 liters is pulled through the sampling apparatus. As the gas passes through the sampling apparatus, a filter collects the particulates, the moisture is removed, and the sampling rate is measured. The amount of moisture removed is measured and the approximate moisture content is calculated. This approximate method should be used only to estimate moisture content.

If the gas stream contains liquid droplets, the following method is used. Determine the stack gas temperature at several designated points in the stack. The moisture content can then be determined by assuming that the gas stream is saturated and by using a psychrometric chart or saturation vapor pressure tables.

5.4.4 Particulates

Procedures for taking a particulate source test are more detailed than those used in sampling gases. Because particulates exhibit inertial effects and are not uniformly distributed within a stack, sampling to obtain a representative sample is more complex than for gaseous

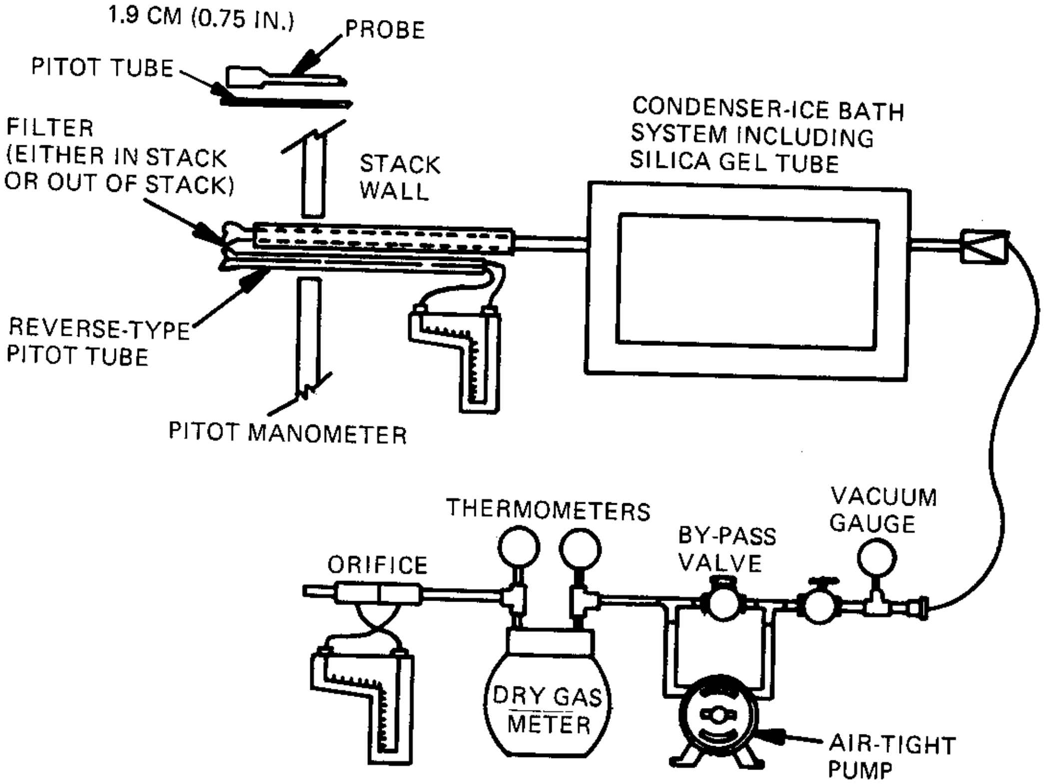


FIGURE 5-13
MOISTURE SAMPLE TRAIN

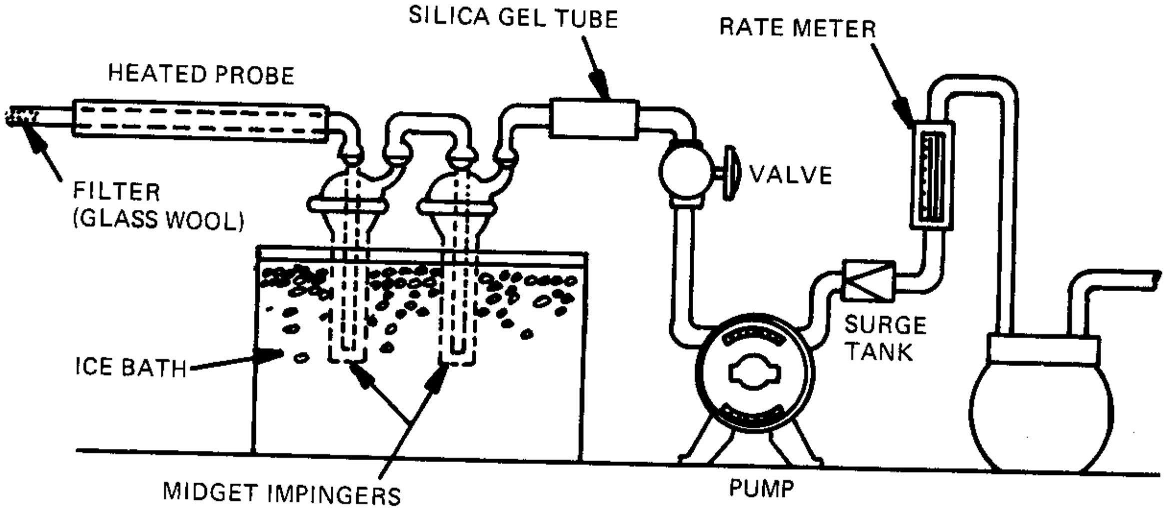


FIGURE 5-14
APPROXIMATE MOISTURE SAMPLE TRAIN

pollutants. EPA Method 5 (as shown in Figure 5-15) is the most widely used procedure for determination of particulate emissions from a stationary source. In-stack sampling guidelines are presented in EPA Method 17.

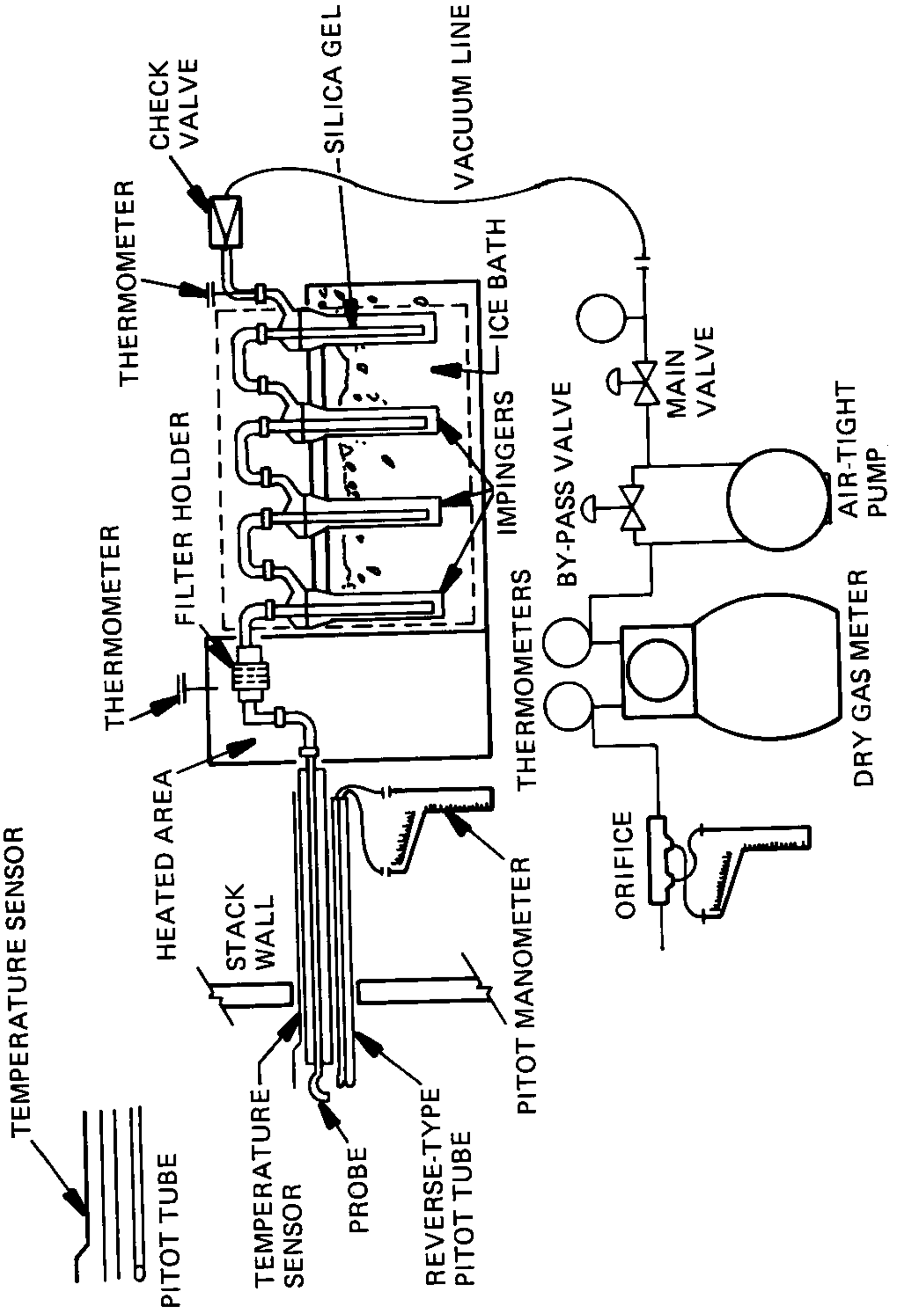


FIGURE 5-15
EPA METHOD 5 PARTICULATE SAMPLE APPARATUS

According to Method 5 (except as applied to fossil-fuel-fired steam generators), a particulate is defined as any material collectible at 250°F on a filtering medium. The sampling apparatus used in Method 5 is designed to catch particulate matter at this specified temperature. Most states accept Method 5, even though they define particulate differently. The sampling apparatus, however, may have to be modified to conform with the state's definition of particulate. For example, a state may define particulate as any material collectible at stack conditions, a definition that would allow the filtering media to be located in the stack.

In performing a particulate source test, samples are taken at several designated sampling points in the stack, which represent equal areas. At each sampling point, the velocity, temperature, molecular weight, and static pressure of the particulate-laden gas stream are measured. The sampling probe is placed at the first sampling point, and the sampling apparatus adjusted to take a sample at the conditions measured at this point. The sampling probe is then moved to the next point, and the process is repeated continuously until a sample has been taken from each designated sampling point. To achieve valid results in a particulate source test, the sample must be taken under the same conditions at each sampling point in the stack. This is commonly referred to as isokinetic sampling. Measurement of stack conditions allows adjustment of the sampling rate to meet this requirement.

As the gas stream proceeds through the sampling apparatus, the particulate matter is trapped on a filter, the moisture is removed, and the volume of the sample is measured. Upon completion of sampling, the collected material is recovered and sent to a laboratory for a gravimetric determination or analysis.

The time required for collection of a particulate sample depends on the number of sampling points required, the sampling time per point, and the sample volume required. A minimum sampling time of 2 minutes per point is recommended. Generally the sampling time is at least 1 hour but less than 4 hours. Three particulate samples per source are required.

Commercial sampling units are available at a cost of approximately $3,500. Following is a list of the additional equipment required for a particulate source test and analysis:

Sampling equipment and supplies

1. Orsat analyzer or equivalent,
2. Thermocouple and potentiometer,
3. Brushes to clean probe,
4. Glass wash bottles (two),
5. Glass sample storage containers (500-ml),
6. Petri dishes (glass or polyethylene),
7. Graduated cylinder,
8. Plastic storage containers,
9. Funnel and rubber policeman,

10. Filters (glass fiber)
11. Silica gel,
12. Crushed ice,
13. Stopcock grease, and
14. Acetone (reagent grade).

Sample analysis equipment and supplies

1. Glass weighing dishes,
2. Desiccator,
3. Analytical balance (to measure within 0.1 mg),
4. Balance (to measure within 0.5 g),
5. Beakers (250-ml),
6. Hygrometer,
7. Temperature gauge, and
8. Desiccant (anhydrous calcium sulfate, indicating type).

Because of breakage, it is advisable to provide a spare set of all glassware used in the field. If the source to be tested has a large stack (greater than 5 feet in diameter), a longer sampling probe is required; this will add to the overall cost. Total cost of equipment for a complete particulate stack test is approximately $10,000.

Different methods of sampling for particulates are based on the definition of particulate matter. The sampling apparatus is modified to collect the particulates at the specified temperature utilizing a specified collecting medium. Considering 250°F as a reference point and allowing for variation depending on the source, collection of particulate matter at a relatively higher temperature generally yields lower values of particulate concentration and collection at a relatively lower temperature generally yields higher values.

5.4.5 Sulfur Dioxide

For gaseous pollutants, the analysis of the sample is more time-consuming than sample collection because chemical solutions are used in the collection of the sample rather than a filter. EPA Method 6 is the reference method for determining emissions of sulfur dioxide (SO_2) from all stationary sources except sulfuric acid plants.

In sampling for SO_2, a gas sample is taken at a single sampling point located at the center of the stack or no closer to the wall than 3.28 feet. In Method 6 the sample must be extracted at a constant rate. This requires adjustments of sample rate to compensate for any changes in stack gas velocity.

As the gas goes through the sampling apparatus, the sulfuric acid mist and sulfur trioxide are removed, the SO_2 is removed by a chemical reaction with a hydrogen peroxide solution and, finally, the sample gas volume is measured. Upon completion of the run, the sulfuric acid mist and sulfur trioxide are discarded, and the collected material containing the SO_2 is recovered for analysis at the laboratory. The concentration of SO_2 in the sample is determined by a titration method.

For determination of the total mass emission rate of SO_2, the moisture content and the volumetric flow rate of the exhaust gas stream must be measured.

For Method 6, the minimum sampling time is 20 minutes per sample and two separate samples constitute a run. Three runs are required, resulting in six separate samples. An interval of 30 minutes is required between each sample. Longer sampling times may be required if a larger sample is needed.

Stack concentrations of 50 to 10,000 parts per million of sulfur dioxide can be determined with this method. The minimum detectable limit has been determined to be 3.4 milligrams of SO_2 per cubic meter of gas (2.1×10^{-7} pound of SO_2 per cubic foot of gas). Collaborative tests have shown that an experienced test team using quality controls can conduct a source test for sulfur dioxide with accuracy within ±4 percent.

Figure 5-16 is a schematic of an assembled sulfur dioxide sampling apparatus. Commercial units are available at a cost of approximately $1,700. In addition to this apparatus, the following equipment and supplies are required:

Sampling equipment and supplies

1. Glass wool (borosilicate or quartz),
2. Stopcock grease,
3. Vacuum gauge,
4. Wash bottles (polyethylene or glass),
5. Storage bottles (polyethylene),
6. Thermocouple and potentiometer,
7. Pipettes (one each: 5-ml, 20-ml, and 25 ml),
8. Volumetric flasks (100-ml and 1,000-ml),
9. Burettes (5-ml and 50-ml),
10. Erlenmeyer flask (250-ml),
11. Dropping bottle (125-ml), and
12. Graduated cylinder.

Sampling analysis supplies

1. Deionized, distilled water,
2. Isopropanol (80 percent),
3. Hydrogen peroxide (3 percent),
4. Thorin indicator (1-(o-arsenophenylazo)-2-napthol-3,6-disulfonic acid, disodium salt, or equivalent),
5. Barium perchlorate solution (0.01 N), and
6. Sulfuric acid standard (0.01 N).

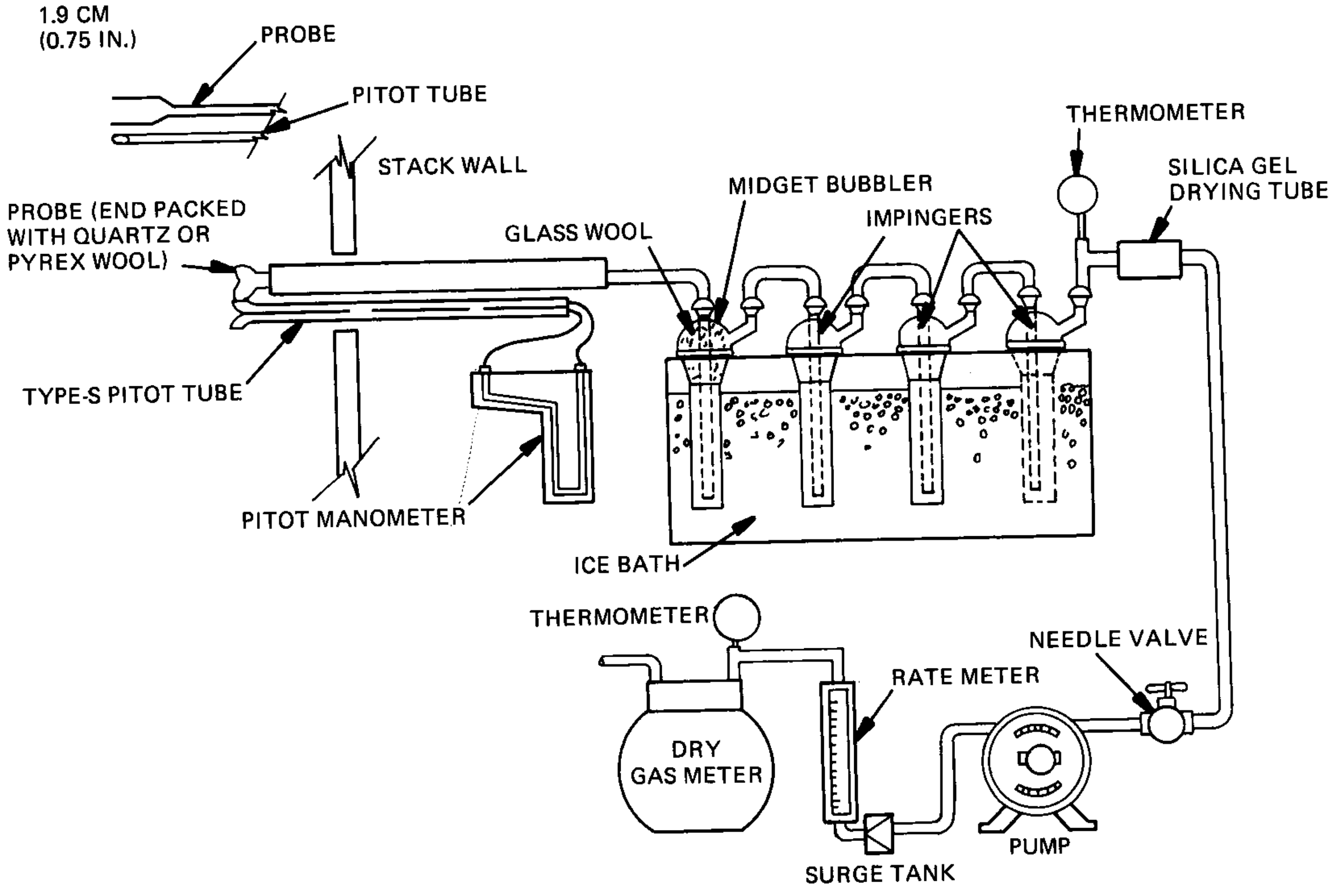


FIGURE 5-16
EPA METHOD 6 SULFUR DIOXIDE SAMPLE TRAIN

Because of breakage it is advisable to provide spare sets of all glassware. Total cost of the equipment for a source test for sulfur dioxide is approximately $3,000.

Other sampling methods utilize different chemical solutions, such as a sodium hydroxide solution, to trap the sulfur dioxide; a different analytical procedure is required. Also EPA Method 8 may be used as an alternative method for determining SO_2 emissions from stationary sources.

Some states specify a sampling method that collects sulfuric acid, sulfur trioxide, and sulfur dioxide. The analysis then gives total sulfur oxides. This method usually yields values only about 1 to 5 percent higher than those obtained with Method 6 in which the sulfur trioxide and sulfuric acid are discarded.

Plant operators should be aware that with the use of Method 6 for sulfur dioxide and application of the F factor to obtain values in pounds of sulfur dioxide per million BTU of heat input, it is critical that an accurate oxygen measurement be made at the same sample point and at the same time that the sulfur dioxide sample is obtained.

Although a technician could learn to sample for sulfur dioxide by reading manuals, it is advisable that testing personnel take a formal training course.

5.4.6 Nitrogen Oxides (NO_x)

EPA Method 7 is the reference method for determining emissions of nitrogen oxides from stationary sources. Sampling for NO_x by this method is relatively simple with the proper equipment.

A sampling probe is placed at any location in the stack, and a grab sample is collected in an evacuated flask. This flask contains a solution of sulfuric acid and hydrogen peroxide, which reacts with the NO_x. The volume and moisture content of the exhaust gas stream must be determined for calculation of the total mass emission rate. The sample is sent to a laboratory where the concentration of nitrogen oxides, except nitrous oxide, is determined colorimetrically.

Each grab sample is obtained fairly rapidly (15-30 seconds), and four grab samples constitute one run. A total of 12 grab samples is required for a complete series of three runs. An interval of 15 minutes between each grab sample is required. The range of this method has been determined to be 2 to 400 milligrams NO_x (as NO_2) per dry standard cubic meter (without dilution). Collaborative tests have shown that an experienced test team can conduct a source test for nitrogen oxides with accuracy within ±6.6 percent.

Figure 5-17 shows a schematic of the sampling apparatus for an NO_x source test. Commercial units are available at a cost of approximately $1,200. Glassware needed to conform to EPA Method 7 is available from several glass manufacturers. In addition to the apparatus as shown, the following equipment is required:

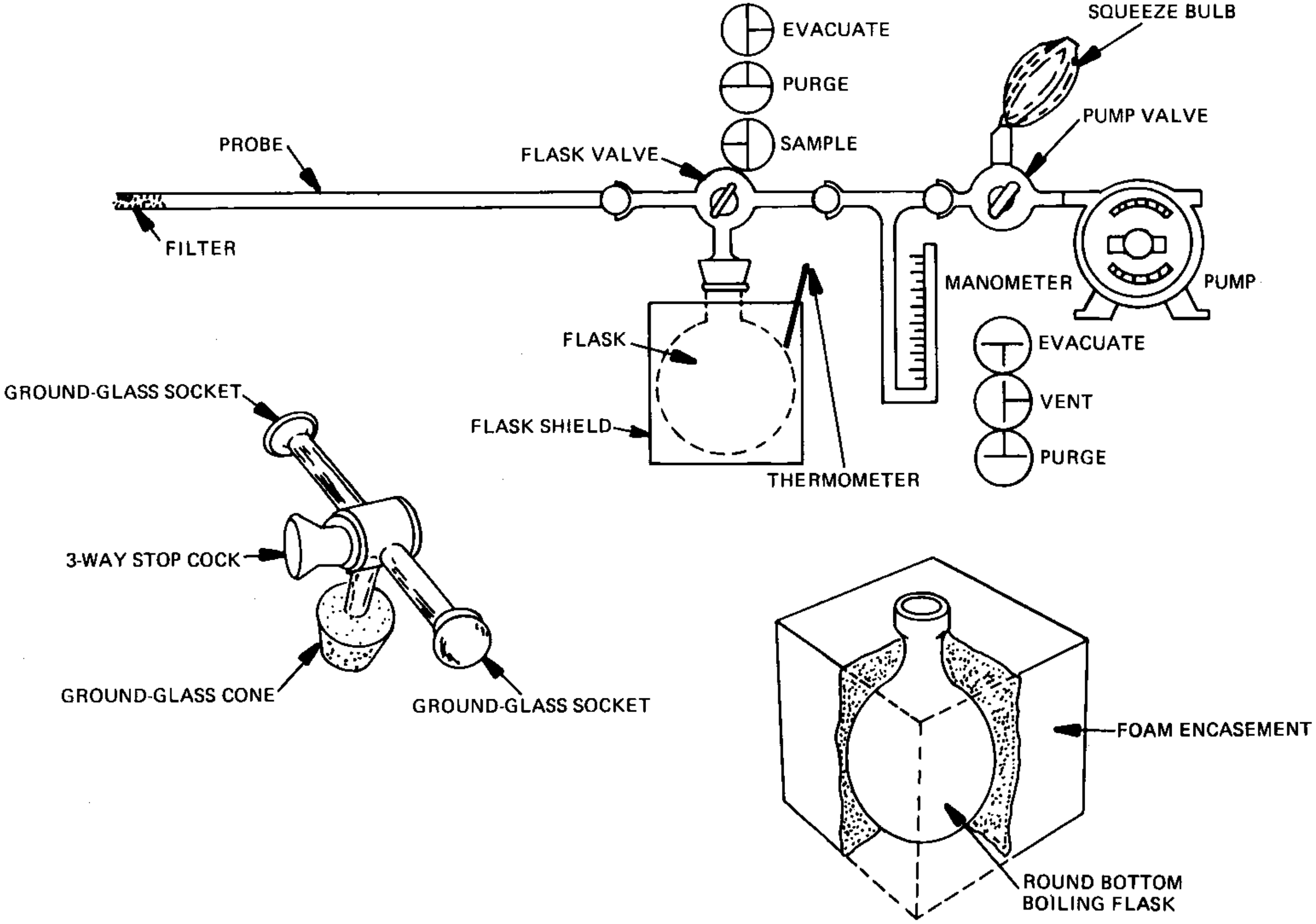


FIGURE 5-17
EPA METHOD 7 NITROGEN OXIDE SAMPLE TRAIN

Equipment and supplies

1. Heating tape capable of maintaining 250°F in the probe,
2. Type-S pitot tube,
3. Stopcock grease,
4. Inclined manometer or equivalent,
5. Connecting tubes for pitot to manometer,
6. Sling-psychrometer,
7. Glass wash bottle,
8. Steam bath,
9. Beakers (250-ml, one for each sample and standard (blank)),
10. Volumetric pipettes (1-, 2-, and 10-ml),
11. Volumetric flask (100-ml, one for each sample and 1,000-ml for the standard blank),
12. Spectrophotometer to measure absorbance at 420 nm,
13. Graduated cylinder (100-ml with 1.0-ml divisions), and
14. Analytical balance to measure to 0.1 mg.

Reagents

1. Concentrated, reagent-grade sulfuric acid,
2. Distilled water,
3. Hydrogen peroxide,
4. Sodium hydroxide,
5. Red litmus paper,
6. Deionized, distilled water,
7. Fuming sulfuric acid (15 to 18 percent by weight),
8. Free sulfur trioxide,
9. Phenol (white solid reagent grade), and
10. Potassium nitrate.

Total cost of the equipment for conducting a source test for NO_x emissions is approximately $2,500.

An accurate oxygen measurement must be made at the same sample point and at the same time the sample is obtained when the F factor calculation is used to determine values in pounds of NO_x per million BTU of heat input. NO_x sampling requires less skill, training, and time than most sampling procedures.

5.4.7 Carbon Monoxide (CO)

EPA Method 10 is the reference method for determining emissions of carbon monoxide from stationary sources. An integrated or a continuous gas sample may be required, depending on operating conditions. Both methods are discussed.

When the operating conditions are uniform and steady (no fluctuations in flow rate or concentration of CO in the gas stream), the continuous sampling method can be used. A sampling probe is placed in the stack at any location, preferably near the center. The sample can be extracted at any convenient and constant sampling rate. As the gas stream passes through the sampling apparatus, any moisture or carbon dioxide in the sample gas stream is removed. The CO concentration is then measured by a nondispersive infrared analyzer, which gives direct readouts of CO concentrations.

Figure 5-18 is a schematic of an assembled sampling apparatus used to determine CO concentrations by the continuous sampling method.

An integrated sampling method is required when operation of the source is uniform but unsteady (fluctuations in flow rate can occur). For an integrated sample, the sampling probe is located at any point near the center of the stack, and the sampling rate is adjusted proportionately to the stack gas velocity. As the stack gas passes through the sampling apparatus, moisture is removed and the sample gas is collected in a flexible bag. Analysis of the sample is then performed in a laboratory with a nondispersive infrared analyzer. Any carbon dioxide or residual moisture in the sample must be removed before the sample is passed through the nondispersive infrared analyzer.

Figure 5-19 is a schematic of an assembled apparatus for integrated sampling of CO. Figure 5-20 also shows the analytical equipment.

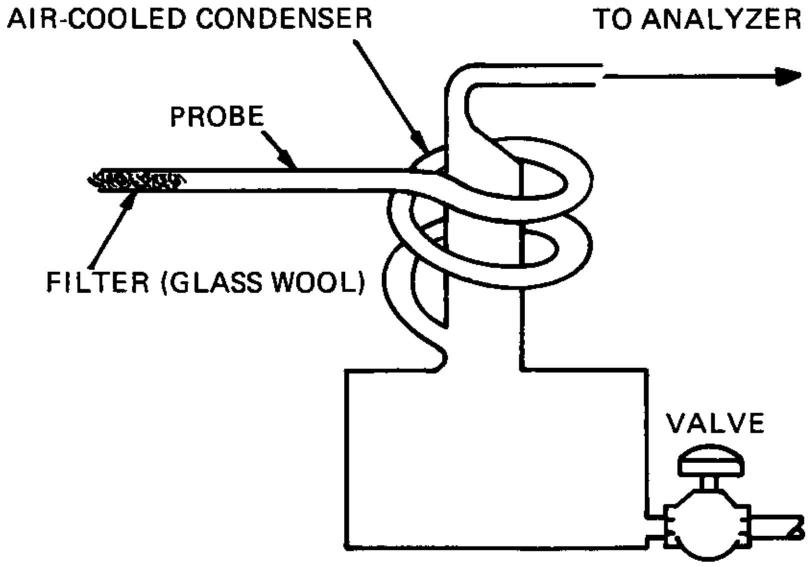


FIGURE 5-18
CONTINUOUS SAMPLE TRAIN FOR CO

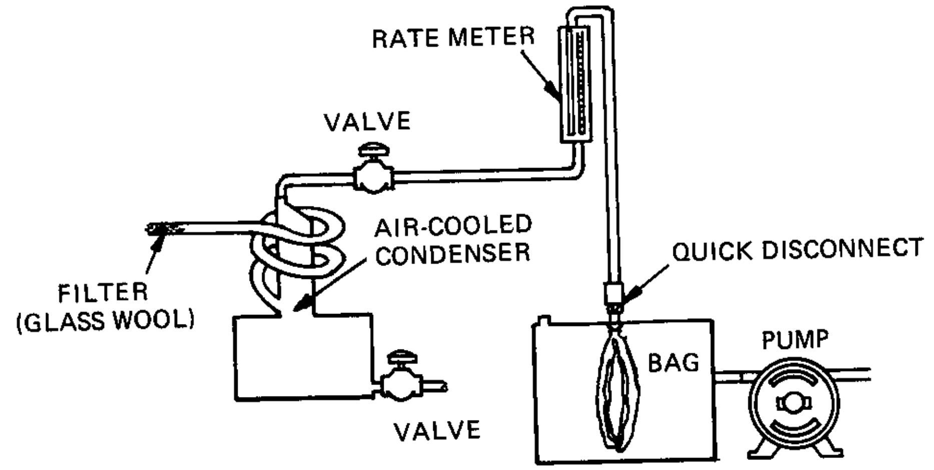


FIGURE 5-19
INTEGRATED SAMPLING TRAIN FOR CO

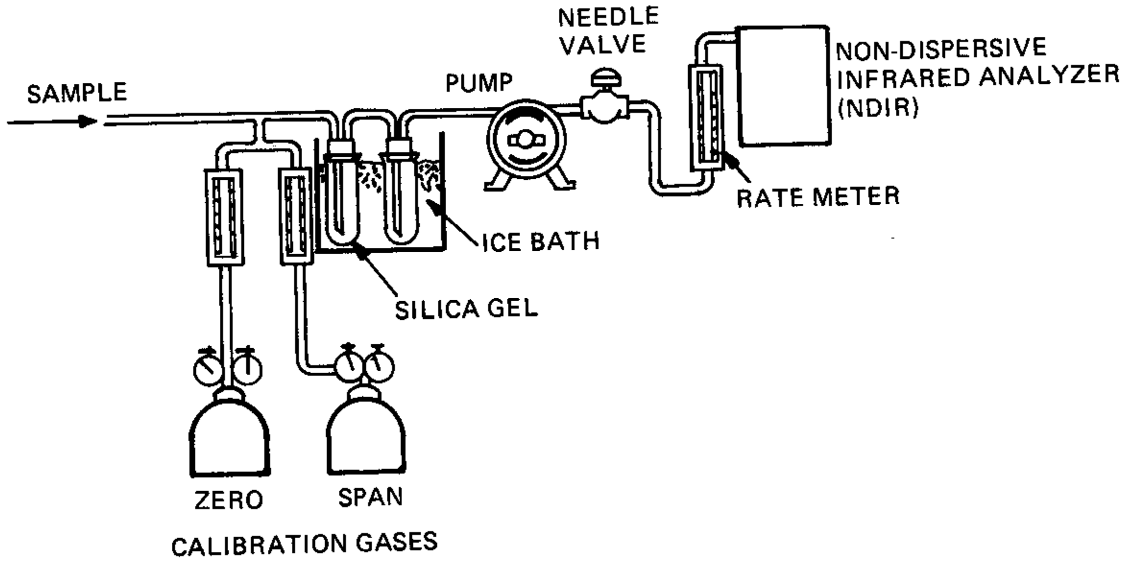


FIGURE 5-20
SAMPLING APPARATUS FOR CO

A 1-hour sampling period is generally required for this method. Sampling periods are specified by the applicable standard, e.g., standards for petroleum refineries require sampling for 1 hour or more.

For Method 10, the minimum detectable concentration of CO has been determined to be 20 ppm in a range of 1 to 1,000 ppm. Collaborative tests have shown that this method can be executed with accuracies within ±101 milligrams of CO per cubic meter.

In addition to the sampling apparatus for continuous and integrated sampling, the following equipment is needed:

Sampling equipment and supplies

1. Pitot tube (type S),
2. Inclined manometer or equivalent, and
3. Tubing to connect pitot tube to manometer.

Analytical equipment and supplies

Calibration gases: N_2 with a known CO concentration, prepurified grade of N_2, and two additional N_2 with CO concentrations corresponding to 30 and 60 percent of span of the nondispersive infrared analyzer.

A spare set of all glassware used in the field should be provided. Total cost of the equipment is approximately $3,500.

An Orsat analyzer or detector tubes may be used to determine the presence of carbon monoxide in a gas stream; these methods, however, are not acceptable because the minimum detectable limit of the Orsat analyzer is 1,000 ppm and the detector tubes are not accurate enough.

Collection of CO for nondispersive infrared analysis presents no special problems and requires no great degree of training. However, operation of the analyzer does require training and experience.

5.4.8 Fluorides

Two EPA reference methods, Method 13A and Method 13B, can be used to determine total fluoride emissions from a stationary source. The difference in the two methods is the analytical procedure for determining total fluorides. Fluorides can occur as particulates or as gaseous fluorides; the particulates are captured on a filter and the gaseous fluorides are captured in a chemical reaction with water.

Samples for either Method 13A or Method 13B are obtained by the procedure outlined in Method 5 for particulates. As the gas stream passes through the sampling apparatus, the gaseous fluorides are removed by a chemical reaction with water, the particulate fluorides are captured on a filter, and the sample volume is measured. The sample is recovered and sent to the laboratory for analysis. Procedures of Methods 13A and 13B are complex and should be performed by an experienced chemist. Method 13A is a colorimetric method, and Method 13B utilizes a specific ion electrode.

A 1-hour sampling period is generally required for both methods. Sampling periods are specified by the applicable standard, e.g., standards applicable to triple superphosphate plants require sampling of 1 hour or more. The standard may also specify a minimum sample volume which will dictate the minimum length of the sampling period.

The determination range of Method 13A is 0 to 1.4 micrograms of fluoride per milliliter; the range of Method 13B is 0.2 to 2,000 micrograms of fluoride per milliliter.

Collaborative tests are currently being performed and evaluated. Preliminary results indicate that the field sampling phase of Methods 13A and 13B is generally reliable.

Figure 5-21 is a schematic of an assembled fluoride sampling apparatus used in Methods 13A and 13B. Commercial units are available at a cost of approximately $3,500. In addition to this apparatus, the following equipment/supplies are required:

Field equipment and supplies

1. Filter heating system capable of heating the filter to ~250°F,
2. Brushes to clean probe,
3. Glass wash bottles (two),
   sample storage bottles (wide-mouth, high-density polyethylene, 1-liter),
4. Plastic storage containers,
5. Graduated cylinder (250-ml), and
6. Funnel and rubber policeman.

Sampling supplies

1. Filters (Whatman No. 1 or equivalent),
2. Silica gel (indicating type),
3. Distilled water,
4. Crushed ice, and
5. Stopcock grease.

Sample analysis for Method 13A or 13B

1. Distillation apparatus shown in Figure 5-22,
2. Hot plate (capable of heating to 500°C),
3. Electric muffle furnace (capable of heating to 600°C),
4. Crucibles (nickel, 75- to 100-ml capacity),
5. Beaker (1,500-ml),
6. Volumetric flask (50-ml),
7. Erlenmeyer flask or plastic bottle (500-ml),
8. Constant-temperature bath (capable of maintaining a constant temperature of ±1°C in room-temperature range),
9. Balance (300-g capacity to measure ±0.5 g),
10. Calcium oxide (certified grade containing 0.005 percent calcium),
11. Phenolphthalein indicator (0.1 percent in 1:1 ethanol-water mixture),

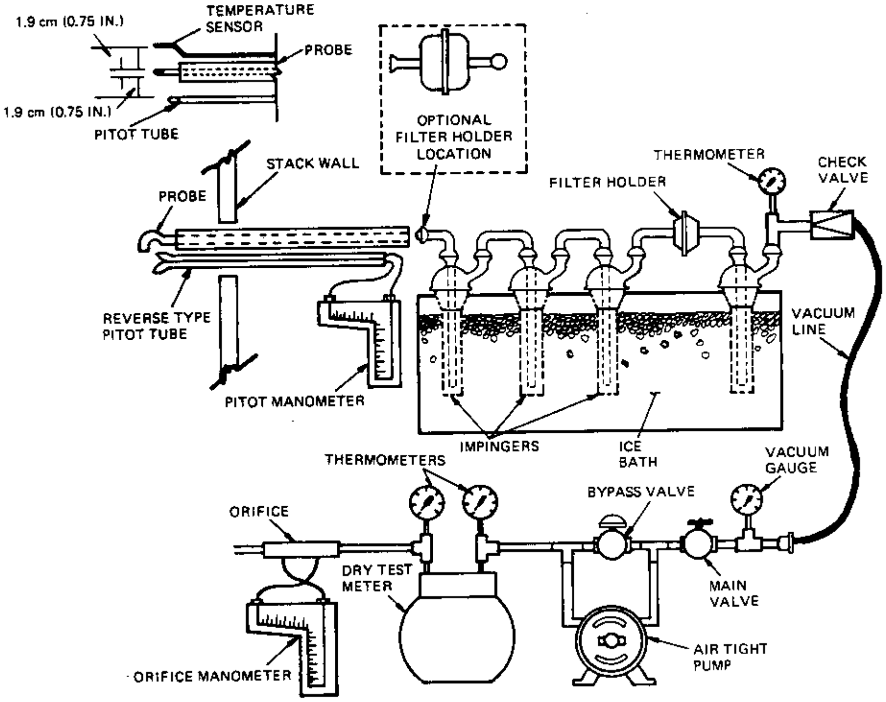


FIGURE 5-21
SAMPLING APPARATUS FOR FLUORIDE

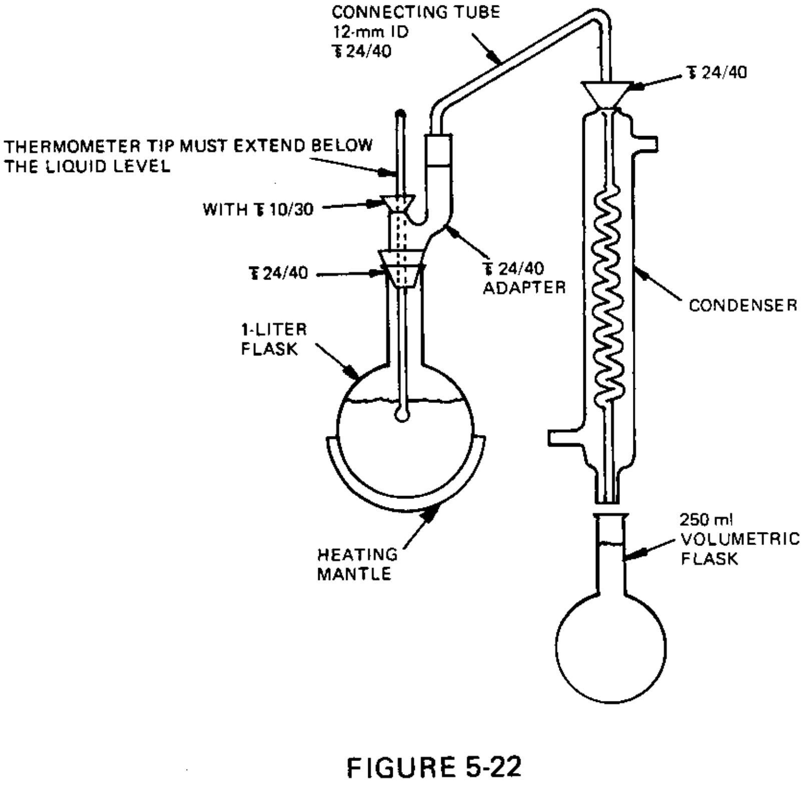


FIGURE 5-22
DISTILLATION APPARATUS

12. Sodium hydroxide (pellets, ACS reagent grade or equivalent),
13. Sulfuric acid (concentrated, ACS reagent grade or equivalent),
14. Filters (Whatman No. 541 or equivalent), and
15. Sodium fluoride (reagent grade).

Additional sample analysis equipment or supplies for Method 13A only

1. Spectrophotometer (to measure absorbance at 570 nm, providing at least a 1-cm light path),
2. Spectrophotometer cells (1-cm),
3. Silver sulfate (ACS reagent grade or equivalent),
4. Hydrochloric acid (concentrated, ACS reagent grade or equivalent),
5. SPADNS solution, and
6. Zirconyl chloride octahydrate.

Additional sample analysis equipment or supplies for Method 13B only

1. Fluoride ion activity sensing electrode,
2. Reference electrode (single junction, sleeve type),
3. Electrometer (a pH meter with millivolt scale capable of ±0.1 mv resolution, or a specific ion meter made specifically for specific ion measurements),
4. Magnetic stirrer and TFE-fluorocarbon-coated stripping bars,
5. Glacial acetic acid,
6. Sodium chloride, and
7. Cyclohexylene dinitrilo tetraacetic acid.

It is advisable to provide a spare set of the glassware used in field sampling. If the source to be tested has a large stack (greater than 5 feet in diameter), a longer sampling probe is required; this will add to the cost. Total cost of equipment for a complete fluoride stack test is approximately $10,000.

Other sampling methods for fluorides use chemical solutions to remove gaseous fluorides from the sample and require different analytical procedures. As an example, the Los Angeles County method utilizes sodium hydroxide to remove the fluorides. The lower detectable limit for this method is approximately 16 micrograms of fluoride in 1.7 cubic meters of sample gas.

Fluoride sampling requires skilled and trained sampling personnel. The analytical procedures require only normal laboratory skills.

5.4.9 Hydrocarbons

The U.S. EPA has not published a reference source testing method for hydrocarbons. Each state or local control agency that regulates emissions of hydrocarbons selects a source test method. If source testing for hydrocarbons is required, the control agency should specify the sampling and analytical method.

Hydrocarbon emissions may contain both condensible and noncondensible hydrocarbons. Noncondensible hydrocarbons are simply gases; condensible hydrocarbons can occur as gases at certain temperatures and as liquids or even solids at lower temperatures. The sampling method must be designed for the type of data that is needed, e.g., total hydrocarbons (condensible + noncondensible), condensible hydrocarbons only, or noncondensible hydrocarbons only. A sampling method for each is described briefly. Some hydrocarbons are photochemically reactive and some are not reactive. No hydrocarbon standards are usually specified for nonreactive hydrocarbons.

1. Continuous method for determination of total hydrocarbons. A sample probe is located at any point in the stack, and the stack gas is drawn through a heated sample line to a gas chromatograph with a flame ionization detector (GC-FID). Concentrations are read from a potentiometric recorder.

2. Grab sampling for determination of noncondensible hydrocarbons only. Grab samples of stack gas are collected with evacuated dry flasks in the same manner as described for nitrogen oxides. A stainless steel sampling probe and evacuated flask should be used instead of glass in the sampling apparatus. Samples may also be collected in the same manner as the CO-integrated bag sample. Analyses may be performed with an infrared spectrophotometer or a gas chromatograph.

3. Adsorption techniques for sampling of condensible hydrocarbons only. A sample is obtained in the same manner as described previously for sulfur dioxide. Chemical solutions that will collect the hydrocarbons are placed in the sampling apparatus. Analysis of the sample can be made with a gas chromatograph. Depending on the chemical solutions, condensible hydrocarbons with boiling points 320°F and greater can be sampled.

4. Adsorption technique for sampling of specific hydrocarbons. A sample may be adsorbed on some collection medium such as silica gel, activated charcoal, or packing. The adsorption medium and sample are brought to the laboratory for analysis. The hydrocarbons are then desorbed into the analyzer. This method is relatively more accurate and reliable when the types of hydrocarbons are known and standard solutions of the anticipated hydrocarbon can be used to calibrate the analytical instruments. When the specific hydrocarbon compounds are not known, the analysis is usually less representative and determination of exact compounds is much more costly.

Selection of the sampling method is critical in sampling for hydrocarbons. Very significant errors, involving both positive and negative bias, can occur. Knowledge of the specific types of hydrocarbons in the exhaust gases will aid in selecting the appropriate sampling method. Total costs, required equipment, sampling times, and detection limits depend on the specific method used.

5.5 References

1. *Journal of the Air Pollution Control Association, 26*(7):713-724, July 1976.

2. Schulze, R.H. *The Economics of Environmental Quality Measurement,* Journal of the Air Pollution Control Association, *23*(8):671-675, August 1973.

3. Gerstle, R.W., and DeWees, W., *Safety Aspects of Emission Testing*, Stack Sampling News, March 1976.

CHAPTER 6

AMBIENT AIR MONITORING/CONTINUOUS STACK MONITORING

6.1 Introduction

This chapter deals with monitoring of the ambient air around industrial plants and with continuous monitoring as it applies to point sources of pollution. It is intended as a guide for industrial planners who may be relatively unfamiliar with the purposes of monitoring and the uses of monitoring data.

The basic concept of ambient air monitoring, as in emission testing, is measurement of a representative sample. In emission testing, the cross-sectional area of the gas stream is fixed, and results are generally representative of the total volume of stack effluent. In ambient air monitoring, however, the measurements are indicative of only a small portion of the atmosphere and cannot be assumed to be representative of the total atmosphere. In theory, the pollutant concentrations measured in ambient air monitoring could be entirely different if the monitoring instruments were located a short distance away. To obtain a truly representative sample of ambient air, one would have to place many monitors in a given area, but such a system would be economically unfeasible.

A company may conduct ambient air monitoring for several reasons. Some state regulations require that industries monitor for particular pollutants, such as fluorides, and some states permit ambient monitoring in lieu of complying with a specified emission limitation. Some regulations include provisions that limit the concentration of a pollutant at the property line, which must be monitored. Some companies perform air monitoring simply to measure the impact of a plant's emissions on local air quality. Ambient monitoring also can provide information that is useful in determining the normal or background level of air quality, in following air quality trends, and in providing guidance for emergency control procedures during air pollution episodes. Regardless of the reason, ambient monitoring is usually performed with respect to a particular polluting source or group of sources to provide measurements of a specific pollutant.

Under the 1970 Amendments to the Clean Air Act, EPA in December 1974 issued final regulations preventing significant deterioration of air quality in areas cleaner than the national ambient air quality standards. These rules went into effect nationwide in June 1975. On August 7, 1977, the new Amendments to the Act generally toughened and expanded the scope of this program.

Basically, the new Amendments require each state to classify clean air areas as either Class I (where air quality has to remain virtually unchanged); Class II (where moderate industrial growth would be allowed); and Class III (where more intensive industrial activity would be permitted). The air quality in each of the three types of areas will be allowed to deteriorate only be specific amounts fixed by the Amendments. In no case, however, will air quality by allowed to exceed federal health standards.

The final rulemaking implements provisions of the Amendments intended by Congress to be immediately effective as of the August 7, 1977 enactment date. Only pollution sources which commenced construction before August 7 are exempt from the immediate changes.

Among these changes is the immediate application of the new ambient air increments mentioned above. These increments are more stringent than those allowed under EPA's old significant deterioration regulations.

These final rules also immediately designate certain areas as Class I, and forbid states to redesignate them into either of the other two classes. They are: (1) international parks, (2) national wilderness areas exceeding 5,000 acres, (3) national memorial parks exceeding 5,000 acres, and (4) national parks exceeding 6,000 acres.

With only a few exceptions, all areas of the United States have been placed in Class II, but may apply for classification as Class I or Class III. In areas designated Class I or Class II, increases in pollutant concentrations will be permitted as shown in Table 6-1.

TABLE 6-1
ALLOWABLE DETERIORATION IN CLASSES I AND II

($\mu g/m^3$)

Pollutant	Class I	Class II
Particulate		
Annual geometric mean	5	10
24-hour maximum	10	30
Sulfur dioxide		
Annual arithmetic mean	2	15
24-hour maximum	5	100
3-hour maximum	25	700

Under the nondegradation scheme, only these incremental amounts may be added to the existing background air quality. Once the increment has been added to the background pollutant concentration, no further industrial or other expansion may take place in this area. Allocations of the allowable increments will be on a first-come/first-served basis.

Review of pollution sources before they are built has been proposed to insure they do not violate the new deterioration increments in actual operation. As required in Section 165 of the Amendments, EPA's proposal will require a preconstruction permit for any of the 28 major pollution source categories named in the Amendments that have potential air pollution emissions of 100 tons per year, or for any other pollution sources that have potential emissions of 250 tons per year. EPA's current regulations cover only 19 source categories (including power plants, steel mills, and other stationary sources).

6.2 Selection of Sites for Ambient Air Monitoring

The number of sites to be incorporated into an ambient air monitoring network will depend largely on the amount of data required to meet the objectives. At a small source where one wind direction usually predominates, monitors are usually operated at two sites: one to monitor the effects of the source, and the other to provide upwind or background concentrations. Where wind directions are variable, or other similar emission sources are operating nearby, additional samplers will be required to identify the concentrations that are attributable to a specific source.

Because ambient air monitoring deals with an open, unconfined volume of air rather than with a volume that is enclosed in a stack, there are no detailed specifications for location of ambient air monitors. Other than such obvious considerations as accessibility, availability of electrical power, and relationship to possible interfering pollutant sources, the principle factors in site selection are meteorology and topography.

6.2.1 Meteorology

Because wind movement accounts for dispersion of the pollutants from the source, it is important to obtain detailed information about local meteorology, and in particular about the local wind patterns. Following are possible sources of meteorological data:

1. Local offices of the U.S. Weather Service
2. Local airports,
3. Stations of the State Fire Weather Service,
4. Military installations,
5. Public utilities and industrial complexes,
6. High schools, colleges, universities, and
7. National Weather Records Center (Ashville, N.C.).

The National Weather Records Center can provide by far the most comprehensive records of meteorological data. In addition to providing current data, the Center will also prepare, on request, a summary of all pertinent data available for a given geographical area. Queries and requests may be addressed to:

Director, National Climate Center
National Oceanographic and Atmospheric Administration
Federal Building
Ashville, North Carolina 28801

At some facilities, none of the seven sources may be available or they may not be applicable. In areas which are topographically much different from the source of meteorological data that have been collected by other groups, it may be necessary, in fact, to monitor the local micrometeorology and conduct upper air studies in varying degrees of intensity either to verify that the published sources accurately predict the local wind patterns or to verify the differences.

The controlling factor in site selection is movement of the winds. With some knowledge of the predominant wind direction in an area, the path of pollutants from the emission source to the point of ground-level impact can be predicted roughly and the most suitable location for an air monitoring site can be determined. The most convenient method of performing this analysis is by the use of a wind rose of the type shown in Figure 6-1.

An annual wind rose of this type can be used for site analysis. The lengths of the lines for each of the 16 wind directions represent the percentage of the time that the wind is blowing from that direction. The percentage value is shown at the end of each line. In this example, the wind comes from the south 24 percent of the time; since this is the highest single percentage, south can be considered the predominant direction. The second most frequent direction is west-northwest, with a frequency of 12.9 percent. If wind direction is the only criterion for site planning, the most logical location for an air monitor in this example is due north of the facility, where the monitor would experience the maximum impact from the source. The second, or background, station would be placed west-northwest of the facility because the wind blows toward this direction the least during the year, and the station would receive impact from the east-southeast only 1.1 percent of the time.

When more precise information is required for site location, computerized atmospheric dispersion models can yield such information. Several models in current use predict for a given situation such things as ground-level concentrations at various points around a source, location of the maximum concentration of pollutants from a source, the combined effects of several sources, and the concentration for any time period from 1 hour to 1 year, at any ground-level receptor, resulting from any source or combination of sources.

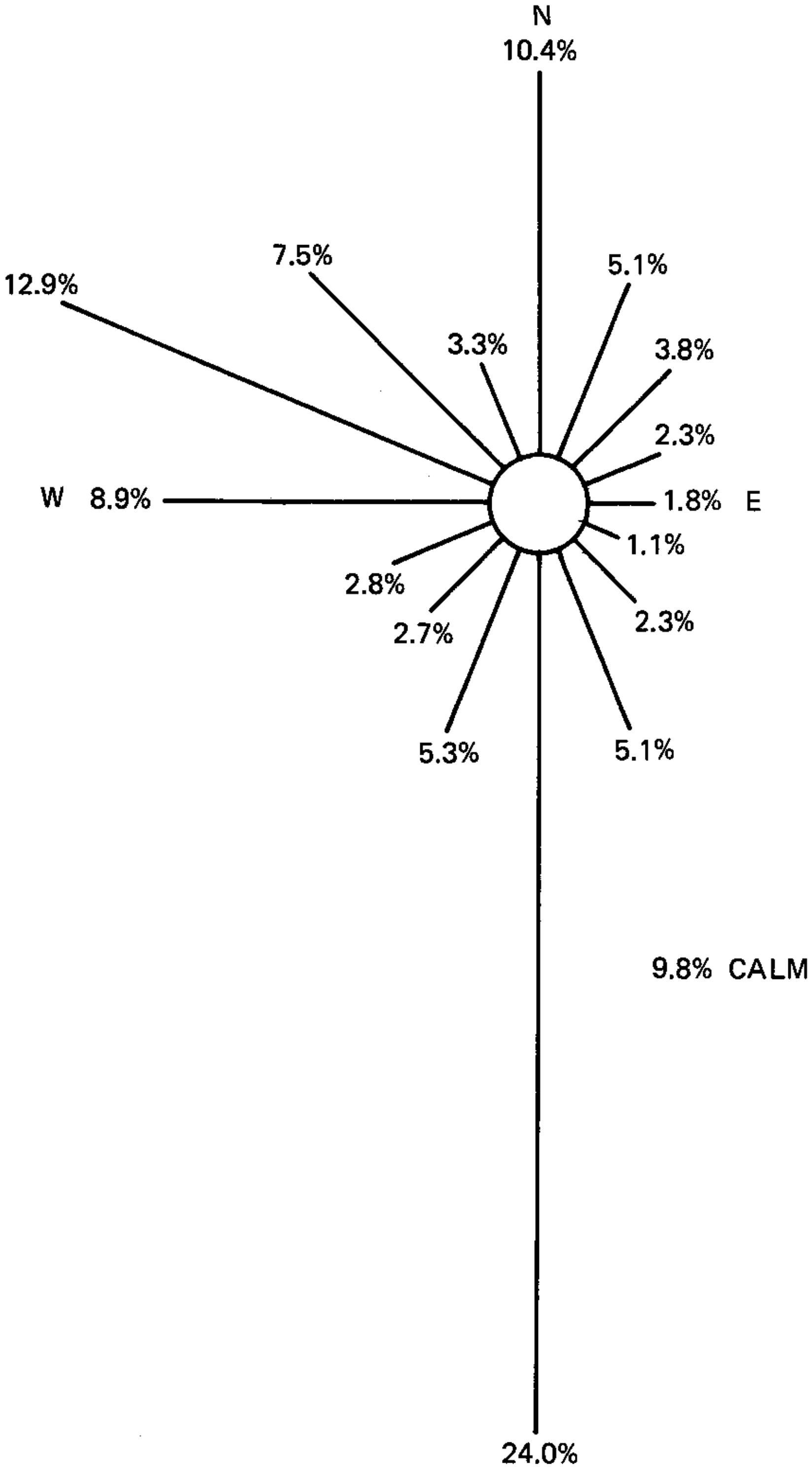


FIGURE 6-1
EXAMPLE OF ANNUAL WIND ROSE

The basis of these models is the Gaussian plume assumption, which says that every plume, regardless of the source, will take on a characteristic shape depending upon the stack parameters and meteorological conditions. This concept is illustrated in Figure 6-2. The Gaussian concept says that pollutant concentrations in the horizontal and vertical directions, relative to the plume centerline (x-axis in Figure 6-2) assume a normal or Gaussian distribution (1).

Because it is desirable to place an air monitor in the area most likely to receive the highest ground-level concentration of pollutants, most modeling efforts are designed to predict where this maximum concentration will occur. Although these models are not totally accurate, they provide valuable guidelines in selection of monitoring sites.

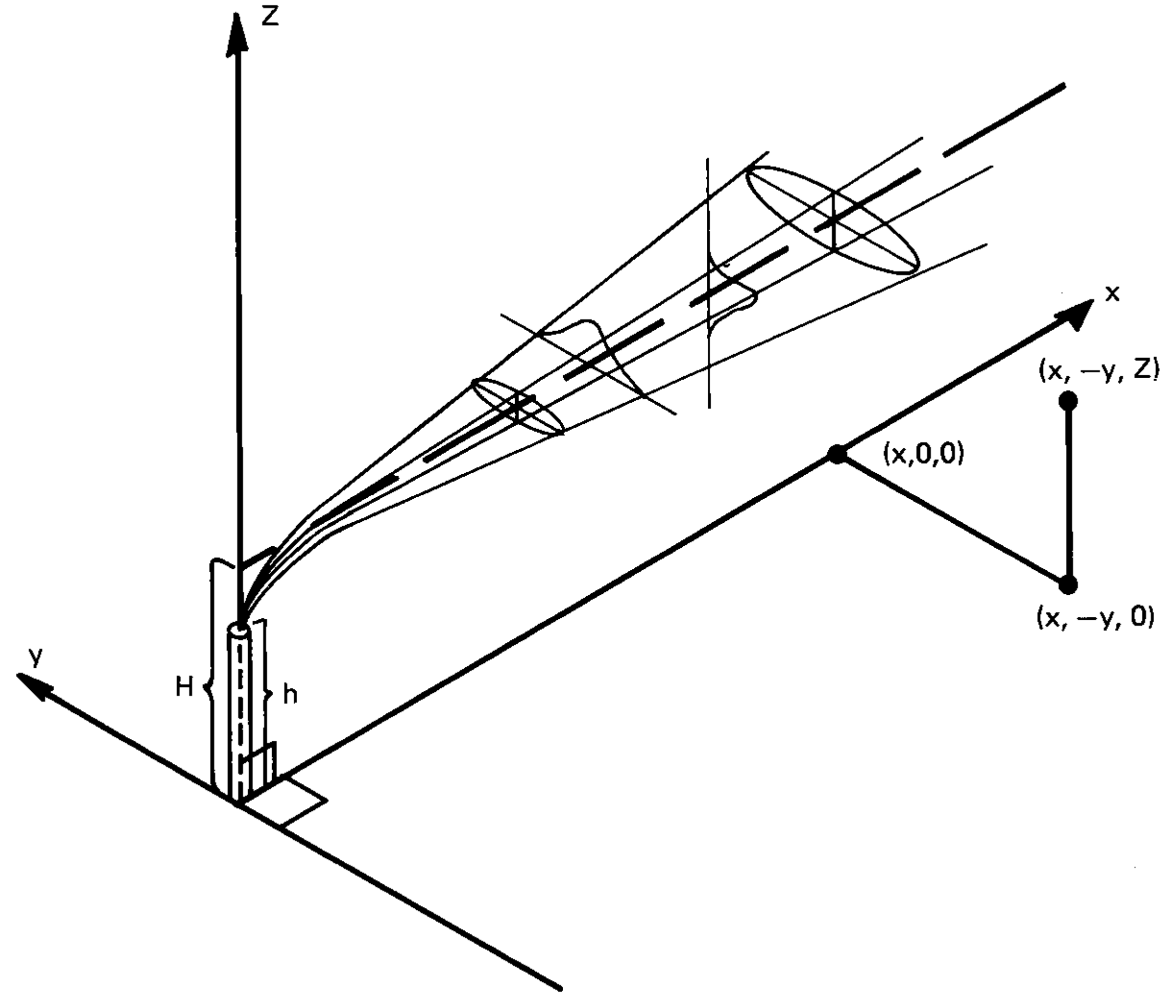


FIGURE 6-2
COORDINATE SYSTEM SHOWING PLUME DISPERSION (1)

6.2.2 Topography

The transport of air pollution is also affected by topographical features. Under conditions of irregular topography, application of the standard Gaussian dispersion equation is often invalid. Obstructions such as hills, mountains, and river valleys have a profound effect on the dispersive capability of the atmosphere. Because none of the current dispersion models do not adequately account for these effects, a certain amount of intuitive judgment is required in choosing an air monitoring site in complex terrain. For example, slopes and valleys are generally poor sites for air monitors because pollutants are generally not well dispersed and the measured concentrations would not be representative. Monitors placed on shorelines usually do not give meaningful results because local circulation patterns (lake and sea breezes) are created by bodies of water (2). Hillsides and mountains cause turbulence and as a result could bias site readings. A manmade obstruction, such as a building, also tends to cause downwash on the leeward side of the building (3). When locating a monitor near a source of ground dust, it is advisable to elevate the equipment above the level of maximum ground turbulence or simply to place it as far as possible from the source. Again, personal judgment is always required, based on a visual inspection of the site.

6.3 Equipment for Ambient Air Monitoring

Most industries organizing an ambient air monitoring program will need to measure concentrations of sulfur dioxide and particulates in a manner that corresponds as far as possible with the methods and averaging times specified in local, state, and federal regulations.

Particulate monitoring is usually done with a high-volume air sampler, a vacuum-type device that provides average concentrations over a 24-hour period. Monitoring for gaseous pollutants can be done with static samplers that give averages over a 30-day period and with dynamic samplers that give 24-hour averages. A typical industrial network would consist of the following:

1. One or several high-volume air samplers;
2. Special monitoring equipment, e.g., for measuring fluorides, corrosion studies, or vegetation sampling; and
3. Several dynamic SO_2 and/or one continuous SO_2 monitor.

Almost all ambient air monitoring programs are accompanied by meteorological monitoring of wind direction and velocity; where it is appropriate and economically feasible, temperature-sensing devices can be operated at various elevations to indicate stability of the air mass.

6.3.1 Particulate Monitoring – Total Suspended Particulates (TSP)

The high-volume sampler, shown in Figure 6-3, has gained wide acceptance in the measurement of concentrations of suspended particulates. This sampler is a rugged, reasonably inexpensive device with good filtering efficiency that can be operated for long periods with minimum maintenance. It has been used in the National Air Sampling Network (NASN) since 1953.

The NASN periodically reports air quality data for all parts of the country including urban and nonurban areas. The nonurban data provide an estimate of the background concentrations of suspended particulates. Long-term averages of NASN data from urban areas can be used for estimating the relative degree of particulate pollution in the air of various communities; the data may also be used for correlation of air quality with population, geographic location, and extent of industrialization. When used in this way, NASN data can be a valuable aid in estimating the degree of pollution in the area being studied.

A high-volume sampler uses a vacuum-cleaner type of motor and blower to draw large volumes of air through a filter on which particulates are collected for measurement and analysis.

A high-volume sampler will handle 30 to 70 cubic feet of air per minute, or 50,000 to 75,000 cubic feet in a typical 24-hour period. The rate of flow varies somewhat, depending on the make of sampler and the type of filter. Ordinarily, the rate of flow falls off considerably as particulate matter collects and builds up on the filter. This is of twofold concern. First, the high-speed motor in the sampler usually requires 25 to 30 cfm of air for proper cooling; if the sampler is operated for extended periods with lower airflow, the motor may overheat and fail. Second, the total volume of air sampled must be estimated with fair accuracy to allow accurate calculation of particulate concentration.

The total airflow through the sampler is determined from rotameter readings at the beginning and end of the operating period. This procedure assumes that the decrease in flow rate is linear with time and that the average rate is representative of the entire sampling period. Figure 6-4 illustrates a typical data sheet.

The high-volume air sampler should provide the following information:

1. Daily 24-hour readings for TSP,
2. Maximum 24-hour values for TSP, and
3. Annual geometric mean value for TSP.

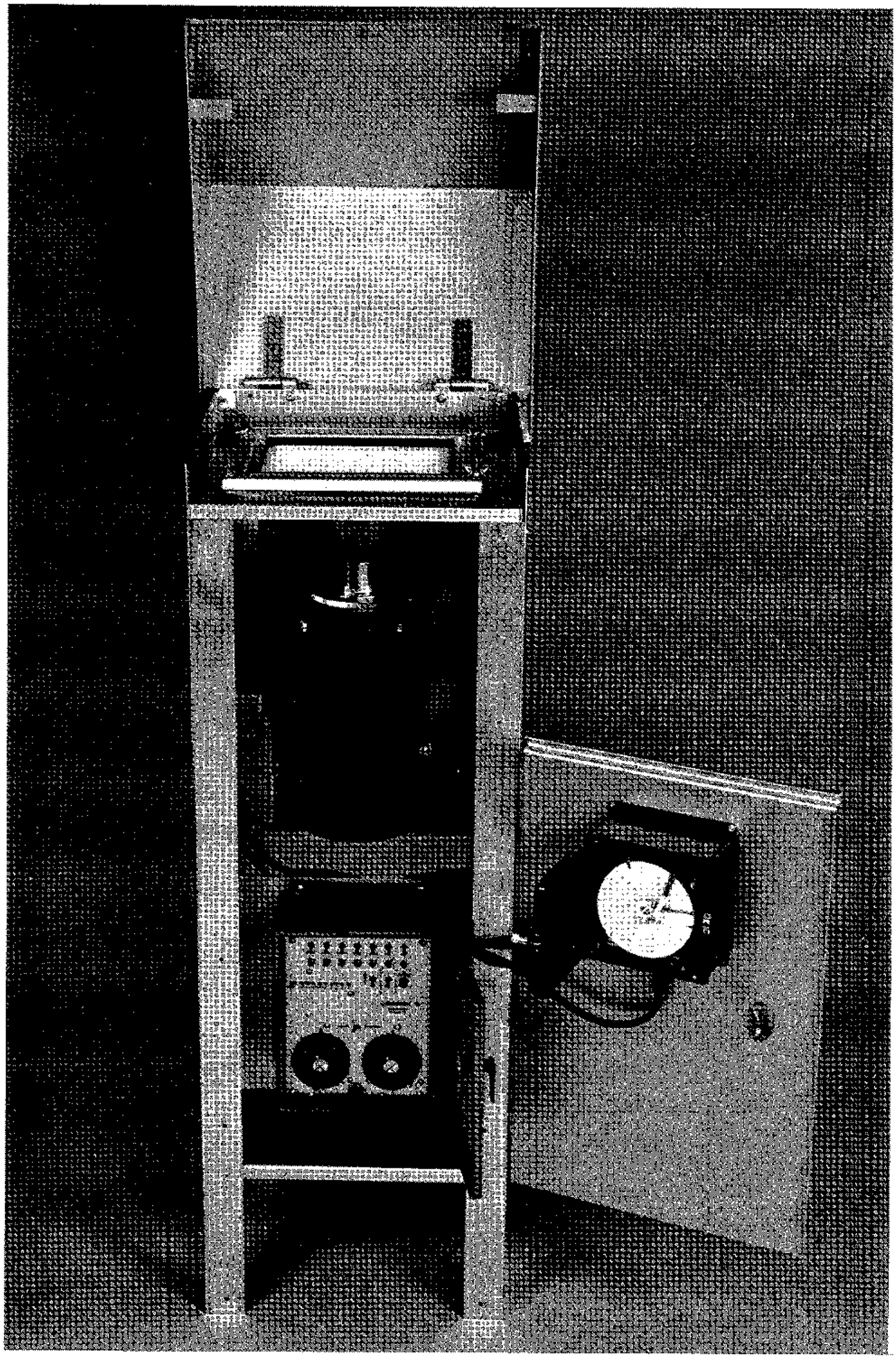


FIGURE 6-3
HIGH-VOLUME AIR SAMPLER

Courtesy: General Metal Works, Inc.,
Cleves, Ohio

HI-VOL DATA RECORD

STATION LOCATION
CITY & STATE ____________________
SITE ADDRESS ____________________
PROJECT ____________ SITE NO. ____________
INSTRUMENT LAST CALIBRATED ____________________

SAMPLER IDENTIFICATION NO. ____________________
FILTER NUMBER ____________________
START SAMPLING ____________________
mo day yr hr min CFM
STOP SAMPLING ____________________
mo day yr hr min CFM
WIND: ____ calm, ____ light, ____ gusty
VISIBILITY: ____ clear, ____ hazy
SKY: ____ clear, ____ scattered, ____ overcast
HUMIDITY: ____ dry, ____ moderate, ____ humid
TEMPERATURE °F: ___ < 20, ___ 20-40, ___ 41-60, ___ 61-80 ___ > 80

- Faceplate must be hand tight
- Flow rate must be ± 10% of established flow rate
- Faceplate gasket must be in good condition
- Rotameter must be free of foreign material
- Rotameter operation must be stable
- Sampler motor brushes must be changed every 400 hrs of operation

Sample was collected in accordance with
the above guidelines

____
signature

REMARKS ____________________
____
____
____

HI-VOL DATA RECORD
(Continued)

Net Particulate Wgt. ____________ grams
Air Volume ____________ m^3
Particulate Concentration ____________ $\mu g/m^3$
Total Sampling Time ________ ________
hours minutes

REMARKS ____________________
____
____
____

FIGURE 6-4
FIELD SHEET FOR HIGH-VOLUME AIR SAMPLER

6.3.2 Monitoring for SO_2

Sulfur dioxide (SO_2) may be monitored by a variety of techniques:

Type monitor	Monitoring techniques	Average time
Static	Sulfation plate	30 days
Dynamic	Bubbler train	24 hours
Continuous	Various instrumental techniques	Variable

The static sampling data can be correlated with the dynamic and/or continuous monitoring data. The correlation relationships, however, vary with meteorological conditions, and data from one location may not be applicable to another location. This technique has, to a greater degree, been replaced by the use of computer modeling techniques that are beyond the scope of this document. The static sampler (sulfation plate, Figure 6-5) is made by coating the inside of a 4.8-cm-diameter, plastic petri dish with lead dioxide paste. To expose a sulfation plate, the lid is removed and the plate is placed in a bracket that will secure the plate in an upside-down position. The petri dish serves as the shelter, shipping container, and lead dioxide support.

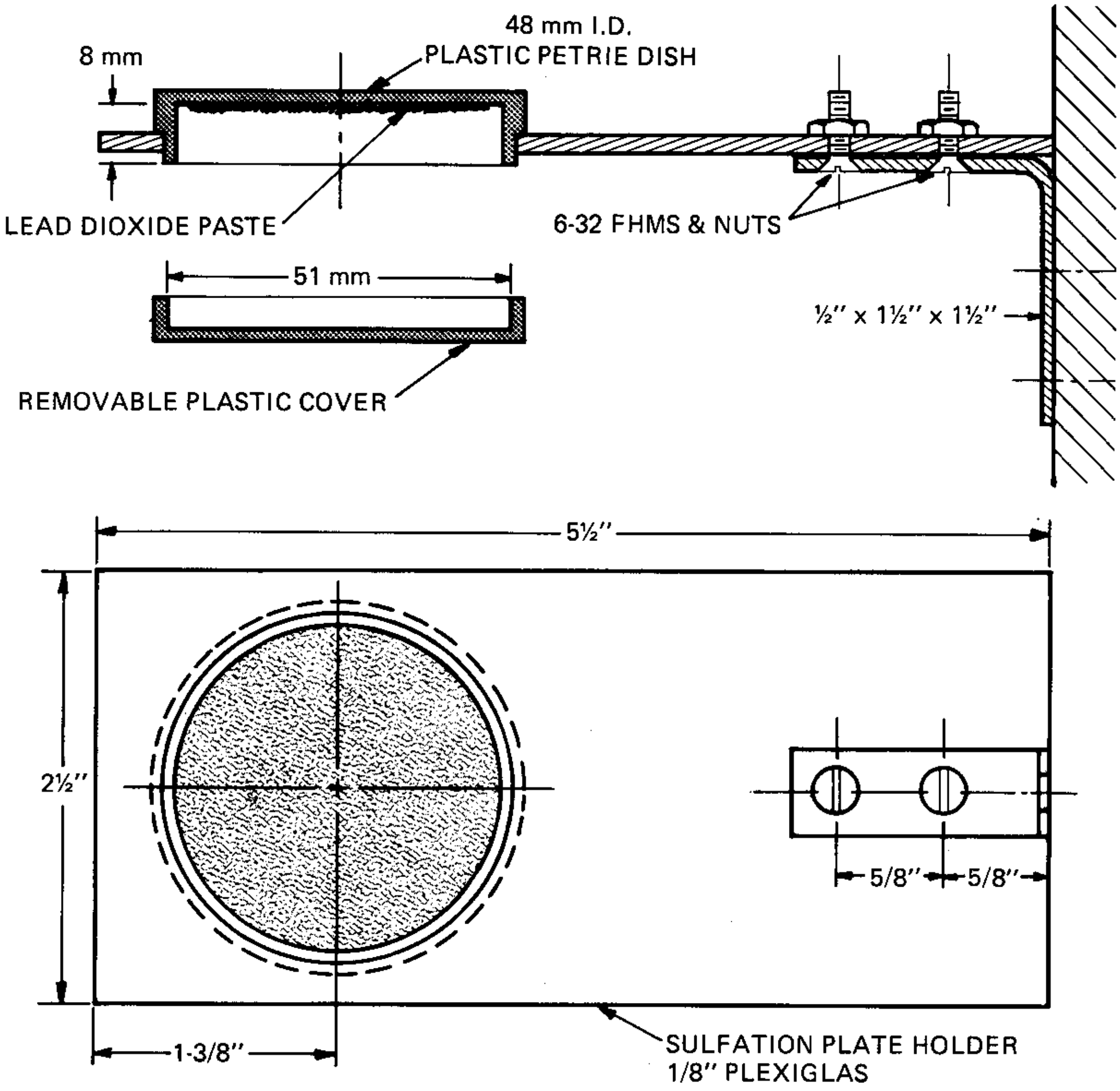


FIGURE 6-5
SULFATION PLATE AND HOLDER

The dynamic and continuous sampling units usually consist of a system incorporating several components, as shown in Figure 6-6. The system for a dynamic gaseous collection unit consists of:

1. Inlet section,
2. Absorption section,
3. Flow regulation device, and
4. Prime mover (usually a pump).

Typical of the absorption devices used in a dynamic sampling train are the midget and Greenberg-Smith impingers. Other devices available are listed in Table 6-2.

The equipment for a continuous monitoring system for gases might consist of:

1. Inlet section,
2. Gas pretreatment section,
3. Detector,
4. Photomultiplier,
5. Spectrometer, and
6. Readout device.

Pretreatment of the gas stream, depending upon the conditions and gas to be monitored, could include techniques for:

1. Pressure adjustment,
2. Removal of particulates (usually a filter),
3. Removal of moisture (usually a silica gel column), and
4. Temperature adjustment (usually a condenser).

Recommended manual and instrumental monitors for gaseous pollutants are listed in Table 6-3.

6.3.3 Meteorological Monitoring

Many industries will wish to establish meteorological monitoring stations to provide data

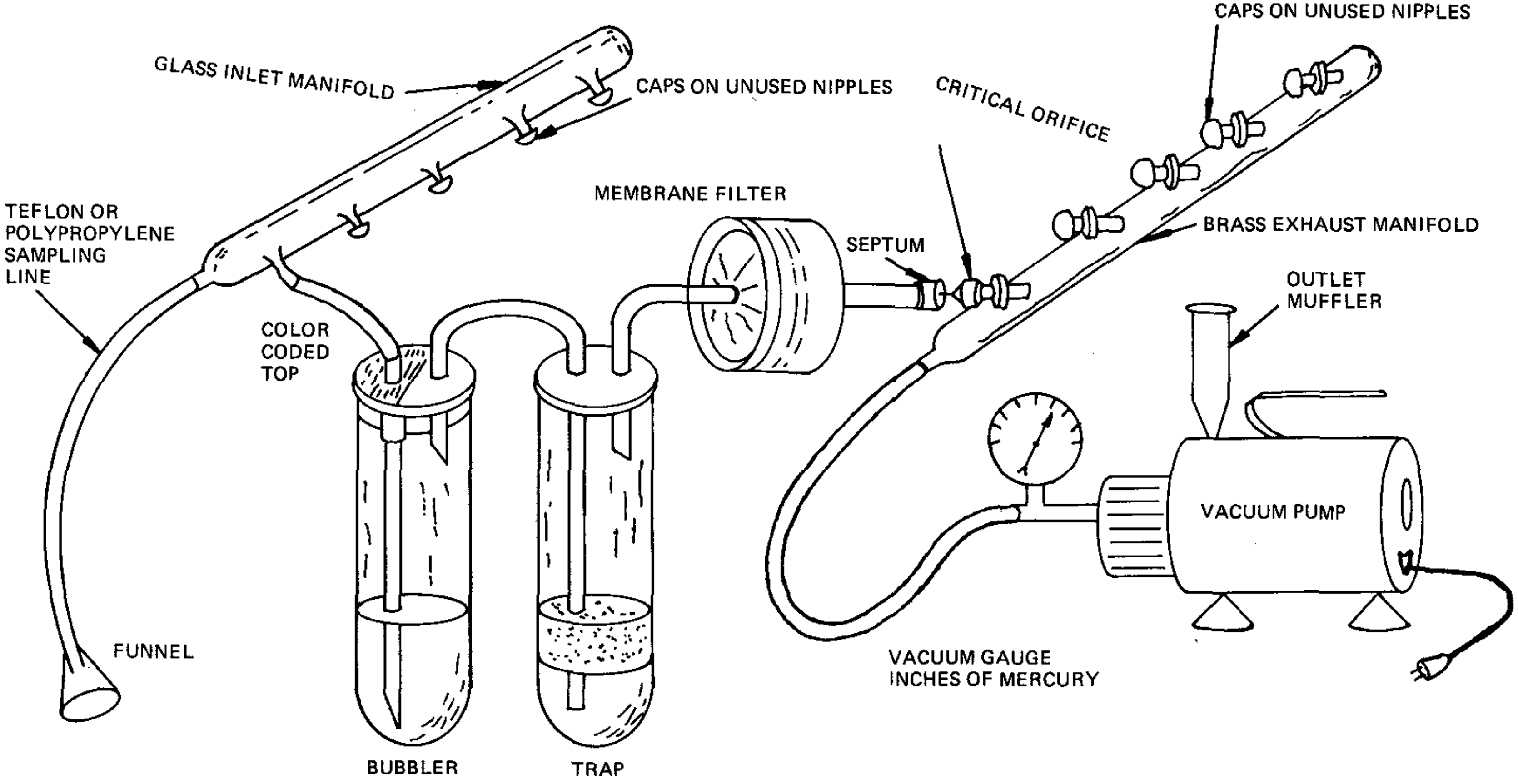


FIGURE 6-6
DYNAMIC SAMPLING UNIT (BUBBLER TRAIN)

for dispersion modeling, for plotting a pollution rose, for correlation with ambient air sampling data, and for validation of complaints. As discussed earlier, most systems will monitor wind direction and wind velocity as a minimum, with possible addition of a temperature tower to obtain atmospheric stability information. Wind speed is measured with an anemometer, and wind direction with a wind vane; a temperature tower is equipped with resistance thermometers and thermocouples.

TABLE 6-2
ABSORPTION SAMPLING DEVICES

Principle of operation	Devices	Capacity (ml)	Sampling rate (l/min)	Efficiency (%)	Comment
Simple gas-washing bottles. Gas flows from unrestricted opening into solution. Glass, conical or cylindrical shape.	Standard	125-500	.1 - .5	90 - 100	Bubblers are large. Reduction of sampling rate increases efficiency. Several units in series raises efficiency.
	Drechsel	125-500	.1 - .5	90 - 100	Similar to above
	Fleming	100	.1 - .5	90 - 100	Difficult to clean
Modified gas-washing bottles	Fritted bubbler	100-500	.1 - 1.5	95 - 100	Fritted tubes available for simple gas-washing items above. Smaller bubblers provide increased gas-liquid contact.
	Glass bead bubbler	100-500	.1 - .5	90 - 100	Provides for longer gas-liquid contact; smaller bubbles.
Large bubbler traverses path extended by spiral glass insert.	Fisher Milligan bottle	275	.1 - .5	90 - 100	
	Greiner-Friedrichs	100-200	.1 - .5	90 - 100	Similar to Fisher Milligan
Impingers, designed principally for collection of aerosols. Used for collection of gases. Restricted opening. Fritted tubes available which allow use as bubbler.	Greenburg Smith	500	.1 - .5	90 - 100	Cylindrical shape
	Midget	100	.1 - .5	90 - 100	
Smog bubbler	Fritted bubbler	10-20	1.0 - 4.0	95 - 100	

TABLE 6-3
RECOMMENDED SAMPLING METHODS

Pollutants	Ambient sampling	
	Manual procedure*	Instrumental**
Sulfur dioxide (SO_2)	Pararosaniline - colorimetric (modified West Gaeke procedure)	Colorimetric (modified West Gaeke procedure) Coulometric Flame photometric
Nitrogen dioxide (NO_2)	Sodium hydroxide-sodium arsonite method by A.A. Christe et al. Analyst, 519-524 (1970)	Colorimetric Coulometric Electrochemical Chemiluminescent
Carbon monoxide (CO)	Evacuated flask or bag with nondispersive infrared	Continuous sampling, nondispersive infrared
Photochemical oxidants (ozone)	Neutral buttered potassium iodide	Chemiluminescent - specific Coulometric - most instruments Colorimetric - not specific for O_3

*Federal Register 36: 8186 April 30, 1971 (official recommendation).

**Hochheiser, Environmental Science and Technology, Volume 5-678, 1971 (not an official recommendation).

6.4 Continuous Stack Monitoring

Continuous stack monitoring as applied in industry is not to be confused with programs of continuous air monitoring. Continuous monitoring of ambient air is seldom conducted by organizations other than control agencies or research groups, or in large-scale operations such as those of the Tennessee Valley Authority. The required equipment is costly and a high degree of technical skill is required for calibration, operation, and maintenance of the automated sampler/analyzers. Continuous monitoring by an industry consists of monitoring emissions at the source (stack) by means of a variety of detectors, which are described later in this section.

The New Source Performance Standards (NSPS) require continuous monitoring of specific pollutants by certain industries (1). At present, the number of industries required to monitor continuously is quite small. Because continuous monitoring provides more comprehensive emissions data than are obtained by manual source test methods, the number of industries required to install monitors will probably continue to increase. Only those industries affected by the NSPS as of February 1977 are discussed here. Since additional continuous monitoring may be required by state and local regulations, it is suggested that industry officials maintain contact with the local control agencies as to current and anticipated requirements.

In addition to meeting NSPS, continuous emissions monitoring can serve as a useful tool for optimization of process and control equipment (2). Unlike manual source tests, continuous monitoring allows the observation of real-time changes in emissions while adjustments are made in process and control equipment. Thus the process operations can be optimized to obtain and maintain maximum efficiency.

In many industries, product lost up the stack is profit blown away. This is true of sulfuric acid plants and other industries. At petroluem refineries where excess particulate emissions from the catalyst regenerator of a catalytic cracking unit may cause loss of valuable catalyst, continuous monitoring could prevent such losses (3). Monitoring of CO_2 or O_2 in stack gases of a power plant can lead to improvements in combustion efficiency (2). Monitoring also serves as an alarm system to alert plant operators when a process malfunction occurs. Primary zinc, lead, and copper smelters can use data obtained from properly operated continuous monitors to demonstrate compliance (1). If utilized properly, the investment in continous stack monitors not only will aid in meeting NSPS requirements but also will pay dividends.

Only industries required by the NSPS to continuously monitor emissions, as of February 1977, are considered in this section. Those industries and pollutants for which continuous monitoring is now required are listed in Table 6-4. Monitoring requirements for new or modified industries affected by NSPS are given in the Code of Federal Regulations (CFR), Vol. 40, Part 60, Standards of Performance for New Stationary Sources. (These requirements were also published in the *Federal Register* of October 6, 1975.)

Continuous monitoring systems to meet NSPS requirements fall into two categories: opacity monitoring for particulates, and continuous (extractive and in-stack) monitoring for gases. Both systems are described briefly in this section; detailed information on specific systems can be obtained from the manufacturer. Regardless of which system is used, all aspects from location of the sampling point to the recording of data should be considered in detail by the purchaser before any purchase is made. Savings on the original purchase are often lost to repeated maintenance of poorly designed and installed continuous monitoring systems.

Industrial planners should consider continuous monitoring as a process control technique as well as an environmental monitoring requirement. Continuous monitoring is expensive; it requires considerable attention, on a continuous basis, to calibration/certification procedures, operation and maintenance, and data handling. If it becomes necessary to consider continuous stack monitoring, a systematic approach should be considered for all aspects of the system. Such an approach is illustrated in Figure 6-7.

Data recording, processing, presentation, and storage are all very important aspects of the continuous monitoring program. There are many methods of data handling, as illustrated in Figure 6-8.

6.4.1 Opacity Monitoring for Particulates

Opacity is a measure of the degree to which the emissions from a stack obscure the view of an object in the background. Opacity readings (in percent) indicate the visibility-obscuring properties of the total gas stream, not the particulates alone. The opacity monitor does not provide a reading of particulate concentration ($\mu g/m^3$ or other units); most stack monitoring that does measure particulate concentration is still done by manual methods. Sampling trains incorporating various procedures collect a sample over a specified period of time (e.g., a minimum of 1 to 2 hours); the total sample collected in this time period is called an integrated sample, whose analysis yields a composite picture of the particulate concentrations during the sampling period.

Equipment for instrumental continuous monitoring of particulates has been in development for several years. A promising commercial unit now on the market uses a filtration beta radiation attenuation technique. This unit incorporates components for di-

TABLE 6-4
INDUSTRY–MONITORING REQUIREMENT MATRIX

Facilities required to monitor emissions	Opacity	SO_2	NO_x	O_2 or CO_2	CFR references
Fossil-fuel-fired steam generator	X	X	X	X	60.45
Nitric acid plant			X		60.73
Sulfuric acid plant		X			60.84
Petroleum refinery	X	X			60.105
Primary copper smelter	X	X			60.165
Primary lead smelter	X	X			60.185
Primary zinc smelter	X	X			60.175
Steel plants, electric arc furnace	X				60.273
Ferroalloy production facility	X				60.264

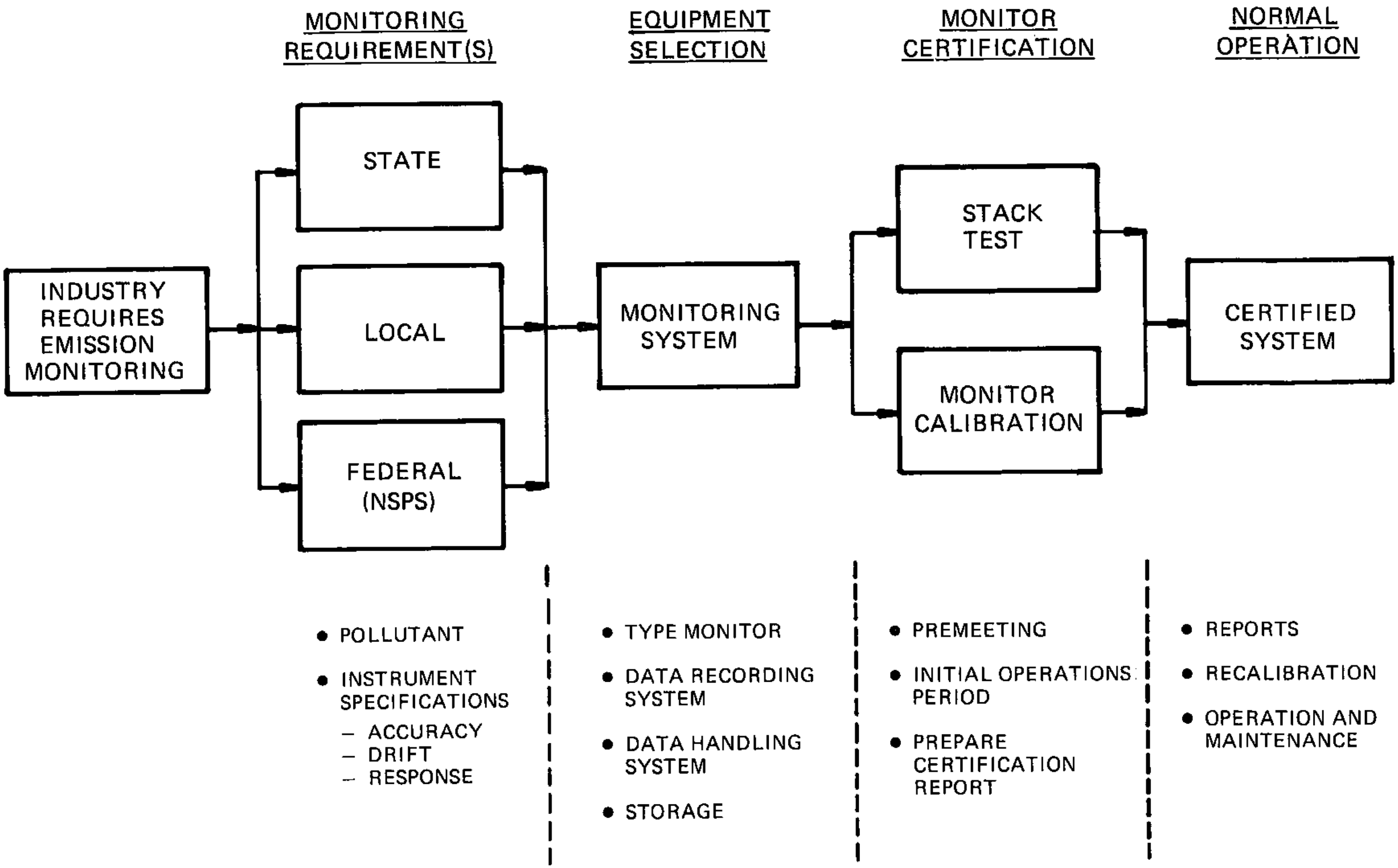


FIGURE 6-7
SYSTEMATIC APPROACH TO CONTINUOUS STACK MONITORING

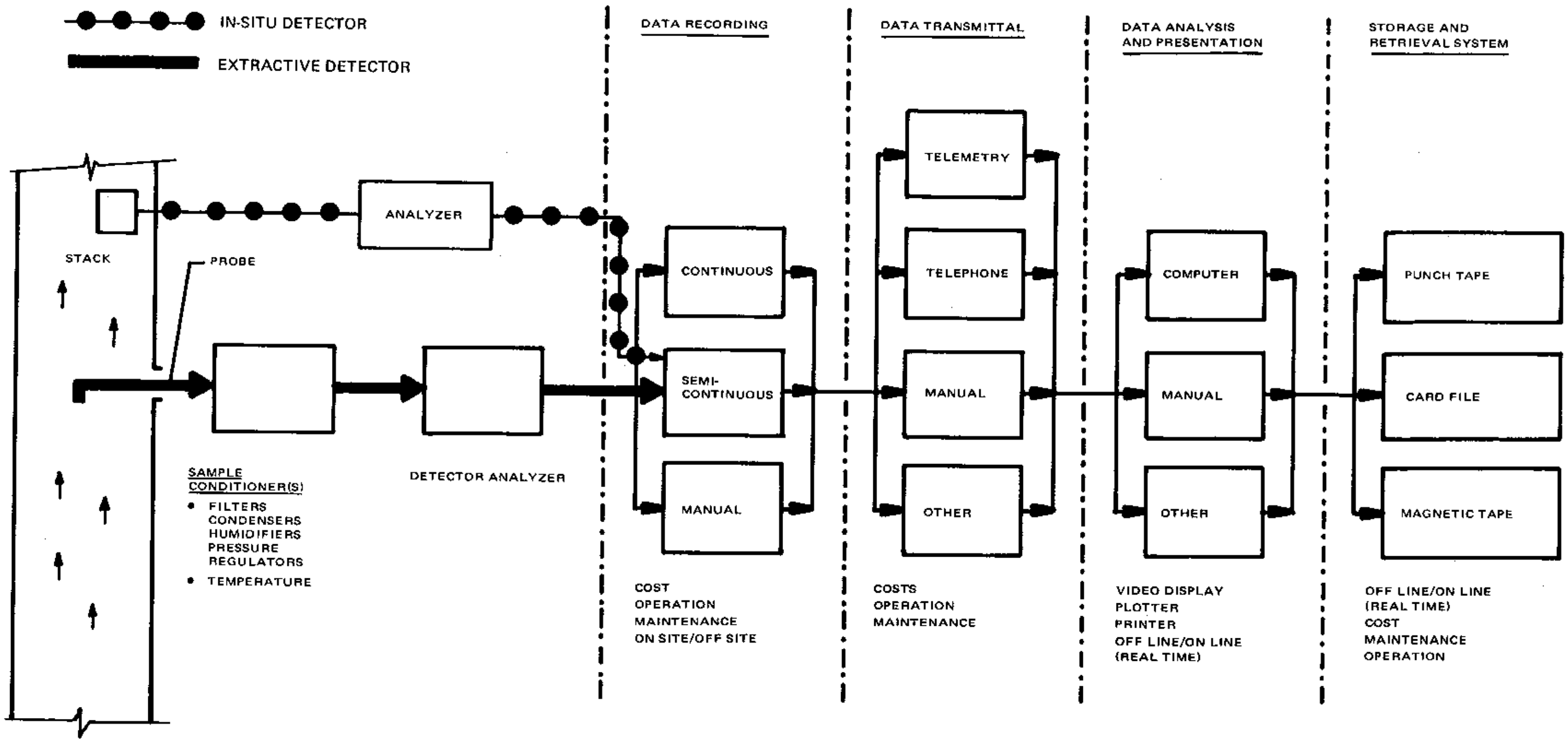


FIGURE 6-8
CONTINUOUS MONITORING SYSTEM

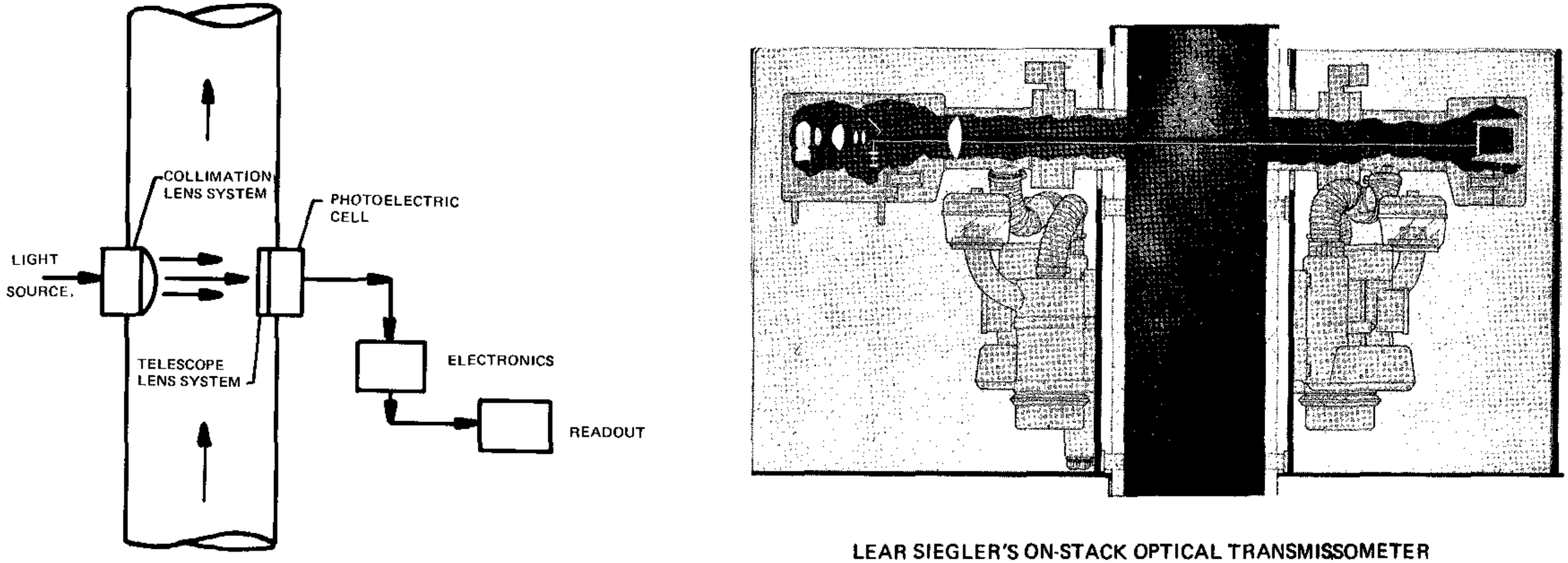
lution, filtration, detection of the attenuation of beta radiation, and recording of data. Research and development of monitoring instrumentation is also producing other advanced systems and new measurement techniques. In this discussion, however, we are focusing on the requirements set forth in the NSPS for industry, and therefore on the theory and uses of opacity monitoring instruments, which are specified in those requirements.

In manual determinations of opacity, the degree of obscurity is determined by trained personnel who visually observe the emissions plume. In commercial opacity monitors, the trained observers are replaced by a light source and a light detector. A beam of light from the source is directed through the emissions to be measured and into the detector. If the emissions do not obscure or diminish the light, then 100 percent of the light reaches the detector and the opacity is zero. If the emissions completely obscure the light so that none of it reaches the detector, then the opacity is 100 percent. By use of filters that absorb known percentages of light, the monitor can be calibrated to determine various degrees of opacity. Readings are corrected to stack exit conditions for comparison with visually observed opacity. Opacity monitors are also referred to as transmissometers or smoke monitors.

Commercial opacity monitors are of two types: single-ended and double-ended (Figure 6-9). Both types operate on the principal of measuring the amount of visible light being absorbed by the emissions. On the double-ended monitor, the light source is located on one side of the stack and the detector on the other side, opposite the source. The light beam makes one pass through the emissions before reaching the detector. The double-ended opacity monitor has been in use the longest and is the least expensive. It does, however, have some inherent problems. Because the source and detector are on opposite sides of the stack, it is difficult to maintain the fine degree of alignment that is required for proper operation. Changes in line voltage between the source and detector will cause changes in opacity readings. Zero and span checks are more difficult with this type of monitor than with a single-ended system.

With the single-ended opacity system, the light source and detector are located on the same side of the stack. A mirror or some type of reflecting device is then located on the other side of the stack, opposite the source. A light beam from the source makes two passes through the emissions before reaching the detector. This doubling of the light path allows for increased sensitivity. Because both the light source and detector are on the same side of the stack, it is a simple matter to make a relative or differential measurement between the light source intensity and the amount of light reaching the detectors. Problems such as voltage variations and electronic drift are cancelled out in this type of relative measurement.

In both types of opacity monitoring systems, the optical windows require a constant purging of clean air to prevent buildup of dust, which reduces sensitivity and induces errors in the readings.



LEAR SIEGLER'S ON-STACK OPTICAL TRANSMISSOMETER
MEASURES SMOKE CAPACITY AND PARTICULATE EMISSIONS

FIGURE 6-9
TECHNIQUE FOR VISIBLE EMISSION DETECTION

Opacity monitoring systems must be capable of measuring opacities at a minimum of once every 10 seconds. Average readings are to be recorded at least once every 6 minutes by an appropriate strip-chart recorder or data-logging device.

Before being placed in operation, the opacity monitoring system must undergo 168 hours of performance testing. Calibration is performed by using certified filters, which give opacity readings at low, mid, and high points. The specifications listed in Table 6-5 must be met during the testing period.

Once an opacity monitor is put into operation, a record of each consecutive 6-minute average, calculated manually or automatically, must be kept for reporting purposes. To assure proper operation, zero and span checks are made daily. Maintenance, cleaning, and optical alignment are performed as needed.

TABLE 6-5
PERFORMANCE SPECIFICATIONS FOR OPACITY MONITORS

Parameters	Specifications
Calibration error	⩽ 3% opacity
Zero drift (24 hours)	⩽ 2% opacity
Calibration drift (24 hours)	⩽ 2% opacity
Response time	10 sec (maximum)

The following questions should be considered in selection of a site for monitoring opacity.

1. Is the monitor located so that the representative emissions from the designated process will be measured?
2. Will the emissions being measured be representative of those being emitted from the stack?
3. Is the site easily accessible?
4. Will the monitor be protected from adverse conditions?

Because at many facilities only certain specific sources must be continuously monitored, site locations are made in relation to these processes. If the process has a control device, the opacity monitor must be located after the device. Facilities with multiple sources using a common stack may be able to use a single monitor if all sources are subject to the same standards. Where multiple sources are using the same stack but are subject to different standards, individual opacity monitors must be used.

Monitoring locations must be selected such that the facility can demonstrate that a representative sample of the emissions is being observed. Areas to be avoided are locations where stratification or layering of dust in the gas stream may occur and areas where water droplets will cause interference. Stratification is common in horizontal ducts as the heavier particles tend to settle toward the bottom (Figure 6-10). Other areas to be avoided are sharp turns, obstructions, or changes in the cross-sectional area of the duct. Junction of two or more gas streams will also cause stratification, even in vertical ducts. Any site under consideration should be thoroughly tested for stratification prior to the installation of an opacity monitor.

Water droplets in the gas stream will have the same effect on the opacity monitor as particulates. If water droplets are a problem, alternative monitoring requirements must be considered.

Accessibility to the opacity monitor is not only good sense but is a requirement of the NSPS (1). Personnel should be able to service the monitor without spending unnecessary time looking for a ladder or climbing over equipment. Some zero and span checks require daily visits to the monitoring site; some opacity monitoring models conduct zero and span checks automatically.

Frequent changes in optical alignment will require unnecessary maintenance. In order to minimize this problem, opacity monitors should be located in areas free from excessive vibration. Another cause of alignment problems is thermal expansion and contraction of the monitor supports.

Even though most opacity monitors are designed to withstand adverse conditions, it is best to provide adequate shelter for both the instrument and personnel.

6.4.2 Continuous Monitoring for Gases

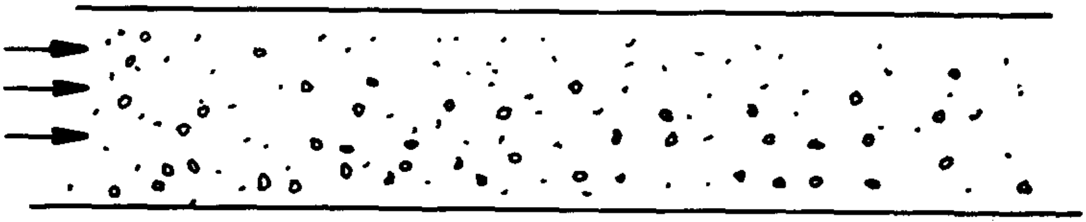
Current technology for continuous monitoring of stack gases is in a state of flux. Most units are prone to interferences from pollutants other than that being analyzed, and they are also subject to electronic instability.

The general considerations for a continuous monitor of gaseous pollutants are listed in Table 6-6.

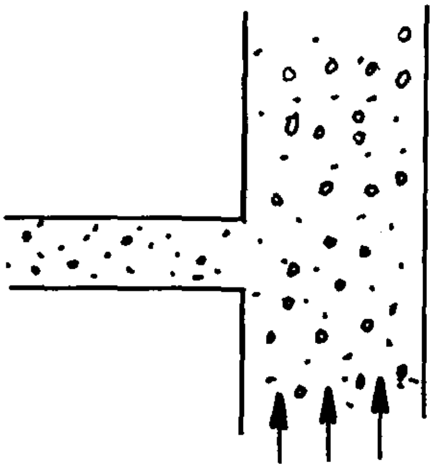
6.4.3 Instrument Specifications and Certification

The EPA has issued specifications for monitoring instruments that are used to determine compliance with the NSPS for specific industries; these are listed in Table 6-7.

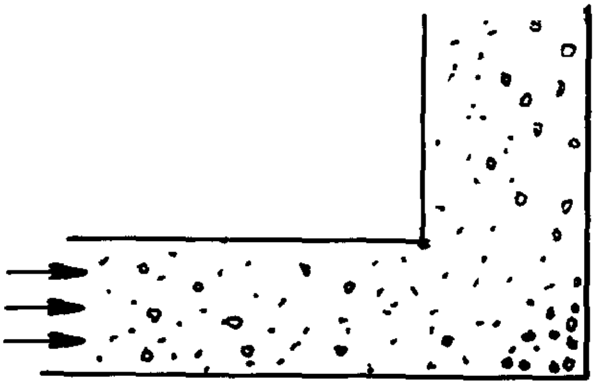
Each continuous monitor installed must be tested to certify that it meets the requirements of Vol. 40 CFR Part 60 (as published in the *Federal Register*, October 6, 1975). Typical of these certifications are the requirements for SO_2 monitors on sulfuric



HORIZONTAL DUCT, STRATIFICATION DUE TO SETTLING



JUNCTIONS, STRATIFICATION DUE TO POOR MIXING



TURNS AND OBSTRUCTIONS, STRATIFICATION DUE TO INERTIA OF PARTICLES AND TURBULENCE

FIGURE 6-10
STRATIFICATION OF PARTICLES IN DUCTS

TABLE 6-6
CRITERIA FOR CONTINUOUS MONITORS FOR GASES

Specificity	Response should be only to trace material(s) of interest.
Sensitivity, range	Method must be sensitive over the concentration range of interest.
Stability	Sample must be stable in the analyzer.
Precision, accuracy	Results must be reproducible, and must represent the actual stack concentration when compared with the reference method gases.
Sample average time	Method must fit into the required sample averaging time for control.
Reliability, feasibility	Instrument investment and maintenance costs, analysis time, and manpower must be consistent with needs and resources.
Calibration	Instrument should not drift; calibration and other corrections should be automatic.
Response	Instrument must function rapidly enough to record significant process changes as they occur.
Effect of ambient conditions	Changes in temperature and humidity must not affect the accuracy of the observed results.
Data output	For some applications, output of the analyzer should be in a machine-readable format.

acid plants. Certification of the continuous monitor's accuracy must be completed in the seven steps outlined below:

Step 1. Analysis of calibration gases. The monitoring instrument must be calibrated at three concentrations of sulfur dioxide: 0, 50 percent, and 90 percent of span. Each calibration gas must be analyzed in triplicate by the EPA reference method.

Step 2. Calibration check. The three calibration gases must be analyzed by the monitor for a total of 15 readings.

Step 3. Zero drift check. The zero must be offset by at least 10 percent of the span to check negative zero drift.

Step 4. Operational test. The monitor must be operated an additional period to verify proper operation.

Step 5. Accuracy test. Gas samples are extracted from the stack and analyzed for SO_2 by the manual reference method. At least nine samples must be collected.

Step 6. Field calibration check. The zero and span drifts must be checked for a minimum of 15, two-hour periods. This check can be simultaneous with the accuracy test.

Step 7. Response time check. With the monitor in place, the time for the instrument to respond from a zero reading to maximum concentration is measured.

Typical procedures used in a certification program for an SO_2 monitor are as follows:

1. Certification Procedure Development

   After a detailed review of the monitoring requirements, a stepwise procedure will be prepared for certification of the SO_2 monitor. This procedure will be specific to plant requirements and operations, and will include log sheets to record data from each step of the certification.

2. Calibration Check of Monitor

   First, the standard gases will be sampled and analyzed to verify their SO_2 concentrations. A minimum of three samples is required by EPA. Each analyzed concentration must be within 20 percent of the mean for that gas. After analysis of the standard gases, the monitor must measure the gases at least 15 times to verify its calibration. The monitor's response time will also be measured a minimum of three times (Steps 1, 2, and 7).

3. Operational Check of Monitor

   After installation, the monitor must be operated for at least 2 weeks for an initial check of all operations. The first week is solely for checking the zero drift. The second week of operation is required to demonstrate the monitor's initial reliability (Steps 3 and 4).

4. Field Accuracy Check of Monitor

   The accuracy of the monitor is established by collecting samples of the stack gas, analyzing the samples by the reference method for SO_2 and comparing the analytical results with the monitor averages for the sampling periods. A minimum of 9 samples over a 9-hour period will be collected for laboratory analysis. Concurrent with this sampling, the monitor will be checked for zero drift and span drift. The drifts will be determined for at least fifteen, 2-hour periods.

TABLE 6-7
INSTRUMENT SPECIFICATIONS

SO_2 and NO_x Monitors:	
Accuracy*	$\leqslant$ 20% of mean value of reference method test data
Calibration error*	$\leqslant$ 5% of each (50%, 90%) calibration gas mixture
Zero drift (2-hour)*	2% of span
Zero drift (24-hour)*	2% of span
Calibration drift (2-hour)*	2% of span
Calibration drift (24-hour)*	2.5% of span
Response time	15 minutes maximum
Operational period	168 hours maximum
O_2 or CO_2 Monitors:	
Zero drift (2-hour)*	$\leqslant$ 0.4% O_2 or CO_2
Zero drift (24-hour)*	$\leqslant$ 0.5% O_2 or CO_2
Calibration drift (2-hour)*	$\leqslant$ 0.4% O_2 or CO_2
Calibration drift	$\leqslant$ 0.5% O_2 or CO_2
Response time	10 minutes
Operational period	168 hours

*Expressed as a sum of absolute mean value plus 95% confidence interval of a series of tests.

5. Report Preparations

All data generated will be tabulated and reduced to a format for comparison with EPA specifications. The results of laboratory analyses will be compared directly with the monitor record. The final report will include the data collected, calculations, and certification of the acceptability of the monitor.

It is apparent that industries must expend considerable time and money in coordinating the certification of stack monitoring equipment to meet the NSPS.

Misinformation about continuous stack monitoring is widespread. Because some in-stack monitors (such as the transmissometers) are available, many persons believe that the average monitoring system also is an in-stack device attached to a detector and recorder. Most stack monitoring systems, however, are extractive rather than in-stack devices. Several pollutants can be analyzed using an extractive system, whereas most in-stack monitors are limited to analyzing a single pollutant. The extractive system, however, presents a serious problem of gas conditioning. For proper operation, the detector must receive gas that is at ambient pressure and temperature, with negligible moisture content. Thus, in an extractive system, the gas entering the detector must be preconditioned to prevent erroneous readings and/or malfunction of the detector.

The average detector for gas monitoring is small and costs in the range of $3,500 to $5,500. The conditioning system, however, requires both a considerable amount of space and a sizable investment. The cost of the conditioning system may well be two to three times the cost of the detector. Care must be taken to select a conditioning system that is compatible with the detection device.

Another significant factor in stack monitoring for gases is location of the monitor; as in particulate sampling, the stratification of gases in ducting and stack must be considered.

Most stack sampling (manual or continuous) is conducted at a location where there is undisturbed flow. The concept of isokinetic sampling for particulates does not necessarily apply to gaseous sampling. It is advisable to conduct a series of exploratory tests across a stack to determine whether the gas being measured is uniform in concentration or is stratified.

If the exploratory examination reveals that the gases are stratified, another location should be considered. In gas sampling, the monitor may be placed at, or following, a turbulent zone, so that mixing of the gases takes place before the gas stream is sampled.

Sulfur Dioxide Instrumentation - Many types of instruments are in current use for continuous analysis of SO_2 gas, including spectrometers and electrochemical sensors. Wet chemical analyzers are not practical for stack monitoring, since they are subject to fouling by mist and particulates and to interference from unremoved gases and water vapor.

The spectrometer using the infrared (IR) or ultraviolet (UV) region of the SO_2 spectrum is the monitor most commonly used, since other types of monitors require withdrawal of a sample from the stack. These monitors use the stack as their optical paths and thereby provide cross-stack average measurements. The SO_2 absorption spectrum is matched against a reference pattern in such a way that other materials do not interfere.

Electrochemical instruments can detect both sulfur dioxide and nitrogen oxides. A fuel cell sensor generates an electric current by electrocatalytic oxidation or reduction of SO_2; the current is directly proportional to the SO_2 concentration in the sample of the gas stream. These sensors must be replaced periodically to provide accurate readings.

The inspector can calibrate the instruments by inserting known concentrations of calibration gas into the analyzer. Two known concentrations can be carried in small sample cylinders and calibrations performed according to the manufacturer's specifications at operating temperatures and pressures. Periodic maintenance is required to remove dust, oil, and condensation from the system.

Nitrogen Oxides and Other Instrumentation - The NSPS for NO_x emissions from new and modified steam generators apply to both NO and NO_2, although less than 5 percent of the NO_x is present as NO_2. Therefore, measurement of the NO content of the stack gas is adequate for monitoring purposes (unless too much excess air is introduced into the exhaust gas stream).

Nitrogen oxides instrumentation includes photometric and spectroscopic analyzers, electrochemical devices, and chemiluminescent detectors. Wet analysis instruments are not practical for in-stack monitoring.

Photometric and spectroscopic analyzers measure light transmission at a specific wavelength. Since these instruments depend upon light transmission, they may give erroneous readings as a result of absorption of radiation by particulate matter or condensates in combustion gases.

Electrochemical instruments, discussed earlier concerning monitoring of SO_2, may give high NO_x readings as a result of the presence of SO_2. An absorber can be installed at the sample inlet system to remove SO_2 from the sample.

Nitric oxide is detected by the chemiluminescent reaction of NO with ozone-producing light (Figure 6-11). The intensity of the light, which is detected by a photomultiplier tube, is proportional to the NO concentration. The instrument is calibrated with standard concentrations of NO by techniques similar to those mentioned for SO_2 calibration.

These are the most common instruments in current use. Depending upon the source, additional continuous monitoring instruments may be required. For combustion sources, it may be necessary to determine combustion efficiency of excess air. This is done by monitoring carbon dioxide or carbon monoxide by nondispersive infrared (NDIR) detection, or by monitoring oxygen with paramagnetic techniques. A schematic of the NDIR system is illustrated in Figure 6-12. At refineries, petroleum storage facilities, or bulk loading facilities for organic chemicals (all of which must be monitored for hydrocarbons), a gas chromatographic system is used. A typical schematic is illustrated in Figure 6-13.

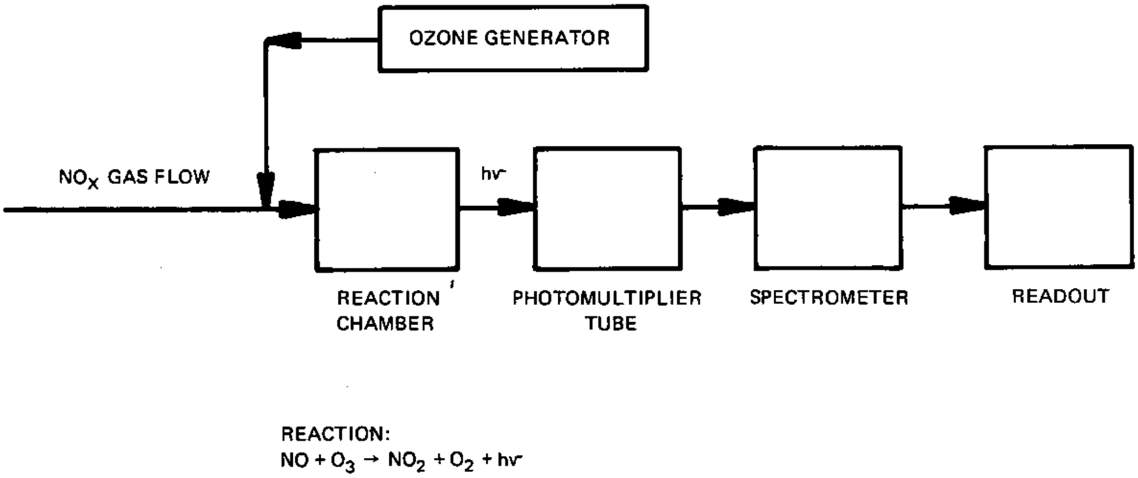
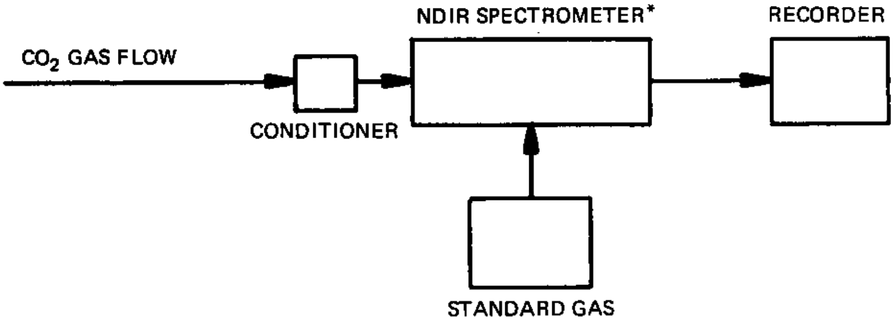


FIGURE 6-11
SCHEMATIC OF CHEMILUMINESCENT TECHNIQUE



*SET AT A GIVEN WAVE LENGTH FOR A PARTICULAR GAS

FIGURE 6-12
SCHEMATIC FOR NONDISPERSIVE INFRARED DETECTION

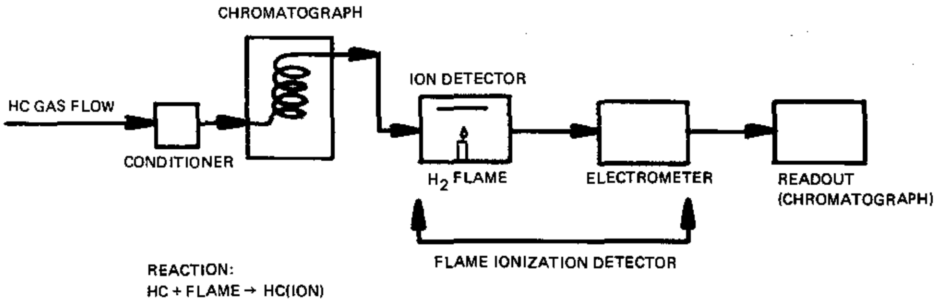


FIGURE 6-13
SCHEMATIC OF CHROMATOGRAPH

6.5 References

1. Turner, D.B., *Workbook of Atmospheric Dispersion Estimates,* U.S. Department of Health, Education, and Welfare, Cincinnati, Ohio, 1970.

2. Munn, R.E., *Descriptive Micrometeorology,* Chapter 13, pp. 118-128, Academic Press, New York, New York, 1966.

3. Slade, D.H., *Meteorology and Atomic Energy,* U.S. Atomic Energy Commission, Office of Information Services, Washington, D.C., July 1968.

CHAPTER 7

THE CONTINUING PROGRAM

7.1 Introduction

Following the establishment of an air quality management program and a successful compliance test, an industrial organization must conduct an active, continuing program to maintain compliance with regulatory requirements. Some of the routine activities of a state and/or local regulatory agency can have a direct effect on the operation of a continuing compliance program. These control activities include scheduling inspections for permit renewal, patrolling industry operations and investigating complaints, and scheduling additional source testing, as circumstances may require.

In order to meet the continuing requirements of regulatory agencies, industrial planners must consider:

1. Plant and control equipment operation,
2. Equipment maintenance,
3. Changes in processes and control equipment, and
4. Testing to verify compliance with emission standards.

This chapter describes the interactions that can be expected with various regulatory agencies and the several facets of an effective industrial program that will ensure compliance with regulations and will promote acceptance by citizens of the community.

Much of the activity of industrial air pollution control programs to date has been directed toward installation of air handling and control systems that will enable the industry to:

1. Comply with state and local pollution control regulations and ordinances,
2. Meet federal NSPS,
3. Assist in meeting the air quality goals set forth in state implementation and maintenance plans, and
4. Comply with the intent of the nondegradation planning concept.

The Council on Environmental Quality, in their seventh annual report to the President, indicated that the cost of operating and maintaining air pollution control equipment for industrial sources alone would be $1.2 billion in 1975 and predicted an increase to $3.1

billion in 1984. The cumulative cost for operation and maintenance from 1975 through 1984 would be $21.7 billion. This expense may be significantly increased in many situations because of a lack of information regarding installation, operation, and maintenance of control equipment.

7.1.1 Process and Raw Material Changes

Often an industry can reduce its air pollutant emissions by process changes, as when a paper mill adds a black liquor oxidation system for odor control, or by a change of process materials, as when a paint spray operation substitutes a solvent containing nonreactive rather than reactive hydrocarbons.

A combination of process modification and raw material changes might be substituted for processes and materials now used in making water-base paints; powder coatings might be substituted for solvent-based paints. Many industrial operators such as printers, lithographers, and makers of cans and barrels can use coating solutions of this type. Pilot studies are needed to determine the feasibility of such changes and to maximize possible economies.

Process Changes–Industry is looking toward process changes as a way to reduce the load on pollution control systems or, preferably, to eliminate the problem at its source. The kraft paper industry is discussed here as an example of pollution reduction by changes in the process. For years the odors from kraft paper mills have been a source of community nuisance complaints. One source of odors is the direct contact evaporator prior to the recovery furnace. The normal flow of black liquor from the digester after blowdown is to the multiple-effect evaporators for concentration, then on to the cascade evaporator (direct-contact evaporator) for further concentration, and then to the recovery furnace for product recovery. Add-on control devices used to control odors from this process are becoming very expensive, and any further reduction in air emissions probably must be accomplished through process modification.

The kraft mill is just one of many examples of process modifications and in-plant changes that reduce or eliminate emissions. Pollutant emissions are affected not only by major process changes of the type just described, but also by relatively minor modifications within a process operation. This is shown in Table 7-1, which defines the effects on emissions of such process variables as fuel temperature and amount of excess air.

Raw Material Changes–A good example of a raw material change that can affect many smaller industrial operations is the type and quality of fossil fuel burned in the boiler. As conversions were made from coal firing to firing of oil and gas, it was believed that emissions would continue to decrease. In recent years, however, with the crisis in availability and cost of fuels, many installations are making fuel substitutions in the reverse direction. Several factors are involved. First is the conversion of equipment required for an oil-burning installation to burn coal. Second, emission control modifications usually are required to prevent an increase in emissions after the substitution of coal for a cleaner fuel.

TABLE 7-1
EFFECTS ON EMISSIONS BY INCREASING VALUES OF SELECTED OPERATING VARIABLES (FUEL OIL COMBUSTION)*

Operating variable	Effect of increase on pollutants			
	NO_x	SO_2	SO_3	Particulates
Percent load	I	–	I	–
Fuel temperature	D	–	I	D
Fuel pressure	D	–	I	D
Excess air	I	–	I	D
Percent CO_2 in stack	D	–	D	I
Dirt in firebox	I	–	D	I
Flue gas recirculation	D	–	–	I
Flame temperature	I	–	I	D
Stack temperature	–	–	I	D
Percent sulfur in oil	–	I	I	I
Percent ash in oil	–	–	D	I

*I = increase
D = decrease
– = no change

7.1.2 Process and Control Equipment Malfunctions

Emissions from an industrial process may meet emission standards during normal operation but far exceed the standards when a malfunction occurs. Malfunctions result from either equipment breakdown or operator error (See Figure 7-1).

Not all malfunctions substantially increase emissions. For example, in a combustion process such as operation of an incinerator or a cement kiln, a failure or malfunction of the refractory would not cause excess emissions but a change in combustion air flow could increase emissions. The factors of concern in regard to malfunctions are:

1. Frequency of occurence,
2. Duration,
3. Effect on emission rate, and
4. Means of minimizing excess emissions.

Various factors related to each industry and process can affect emission rates from malfunctions. Typical malfunctions that can occur with an incinerator are listed in Table 7-2.

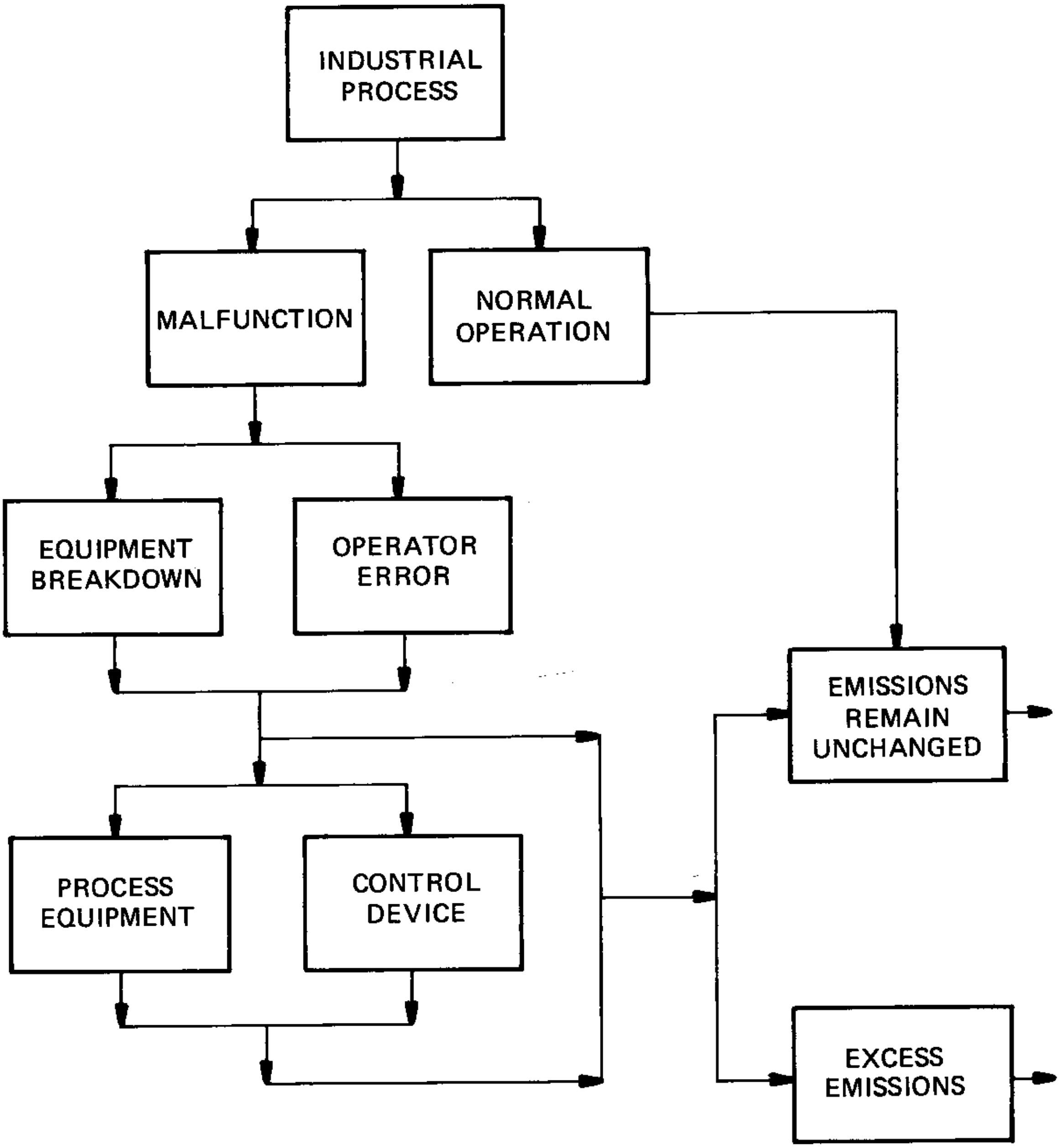


FIGURE 7-1
TYPES OF VARIATION IN PROCESS OPERATION

TABLE 7-2
INCINERATOR MALFUNCTIONS THAT AFFECT EMISSION RATES

Malfunction	Frequency of occurrence	Duration	Effect on emission rate	Means to minimize excess emissions
Damage to grate*	Depends upon maintenance and care used in charging procedures.	Unit repaired at next shutdown.	Minor unless severe damage.	—
Breakdown of flue gas cooling systems	Infrequent.	About one hour until incinerator can be brought off-line.	Requires bypassing of emission controls.	Immediately curtail refuse charging operations.
Excessive air infiltration	—	Results from poor maintenance and will continue until corrected.	Dependent upon amount of air and location.	Usually results from long-term negligence of maintenance.
Plugged air ports	Infrequent.	1 or 2 days.	May be substantial.	Air flow redistribution by dampers.
Precipitators:	Several times/year for well-maintained unit; can be higher if unit is poorly designed or maintained.		Varies but can be substantial.	Reduce gas flow volume to precipitation (i.e., reduce charging rate); have spare parts available.
Plugged spray nozzles		6 to 8 hours.		
Frozen rapping systems		Minimum of 4 hours.		
Broken or dirty electrodes		Varies.		
ESP section out		ESP can usually be repaired in a few hours.		
Bag failures	Average occurrence about once per month.	1 to 4 hours.	Air contaminants will be uncontrolled in the gas stream going through the broken bags.	Check bags periodically for minute leaks and work fabric.

*Reciprocating grates frequently become so clogged that the incinerator will be shut down for grate repair and cleanout. These shutdowns are usually planned, and are not considered malfunctions.

To correct a malfunction in the air pollution control system, the entire process is either shut down or the control device is bypassed. When the malfunction is in the process (depending upon its severity and its effect on air emissions), operation will continue until the normal shutdown period or the process will be shut down for temporary or complete repair. The process may also continue to operate, but it may be necessary to bypass the control device. Certain types of malfunctions cause a temperature increase or excess moisture that could adversely affect a baghouse as well as the air emissions.

Malfunctions often occur during the initial startup of a process. During this time most turnkey plants and control equipment are under warranty; the equipment company/contractor should make the necessary adjustments or modifications that will enable the system to meet the design capacity of the plant and the emission control guarantees. Generally, the purchaser withholds monies during this initial startup period until the process and/or control equipment are functioning satisfactorily and the guarantees are fulfilled. With respect to guarantees on air pollution control equipment it is important that:

1. The air emission test procedures specified in the guarantee are acceptable to all of the regulatory agencies involved; and

2. The emission limitations stipulated in the guarantee are acceptable now and in the forseeable future, to all of the regulatory agencies involved.

7.1.3 Startup/Shutdown and Upset Operating Conditions

Often a malfunction results in the temporary shutdown of a process. The length of the shutdown may have a marked effect on the emissions, as in the shutdown of a sulfuric acid plant. As listed in Table 7-3, the longer a sulfuric acid plant is shut down, the greater will be the sulfur dioxide emissions during startup.

TABLE 7-3
EFFECT OF SHUTDOWN DURATION ON
EFFLUENT SO_2 CONCENTRATIONS DURING STARTUP

Shutdown duration, hours	Peak SO_2 during startup, ppm by volume
<1	185
1-2	520
2-6	1,920
6-10	1,600
10-15	2,250
15+	2,970

In most industrial processes, the shutdown poses no particular problem if normal operating procedures are followed. Shutdowns of most processes do not cause excess emissions. Upset conditions are generally documented on forms such as that illustrated in Figure 7-2.

A cold startup of an industrial process will generally result in excess emissions until the process reaches a stable condition for a given production rate. At startup of a power plant, the particulate emissions and opacity readings will be higher than normal and will continue high until the operation is stabilized (see Figure 7-3). The factors involved in stability of operation include operating temperature, feed rates, air flow, and chemical reactions. The predominant types of air pollution control equipment installed on industrial processes are: (1) baghouse filters and electrostatic precipitators (ESP) for control of particulates, and (2) scrubbers for control of gaseous pollutants.

Procedures for startup of a baghouse system depend upon the equipment and the process. An important basic guideline for any process in which hot moist gases are generated is to preheat the baghouse. This is done to prevent condensation which results in mudded bags. Mudded bags must either be dry-cleaned or replaced. The other condensation hazard is corrosion of the baghouse materials. After the baghouse is preheated, the process can be put into full operation and all functions of the baghouse can be operated. In processes where the acid dewpoint is of concern, the baghouse should be bypassed during startup until the acid dewpoint has been passed.

Startup of an ESP is more complex, requiring a pre-startup inspection as well as specific startup procedures. Details of the pre-startup inspection, routine startup, and routine shutdown are given in Appendix D.

7.2 Control Equipment Maintenance

Although installation of control equipment can aid in maintaining compliance with emission regulations, continuing compliance will not be realized unless the control systems are properly operated and maintained. Industries in the NSPS categories must regularly submit reports to EPA on emission violations and production rates. These reports will reflect satisfactory compliance efforts only where the industry conducts a systematic operation and maintenance program, including the following procedures:

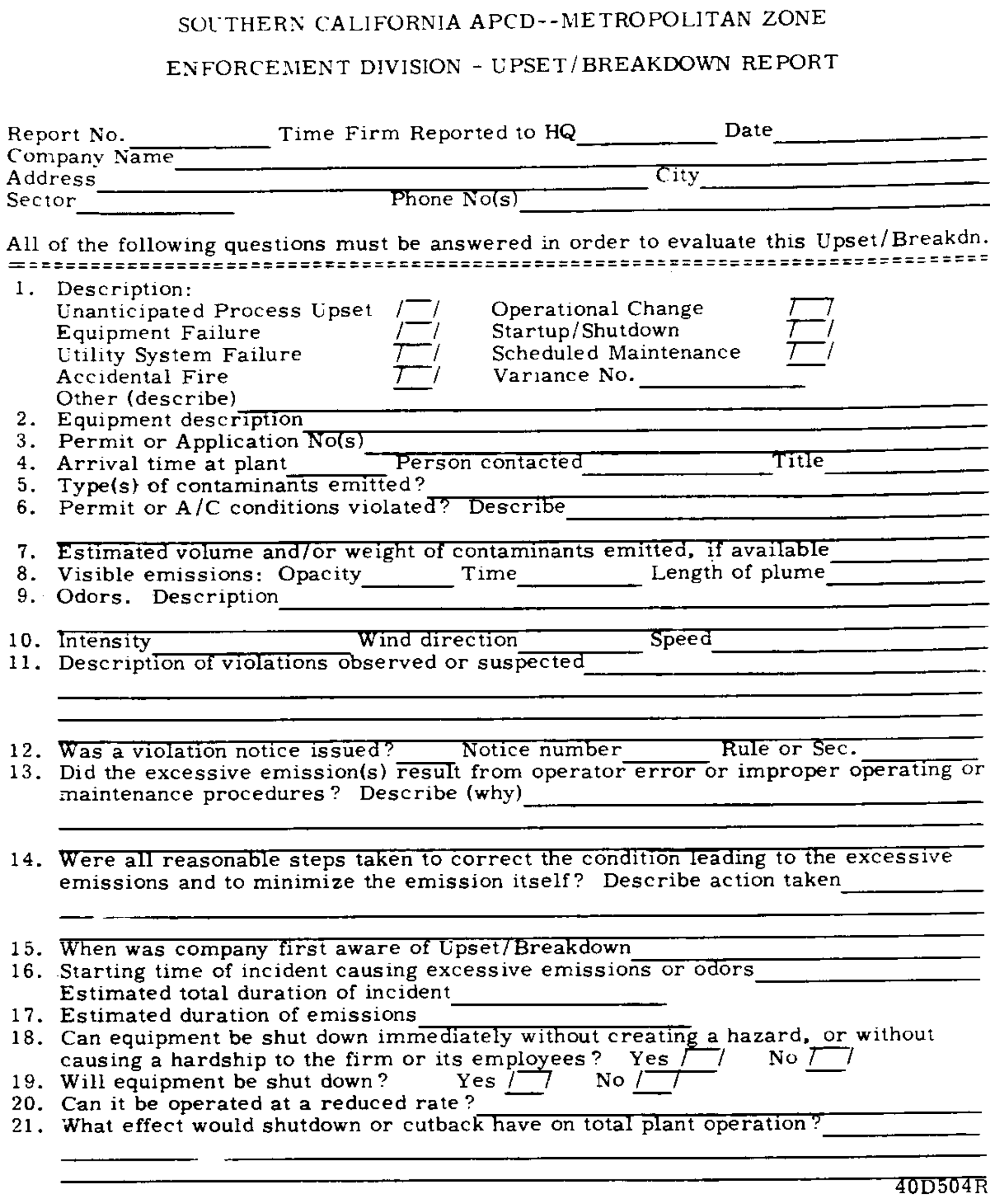
1. Early detection of malfunctions,

2. Prediction and prevention of equipment failures,

3. Identification and correction of problems as they occur,

4. Prevention of damage to equipment, and

5. Reduction of emissions, with increase in product recovery.



SOUTHERN CALIFORNIA APCD--METROPOLITAN ZONE

ENFORCEMENT DIVISION - UPSET/BREAKDOWN REPORT

Report No.__________ Time Firm Reported to HQ__________ Date__________
Company Name__________
Address__________ City__________
Sector__________ Phone No(s)__________

All of the following questions must be answered in order to evaluate this Upset/Breakdn.

==

1. Description:
   Unanticipated Process Upset ☐ Operational Change ☐
   Equipment Failure ☐ Startup/Shutdown ☐
   Utility System Failure ☐ Scheduled Maintenance ☐
   Accidental Fire ☐ Variance No.__________
   Other (describe)__________
2. Equipment description__________
3. Permit or Application No(s)__________
4. Arrival time at plant__________ Person contacted__________ Title__________
5. Type(s) of contaminants emitted?__________
6. Permit or A/C conditions violated? Describe__________
7. Estimated volume and/or weight of contaminants emitted, if available__________
8. Visible emissions: Opacity__________ Time__________ Length of plume__________
9. Odors. Description__________
10. Intensity__________ Wind direction__________ Speed__________
11. Description of violations observed or suspected__________
12. Was a violation notice issued?__________ Notice number__________ Rule or Sec.__________
13. Did the excessive emission(s) result from operator error or improper operating or maintenance procedures? Describe (why)__________
14. Were all reasonable steps taken to correct the condition leading to the excessive emissions and to minimize the emission itself? Describe action taken__________
15. When was company first aware of Upset/Breakdown__________
16. Starting time of incident causing excessive emissions or odors__________
    Estimated total duration of incident__________
17. Estimated duration of emissions__________
18. Can equipment be shut down immediately without creating a hazard, or without causing a hardship to the firm or its employees? Yes ☐ No ☐
19. Will equipment be shut down? Yes ☐ No ☐
20. Can it be operated at a reduced rate?__________
21. What effect would shutdown or cutback have on total plant operation?__________

40D504R

FIGURE 7-2
UPSET/BREAKDOWN REPORT FORM

22. Are operating records available? Yes ☐ No ☐ What do they indicate? ____

23. Describe measures which can or have been taken to reduce the frequency, duration, and intensity of these incidents and the time table for taking these measures ____

24. Does company have a preventative maintenance program? ____
25. How is it being followed? ____

26. Were any samples taken? ____
27. Describe: Sample ____ Source ____

28. Was equipment in operation? ____
29. Were complaints received? ____ Complaint numbers ____

30. Number of nuisance complaint forms received ____
31. Will company file for a variance? ____ When? ____
32. ADDITIONAL INFORMATION ____

(Use I.R. for further additional information)

Inspector's Signature ____ Departure Time ____

SUPERVISOR'S REVIEW

Should reinspection be made? ____ By whom? ____ When ____
Are all breakdown criteria met? Yes ☐ No ☐ Issue notice of viol? ____
Supervisor's recommendations or summary ____

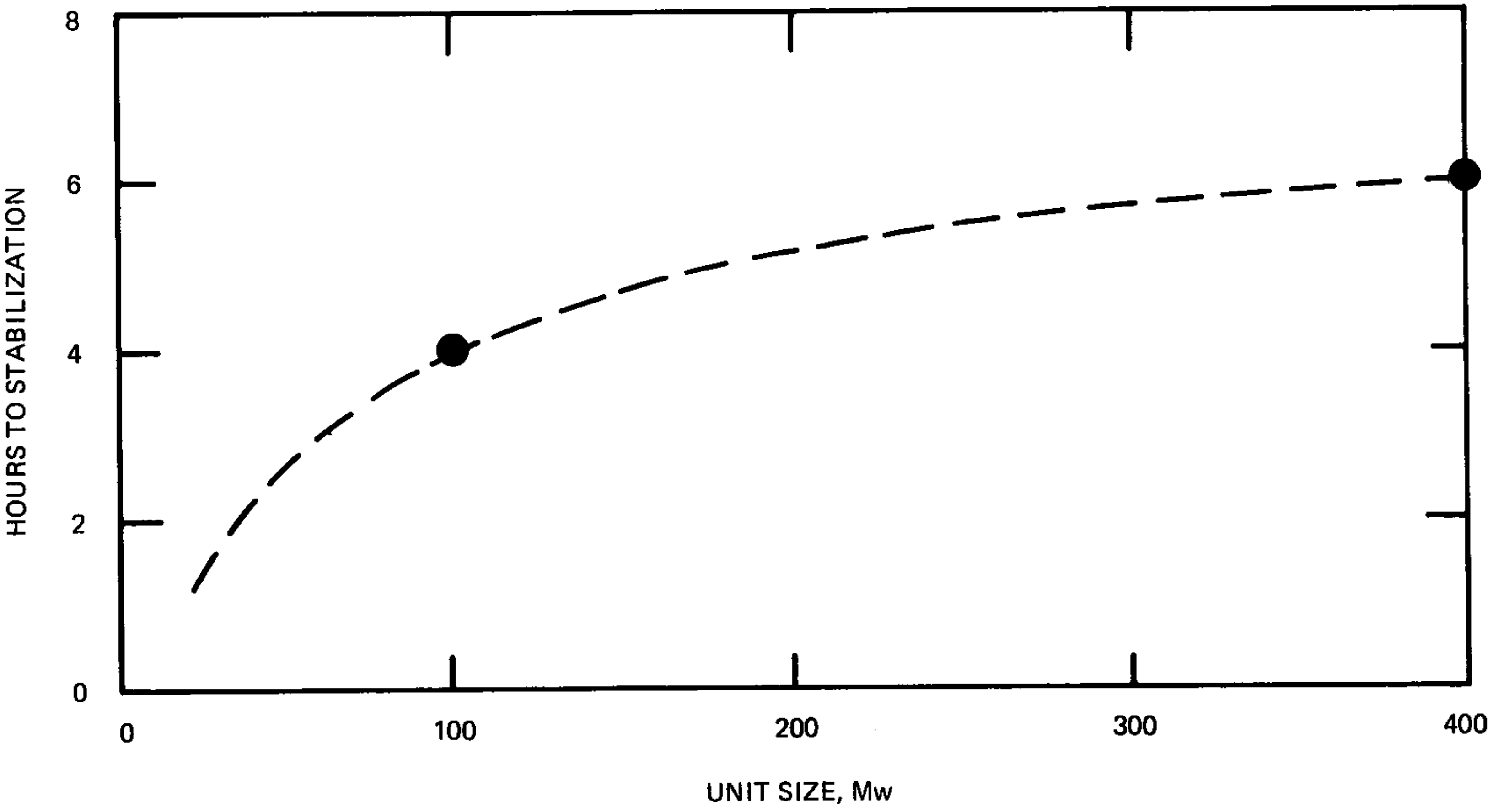
==

Ex-parte variance filed ____ Variance requested from ____
rule(s) or section(s)

What final action was taken? ____

Immediate Supv. Signature ____ Date ____
Immediate Head Inspector's Signature ____ Date ____
Plant Supv. Signature ____ Date ____
Head Inspector Signature ____ Date ____
Reviewed by Asst. Chief ____ Date ____

FIGURE 7-2 (Cont.)
UPSET/BREAKDOWN REPORT FORM



Ref: Inspection Manual for Enforcement of New Source Performance Standards: Fossil-Fuel-Fired Steam Generators, U.S. Environmental Protection Agency, EPA 340/1-75-002, February 1975.

FIGURE 7-3

REQUIRED STARTUP TIME TO ACHIEVE ON-LINE LOAD DEMAND FOR FOSSIL-FUEL-FIRED STEAM GENERATORS

Industrial managers should also be aware of the benefits of such a program, which may include:

1. Reduction of operating costs through reduction of operator time, power, fuel, services, equipment replacement, and parts inventory,
2. Compliance with emission regulations/standards,
3. Extension of operating life of control equipment, and
4. Recovery of valuable products.

Preventive maintenance is more efficient and more economical than repair after breakdown and also keeps production moving. Preventive maintenance includes establishing priorities, organizing the maintenance system, scheduling, and checking control costs. A systematic approach to operation and maintenance of typical control equipment is shown schematically in Figure 7-4. Some of the items that should be part of a system maintenance inspection for air pollution control systems are listed below:

1. Air infiltration
    a. Process equipment,
    b. Breaching and ducts,
    c. Access doors and panels, and
    d. Expansion joints.
2. Induced-draft fan
    a. Vibration,
    b. Bearing temperature,
    c. Bearing lubrication,
    d. Coupling lubrication,
    e. V-Belt condition,
    f. Motor bearing lubrication,
    g. Foundation bolts, and
    h. Variable speed drive.
3. Thermal insulation
    a. Integrity, and
    b. Cold spots.
4. Dampers
    a. Function, and
    b. Lubrication.

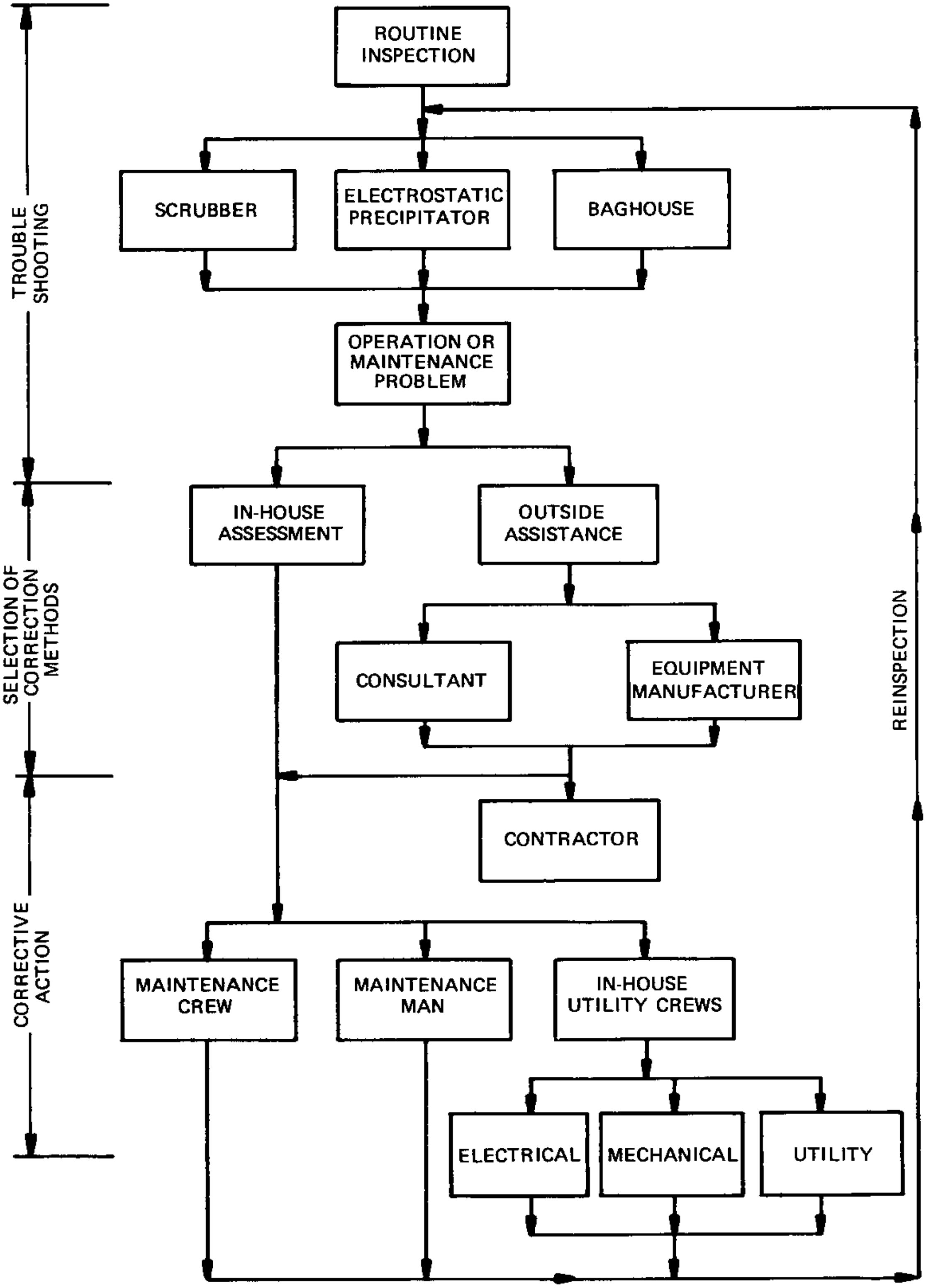


FIGURE 7-4
SYSTEMATIC APPROACH TO TYPICAL AIR POLLUTION CONTROL EQUIPMENT OPERATION AND MAINTENANCE

5. Temperature elements
    a. Thermocouples,
    b. Pyrometers, and
    c. Hot wires.

6. Pressure sensors
    a. Taps and lines, and
    b. Transmitters.

We have considered some of the ways in which process operation can affect pollutant emissions. Similarly, the maintenance of process equipment strongly affects the process effluent, since malfunction of this equipment can virtually negate the effectiveness of the air pollution control system. The detailed discussion that follows concerns the maintenance of control equipment rather than of process equipment. Further, it is limited to the devices that are most efficient in control of fine particulates: the baghouse filter, the venturi scrubber, and the electrostatic precipitator. These are the units most often installed in industrial facilities for the purpose of achieving and maintaining compliance with current and possible future regulations. Systems for control of gaseous pollutants include those based on adsorption, combustion, and oxidation techniques. An afterburner which incinerates solvent fumes is shown in Figure 7-5. These are to be considered in industrial guides for control of process gases.

In describing the maintenance of these three major pollution control systems, this section first discusses briefly the operation of the system, then presents such factors as inspection procedures, trouble-shooting and corrective measures, spare parts requirements, and manpower requirements. These are discussed in enough detail that managers of industrial operations controlled by these devices can visualize the extent of maintenance time/cost required to keep them operating efficiently.

7.2.1. The Baghouse

Basically, a baghouse is a large metal box divided into two chambers or plenums, one for dirty air and one for clean air. Rows of cloth bags form a partition or interface between the plenums. A polluted gas stream is ducted into the dirty air plenum where it is distributed evenly to the bags. The gas passes through the bags, enters the clean air plenum, and is exhausted into the atmosphere through a stack. Almost 100 percent of the particulate matter in the process effluent can be filtered out by the bags if the system is designed, operated, and maintained properly.

When a new baghouse is first started up with factory-fresh bags, some stack emissions are usually visible. This is because the filtering medium (which is the fabric of the bags) is porous and allows a certain amount of very fine particulate matter to pass through the interstices between the fibers. After a short period of operation, a dust cake builds up on the surface of the bags and becomes the actual filtering medium. The bags, in effect, act primarily as a matrix to support the dust cake.

The dust cake is desirable only up to a point; when that point is reached, the bag must be cleaned. If it is not cleaned properly, the pressure drop through the filter system will continue to increase. At high pressure drops, particles of dirt can be forced into the bag fiber, causing the bags to become blinded. When this happens, air flow is restricted and the bags may have to be replaced or removed and cleaned to restore proper operating capacity. In addition to the costs of replacement or cleaning, a high pressure drop increases the cost of moving air through the system. An installation of a typical baghouse is shown in Figure 7-6.

Routine Inspection and Troubleshooting—The key to baghouse maintenance is frequent and routine inspection. It is essential that a regular program of routine maintenance be established and followed. Records should be kept of all inspections and maintenance. Inspection intervals will depend on the type of baghouse, the manufacturer's recommendation, and the process on which the unit is installed. The important thing is to be sure that the checks are performed regularly and as frequently as necessary, and that no components are neglected.

Table 7-4 lists the items requiring regular inspection and what to look for. When troubles are located and isolated during routine or other inspection, it is important that corrections are made as quickly as possible to avoid possible equipment downtime or excess emissions due to bypassing the control system. When there is a baghouse failure, the unit is usually shut down and/or bypassed and the malfunction is corrected.

Plant managers should expect that considerable maintenance time will be expended on troubleshooting and correction of baghouse malfunctions. Maintenance personnel must learn to recognize the symptoms that indicate potential problems, to determine the cause of the difficulty, and to remedy it, either by in-plant action or by contact with the manufacturer or other outside resource. High pressure drop across the system exemplifies one symptom for which there are many possible causes, e.g. difficulties with the bag-cleaning mechanism, low compressed-air pressure, weak shaking action, loose bag tension, or excessive reentrainment of dust. Many other factors can cause excessive pressure drop, and several options are usually available for corrective action appropriate to each cause. Thus the ability to locate and correct malfunctioning baghouse components requires a thorough understanding of the system. A detailed tabulation of troubleshooting and corrective measures is given in Appendix E.

The frequency of failure or breakdown of basic parts is presented in Table 7-5, which includes requirements for frequency of inspection and inspection time as well as the times required for repairs.

Spare Parts—Every baghouse maintenance program includes an inventory of spare or replacement parts. Table 7-6 lists the typical items that should be stocked, the approximate quantities, and, if the parts are not stocked, the approximate delivery time and cost.

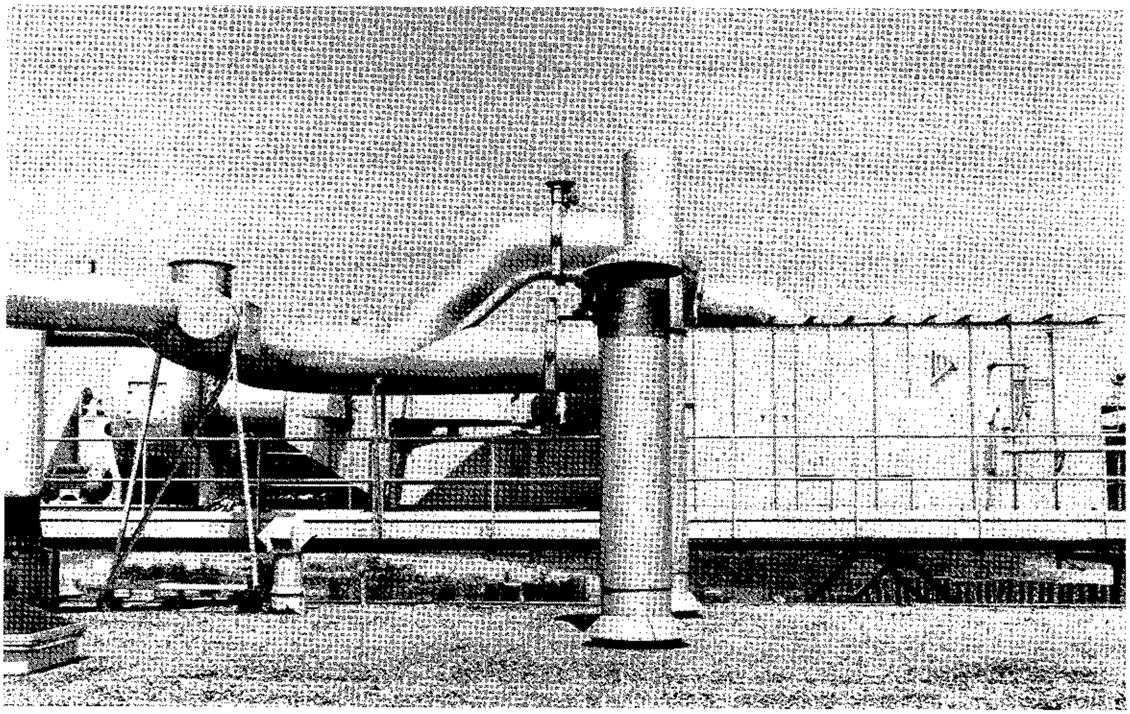


FIGURE 7-5
INCINERATOR USED TO CONTROL SOLVENT FUMES

FIGURE 7-6
BAGHOUSE INSTALLATION ON AN ASPHALT BATCH PLANT

TABLE 7-4
CHECKLIST FOR ROUTINE INSPECTION OF BAGHOUSE*

Component**	Checklist
Shaker mechanism (S)	Proper operation without binding; loose or worn bearings, mountings, drive components; proper lubrication.
Bags	Worn, abraided, damaged bags; condensation on bags; improper bag tension (S) (RF); loose, damaged, or improper bag connections.
Magnehelic gauge or manometer	Steadiness of pressure drop (should be read daily).
Dust removal system	Worn bearings, loose mountings, deformed parts, worn or loose drive mechanism, proper lubrication.
Baghouse structure (housing, hopper)	Loose bolts, cracks in welds; cracked, chipped, or worn paint; corrosion.
Ductwork	Corrosion, holes, external damage, loose bolts, cracked welds, dust buildup.
Solenoids, pulsing valves (RP)	Proper operation (audible compressed air blast).
Compressed air system (RP, PP)	See above; proper lubrication of compressor; leaks in headers, piping.
Fans	Proper mounting, proper lubrication of compressor; leaks in headers, piping.
Damper valves (S, PP, RF)	Proper operation and synchronization; leaking cylinders, bad air connections, proper lubrication, damaged seals.
Doors	Worn, loose, damaged, or missing seals; proper tight closing.
Baffle plate	Abrasion, excessive wear.

*Refer to Appendix E for detailed troubleshooting procedures.

**RP — reverse pulse; PP — plenum pulse; S — shaker; RF — reverse flow.

TABLE 7-5
BAGHOUSE COLLECTOR MAINTENANCE

Item	Frequency of breakdown	Frequency of inspection	Time required to perform inspection	Time to repair	Type of person to repair	Comments
INSIDE BAG COLLECTOR						
Bags						
5" ϕ (14')	Monthly	Monthly	1.5-3 mh per 100 bags[1]	10-30 min per bag[2]	Laborer[3]	Complete replacement
8" ϕ (22')	Monthly	Monthly	2-4 mh per 100 bags[1]	15-45 min per bag[2]	Laborer[3]	2 years same
12" ϕ (30')	Monthly	Monthly	2.5-5 mh per 100 bags[1]	20-60 min per bag[2]	Laborer[3]	Same
Door seals	2-4 years	Monthly	5 min per door	1 hr per door	Laborer	
Cleaning mechanism						
Shaker	6 months	Monthly	5 min per row	30 min per row	Maint. man	
Reverse air	2 years	Monthly	15 min	2 hours	Maint. man	
Dust removal system						
Screw conveyors	1-2 years	6 months	1 hour	2-4 hours	Maint. man	
Air locks	1-2 years	6 months	30 min	1-2 hours	Maint. man	
Pneumatic	2-3 years	6 months	1 hour	8 hours	Maint. man	
Baffle plate	4 years	1 year	30 min	8 hours	Maint. man	
Damper valves	2-3 years	Monthly	15 min per valve	1-24 hours	Maint. man	
OUTSIDE BAG COLLECTOR						
All bags	Monthly	Monthly	0.6 mh per 100 bags	6-10 min per bag	Laborer	Assumes top bag removal
Cleaning mechanism						
Pulse jet	2 years	Monthly	2 min per row	30 min	Maint. man	
Pulsing plenum	2 years	Monthly	2 min per row	1 hour	Maint. man	
Door seals	2-4 years	Monthly	5 min per door	1 hour per door	Laborer	
Dust removal system						
Screw conveyors	1-2 years	6 months	1 hour	2-4 hours	Maint. man	
Air locks	1-2 years	6 months	30 min	1-2 hours	Maint. man	
Pneumatic	2-3 years	6 months	1 hour	8 hours	Maint. man	
Baffle plate	4 years	1 year	30 min	8 hours	Maint. man	
Damper valves	2-3 years	Monthly	15 min per valve	1-24 hours	Maint. man	

[1] 1.5 mh per 100 bags for 24" reach, 3.0 mh per 100 bags for 36" reach (time may be cut by 70% if injection of fluorescent particles and black light is used).

[2] Low value is total change out per bag and high value is individual bag change.

[3] 3-man crew minimum.

TABLE 7-6
LIST OF REPLACEMENT PARTS FOR A BAGHOUSE FILTER

Type of part	% of total parts in baghouse that should be stocked	Delivery time if not stocked (weeks)	Estimated cost $	Comments
Bags	15	4-8	See separate sheet	
Door seals	20	2-4	10 per seal	Typical 18-in. x 48-in. door
Mechanism				
Shaker	20	2-4	10 per item	Bearings, knife blades, belts
Reverse air	100	6-10	25 per item	Belts
Pulse jet	20	2-4	3 per item	Valve rebuild kit
Pulsing plenum	20	2-4	5 per item	Solenoid valves, seals, cylinders
Screw conveyor	20	8-10	10 per item	Bearings
Air locks	20	8-10	10 per item	Seals
Pneumatic		8-10		Variable
Baffle plates		4-6	100 per plate	
Damper valves	20	4-6	10 per item	Solenoid valves, seals, cylinders

Perhaps the major maintenance item, and the most costly because of the numbers involved, is the filter bag. Baghouses are often classified according to collection of the particulate on the inside of the bags. Table 7-7 lists the cost of various materials for inside and outside type units on a per-square-foot basis.

7.2.2 Venturi Scrubber

The total venturi scrubber system consists of a fan, the venturi section, the separator chamber, a mist eliminator, and the appropriate duct work. In discussing maintenance of the venturi scrubber, various parts of the system must be considered because of the special corrosion and abrasion problems associated with the wet system; these problems do not occur with the baghouse or the ESP, which are essentially dry particulate handling systems. A typical scrubber installation is shown in Figure 7-7.

TABLE 7-7
COST OF BASE REPLACEMENT
IN FABRIC FILTERS

(Information supplied by R. P. Bundy, Standard Havens, Inc.)

Type material	Cost of material (per square foot)	
	Inside bag collector	Outside bag collector
Acrylic	$0.19	$0.38
Cotton	.19	N/A
Glass	.40	.50
Nomex	.80	.88
Polyester	.16	.25
Polypropylene	.31	.30
Teflon	2.89	5.70

Note: Cost differences are because of the type or weight of material. Outside bags are usually 14 oz. Feltco material and inside bags are 8-12 oz. woven material.

Maintenance—The major problems with the scrubber from a maintenance standpoint are corrosion, scaling, and plugging. Corrosion is best prevented by a proper pressure/ temperature balance in the system; when problems do arise, maintenance entails replacement of parts and/or patching of the unit. Scaling results from an improper chemical balance in the system and is corrected by chemical or hand cleaning. Plugging occurs as solids build up at transition points in the system. Table 7-8 indicates the manpower requirements for maintenance that involves scaling and plugging for both the wet approach and liquid injection venturi scrubbers.

The venturi scrubber unit is used for a variety of applications. Table 7-9 lists the maintenance requirements for two ranges of pressures, various lining materials, and gas characteristics. This table should be useful in the selection of scrubber liners for venturi units in various applications.

TABLE 7-8
MAINTENANCE FOR PLUGGING AND SCALING VENTURI SCRUBBER
(From interview with P. Wechselblatt – Chemico)

Type of venturi scrubber	Type of problem			
	Plugging		Scaling	
	Mechanical cleaners	Cylinder cleaners	Chemical cleaning	Hand cleaning
Wet approach	1 Man/shift/ month	1 Man/shift/ month	3 Men/shift/ week	1 Man/shift/ week
Liquid injection	1 Man/shift/ month	1 Man/shift/ month	3 Men/shift/ week	1 Man/shift/ week

Spare Parts–The minimum inventory of spare parts is one each for each venturi scrubber. The spare parts inventory for a venturi system is given in Table 7-10.

Manpower Requirements–This section has indicated the maintenance items, maintenance times, and spare parts inventory for a venturi scrubber system. Table 7-11 completes this picture by presenting the types of personnel generally required to perform maintenance on various parts of the venturi scrubber system.

A great variety of wet scrubbers, ranging from low- to high-energy systems, can remove various size particles and gases. Attention is directed to high-energy systems, which remove very fine particulates and thus satisfy the more stringent air pollution control codes. The high-energy venturi scrubber is one example. Maintenance procedures applicable to this type of system can be easily adapted to other scrubber systems.

When gas containing dust is swept through an area containing liquid droplets, dust particles will strike or impinge upon the droplets; if they adhere, the particles will be collected by the droplets. The collecting liquid is called droplets and the material in the gas stream that is to be collected is called particles, whether it is solid or liquid. In general, the collection effect is most efficient when the size of the liquid droplet is approximately 100 to 300 times the size of the dust particle (range from 100 to 1,000 microns), allowing for large numbers of collisions.

TABLE 7-9
SCRUBBER MAINTENANCE
(From interview with P. Wechselblatt - Chemico)

Type of liner	Pressure drop				Gas characteristics			Comments
	>30 in. ΔP		<30 in. ΔP					
	Life cycle (yrs)	Repair Time	Life cycle (yrs)	Repair time	Corrosive	Abrasive	Corrosive and abrasive	
Ceramic								
Silicon carbide	3-4	2 men/ 1 week	10	2 men/ 1 week	Poor	Excellent	Good (mildly corrosive)	
Cement	1	2 men/ 1 week	4	2 men/ 1 week	Poor	Poor	Good (mildly corrosive)	
Rubber	1	2 men/ 2 weeks	5	2 men/ 2 weeks	Excellent	Good	Good	For cutting type particles
	5	2 men/ 2 weeks	10	2 men/ 2 weeks	Excellent	Good	Good	For erosive but not sharp particles
Plastic			indefinite	1 day				Patchable lining
Steels								
Carbon	2-6	Patchable	6	Patchable	Poor	Fair	Fair	Good for chlorides
316	2-6	Patchable	6	Patchable	Excellent (arid)	Fair	Fair-good	Not good on chlorides
304	2-6	Patchable	6	Patchable	Good (arid)	Fair	Good	Except for SO_3 and Cl
Inconel 625	2-6	Patchable	6	Patchable	Good	Good	Good	
Hastology	2-6	Patchable	6	Patchable	Excellent	Good	Good	

TABLE 7-10

SPARE PARTS INVENTORY FOR VENTURI SCRUBBER

(From interview with P. Wechselblatt – Chemico)

Section of the system	Type of parts								
	Motors	Mist eliminator modules	Seals	Bearings	Impeller	Reamers (50% of total)	Patching material	Adjustable throat-damper	None
Scrubber						X	X		
Separator								X	
Fan	X		X	X	X				
Pump(s)	X		X	X	X				
Mist eliminator		X							

TABLE 7-11
TYPE OF MAINTENANCE REQUIRED – VENTURI SCRUBBER SYSTEMS

(From interview with P. Wechselblatt – Chemico)

Section of the system	Type of worker				
		Maintenance man			
	Laborer	Electrical	Plumber	Wastewater treatment operator	Mechanical
Scrubber	X				
Separator	X				
Fan		X			
Pump		X	X		X
Piping, valves			X		
Water treatment equipment		X	X	X	X

In a venturi scrubber, the gas velocity is increased in the venturi (or constricted section), and water may be injected under pressure to provide intimate contact between the gas stream and water particles.

The wet-dry line area must be periodically inspected to be sure that solids buildup is not occurring. Spray nozzles and liquid inlets must be checked to see that they are open and distributing the liquid properly. The inspector should especially watch for corrosion underneath scale buildup.

The second major problem in most high-energy scrubbers is associated with abrasion. High-velocity liquid containing dust strikes the impingement surfaces in the venturi scrubber, especially at the highest-velocity area, i.e., the venturi or throat of the unit.

Places susceptible to corrosion and abrasion must be inspected frequently. These include throats, orifices, elbows, and other high-wear areas. Any wearing of coatings and metals should be repaired as needed.

Failure of wet scrubbers rarely involves the scrubber itself, since many scrubbers have few moving parts or none. The other system components must be investigated, i.e., the connecting duct work, dampers, fans, centrifugal pumps, valves, and piping. Each of these components provides the designer with unique problems and must be monitored carefully during inspection.

7.2.3 The Electrostatic Precipitator

An electrostatic precipitator (ESP) consists very basically of a precipitator chamber and an electrical unit (see Figure 7-8). The precipitator chamber includes discharge and collection electrodes, an electronic cleaning system, gas distribution devices, and a precipitator shell and hopper. The electrical unit is made up of a power supply, high voltage transformers, rectifiers, and precipitator bus sections.

ESP is a physical process by which a particulate suspended in a gas stream is charged electrically and then, in the influence of an electrical field, is separated and removed from the gas stream. The system that does this consists of a positively charged collecting plate in close proximity to a negatively charged electrode. A high-voltage charge is imposed on the electrode, which establishes an electrical field between the electrode and the grounded collection surface. The dust particles pass between the electrodes, where they are negatively charged and diverted to the positively charged collection plate(s).

Periodically, the collected particles must be removed from the collecting surface. This is done by vibrating (usually by rapping) and/or water washing the surface of the collection plates to dislodge the dust. The dislodged dust drops into a dust removal system and is collected for disposal.

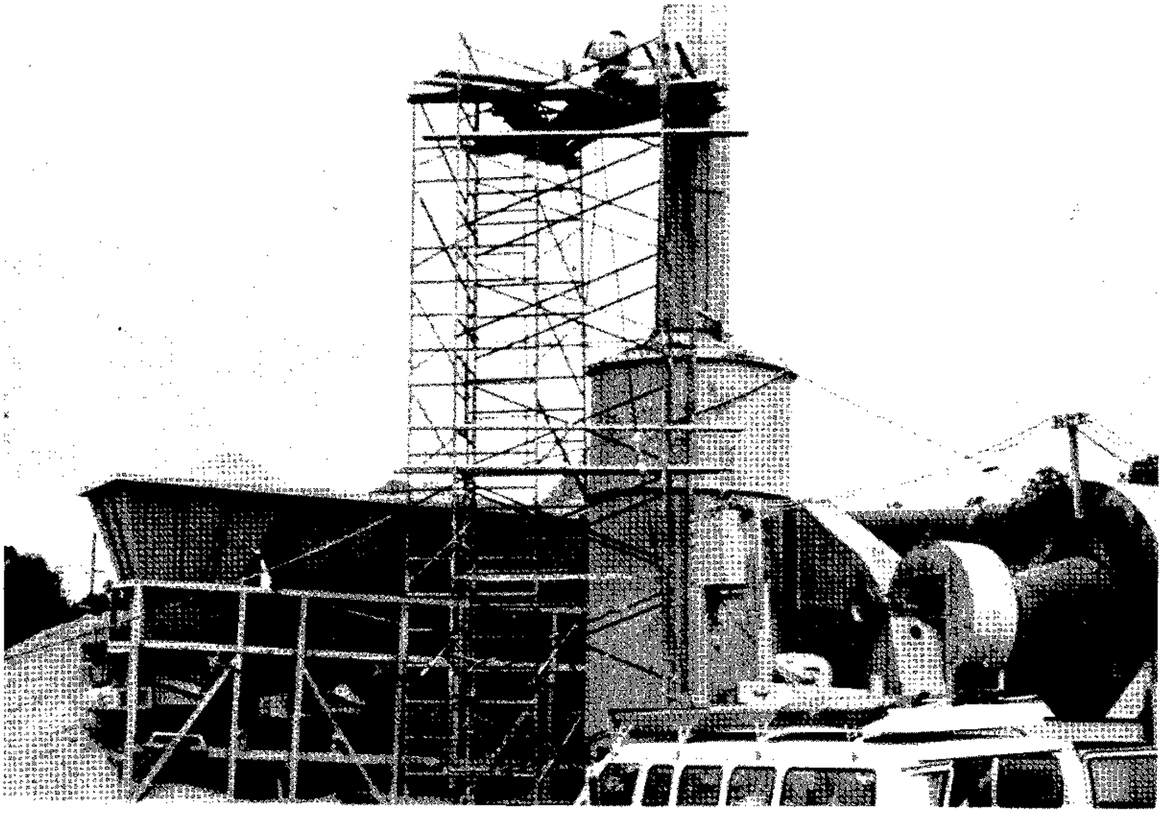


FIGURE 7-7
WET SCRUBBER INSTALLATION ON AN ASPHALT BATCH PLANT

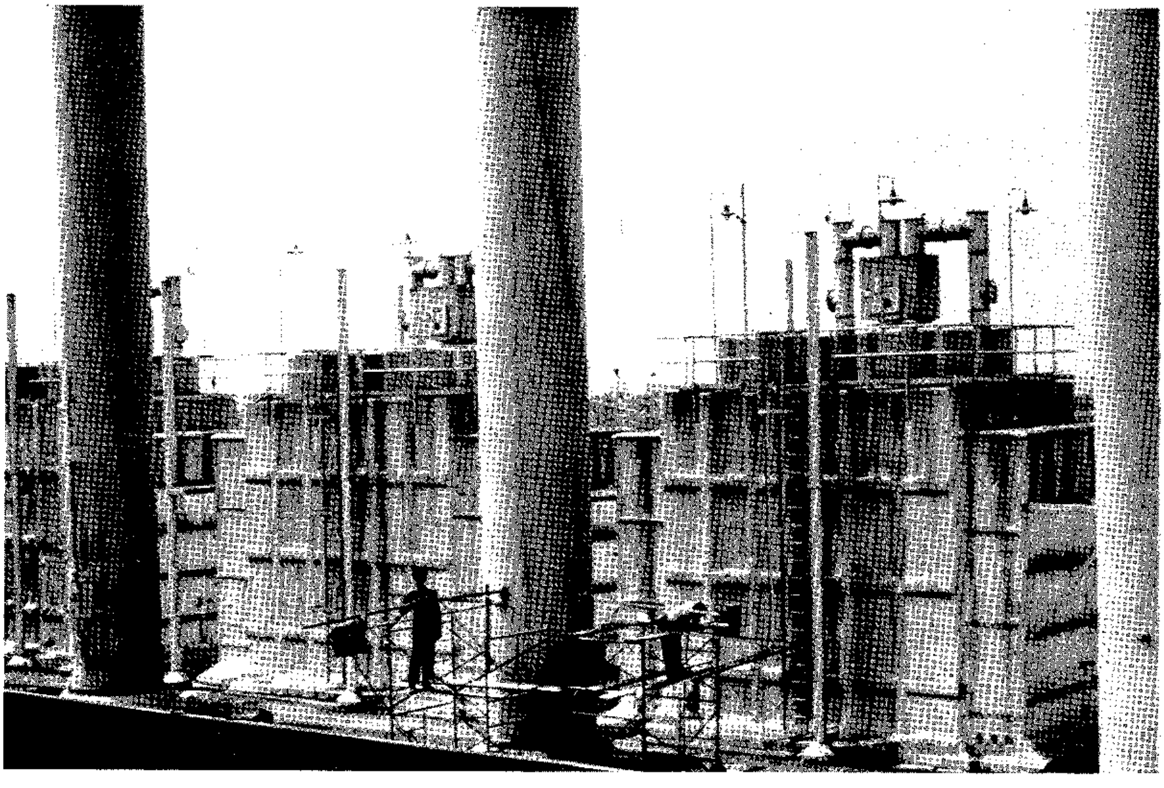


FIGURE 7-8
ELECTROSTATIC PRECIPITATOR INSTALLATION ON POWER BOILER

The advantages and disadvantages of electrostatic precipitators are summarized below:

Advantages

1. High collection efficiency is obtained on particles as small as 0.01 micron; range of collection efficiency is 80 to 99.9 percent.
2. Operating costs are low.
3. Low pressure drops of 0.1 to 0.5 inch water are typical.
4. Gas flows as high as 4 million cfm can be handled effectively.
5. Gas pressure and vacuum operating conditions can be used.
6. There is essentially no limit to usage of solids, liquids, or corrosive chemicals.
7. Particulate concentrations from 0.0001 to 100 grains/cubic feet can be handled.
8. Gas temperatures can range as high as 1,200°F.
9. The units handle a wide range of gas velocities.
10. Units of the precipitator can be removed from operation for convenience in cleaning.

Disadvantages

1. Installed costs are high.
2. Space requirements are high for cold precipitators and even greater for hot precipitators.
3. Explosions can occur when the precipitator is collecting combustible gases or particulates.
4. Ozone (a poisonous gas) is produced by the negatively charged discharge electrodes during ionization.
5. Operating procedures can be complicated. Great precautions must be exercised to maintain safety and proper gas flow distribution, dust resistivity, particulate conductivity, and corona sparkover rate.

Discharge electrode failure is the primary cause of operational breakdown. After this (in order of highest rate of mechanical failure) are rapper malfunctions, insulator failures, shorts caused by dust buildup, hopper plugging, and transformer-rectifier failures. Most of these problems occur when proper preventive measures are not used. For example, discharge electrode failures can be reduced if the hoppers are properly discharged and cleaned to prevent grounding out and burning off of the discharge electrodes. Failure to inspect rappers over extended rapping cycles also causes discharge electrode breakage through fatigue failure.

In addition to the electrical and rapping problems, the remaining possible precipitator problems generally involve gas flow and mechanical systems. Uneven gas flow can cause erosion of the collection plates and thereby reduce efficiency. Uneven gas flow also can cause dust fallout and accumulation on turning vanes and on ductwork. This dust buildup eventually plugs the distribution plates and results in further uneven gas flow and system upset.

Rapping is a mechanical system for removing particles from the collection and discharge electrodes. Rapping is effective only if sufficient force is transmitted to the electrodes. Variations in the design of the supporting structure and in the electrodes themselves can result in inadequate rapping. In many installations that handle fly ash, rapping accelerations of 60 g (60 times the gravitational force) are required.

Fly ash buildup on the collecting plates should normally be about 1/8 to 1/4 inch. If the buildup exceeds this thickness, the intensity of the plate rappers should be increased. If the collecting plates are clean, this may be an indication of high gas velocity or low operating voltage.

Collecting plates should be checked for proper alignment and spacing. Hangers and spacers at the top and bottom should be adjusted so that they do not bind the plates or prevent proper rapping. It is necessary to check for corrosion.

Hoppers should be checked periodically to be sure they empty properly and to inspect for corrosion, which is likely to be most severe at points where dust builds up. The heating system and insulation on the hoppers are checked to prevent condensation.

Insulator compartments and housings must be checked frequently. Leakage of corrosive gases from the precipitator into this area can cause dirt deposits that result in breakdown of the electrical insulators.

The spark rate control is inspected to maintain the proper number of sparks per minute; this control can be adjusted if necessary.

The current and voltage limit controls must be checked and properly adjusted to prevent damage to the electrical components in the system.

Any electrical surge, overload, and automated systems must be checked.

Transformers are checked to maintain liquids at the proper level.

Relays are disassembled and contacts cleaned once a year; the units are then recalibrated.

Filter elements in the system must be removed and cleaned or replaced periodically.

Most rectifiers use vacuum tube or solid-state systems. Normal vacuum tube life ranges from 12,000 to 20,000 hours, and servicing usually involves replacement of defective tubes. Solid-state rectifiers are usually trouble-free, requiring little maintenance other than periodic check of transformer oil.

Precipitator wires, which may amount to 30,000 feet of wire per unit, frequently require servicing even under the best conditions of maintenance and operation.

Inspection should include a check for air leaks and examination of the collecting plates for evidence of back corona. The precipitator should be maintained above the dew point to prevent corrosion inside the precipitator.

Inspection and Maintenance–Following is a typical inspection and maintenance schedule. Figure 7-9 illustrates a systematic approach to an ESP maintenance program.

Annual Inspection

A. Internal inspection

   1. Observe dust deposits on collecting plates and wires before cleaning (a 1/4-inch deposit is normal). If metal plates are clean, there is a possibility that a section is shorting out. If more than 1/4-inch of dust is on the plates, rappers are not cleaning.

   2. Observe dust buildup and corona tufts on wires.

   3. Check for interior corrosion, which could indicate an air leak through housing or moisture carryover from the air heater washer.

   4. Check plate alignment and spacing.

   5. Check to see that discharge wire spacers and hanger weights are in place. Measure to be sure the wires hang midway between plates.

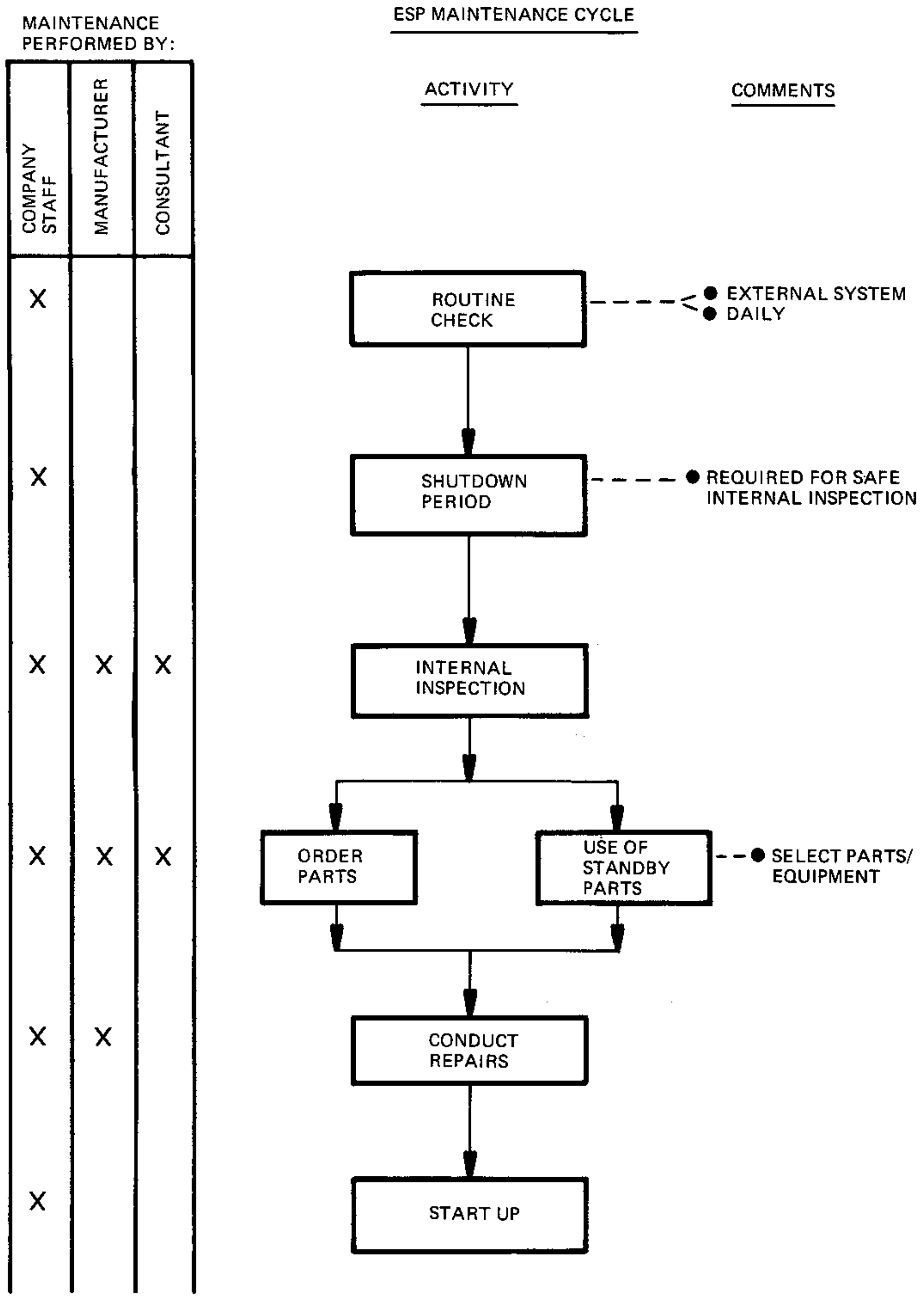
   6. Replace broken wires.

B. Hopper inspection

   1. Check for dust buildup in corners.

   2. Check high tension weights. If one has dropped 3 inches, this indicates a broken wire.

   3. Check hopper valve for debris.



COMPANY STAFF	MANUFACTURER	CONSULTANT
X		
X		
X	X	X
X	X	X
X	X	
X		

FIGURE 7-9
ESP MAINTENANCE CYCLE

C. Penthouse inspection

   1. Check for corrosion due to condensation and/or leakage of gas into housing.

   2. Excessive dust in penthouse indicates air sealing pressure too low.

   3. Clean all high-tension insulators.

   4. Check that all electrical connections are secure.

D. Transformer-rectifier inspection

   1. Check liquid level.

   2. Clean lines, insulators, bushings, and terminals.

   3. Check surge arrestors; spark gap should be 1/32 inch.

E. Control cabinet inspection

   1. Clean and dress relay contacts.

F. Check and calibrate all instruments and controls

Quarterly Inspection

A. Rappers

   1. Clean, replace, and lubricate distributor switch contacts.

   2. Check rapper assembly for free movement.

B. Vibrators

   1. Check contacts on load cams.

   2. Check vibrators to see that they operate at proper intervals.

Shift Inspection

A. Record electrical reading for each control unit and check for abnormal readings.

B. Check rapper controls.

C. Check vibrator controls.

Shutdown Procedures and Maintenance of ESP Internals—These steps are necessary primarily for safety and efficiency. An external inspection of a precipitator is performed daily. Details of troubleshooting procedures, with probable causes and remedies, are given in Appendix D.

The internal maintenance inspection of an ESP and the maintenance time requirements for servicing depend on the interval required before maintenance personnel can enter the unit after it is shut down. Typical shutdown times are listed in Table 7-12. Because of the variety of ESP applications, maintenance problems also vary with each installation. Table 7-13 indicates some typical industrial maintenance operations. The frequency of parts failure in an ESP is very low; repair times are minimal after diagnosis and shutdown.

An example of a typical troubleshooting chart for an electrostatic precipitator is presented in Appendix F.

A further note regarding precipitator maintenance concerns opacity monitors. In addition to the obvious use of opacity monitors to maintain compliance, industrial users find a correlation between optical density and the concentration of particulates leaving the stack. The Pennsylvania Power and Light Company has correlated their emissions with optical density, as illustrated in Figure 7-10. They have also found that the following variables which affect precipitator performance can be evaluated by opacity monitoring:

1. Fuel resistivity and ash content,

2. Boiler load,

3. Boiler outlet gas temperature,

4. Boiler excess air level,

5. Precipitator operating voltage,

6. Precipitator rapping intensity and programming, and

7. Precipitator internal conditions.

Many of these variables affect not only emissions but also maintenance of the precipitators.

TABLE 7-12
ESP INSPECTION TIMETABLE

Application	Daily external inspection (hrs)	Shutdown time for maintenance inspection/repair					Internal inspection (hrs)
		Immediate	4 hrs	8 hrs	12 hrs	3-7 days	
Acid mist	1	X					2
Tar (coke oven)	1		X				2
Power boilers							
100-350°F	1			X			N/A
650-800°F	1				X		N/A
Catalytic cracker	1					X*	2
Paper mills	1			X			2

*3 days to shut down – 7 days to start up.

TABLE 7-13
MAINTENANCE OF TYPICAL INDUSTRIAL ESP

	Electrical repair, external				Mechanical/electrical repair, internal					
Reliability and repair	Rectifier controls	Transformer	Rapper coil	Pressure fans	Collecting electrodes	Discharge electrodes	Top and bottom high tension frames	Support bushings	Lower high tension stabilizer bars	Rapper shafts
Frequency of failure	Seldom	Seldom	Seldom	Seldom	No failure (1)	5-7 yrs (2)	No failure (3)	5-10 yrs	Seldom	No failures
Time to repair	1-6 hrs	1 day	1 hr	2 hrs	1 wk (one section)	1 hr	—	2 hrs	1 hr	—
Parts	Stocked	Stocked	Stocked	Not stocked	Not stocked	Not stocked	Not stocked	Stocked	Stocked	Stocked
Complete units	12 wks	12 wks	Stocked	6-8 wks	4-6 wks	1 wk	2 wks	—	—	—

[1] Papermills: 5-7 year life.

[2] Replace with collecting electrodes.

[3] Possibly replace with collecting electrodes.

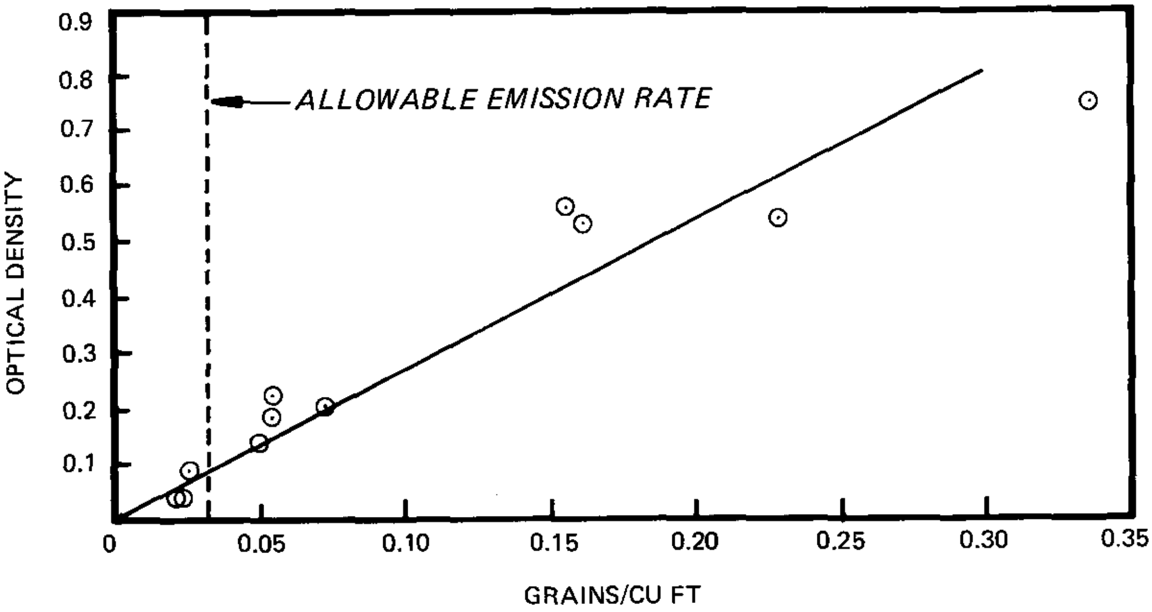


FIGURE 7-10
TEST DATA RELATING OPTICAL DENSITY TO OUTLET GRAIN LOADING
(Example for kraft pulp mill recovery furnace)

BIBLIOGRAPHY

Atmospheric Emissions from Fuel Oil Combustion, Environmental Health Series, U.S. Department of Health, Education, and Welfare, Public Health Service, November 1962.

Compilation of Air Pollutant Emission Factors (2nd edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA AP-42, April 1973.

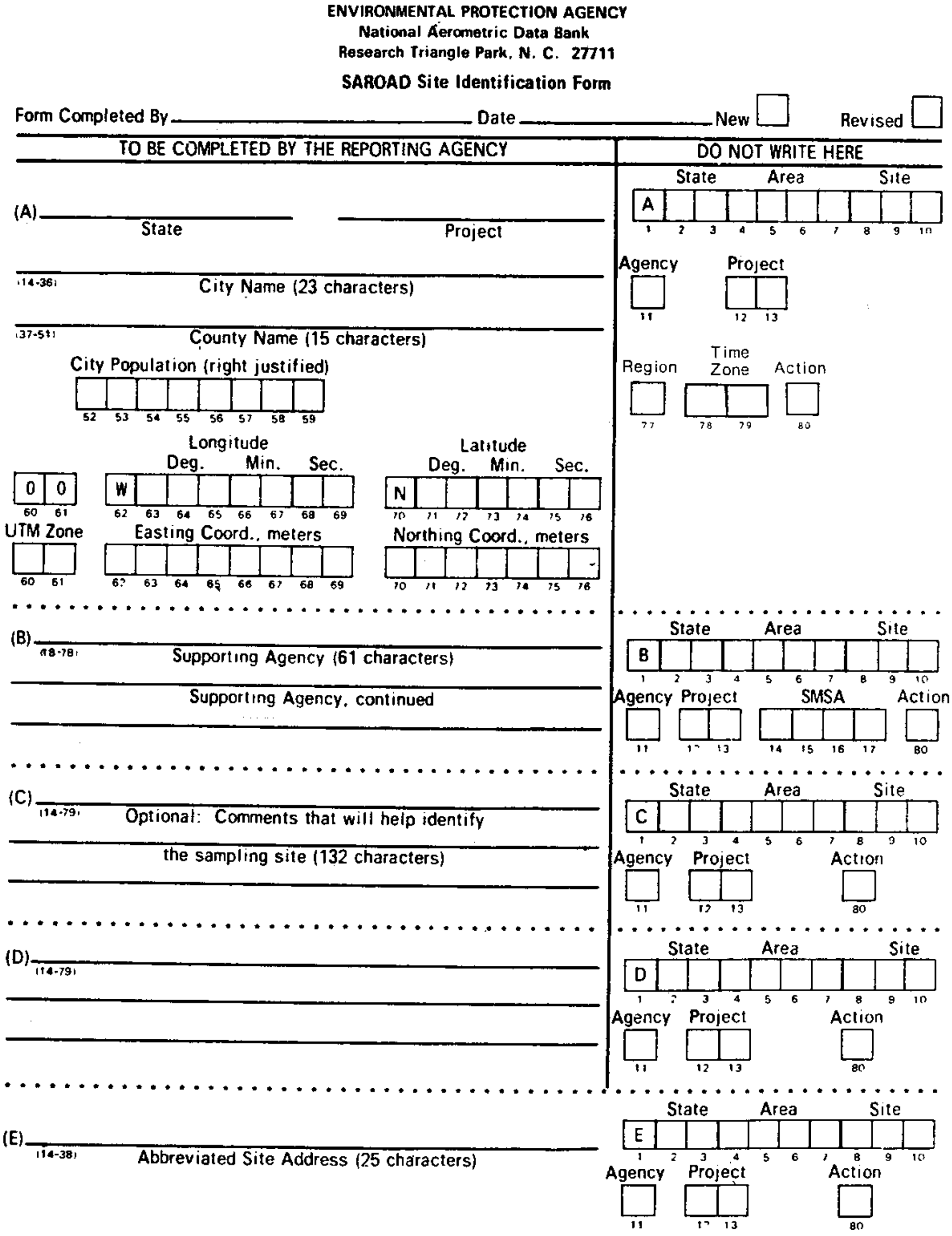
Environmental Quality - 1976 (The Seventh Annual Report of the Council on Environmental Quality), Environmental Quality–1976, September 1976.

Handbook for the Operation and Maintenance of Air Pollution Control Equipment, edited by Frank L. Cross Jr., P.E., and Howard E. Hesketh, Ph.D., P.E., Technomic Publishing Co., Inc., Westport, Conn., 1975.

Inspection Manual for Enforcement of New Source Performance Standards–Municipal Incinerators, U.S. Environmental Protection Agency, Stationary Source Enforcement Series, EPS 340/1-75-003, February 1975.

Sulfuric Acid Plant Emissions During Start-up. Shutdown, and Malfunction, U.S. Environmental Protection Agency, EPA-600/2-76-010, January 1976.

APPENDIX A
SAMPLE SAROAD AND NEDS FORMS



ENVIRONMENTAL PROTECTION AGENCY
National Aerometric Data Bank
Research Triangle Park, N. C. 27711

SAROAD Site Identification Form

Form Completed By ____________ Date ____________ New ☐ Revised ☐

TO BE COMPLETED BY THE REPORTING AGENCY | DO NOT WRITE HERE

(A) ____________ State ____________ Project

(14-36) ____________ City Name (23 characters)

(37-51) ____________ County Name (15 characters)

City Population (right justified) ☐☐☐☐☐☐☐☐ (52 53 54 55 56 57 58 59)

Longitude Deg. Min. Sec.: [0][0] (60 61) [W]☐☐☐☐☐☐☐ (62 63 64 65 66 67 68 69)

Latitude Deg. Min. Sec.: [N]☐☐☐☐☐☐ (70 71 72 73 74 75 76)

UTM Zone ☐☐ (60 61) Easting Coord., meters ☐☐☐☐☐☐☐☐ (62 63 64 65 66 67 68 69) Northing Coord., meters ☐☐☐☐☐☐☐ (70 71 72 73 74 75 76)

DO NOT WRITE HERE:

State Area Site: [A]☐☐☐☐☐☐☐☐☐ (1 2 3 4 5 6 7 8 9 10)

Agency ☐ (11) Project ☐☐ (12 13)

Region ☐ (77) Time Zone ☐☐ (78 79) Action ☐ (80)

• • • • • • • • • • • • • • • • • • • •

(B) (18-78) ____________ Supporting Agency (61 characters)

____________ Supporting Agency, continued

DO NOT WRITE HERE:

State Area Site: [B]☐☐☐☐☐☐☐☐☐ (1 2 3 4 5 6 7 8 9 10)

Agency ☐ (11) Project ☐☐ (12 13) SMSA ☐☐☐☐ (14 15 16 17) Action ☐ (80)

• • • • • • • • • • • • • • • • • • • •

(C) (14-79) ____________ Optional: Comments that will help identify

____________ the sampling site (132 characters)

DO NOT WRITE HERE:

State Area Site: [C]☐☐☐☐☐☐☐☐☐ (1 2 3 4 5 6 7 8 9 10)

Agency ☐ (11) Project ☐☐ (12 13) Action ☐ (80)

• • • • • • • • • • • • • • • • • • • •

(D) (14-79) ____________

DO NOT WRITE HERE:

State Area Site: [D]☐☐☐☐☐☐☐☐☐ (1 2 3 4 5 6 7 8 9 10)

Agency ☐ (11) Project ☐☐ (12 13) Action ☐ (80)

• • • • • • • • • • • • • • • • • • • •

(E) (14-38) ____________ Abbreviated Site Address (25 characters)

DO NOT WRITE HERE:

State Area Site: [E]☐☐☐☐☐☐☐☐☐ (1 2 3 4 5 6 7 8 9 10)

Agency ☐ (11) Project ☐☐ (12 13) Action ☐ (80)

(over)

FIGURE A-1
SAROAD SITE IDENTIFICATION FORM

SAROAD Site Identification Form (continued)

TO BE COMPLETED BY THE REPORTING AGENCY

(F) ______________________________
(14 - 54) Sampling Site Address (41 characters)

____
Address, continued

Check the ONE major category that best describes the location of the sampling site.

Next, check the subcategory that best describes the dominating influence on the sampler within approximately a 1-mile radius of the sampling site.

1. ☐ CENTER CITY
   - ☐ 1. Industrial
   - ☐ 2. Residential
   - ☐ 3. Commercial
   - ☐ 4. Mobile

2. ☐ SUBURBAN
   - ☐ 1. Industrial
   - ☐ 2. Residential
   - ☐ 3. Commercial
   - ☐ 4. Mobile

3. ☐ RURAL
   - ☐ 1. Near urban
   - ☐ 2. Agricultural
   - ☐ 3. Commercial
   - ☐ 4. Industrial
   - ☐ 5. None of the above

4. ☐ REMOTE

Specify units ______________________________
Elevation of sampler above ground

Specify units ______________________________
Elevation of sampler above mean sea level

Circle pertinent time zone: EASTERN CENTRAL MOUNTAIN PACIFIC YUKON ALASKA BERING HAWAII

DO NOT WRITE HERE

State: F ☐ ☐ (1 2 3) Area: ☐ ☐ ☐ ☐ (4 5 6 7) Site: ☐ ☐ ☐ (8 9 10)

Agency ☐ (11)

Project ☐ ☐ (12 13)

Station Type ☐ ☐ (55 56)

County Code ☐ ☐ ☐ ☐ (57 58 59 60)

AQCR Number ☐ ☐ ☐ (61 62 63)

AQCR Population ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ (64 65 66 67 68 69 70 71)

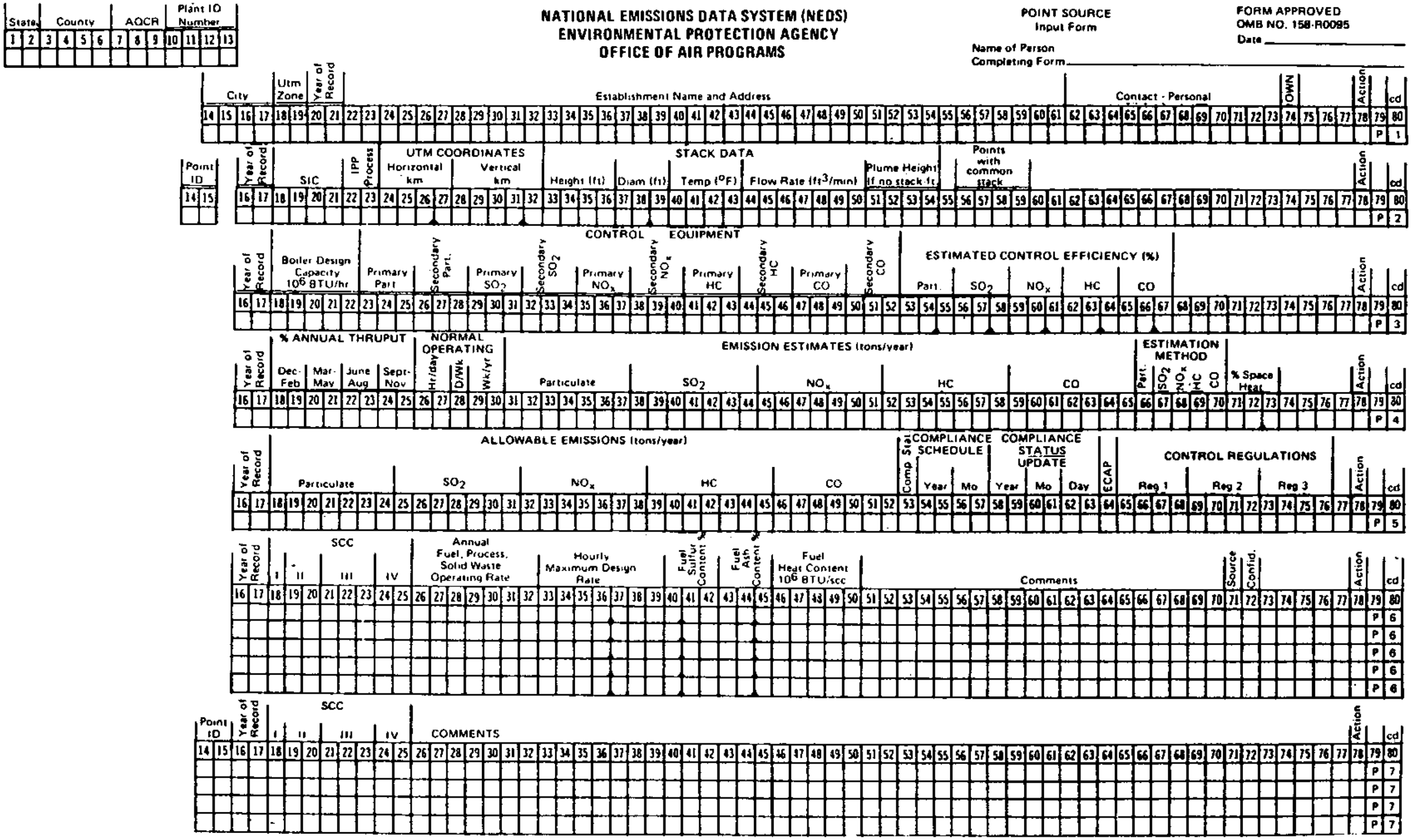
Elevation/Gr ☐ ☐ ☐ (72 73 74)

Elevation/MSL ☐ ☐ ☐ ☐ (75 76 77 78)

Time Zone ☐ (79)

Action ☐ (80)

FIGURE A-1 (Cont.)
SAROAD SITE IDENTIFICATION FORM



State | County | AQCR | Plant ID Number

NATIONAL EMISSIONS DATA SYSTEM (NEDS)
ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR PROGRAMS

POINT SOURCE
Input Form

Name of Person Completing Form

FORM APPROVED
OMB NO. 158-R0095
Date

City | Utm Zone | Year of Record | Establishment Name and Address | Contact - Personal | OWN | Action | cd — P 1

Point ID | Year of Record | SIC | IPP Process | UTM COORDINATES: Horizontal km, Vertical km | STACK DATA: Height (ft), Diam (ft), Temp (°F), Flow Rate (ft³/min), Plume Height (if no stack ft) | Points with common stack | Action | cd — P 2

Year of Record | Boiler Design Capacity 10⁶ BTU/hr | CONTROL EQUIPMENT: Primary Part, Secondary Part., Primary SO₂, Secondary SO₂, Primary NOₓ, Secondary NOₓ, Primary HC, Secondary HC, Primary CO, Secondary CO | ESTIMATED CONTROL EFFICIENCY (%): Part., SO₂, NOₓ, HC, CO | Action | cd — P 3

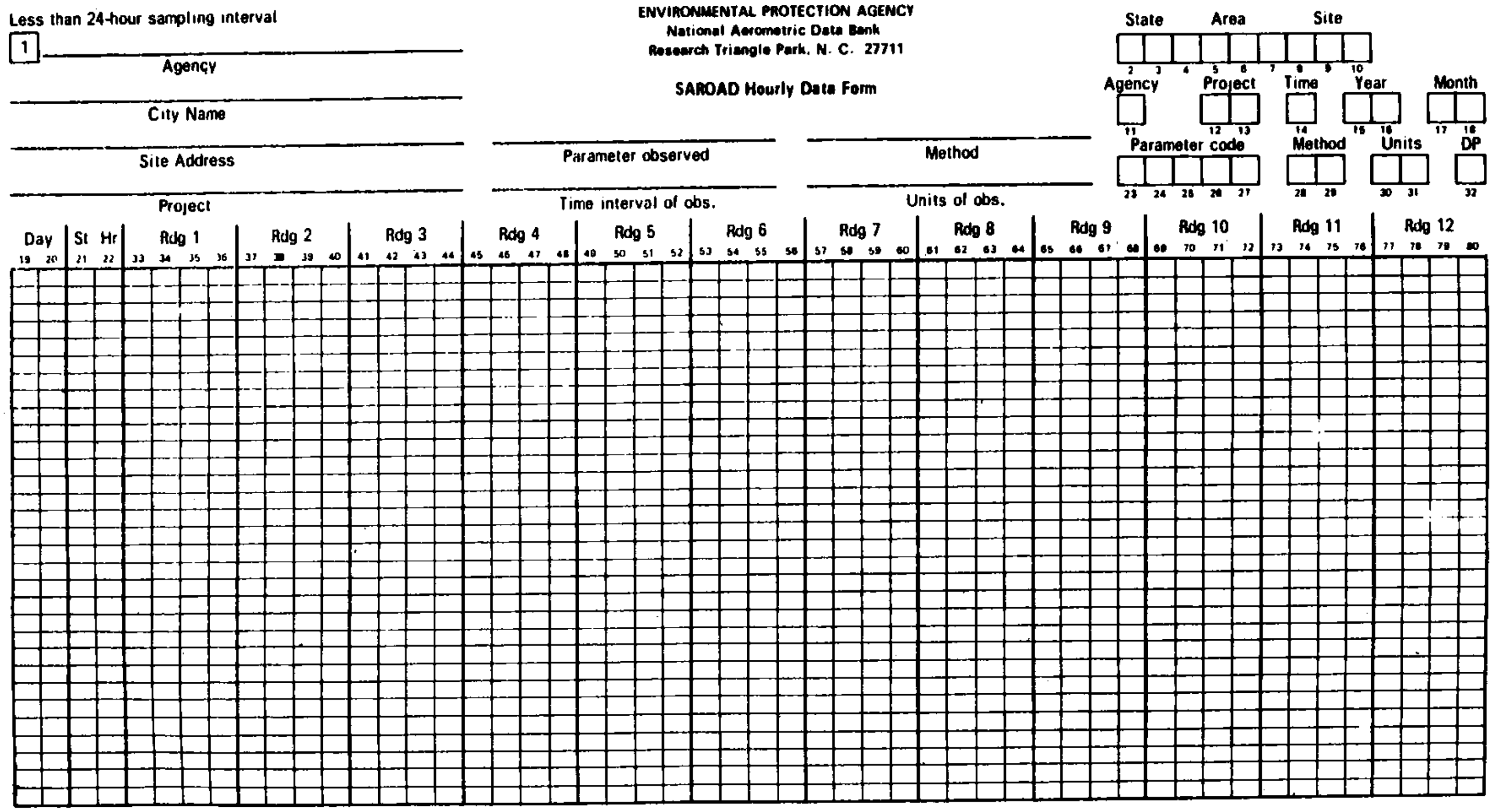
Year of Record | % ANNUAL THRUPUT: Dec-Feb, Mar-May, June-Aug, Sept-Nov | NORMAL OPERATING: Hr/day, D/Wk, Wk/yr | EMISSION ESTIMATES (tons/year): Particulate, SO₂, NOₓ, HC, CO | ESTIMATION METHOD: Part., SO₂, NOₓ, HC, CO | % Space Heat | Action | cd — P 4

Year of Record | ALLOWABLE EMISSIONS (tons/year): Particulate, SO₂, NOₓ, HC, CO | Comp Stat | COMPLIANCE SCHEDULE: Year, Mo | COMPLIANCE STATUS UPDATE: Year, Mo, Day | ECAP | CONTROL REGULATIONS: Reg 1, Reg 2, Reg 3 | Action | cd — P 5

Year of Record | SCC: I, II, III, IV | Annual Fuel, Process, Solid Waste Operating Rate | Hourly Maximum Design Rate | Fuel Sulfur Content % | Fuel Ash Content % | Fuel Heat Content 10⁶ BTU/scc | Comments | Source | Confid. | Action | cd — P 6

Point ID | Year of Record | SCC: I, II, III, IV | COMMENTS | Action | cd — P 7

FIGURE A-2
NATIONAL EMISSIONS DATA SYSTEM (NEDS) FORM



Less than 24-hour sampling interval

☐ 1 ____________________
Agency

____
City Name

____
Site Address

____
Project

ENVIRONMENTAL PROTECTION AGENCY
National Aerometric Data Bank
Research Triangle Park, N. C. 27711

SAROAD Hourly Data Form

____
Parameter observed

____
Time interval of obs.

____
Method

____
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 A-3
SAROAD HOURLY DATA FORM

APPENDIX B
SAMPLING AND FACILITY OPERATION CHECKLISTS

TEST PROGRAM MEETING REPRESENTATIVES

Plant Name____________________ Date__________

Plant Address____________________

Source to be Tested____________________

Plant Representative____________________ Phone__________

Plant Manager____________________ Phone__________

Test Team Company Name____________________

Team Representative____________________ Phone__________

Responsible Person____________________ Phone__________

Members of Test Team	Title

Agency(s)____________________

Agency Representative____________________ Phone__________

Responsible Person____________________ Phone__________

Agency Observers	Affiliation and Tasks

FIGURE B-1
TEST PROGRAM MEETING REPRESENTATIVES FORM
(Note: This figure is also shown as Figure 5-1.)

TEST PROGRAM MEETING PARTICIPANTS

Name	Affiliation

FIGURE B-2
TEST PROGRAM MEETING PARTICIPANTS FORM

TEST PROGRAM PLANT REQUIREMENTS AND TESTING METHODOLOGY

Plant Requirements:

Safety ____________________

Entrance ____________________

Other (Photo) ____________________

Sample Site

Acceptable ________ No. of Points Req'd. ________ Diagram in Program ________ Other ________

Sampling Methodology to be Used

Pollutant	Method	Remarks, Additional Quality Assurance, and/or Modifications

FIGURE B-3
FORM FOR TEST PROGRAM PLANT REQUIREMENTS
AND TESTING METHODOLOGY

TEST PROGRAM AGREEMENT ON FACILITY OPERATION

Process

1) Method of process weight or rate determination

2) Process parameters to be monitored and recorded, and their acceptable limits to document process operation

3) Raw material feed and/or fuel acceptable analyzed values

4) Normal operating cycle or procedures

5) Portions of the operating cycle or procedure that will be represented by each run

Control Equipment

6) Control equipment and effluent parameters to be monitored and recorded, and their acceptable limits to document control equipment operations

7) Normal operating cycle (cleaning, dust removal, etc.)

8) Normal maintenance schedule

9) Manner in which the control equipment will be operated during test

FIGURE B-4
FORM FOR TEST PROGRAM AGREEMENT ON FACILITY OPERATION
(Note: This figure is also shown as Figure 5-3.)

TEST PROGRAM AGREEMENT ON CONTINUING COMPLIANCE CONDITIONS

Process

1) Process parameters that must be recorded and submitted to agency or kept on file for later inspection

2) Percentage by which each process parameter can exceed the tested rate and on what time-weighted average

3) Future operating procedures

Control Equipment

4) Control equipment parameters that must be recorded and submitted to the agency or kept on file for later inspections

5) Normal operating procedures

6) Normal maintenance schedule

7) Frequency of scheduled inspections by agency

Reviewed and approved by:

Agency______________________________ Facility______________________ Tester__________

FIGURE B-5
FORM FOR TEST PROGRAM AGREEMENT ON
CONTINUING COMPLIANCE CONDITIONS

FIELD OBSERVATION CHECKLIST

GENERAL/ADMINISTRATIVE

Plant name____________________ Date__________

Plant address ____________________

Source to be tested ____________________

Plant contact____________________ Phone __________

Observers____________________ Affiliation____________________

Reviewed test program?__________ Comments ____________________

Reviewed test program meeting notes?__________ Comments__________

Reviewed correspondence?__________ Comments ____________________

Test team company name____________________ Phone__________

Supervisor's name____________________ Address____________________

Other members____________________ Title____________________

FIGURE B-6
FIELD OBSERVATION CHECKLIST

GENERAL/SAMPLING SITE

Stack/duct cross section dimensions__________ Equivalent diameter______

Material of construction__________ Corroded?________ Leaks?______

Internal appearance - Corroded?______ Caked particulate?______ Thickness______

Insulation?________ Thickness_____ Lining?______ Thickness______

Nipple?______ I.D. _____ Length_____ Flush with inside wall?________

Straight run before ports________ Diameters____________

Straight run after ports________ Diameters____________

Photos taken?________ Of what ________________

Drawing of sampling location:

Minimum information on drawing: stack/duct dimensions, location and description of major disturbances and all minor disturbances (dampers, transmissometers, etc.), and cross sectional view showing dimensions and port locations.

FIGURE B-6 (Cont.)
FIELD OBSERVATION CHECKLIST

GENERAL/SAMPLING SYSTEM

Sampling method (e.g., EPA 5) ____________________

Sampling train schematic drawing:

Modifications to standard method ____________________

____

Pump type: Fibervane with in-line oiler __X__ Carbon vane __X__ Diaphragm __X__

Probe liner material __________ Heated? __________ Entire length? __________

Type "S" pitot tube: __________ Other __________

Pitot tube connected to: Inclined manometer __________ Or magnehelic gauge __________

Range __________ Approx. scale length __________ Divisions __________

Orifice meter connected to: Inclined manometer ____ Or magnehelic gauge __________

Range __________ Approx. scale length __________ Divisions __________

Meter box brand ____X____ Sample box brand ____X____

Recent calibration of orifice meter-dry gas meter? __________ Pitot tubes? __________

Nozzles ______ Thermometers or thermocouples? ______ Magnehelic gauges? ______

Number of sampling points/traverse from Fed. Reg. ______ Number to be used ______

Length of sampling time/point desired __________ Time to be used __________

X– Not required by regulations

FIGURE B-6 (Cont.)
FIELD OBSERVATION CHECKLIST

TRAIN ASSEMBLY/FINAL PREPARATIONS Run # ____________

(Use one sheet per run if necessary)

Filter holder clean before test?__________ Filter holder assembled ________________

Correctly?_________ Filter media type________ Filter clearly identified?____________

Filter intact?__________ Probe liner clean before test?______________________

Nozzle clean?__________ Nozzle undamaged?__________________________

Impingers clean before test?______________ Impingers charged correctly?___________

Ball joints or screw joints?______________ Grease used?____________________

Kind of grease__________ Pitot tube tip undamaged?____________________

Pitot lines checked for leaks?____________ Plugging?______________________

Meter box leveled?___________ Pitot manometer zeroed?___________________

Orifice manometer zeroed?__________ Probe markings correct?________________

Probe hot along entire length?________________ Filter compartment hot? __________

Temperature information available?______________ Impingers iced down?__________

Thermometer reading properly?________ Barometric pressure measured?____________

If not, what is source of data___________ $\Delta H_{@}$ from most recent calibration__________

$\Delta H_{@}$ from check against dry gas meter_________________________________

Nomograph check:

If $\Delta H_{@} = 1.80$, $T_m = 100°F$, $\% H_2O = 10\%$, $P_s/P_m = 1.00$, C = __X__ (0.95)

If $C = 0.95$, $T_s = 200°F$, $DN = 0.375$, Δp reference = ___X___ (0.118)

Align $\Delta p = 1.0$ with $\Delta H = 10$; @ $\Delta p = 0.01$, ΔH = ___X___ (0.1)

For nomograph set-up:

Estimated meter temperature__X__°F. Estimated value of P_s/P_m __X______

Estimated moisture content __X__ %. How estimated? ____X__________

C factor___X___ Estimated stack temperature__X__°F.

Desired nozzle diameter ___X___

Stack thermometer checked against ambient temperature?_______________________

Leak test performed before start of sampling?________Rate______CFM @ ______in. Hg.

FIGURE B-6 (Cont.)
FIELD OBSERVATION CHECKLIST

SAMPLING (Use one sheet for each run if necessary) Run #________

Probe-sample box movement technique:

Is nozzle sealed when probe is in stack with pump turned off? ________________

Is care taken to avoid scraping nipple or stack wall? ________________

Is an effective seal made around probe at port opening? ________________

Is probe seal made without disturbing flow inside stack? ________________

Is probe moved to each point at the proper time? ________________

Is probe marking system adequate to properly locate each point? ________________

Are nozzle and pitot tube kept parallel to stack wall at each point? ________________

If probe is disconnected from filter holder with probe in the stack on a negative pressure source, how is particulate matter in the probe prevented from being sucked back into the stack?

____

If filters are changed during a run, was any particulate lost? ________________

Meterbox operation:

Is data recorded in a permanent manner? ________ Are data sheets complete?

____

Average time to reach isokinetic rate at each point ________________

Is nomograph setting changed when stack temperature changes significantly? ________

Are velocity pressures (Δp) read and recorded accurately? ________________

Is leak test performed at completion of run? ________ cfm @ ________ in. Hg.

General comment on sampling techniques ________________

If Orsat analysis is done, was it: From stack ________ From integrated bag ________

Was bag system leak tested? ________ Was Orsat leak tested? ________________
Check against air? ________________

If data sheets cannot be copied, record: aproximate stack temperature ________°F

Nozzle dia. ________ in. Volume metered ________ ACF

First 8 Δp readings ____ ____ ____ ____ ____ ____ ____ ____

FIGURE B-6 (Cont.)
FIELD OBSERVATION CHECKLIST

SAMPLE RECOVERY

General environment-clean up area ____________

Wash bottle clean? ________ Brushes clean? ________ Brushes rusty? ________

Jars Clean? ________ Acetone grade ________ Residue on evap. spec. ________ %

Filter handled OK? ________ Probe handled OK? ________ Impingers handled OK? ________

After cleanup: Filter holder clean? ________ Probe liner clean? ________

Nozzle clean? ________ Impingers clean? ________ Blanks taken? ________

Description of collected particulate ____________

Silica gel all pink? Run 1 ________ Run 2 ________ Run 3 ________

Jars adequately labeled? ________ Jars sealed tightly? ________

Liquid level marked on jars? ________ Jars locked up? ________

General comments on entire sampling project:

Observer's name ____________ Title ________

Affiliation ____________ Signature ________

FIGURE B-6 (Cont.)
FIELD OBSERVATION CHECKLIST

SAMPLE CHAIN OF CUSTODY

Plant

Date Sampled Test number

Run number

Sample Recovery

Container Code	Description

Person engaged in sample recovery

Signature

Title

Location at which recovery was done

Date and time of recovery

Sample(s) recipient, upon recovery if not recovery person

Signature

Title

Date and time of receipt

Sample storage

Laboratory person receiving sample

Signature

Title

Date and time of receipt

Sample storage

Analysis

Container code	Method of analysis	Date and time of analysis	Signature of analyst

FIGURE B-7
SAMPLE CHAIN OF CUSTODY FORM

SAMPLE TRANSPORT PARTICULATE CHECKLIST

____ Samples are to be the direct responsibility of a senior member of the source test team until the responsibility is transferred to the laboratory supervisor.

____ All liquid samples must be air-tight, the liquid level marked and stored upright properly to prevent spillage or breakage.

____ All solid samples are sealed and stored to prevent the loss of samples or contamination from the ambient sources.

____ All sample containers properly marked on outside to avoid rough handling during transport of the sample to the laboratory.

____ All sample containers locked to insure the sample integrity during transport.

____ The sample log (chain of custody) is initiated during sample recovery to insure quality assurance from the moment of collection.

FIGURE B-8
SAMPLE TRANSPORT PARTICULATE CHECKLIST

ANALYTICAL PARTICULATE CHECKLIST

____ Analytical balance should be calibrated with Class S weights at the time of use.

____ Desiccator contains anhydrous calcium sulfate.

____ Filter and any loose particles from the sample container desiccated from 24 to 96 hours to a "constant weight" means a difference of no more than 0.5 mg or 1% of total weight less tare weight, whichever is greater, between consecutive weighings, with no less than 6 hours of desiccation time between weighings and no more than 2 minutes exposed to the laboratory atmosphere (must be less than 50% relative humidity) during weighing.

____ Record level of liquid in containers on analytical data sheet to determine if leakage occurred during transport.

____ Blank filters desiccated to a constant weight. Blank weight should not vary from original weight by more than ±1.0 mg.

____ Liquid in sample containers remeasured by the analyst either volumetrically to ± 1 ml or gravimetrically to ±0.5 g.

____ Acetone rinse samples evaporate to dryness at ambient temperature and pressure in a tared 250 ml beaker. Prevent dust or objects from entering the beaker by placing a watch glass over the beaker during evaporation.

____ The dried sample was desiccated to a constant weight and reported to the nearest 0.1 mg.

____ The acetone blank was analyzed simultaneously with the acetone rinse using the same procedures.

____ Silica gel was weighed to the nearest 0.5g using a balance in the field or laboratory.

____ Sample beakers covered with parafilm and stored along with used filters until report is accepted by control agency or until such time as specified by the agency.

____ Was analysis observed or checklist given to test team leader?

FIGURE B-9
ANALYTICAL PARTICULATE CHECKLIST

TABLE B-1

ALLOWABLE OPERATING PARAMETERS FOR A POWER PLANT

Process: (SIP)

Parameters	Allowable limits compared to average compliance test conditions	Time weighted basis
Steam production	110% of the average steam production tested rate	8 hour average recorded hourly
Megawatt rate	110% of the average megawatt tested rate	8 hour average recorded hourly
Excess air	[a] 2% increase in oxygen content over the average tested excess air value while operating at or about 90% of the average steam production rate	1 hour average recorded hourly
Fuel analysis:[b]		
Ash content	An increase of 1.0% ash content above the average ash content analysis of the test fuel	monthly average collected daily combined and analyzed weekly
Sulfur content	[c] An increase of 0.25% sulfur content above the average sulfur content analysis of the test fuel	monthly average collected daily combined and analyzed weekly
	[d] A decrease of 0.50% sulfur content below the average sulfur content analysis of the test fuel	monthly average collected daily combined and analyzed weekly

[a] Does not apply during changing load conditions.

[b] Ash content is the ash content divided by the heating value of the fuel.
Sulfur content is the sulfur content divided by the heating value of the fuel.

[c] Does not apply to flue gas desulfurization systems.

[d] Applies only to coal fired boilers with electrostatic precipitators.

TABLE B-1 (Cont.)
ALLOWABLE OPERATING PARAMETERS FOR A POWER PLANT

Fuel feed will operate on – Manual ______________ Automatic ______________________

Combustion air will operate on – Manual ____________ Automatic ______________________

Fly ash reinjection – Yes ________ No ________

Soot blowing – Continuous ________ Intermittent ________ Maximum frequency ______________

Bottom ash removal – Continuous ________ Intermittent ____________ Maximum frequency ________

Control Equipment: (SIP)

Flue gas conditioning – No ________ Yes ________ Acceptable conditions ______________________

Fly ash removal – Continuous ________ Intermittent ________ Maximum frequency ______________

Scheduled preventative maintenance ____

Electrostatic precipitator – A once-a-shift recording of all individual fields in the electrostatic precipitator as to whether each field is on or off. The agency must be notified under the following conditions if the boiler is to be operated:

1) Complete outage of all fields
2) 50% or more outage for more than 24 hours of boiler usage
3) 25% or more outage for 48 hours of boiler usage
4) Any outage for more than 60 hours of boiler usage during any 30 day period

Scrubbing system – A once-a-shift recording of the scrubbing liquid to steam production rate ratio. The agency must be notified under the following conditions if the boiler is to be operated:

1) Complete stoppage of liquid flow
2) 50% or less ratio of liquid to steam production for more than 24 hours of boiler usage
3) 80% or less ratio of liquid to steam production for more than 48 hours of steam production
4) 90% or less ratio for more than 60 hours of boiler usage in any 30 day period

TABLE B-1 (Cont.)

ALLOWABLE OPERATING PARAMETERS FOR A POWER PLANT

Fabric filters – Torn bags must be replaced or blanked off whenever the facility exceeds the allowable visible opacity for more than 2 hours in any 24 hours and/or every 120 days. Bags may be blanked off up to 15% of the total bags as long as the facility meets the visible emission limits. All torn and blanked off bags must be replaced every 12 months or when over 15% of the bags are blanked off, whichever is more restrictive. The agency must be notified under the following conditions if the boiler is to be operated:

1) 30 days prior to all scheduled maintenance
2) Whenever the allowable visible opacity limit is exceeded for more than 2 hours in any 24 hours
3) If the facility plans on by-passing the baghouse for any reason.

Agency Inspections:

The agency will make at least one scheduled inspection every year to review the execution of the conditions of the conditional compliance. The facility will be notified of the date of the first inspection in the conditional compliance letter from the agency. The facility will have all required data available for inspection. The facility will then be notified after each scheduled and unscheduled inspection of the results of the inspection, any actions that must be taken by the facility and the date of the next scheduled inspection. This does not waive the right of the agency to make as many unscheduled inspections as they deem necessary to ensure "good working operation" by the facility.

FACILITY OPERATING PARAMETERS DURING TEST PERIOD FOR A POWER PLANT

Process (SIP)

Designation of unit being tested ____________________

Boiler nameplate capacity __________ Pounds steam/hr.

Electric generator capacity __________ megawatts

Firing type – Front wall ________ Opposed wall ________ Vertical ________ Tangential or corner ________

Boiler operation – Base load ________ Peak load ________

Parameter	Acceptable limits	Units	Where gathered	Interval of recording
Steam production		lb steam/hr		
Megawatt rating		megawatts		
Fuel scales (meter)				
Excess air	–	–		

Fuel sample – Wt per collection __________ Interval of collection __________

Fuel feed – Manual __________ Automatic __________

Combustion air – Manual __________ Automatic __________

Fly ash reinjection – No __________ Yes __________ Location(s) __________

Soot blowing – Continuous __________ Intermittent __________ Frequency __________

Bottom ash removal – Continuous __________ Intermittent __________ Frequency __________

FIGURE B-10
FACILITY OPERATING PARAMETERS
DURING TEST PERIOD FOR A POWER PLANT

Fuel (SIP)

Fuel type Percentage

Coal ____________ ____________

Oil ____________ ____________

Gas ____________ ____________

Other ____________ ____________

Coal (classified by ASTMD 388-66)

Bituminous subbituminous anthracite lignite

Coal feed measurement and location

Automatic conveyor scale

Batch weighing – dumping hoppers

Other (describe) ____

Location of scale ____

None

Liquid fossil fuel

Crude residual distillate

Liquid fuel feed measurement and location

Volumetric flow meter, make ____________ model ______________

Other (describe) ____

Location of meter ____

None

Gaseous fossil fuel

Natural gas propane butane other

Gaseous fuel feed measurement and location

Volumetric flow meter, make __________ model ______________

Other (describe) ____

FIGURE B-10 (Cont.)
FACILITY OPERATING PARAMETERS
DURING TEST PERIOD FOR A POWER PLANT

Location of meter ______________________________

None

Other fuel (describe) ______________________________

Other fuel feed measured by ______________________________

____

FUEL ANALYSIS

PROXIMATE ANALYSIS – As-fired solid and liquid fuels

Component	% by weight	
	Typical	Acceptable Range
Moisture		
Ash		
Volatile Matter		
Fixed Carbon		
Sulfur		
Heat value, BTU/lb		

or ultimate analysis – which includes the proximate analysis plus the following

Nitrogen		
Oxygen		
Hydrogen		
Carbon		

FIGURE B-10 (Cont.)
FACILITY OPERATING PARAMETERS
DURING TEST PERIOD FOR A POWER PLANT

Control Equipment

Parameter	Acceptable limits	Units	Where gathered	Interval of recording

Flue gas conditioning – No __________ Yes __________ Explain ______________________________

Fly ash removal – Continuous __________ Intermittent __________ Frequency ______________________________

Normal maintenance schedule ______________________________

____

Conditions of Test Runs

Run 1 ______________________________

Run 2 ______________________________

Run 3 ______________________________

Other ______________________________

FIGURE B-10 (Cont.)
FACILITY OPERATING PARAMETERS
DURING TEST PERIOD FOR A POWER PLANT

PROCESS DATA DURING TEST

Record the following data every 30 minutes during compliance test (SIP).
Mark chart at the start and finish of each test and obtain copy of chart(s).

Parameter	Units	Values								Integrator factor
Recording time	24 hr.									
Steam load	lb/hr.									
Air load	lb/hr.									
Megawatt	megawatt									
CO_2	%									
O_2	%									
Soot blowing	minutes									
Bottom ash removal	minutes									
Fly ash removal	minutes									
Opacity	%									

Fuel feed – Manual ____________ Automatic ____________

Combustion air – Manual ____________ Automatic ____________

Fly ash reinjection – No ________ Yes ________ Locations ________

FIGURE B-11
FORM FOR PROCESS DATA DURING TEST

FUEL INPUT DATA DURING TEST

Automatic weighing or metering

	Counter (totalizer) Reading			
	Time	Coal	Oil	Gas
End test	______	______	______	______
Begin test	______	______	______	______
Difference	______	______	______	______
Units fed during test	______	______	______	______
Counter conversion factor	______	______	______	______
Fuel per counter unit	______ tons	______gal.	______ ft.^{3}	
Fuel fed during test	______ tons	______gal.	______ ft.^{3}	
Fuel sampled during test				
Number of samples	______	______	______	
Total quantity of sample	______	______	______	
Date of last calibration of automatic metering device	______	______	______	

Manual weighing or other procedure. Use this space for monitoring procedure and calculations. ____

____

____

____

____

____

____

FIGURE B-12
FORM FOR FUEL INPUT DATA DURING TEST

APPENDIX C
DATA SHEETS (ELECTROSTATIC PRECIPITATOR, PARTICULATE SCRUBBER, FABRIC FILTER, AND CENTRIFUGAL COLLECTOR)

ELECTROSTATIC PRECIPITATOR DATA SHEET —PARAMETERS OF DESIGN AND OPERATION AFFECTING PERFORMANCE

Facility____________________ Boiler No.________________

Monitor Name____________________ Test No. ________________

Design Efficiency____________________ Test Date________________

Recording Interval[a]		Operating Voltage (kV)				Operating Current (mA)				Spark-Rate (Sparks/ minute)
Sampling Time (minutes) 0	Clock Time (24 hr. clock)	Field Number				Field Number				
		1	2	3	4	1	2	3	4	
	Representative									
	design									

Rapper timing/sequence:

Representative____________________

During Test: ____________________

Hopper ash removal sequence:

Representative____________________

During Test: ____________________

[a] Recording intervals – 15-30 minutes.

FIGURE C-1
DATA SHEET - ELECTROSTATIC PRECIPITATOR

PARTICULATE SCRUBBER DATA SHEET – PARAMETERS OF DESIGN AND OPERATION AFFECTING PERFORMANCE

Facility ____________________ Boiler No. __________

Monitor Name ____________________ Test No. __________

Design Efficiency ____________________ Test Date __________

Recording Interval[a]		Static Pressure (in. H_2O)[b]		Pressure Drop Across Scrubber (in. H_2O)	Water Flow Rate (gpm)
Sampling Time (minutes)	Clock Time (24 hr. clock)	Inlet	Outlet		
0					
		Representative			
		Design			

[a] Recording intervals — 15-30 minutes.

[b] If direct reading of pressure drop is not available.

FIGURE C-2
DATA SHEET - PARTICULATE SCRUBBER

FABRIC FILTER DATA SHEET – PARAMETERS OF DESIGN AND OPERATION AFFECTING PERFORMANCE

Facility ________________________ Boiler No. __________

Monitor Name ________________________ Test No. __________

Design Efficiency ________________________ Test Date __________

Recording Interval[a]		Pressure Drop Across Baghouse (in. H_2O)	Pressure Drop Across Compartment (in. H_2O)				
Sampling Time (minutes)	Clock Time (24 hr. clock)		1	2	3	4	5
	Representative						
	Design						

	Design/Normal	During Test (flue gas temp.)
Temperature range of filter fabric		
Fan damper position		
Fan current (amps)		
Cleaning cycle		
Total no. of bags in operation		b

Are any bags blanked off?[b] no ______ yes ______ , number ________

Are any bags leaking?[b] no ______ yes ______ , number ________

[a] Recording intervals – 10 minutes. If a compartment is isolated sequentially for cleaning throughout the test timing mechanisms, data readings should be synchronized with cleaning cycle.

[b] This information is generally not available. It can be obtained during boiler shut-down prior to or after testing; however, for many constant demand-type boilers, this is not possible.

FIGURE C-3
DATA SHEET - FABRIC FILTER

CENTRIFUGAL COLLECTOR DATA SHEET – PARAMETERS OF DESIGN AND OPERATION AFFECTING PERFORMANCE

Facility____________________ Boiler No.______________

Monitor Name__________________ Test No.______________

Design Efficiency_______________ Test Date______________

	Design	During test		
		Beginning	Mid-Point	End
Pressure drop across collector, in. H_2O				
Fan motor amperes				

Is the collector sectionalized with dampers for control of Δp

No______ Yes ______

If yes, how were dampers positioned during test? ____________________

Hopper ash removal sequence:

Representative____________________

During test ____________________

FIGURE C-4
DATA SHEET - CENTRIFUGAL COLLECTOR

APPENDIX D
PROCEDURES FOR STARTUP AND SHUTDOWN OF ELECTROSTATIC PRECIPITATORS

General

1. Visually inspect the mechanical dust collector units, induced draft fans, and dust handling equipment before the system is operated.

2. Close and secure all access hatches prior to operation.

3. Determine that all system internal areas are completely free of tools, scrap, and foreign material before the fan(s) is started.

4. Verify that primary power is available to thermostatically controlled heaters if provided. Circuit breakers for this equipment may have to be energized several hours prior to system operation.

5. Check all interlocks and voltage control modules.

6. Check main off/test selector switch and place in off position.

7. Check grounding connections.

Rapper System

1. Ground the power unit in the control cubicle.

2. Check distributor switch rapper connections.

3. Check ground return leads for proper connections to sectionalized control adjustments.

4. Check for proper mechanical adjustment.

5. Adjust each manual sectional control for proper rapping intensity.

6. Check spark rate feed circuit and signals for proper connections.

Rectifiers and Transformers

1. Check all connections, switches, and insulators.

2. Check oil (liquid) levels.

3. See that high-tension duct vent ports are installed and free.
4. Be sure grounds are completed on transformer-rectifiers, bus duct, and conduits.

Routine Start-Up

If hot gases are to be passed through the precipitator, the system should be warmed up to operating temperature before gas flows are started.

1. All inspection ports should be closed and dampers adjusted for proper air flow.
2. In wet precipitators, the liquid supply should be turned on and adjusted.
3. High-voltage current should be energized.
4. Start collector and discharge electrode rappers if provided on the system.
5. Turn on product discharge system.
6. Bring fan to full rpm with exit damper closed.
7. Adjust damper for desired gas flow.
8. Record system pressure drop and fan pressure drop.

If the system is not equipped with external heating facilities, reverse the procedures so that the inlet gases enter before the precipitator is energized. When the precipitator reaches operating temperature, turn on the high-voltage power.

Most wet scrubbers operate in a similar manner, such that their prestart-up and start-up procedures are similar. These procedures are as follows:

Prestart-Up Checkout

After installation of equipment is complete, it is advisable to provide about a 2-week shakedown period in order to be assured that the system is ready for routine start-up. Some of the items always checked are the following:

1. Bump pumps and fans to check rotation.
2. Disconnect pump suction piping where possible and flush system with external sources of water.

3. Install temporary strainers in pump suctions and commence liquid recycle. These strainers may be mesh cones installed directly in the lines.

4. With recycle flow on, set valves to determine operating positions for desired flow rates. Noting valve position at this time is useful in determining pump wear during operation.

5. The fan is dynamically balanced by the fan vendor and checked for vibration. Two or three mils is usually an acceptable vibration amplitude.

6. Check and record all system pressure drops under these "clean conditions."

7. Check instrumentation for liquid in impulse lines, level recorder, and other places.

8. Check and follow all lubrication instructions.

9. Shut down fan, drain system, inspect internals, and remove temporary strainers.

10. Review operating instructions with all appropriate plant personnel.

Routine Start-Up

1. Allow vessels to fill with liquid through normal level controls if practical. Frequently, large volume basins such as thickeners must be filled from external sources.

2. Start control liquid to all pump glands and fan sprays.

3. Start recycle pumps with liquid bleed closed.

4. Check system isolation dampers and place scrubber in series with primary operation.

5. Start fan and check vibration. If fan has an inlet control damper, it should be normally closed until fan reaches speed, usually between one and two minutes.

6. Check most important operating variables, i.e., gas saturation, liquid flows, liquid levels, fan pressure drop, duct pressure drops, and scrubber pressure drop.

7. Slowly open bleed to pond, thickener or other drain system so that slurry concentration is allowed to build up slowly. Check final concentration as a cross-check on bleed rate calculation.

Routine Shutdown

1. Shut down fan and fan spray water and isolate scrubbing system from operation.
2. Allow liquid system to operate for as long as practical. This will cool the scrubber and will reduce scrubbing liquid slurry concentrations.
3. Shut off makeup water to system allowing system to bleed normally.

APPENDIX E
PROCEDURES FOR TROUBLESHOOTING AND CORRECTION OF BAGHOUSE MALFUNCTIONS

(RP--reverse pulse; PR–plenum pulse; S–shaker; RF–reverse flow)

SYMPTOM	CAUSE	REMEDY
High baghouse pressure drop	Baghouse undersized	Consult manufacturers. Install double bags. Add more compartments or modules.
	Bag cleaning mechanism not adjusted properly	Increase cleaning frequency. Clean for longer duration. Clean more vigorously.
	Compressed air pressure too low (RP, PP)	Increase pressure. Decrease duration and/or frequency. Check dryer and clean if necessary. Check for obstruction in piping.
	Repressuring pressure too low (RF)	Speed up repressuring fan. Check for leaks. Check damper valve seals.
	Shaking not strong enough (S)	Increase shaker speed.
	Isolation damper valves not closing (S, RF, PP)	Check linkage. Check seals. Check air supply on pneumatic operators.
	Bag tension too loose (S)	Tighten bags.
	Pulsing valves failed (RP)	Check diaphragm. Check pilot valves.
	Cleaning timer failure	Check to see if timer is indexing to all contacts. Check output on all terminals.

SYMPTOM	CAUSE	REMEDY
	Not capable of removing dust from bags	Condensation on bags (see below). Send sample of dust to manufacturer. Send bag to lab for analysis for binding. Dry clean or replace bags. Reduce air flow.
	Excessive re-entrainment of dust	Continuously empty hopper. Clean rows of bags randomly, instead of sequentially (PP, RP).
	Incorrect pressure reading	Clean out pressure taps. Check hoses for leaks. Check for proper fluid in manometer. Check diaphragm in gage.
Low fan motor amperage/low air volume	High baghouse	See above.
	Fan and motor sheaves reverse	Check drawings and reverse sheaves.
	Ducts plugged with dust	Clean out ducts and check duct velocities.
	Fan damper closed	Open damper and lock in position.
	System static pressure too high	Measure static on both sides of fan and review with design. Duct velocity too high. Duct design not proper.
	Fan not operating per design	Check fan inlet configuration and be sure flow is even.
	Belts slipping	Check tension and adjust.

SYMPTOM	CAUSE	REMEDY
Dust escaping at source	Low air volume	See above.
	Ducts leaking	Patch leaks so air does not bypass source.
	Improper duct balancing	Adjust blast gates in branch ducts.
	Improper hood design	Close open areas around dust source. Check for cross drafts that overcome suction. Check for dust being thrown away from hood by belt, etc.
Dirty discharge at stack	Bags leaking	Replace bags. Tie off bags and replace at later date. Isolate leaking compartment if allowable without upsetting system.
	Bag clamps not sealing	Check and tighten clamps. Smooth out cloth under clamp and re-clamp.
	Failure of seals in joints at clean/dirty air connection	Caulk or weld seams.
	Insufficient filter cake	Allow more dust to build up on bags by cleaning less frequently. Use a precoating of dust on bags (S, RF).
	Bags too porous	Send bags in for permeability test and review with manufacturer.

SYMPTOM	CAUSE	REMEDY
Excessive fan wear	Fan handling too much dust	See above.
	Improper fan	Check with fan manufacturer to see if fan is correct for application.
	Fan speed too high	Check with manufacturer.
Excessive fan vibration	Buildup of dust on blades	Clean off and check to see if fan is handling too much dust (see above). Do not allow any water in fan (check cap, look for condensation, etc.).
	Wrong fan wheel for application	Check with manufacturer.
	Sheaves not balanced	Have sheaves dynamically balanced.
	Bearings worn	Replace bearings.
High compressed air consumption	Cleaning cycle too frequent	Reduce cleaning cycle if possible.
	Pulse too long	Reduce duration (after initial shock, all other compressed air is wasted).
	Pressure too high	Reduce supply pressure if possible.
	Damper valves not sealing (PP)	Check linkage. Check seals.
	Diaphragm valve failure	Check diaphragms and springs. Check pilot valve.

SYMPTOM	CAUSE	REMEDY
Reduced compressed air pressure (RP, PP)	Compressed air consumption too high	See above.
	Restrictions in piping	Check piping.
	Dryer plugged	Replace dessicant or bypass dryer if allowed.
	Supply line too small	Consult design.
	Compressor worn	Replace rings.
Premature bag failure – decomposition	Bag material improper for chemical composition of gas or dust	Analyze gas and dust and check with manufacturer. Treat with neutralizer before baghouse.
	Operating below acid dew point	Increase gas temperature. Bypass at start-up.
Moisture in baghouse	Insufficient preheating	Run system with hot air only before starting process gas flow.
	System not purged after shut-down	Keep fan running for 5-10 minutes after process is shut down.
	Wall temperature below dew point	Raise gas temperature. Insulate unit. Lower dew point by keeping moisture out of system.
	Cold spots through insulation	Eliminate direct metal line through insulation.
	Compressed air introducing water (RP, PP)	Check automatic drains. Install aftercooler. Install dryer.

SYMPTOM	CAUSE	REMEDY
	Repressuring air causing condensation (RF, PP)	Preheat repressuring air. Use process gas as source of repressuring air.
High screw conveyor wear	Screw conveyor undersized	Measure hourly collection of dust and consult manufacturer.
	Conveyor speed too high	Reduce speed.
High air lock wear	Air lock undersized	Measure hourly collection of dust and consult manufacturer.
	Thermal expansion	Consult manufacturer to see if design allows for thermal expansion.
	Speed too high	Reduce speed.
Material bridging in hopper	Moisture in baghouse	See above.
	Dust being stored in hopper	Remove dust continuously.
	Hopper slope insufficient	Rework or replace hoppers.
	Conveyor opening too small	Use a wide flared trough.
Frequent screw conveyor/air lock failure	Equipment undersized	Consult manufacturer.
	Screw conveyor misaligned	Align conveyor.
	Overloading components	Check sizing to see that each component is capable of handling a 100% delivery from screw conveyor.

SYMPTOM	CAUSE	REMEDY
High pneumatic conveyor wear	Pneumatic blower too fast	Reduce blower speed.
	Piping undersized	Review design and reduce speed of blower or increase pipe size.
	Elbow radius too short	Replace with long radius elbows.
Pneumatic conveyor pipes plugging	Overloading pneumatic conveyor	Review design.

APPENDIX F
TYPICAL TROUBLESHOOTING CHART FOR AN ELECTROSTATIC PRECIPITATOR (EXAMPLE ONLY)

SYMPTOM	PROBABLE CAUSE	REMEDY
1. No primary voltage. No primary current. No precipitator current. Vent fan on. Alarm energized.	Overload condition	Check overload relay settings. Check wiring and components.
	Misadjustment of current limit control	Check adjustment of current limit control setting.
	Overdrive of SCR's	Check signal from firing circuit module.
2. No primary voltage. No primary current. No precipitator current. Vent fan off. Alarm energized.	Relay panel fuse blown	Replace.
	Circuit breaker tripped	Reset circuit breaker.
	Loss of supply power	Check supply to control unit.
3. Control unit trips out on overcurrent when sparking occurs at high currents.	Circuit breaker defective or incorrectly sized	Check circuit breaker.
	Overload circuit incorrectly set.	Reset overload circuit.
	Short circuit condition in primary.	Check primary power wiring.
4. High primary current. No precipitator current.	Transformer or rectifier short	Check transformer and rectifiers.
5. No primary voltage. No primary current. No precipitator current. Vent fan on. Alarm not energized.	SCR and/or diode failure	Replace.
	No firing pulse from firing circuit and/or amplifier	Check signal from firing circuit and/or amplifier.

SYMPTOM	PROBABLE CAUSE	REMEDY
6. Same as #5 above, even after replacing components or subpanels, changing wires, or repair.	SCR's being fired out of phase	Reverse input wires
7. Low primary voltage. High secondary current.	Short circuit in secondary circuit or precipitator	Check wiring and components in H.V. circuit and pipe and guard. Check precipitator for: Interior dust build-up Full hoppers Broken wires Ground switch left on Ground jumper left on Foreign material on H.V. frame or wires Broken insulators
8. Abnormally low precipitator current and primary voltage with no sparking.	Misadjustment of current and/or voltage limit controls	Check settings of current and voltage limit controls
	Misadjustment of firing circuit control	Turn to maximum (clockwise) and check setting of current and voltage limit controls
9. Spark meter reads high – off scale.	Continuous conduction of spark counting circuit	De-energize, allow integrating capacitor to discharge and re-energize
Low primary voltage and current.	Spark counter counting 60 cycles peak	Readjust
No spark rate indication.	Failure	Replace

SYMPTOM	PROBABLE CAUSE	REMEDY
10. Spark meter reads high; primary voltage and current very unstable.	Misadjustment of PC-501	Readjust
	Loss of limiting control	Replace
11. Neither spark rate, current nor voltage at maximum.	Misadjustment of PC-501	Readjust setting
	Failure	Replace
	Failure of signal circuits	Check signal circuits
12. No spark rate indication; voltmeter and ammeter unstable, indicating sparking.	Failure of spark meter	Replace spark meter
	Failure of integrating capacitor	Replace capacitor
	Spark counter sensitivity too low	Readjust
13. No response to current limit adjustment; however, does respond to other adjustments.	Controlling on spark rate or voltage limit	None needed if unit is operating at maximum spark rate or voltage adjustment Reset voltage or spark rate if neither is at maximum
	Failure	Replace
	Current signal defective	Check signal circuit

SYMPTOM	PROBABLE CAUSE	REMEDY
14. No response to voltage limit adjustment; however, does respond to current adjustment.	Controlling on current limit or spark rate	None needed if unit is operating at maximum current or spark rate. Reset current and spark rate adjustment if neither is at maximum
	Voltage signal defective	Check voltage signal circuit
	Failure	Replace
15. No response to spark rate adjustment; however, does respond to other adjustment.	Controlling on voltage or current	None needed if unit is operating at maximum voltage or current. Reset voltage and current adjustment if neither is at maximum
	Failure	Replace
16. Precipitator current low with respect to primary current. Low or no voltage across ground return resistors.	Surge arrestors shorted	Reset or replace surge arrestors
	H.V. rectifiers failed	Replace H.V. rectifiers
	H.V. transformer failed	Replace H.V. transformer
	Ground or partial ground in the ground return circuit	Repair ground return circuit

☆ U.S. GOVERNMENT PRINTING OFFICE: 1980-657-165/0168