An Introduction to Incinerator Emissions and Permitting

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1. INCINERATOR EMISSIONS

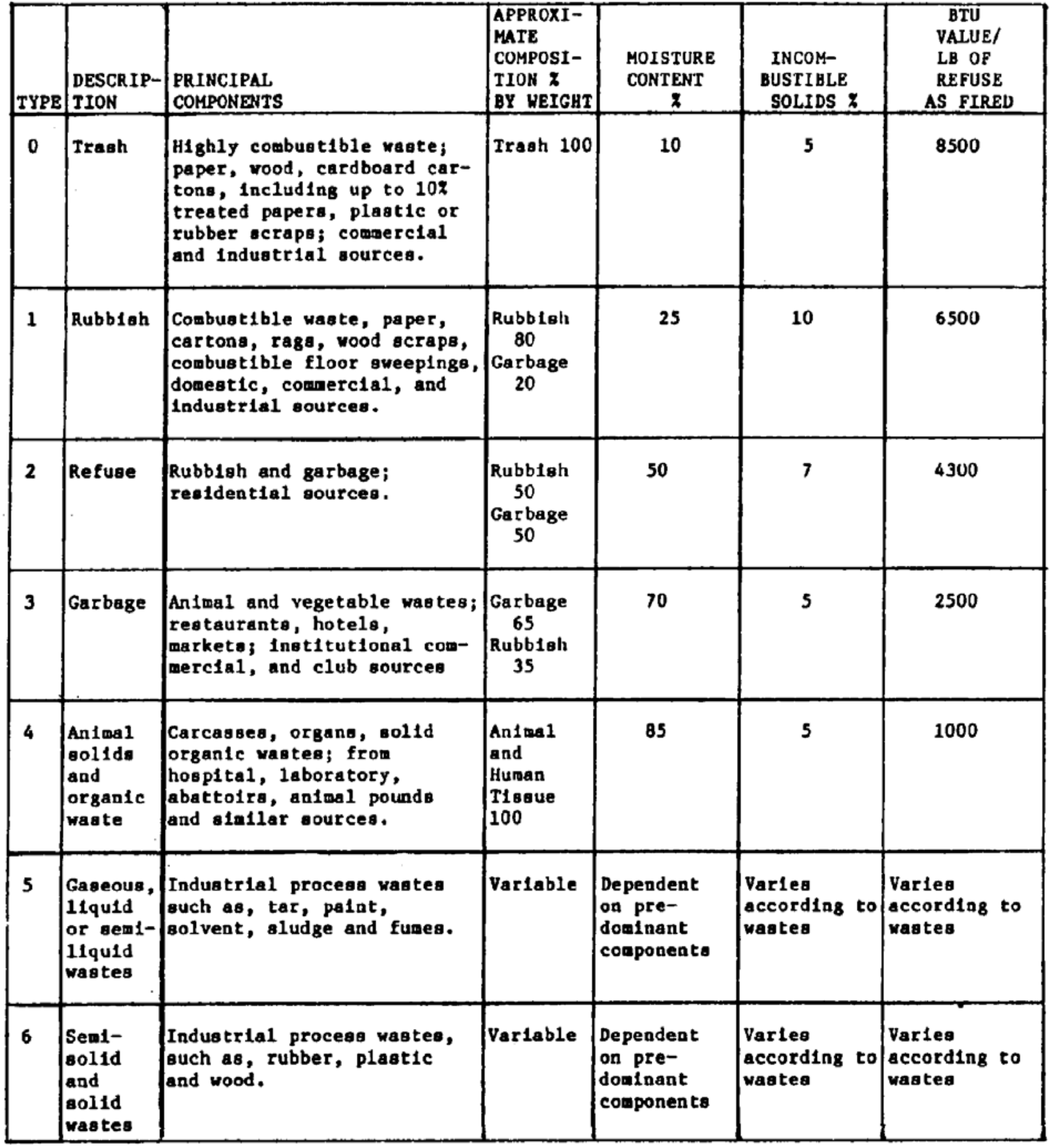
1.1 INCINERATION This publication describes and quantifies, whenever possible, the air pollution particulate emissions which are the direct result of the incineration process.

1.1.1 INCINERATION PROCESS. The incineration process consists of burning solid, semisolid, liquid, or gaseous waste to produce carbon dioxide, water, and ash. It is an efficient means of reducing waste volume. The solid, incombustible residue of incineration is inert, sanitary, and sensibly odorless.

1.1.2 EMISSIONS. Incineration contributes to air pollution. The polluting emissions are ash, hydrocarbons, sulfur oxides (SO_X), nitrous oxides (NO_X), chlorides, and carbon monoxide. Estimating absolute quantities of these pollutants is not an exact science, hut historical testing data from typical incinerators allow estimates of emissions to be made. Also, measurement methods for incinerator emissions are sufficiently advanced to permit actual data to be obtained for any existing incinerator. These measurements are preferred in all cases over analytical estimates.

1.1.3 POLLUTION CODES. Air pollution particulate emissions must be considered as they relate to the federal, state and local pollution codes. In general, incinerators cannot meet current pollution code requirements without particulate control devices.

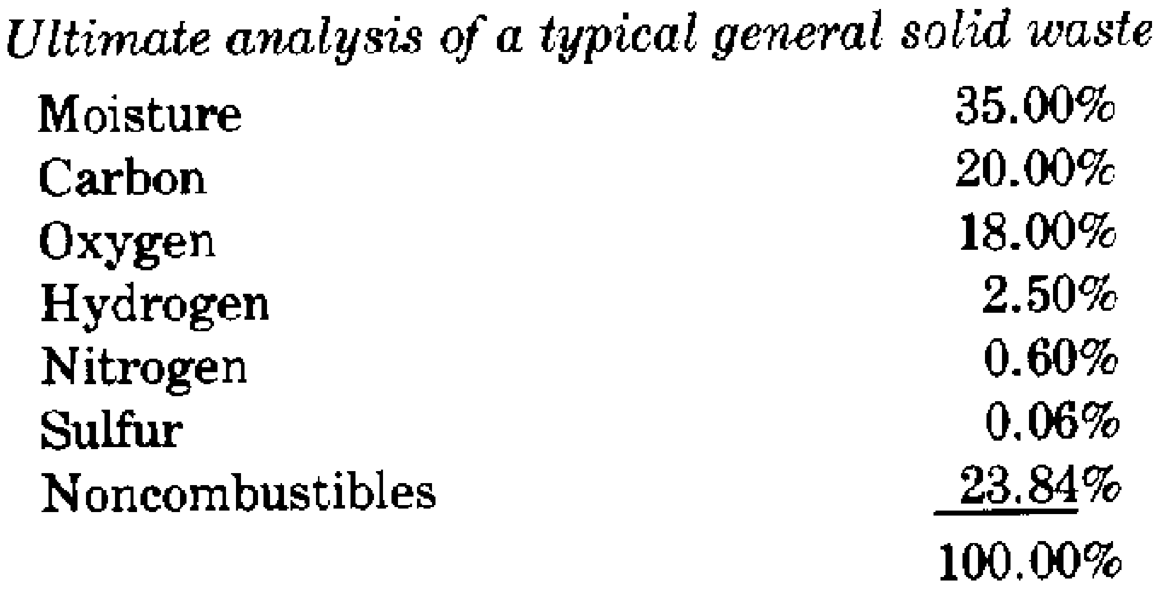
1.2 TYPES OF INCINERATOR WASTE MATERIALS. Waste materials are classified as shown in Table 1. An ultimate analysis of a typical general solid waste is shown in Table 2. Because of the wide variation in composition of waste materials, an analysis of the actual material to be incinerated should be made before sizing the incineration equipment.



TYPE	DESCRIPTION	PRINCIPAL COMPONENTS	APPROXIMATE COMPOSITION % BY WEIGHT	MOISTURE CONTENT %	INCOMBUSTIBLE SOLIDS %	BTU VALUE/ LB OF REFUSE AS FIRED
0	Trash	Highly combustible waste; paper, wood, cardboard cartons, including up to 10% treated papers, plastic or rubber scraps; commercial and industrial sources.	Trash 100	10	5	8500
1	Rubbish	Combustible waste, paper, cartons, rags, wood scraps, combustible floor sweepings, domestic, commercial, and industrial sources.	Rubbish 80 Garbage 20	25	10	6500
2	Refuse	Rubbish and garbage; residential sources.	Rubbish 50 Garbage 50	50	7	4300
3	Garbage	Animal and vegetable wastes; restaurants, hotels, markets; institutional commercial, and club sources	Garbage 65 Rubbish 35	70	5	2500
4	Animal solids and organic waste	Carcasses, organs, solid organic wastes; from hospital, laboratory, abattoirs, animal pounds and similar sources.	Animal and Human Tissue 100	85	5	1000
5	Gaseous, liquid or semi-liquid wastes	Industrial process wastes such as, tar, paint, solvent, sludge and fumes.	Variable	Dependent on predominant components	Varies according to wastes	Varies according to wastes
6	Semi-solid and solid wastes	Industrial process wastes, such as, rubber, plastic and wood.	Variable	Dependent on predominant components	Varies according to wastes	Varies according to wastes

Table 1

Waste classifications



Ultimate analysis of a typical general solid waste

Moisture	35.00%
Carbon	20.00%
Oxygen	18.00%
Hydrogen	2.50%
Nitrogen	0.60%
Sulfur	0.06%
Noncombustibles	23.84%
	100.00%

Table 2

Ultimate analysis of a typical general solid waste

1.3 FUNCTION OF INCINERATORS. Incinerators are engineered apparatus capable of withstanding heat and are designed to effectively reduce solid, semi-solid, liquid, or gaseous waste at specified rates, so that the residue contain little or no combustible material. In order for an incinerator to meet these specifications, the following principles of solid fuel combustion generally apply:

- Air and fuel must be in the proper proportion;
- Air and fuel, especially combustible gases, must be properly mixed;
- Temperatures must be high enough to ignite both the solid fuel and the gaseous components;
- Furnace volumes must permit the proper retention time needed for complete combustion; and
- Furnace configurations must maintain ignition temperatures and minimize fly-ash entrainment.

1.4 EFFECT OF WASTE PROPERTIES. The variability of chemical and physical properties of waste materials, such as ash content, moisture content, volatility, burning rate, density, and heating value, makes control of incineration difficult. All of these factors affect to some degree the operating variables of the flame-propagation rate, flame travel, combustion temperature, combustion air requirements, and the need for auxiliary heat. Maximum combustion efficiency is maintained primarily through optimum incinerator design.

1.5 TYPES OF INCINERATORS.

1.5.1 MUNICIPAL INCINERATORS. Incinerators are classified either as large or small units, with the dividing point at a processing rate of 50 tons of waste per day. The trend is toward the use of the smaller units because of their lower cost, their simplicity, and lower air emission control requirements. There are three major types of municipal incinerators discussed below.

1.5.1.1 RECTANGULAR INCINERATORS. The most common municipal incinerator is the rectangular type. The multiple chamber units are either refractory lined or water cooled and consist of a combustion chamber followed by a mixing chamber. The multi-cell units consist of two or more side-by-side furnace cells connected to a common mixing chamber. Primary air is fed under the grate. Secondary air is added in the mixing chamber to complete combustion. A settling chamber often follows the mixing chamber. Ash is removed from pits in the bottom of all of the chambers

1.5.1.2 VERTICAL CIRCULAR INCINERATORS. Waste is usually fed into the top of the refractory lined chamber. The grate consists of a rotating cone in the center surrounded by a stationary section with a dumping section around it. Arms attached to the rotating cone agitate the waste and move the ash to the outside. Primary air is fed underneath the grate. Overfire air is fed into the upper section of the chamber.

1.5.1.3 ROTARY KILN INCINERATORS. Rotary kiln incinerators are used to further the combustion of waste that has been dried and partially burned in a rectangular chamber. The waste is mixed with combustion air by the tumbling action of the kiln. Combustion is completed in the mixing chamber following the kiln where secondary air is added. The ash is discharged at the end of the kiln.

1.5.2 INDUSTRIAL AND COMMERCIAL INCINERATORS*.* Industrial and commercial incinerators generally fall into six categories discussed below. The capacities of these incinerators generally range from a half to less than 50 tons per day. They are usually operated intermittently.

1.5.2.1 SINGLE CHAMBER INCINERATORS. Single chamber incinerators consist of a refractory lined combustion chamber and an ash pit separated by a grate. There is no separate mixing chamber. An auxiliary fuel burner is normally provided underneath the grate. The units are normally natural draft (no fans). Emissions from single chamber units are high because of incomplete combustion.

1.5.2.2 MULTIPLE CHAMBER INCINERATORS. Multiple chamber refractory lined incinerators normally consist of a primary chamber, a mixing chamber and a secondary combustion chamber. The primary chamber is similar to a single chamber unit. Air is fed under the grate and through overfire air ports. Secondary air is added in the mixing chamber. Combustion is completed in the secondary combustion chamber where some settling occurs. These units are also normally based on natural draft.

1.5.2.3 CONICAL INCINERATORS. Conical incinerators known commonly as "tee-pee" burners have been used primarily in the wood product industry to dispose of wood waste. Since they cannot meet most local particulate emission requirements, and since wood waste is becoming more valuable as a fuel, conical incinerators are being phased out.

1.5.2.4 TRENCH INCINERATORS. Trench incinerators are used for the disposal of waste with a high heat content and a low ash content. The incinerator consists of a U-shaped chamber with air nozzles along the rim. The nozzles are directed to provide a curtain of air over the pit and to provide air in the pit.

1.5.2.5 CONTROLLED-AIR INCINERATORS. Controlled-air incinerators consist of a refractory lined primary chamber where a reducing atmosphere is maintained, and a refractory lined secondary chamber where an oxidizing atmosphere is maintained. The carbon in the waste burns and supplies the heat to release the volatiles in the waste in the form of a dense combustible smoke. Overfire air is added between chambers. The smoke is ignited in the secondary chamber with the addition of air. Auxiliary fuel burners are sometimes provided in the secondary chamber if the mixture does not support combustion. Air for this type of incinerator is provided by a forced draft fan and is controlled by dampers in order to provide the proper distribution. Controlled-air incinerators are efficient units with low particulate emission rates.

1.5.2.6 FLUIDIZED BED INCINERATORS. Fluidized bed incinerators consist of a refractory lined vertical cylinder with a grid in the lower part that supports a bed of granular material, such as sand or fine gravel. Air is blown into the chamber below the grid causing the bed to fluidize. Waste is fed above the bed and then mixes with the media where it burns. Fluidized bed incinerators are normally self-sustaining and require an auxiliary fuel burner only for startup. Fluidizing air is supplied by a centrifugal blower. Ash leaves the fluidized bed incinerator when it becomes fine enough to be carried out by the flue gas. Fluidized bed incinerators are capable of burning most types of liquid or solid waste.

1.5.3 SLUDGE INCINERATORS. Sludge incinerators handle materials high in water content and low in heat content. Two types of incinerators are normally used for sludge Incineration and are discussed below.

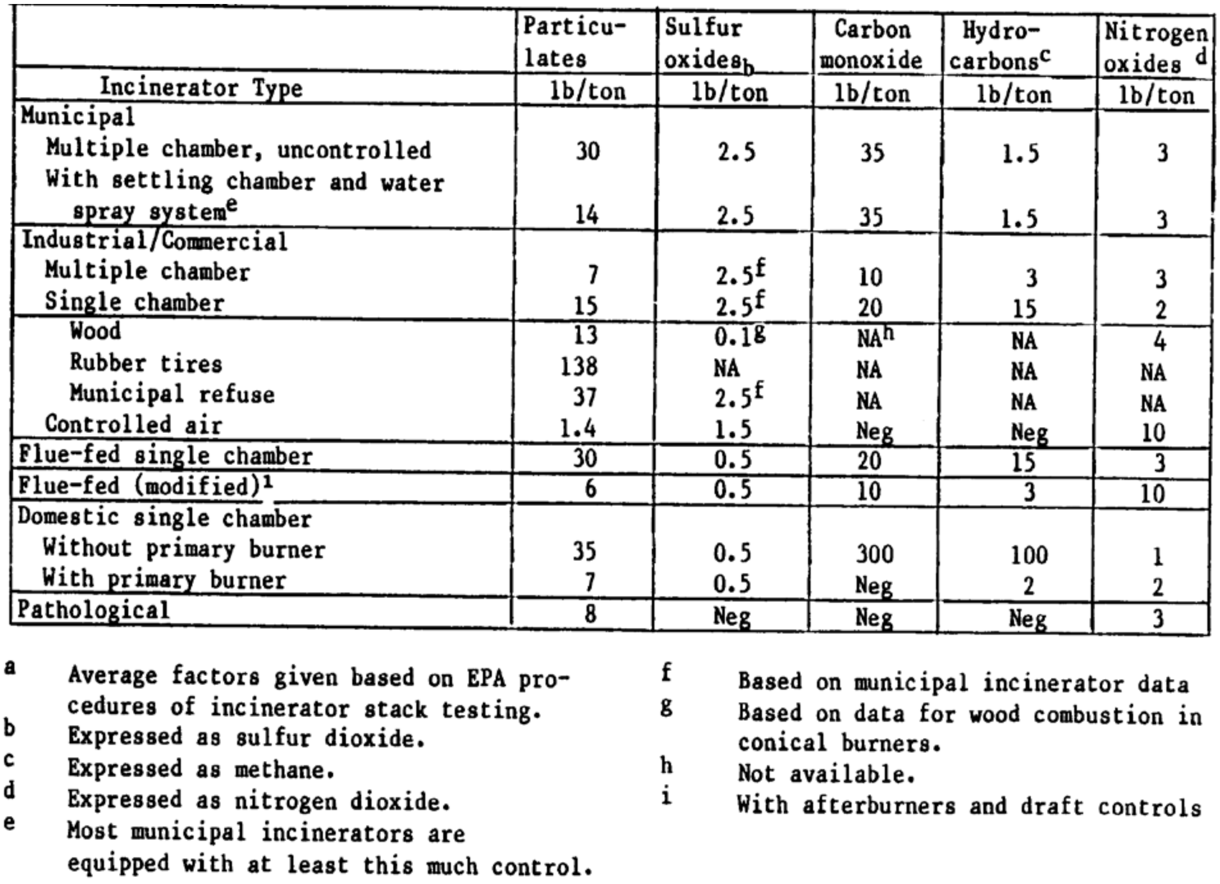
1.5.3.1 MULTIPLE HEARTH INCINERATORS. Multiple hearth incinerators consist of vertically stacked grates. The sludge enters the top where the exiting flue gas is used to drive off the moisture. The burning sludge moves through the furnace to the lower hearths. Ash is removed from under the last hearth.

1.5.3.2 FLUIDIZED BED INCINERATOR. Fluidized bed incinerators are particularly well suited for sludge disposal because of the high heat content of the bed media. Heat from the combustion of the sludge is transferred to the bed media. This heat is then transferred back to the incoming sludge, driving off the moisture.

1.6 PARTICULATE EMISSION STANDARDS. The Clean Air Act requires all states to issue regulations regarding the amount of particulate emission from incinerators. Each state must meet or exceed the primary standards set forth by the federal act, limiting particulate emissions for incinerators with a charging rate of more than 50 tons per day of solid to .08 grains per standard cubic foot (gr/std ft^3) of dry gas at 12 percent carbon dioxide (CO_2). Federal guidelines for sewage sludge incinerators limit emissions to 1.3 pounds (lbs) per ton of dry sludge input and opacity to 20 percent maximum. No federal guidelines currently exist for gaseous emissions. State and local regulations may meet or exceed the federal guidelines. These regulations are subject to change and must be reviewed prior to selecting any air pollution control device.

1.7 PARTICULATE EMISSION ESTIMATING. In order to select a proper pollution control device, the quantities of particulate emissions from an incinerator must be measured or estimated. Measurement is the preferred method. For new incinerator installations where particulate emissions must be estimated, Tables 3 and 4 should be used unless concurrent data guaranteed by a qualified vendor is provided.

1.7.1 FACTORS AFFECTING EMISSION VARIABILITY. The quantity and size of particulate emissions leaving the furnace of an incinerator vary widely, depending upon such factors as incinerator design, refuse type, incinerator capacity, method of feeding, and method of operation. Improved incinerator performance reduces both dust loading and mean particle size.

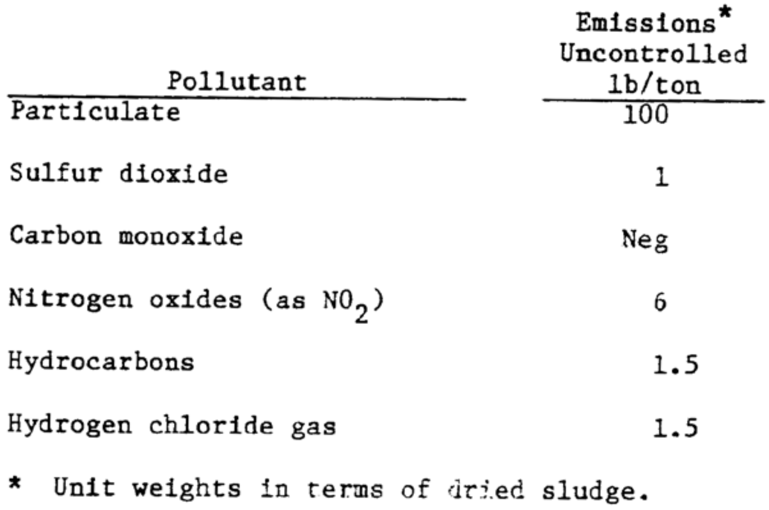


Incinerator Type	Particulates lb/ton	Sulfur oxides[b] lb/ton	Carbon monoxide lb/ton	Hydrocarbons[c] lb/ton	Nitrogen oxides[d] lb/ton
Municipal					
Multiple chamber, uncontrolled	30	2.5	35	1.5	3
With settling chamber and water spray system[e]	14	2.5	35	1.5	3
Industrial/Commercial					
Multiple chamber	7	2.5[f]	10	3	3
Single chamber	15	2.5[f]	20	15	2
Wood	13	0.1[g]	NA[h]	NA	4
Rubber tires	138	NA	NA	NA	NA
Municipal refuse	37	2.5[f]	NA	NA	NA
Controlled air	1.4	1.5	Neg	Neg	10
Flue-fed single chamber	30	0.5	20	15	3
Flue-fed (modified)[i]	6	0.5	10	3	10
Domestic single chamber					
Without primary burner	35	0.5	300	100	1
With primary burner	7	0.5	Neg	2	2
Pathological	8	Neg	Neg	Neg	3

[a] Average factors given based on EPA procedures of incinerator stack testing.
[b] Expressed as sulfur dioxide.
[c] Expressed as methane.
[d] Expressed as nitrogen dioxide.
[e] Most municipal incinerators are equipped with at least this much control.
[f] Based on municipal incinerator data
[g] Based on data for wood combustion in conical burners.
[h] Not available.
[i] With afterburners and draft controls

Table 3

Emission factors for refuse incinerators without controls [a]



Pollutant	Emissions* Uncontrolled lb/ton
Particulate	100
Sulfur dioxide	1
Carbon monoxide	Neg
Nitrogen oxides (as NO_2)	6
Hydrocarbons	1.5
Hydrogen chloride gas	1.5

* Unit weights in terms of dried sludge.

Table 4

Emission factors for sewage sludge incinerators

1.7.1.1 INCINERATOR CAPACITY. Large incinerators burn refuse at higher rates creating more turbulent gas flow conditions at the grate surface. Rapid and turbulent combustion aided by the use of more underfire air causes particle suspension and carry-over from the incinerator grate surface, thereby resulting in higher emission rates for large incinerators.

1.7.1.2 UNDERFIRE AIR FLOW. The effect of increasing underfire grate air flow is to increase particulate emission rate.

1.7.1.3 EXCESS AIR Excess air is used to control combustion efficiency and furnace temperatures. Incinerators are operated at levels of excess air from 50 percent to 400 percent. However, particulate emission levels increase with the amount of excess air employed. Increases in excess air create high combustion gas velocities and particle carry-over. Excess air is important as a furnace temperature control because incomplete combustion will occur at furnace temperatures below 1400 degrees Fahrenheit, and ash slagging at the grate surface and increased NOx emissions will occur above furnace temperatures of 1900 degrees Fahrenheit.

1.7.2 DATA REDUCTION. The state regulations for particulate emissions are expressed in a variety of units. The following techniques permit the user to reduce particulate test data to grains per dry standard cubic foot at 12 percent CO, as well as to convert other particulate concentration units, as used by some states, to this basis.

1.7.2.1 TEST CONVERSION to grains per dry standard cubic foot at 12% CO_2 is performed using Equation 1 as follows:

$$C_S \text{ at } 12\%\ CO_2 = 0.68/CO_2 \times [(t_m + 460)/p] \times C \qquad \text{(Eq. 1)}$$

Where C_s at 12% CO_2 particulate concentration in grains per dry standard cubic foot at gas conditions corrected to 12% CO_2 and standard temperature of 68 degrees F.

C = particulate concentration at test conditions in grains per dry cubic foot of gas
T_m = gas temperature at the test equipment condition
CO_2 = percent by volume of the CO_2 in the dry gas
P = barometric pressure in inches of mercury at the test equipment conditions.

1.7.2.2. TO CONVERT particulate loadings given as pounds per 1000 pounds of dry gas at 50% excess air, Equation 2 applies:

$$C_s \text{ at } 12\%\ CO_2 = [C \text{ at } 50\%\ EA/CO_2] \times 0.325 \times [A_T/A_A] \times M \qquad \text{(Eq. 2)}$$

Where:

C at 50% EA = pounds of particulate per 100 pounds of gas at 50% excess air (EA)

A_T/A_A = theoretical air required per actual air used

M = molecular weight of the gas sample

$A_T/A_A = [N_2 - 3.788 (O_2 - 0.5 CO)]/N_2$ (Eq. 3)

$M = 0.16 CO_2 + 0.04 O_2 + 28$ (Eq. 4)

Where:

N_2 = percent N_2 from Orsat analysis
O_2 = percent O_2 from Orsat analysis
CO = percent CO from Orsat analysis
CO_2 = percent CO_2 from Orsat analysis

1.7.2.3 TO CONVERT grains per dry standard cubic foot at 50% excess air to grains per dry standard cubic foot at 12% CO_2, Equation 5 applies:

C_s at 12% CO_2 = [(18 x C_s at 50% EA)/ CO_2] x A_T/A_A (Eq. 5)

1.7.2.4 TO CONVERT pounds of particulate per ton of refuse charged to grains per dry standard cubic foot at 12% CO_2, Equation 6 applies:

C_s at 12% CO_2 = [lbs of par./tons of refuse] x [(0.42 x 10^6)/GCV] x [1/F_c] (Eq. 6)

Where:

GCV = gross calorific value of waste, Btu/lb
F_c = carbon F factor, std ft^3/million (MM) Btu

$F_c = [0.321 \times 10^6 \times \text{percent carbon}]/GCV$ (Eq. 7)

Percent carbon is by weight from the ultimate analysis of the refuse. The GCV and tons of refuse must be consistent with the ultimate analysis. If the ultimate analysis is on a dry basis, the GCV and tons of refuse must be on a dry basis.

1.7.2.5 TO CONVERT grains per dry standard cubic foot at 7% O_2 to grains per dry standard cubic foot at 12% CO_2, Equation 8 applies:

C_s at 12% CO_2 = 1.714 x C_s at 7% O_2 x O_2/ CO_2 (Eq. 8)

2. STACK EMISSION REGULATIONS AND THE PERMITTING PROCESS

2.1 STACK EMISSIONS. The discharge of pollutants from the smokestacks of incinerators is regulated by both federal and state agencies. A permit to construct or modify an emission source will almost certainly be required.

a. The emissions must comply with point source regulations, dependent upon characteristics of the point source, and also with ambient air quality limitations which are affected by physical characteristics of the location and the meteorology of the area of the new source.

b. The permitting procedure requires that estimates be made of the effect of the stack emissions on the ambient air quality. Predictive mathematical models are used for arriving at these estimates.

c. Due to the time requirements and the complexity of the process and the highly specialized nature of many of the tasks involved, it is advisable to engage consultants who are practiced in the permitting procedures and requirements. This should be done at a very early stage of planning for the project.

2.2 AIR QUALITY STANDARDS.

a. Federal Standards — Environmental Protection Agency Regulations on National Primary and Secondary Ambient Air Quality Standards (40 CER 50).

b. State standards. Federal installations are also subject to State standards.

2.3 PERMIT ACQUISITION PROCESS.

2.3.1 NEW SOURCE REVIEW. The state agency with jurisdiction over pollution source construction permits should be contacted at the very beginning of the project planning process because a New Source Review (NSR) application will probably have to be filed in addition to any other State requirements. A New Source Review is the process of evaluating an application for a "Permit to Construct" from the Air Quality Regulatory Agency having jurisdiction.

2.3.2 PLANNING. Consideration of air quality issues very early in the planning process is important because engineering, siting, and financial decisions will be affected by a New Source Review. Engineering and construction schedules should include the New Source Review process which can take from 6 to 42 months to complete and which may require the equivalent of one year of monitoring ambient air quality before the review process can proceed.

2.3.3 EMISSION LEVELS. One must file for a New Source Review application if, after use of air pollution control equipment, the new boiler or incinerator will result in increased emissions of any pollutant greater than a specified limit. Proposed modifications of existing boilers and incinerators that will cause increases in pollutant emissions greater than certain threshold levels ("de minimis" emission rate) require a New Source Review.

2.3.4 GENERAL DETERMINANTS FOR STEPS REQUIRED FOR PERMITTING. Steps required for a New Source Review depend on the location of the new source, characteristics of the other sources in the area, discussions with the State Air Pollution Control Agencies, possibly the EPA, and how well one is current with the changes in regulations and administrative practices. Because of the constantly changing picture, it is usually very beneficial to engage an air quality consultant to aid in the planning permitting activities.

2.3.5 TECHNICAL TASKS. The principal technical tasks that are required for the permitting effort in most cases may be summarized as follows:

(1) Engineering studies of expected emission rates and the control technology that must be used.

(2) Mathematical modeling to determine the expected impact of the changed emission source.

(3) Collection of air quality monitoring data required to establish actual air quality concentrations and to aid in the analysis of air quality related values. All technical tasks are open to public questioning and critique before the permitting process is completed.

2.3.6 NEW SOURCE REVIEW PROGRAM STEPS. The steps required in a New Source Review vary. However, it is always required that a separate analysis be conducted for each pollutant regulated under the Act. Different pollutants could involve different paths for obtaining a permit, and may even involve different state and federal agencies.

2.3.6.1 ATTAINMENT OR NONATTAINMENT AREAS. A concern which must be addressed at the beginning of a New Source Review is whether the location is in a "nonattainment" or “attainment” area. An area where the National Ambient Air Quality Standards (NAAQS) are not met is a "nonattainment" area for any particular pollutant exceeding the standards. An area where the National Ambient Air Quality Standards (NAAQS) are being met is designated as an "attainment" area. Designation of the area as "attaining", or "nonattaining", for each pollutant encountered determines which of the two routes is followed to procure a permit. Note that the area can be attaining for one pollutant and nonattaining for another pollutant. If this occurs one must use different routes for each of the pollutants and would have to undertake both "prevention of significant deterioration" (PSD) and "nonattainment" (NA) analyses simultaneously.

2.3.6.2 ATTAINMENT AREA. If the proposed source is in an "attainment" area, there is a specified allowed maximum increase, or "increment", of higher air pollutant concentrations. The upper limit of this increment may be well below the prevailing

National Ambient Air Quality Standard (NAAQS). The increment" concept is intended to "prevent significant deterioration" of ambient air quality. The new source might be allowed to consume some part of the “increment‘‘ as determined by regulatory agency negotiations.

2.3.6.3 NONATTAINMENT AREA. If the proposed new source is in a "nonattainment" area, it may have to be more than off-set by decreases of emissions from existing sources, resulting in air cleaner after addition of the new source than before it was added. In the absence of pollutant reductions at an existing source which is within administrative control, it may be necessary to negotiate for, and probably pay for, emission reductions at other sources.

2.3.6.4 SUMMARY OF PERMITTING PATH. The steps listed below present a summary of the permitting steps:

(a) Formulate a plan for obtaining a construction permit. It is usually advisable to engage a consultant familiar with the permitting procedures to aid in obtaining the permit.

(b) Contact state regulatory agencies.

(c) Determine if the modification could qualify for exemption from the New Source Review process.

(d) Determine if the proposed facility will be considered a "major source" or "major modification" as defined by the regulations.

(e) Determine if, and how, with appropriate controls, emissions can be held to less than "de minimis" emission rates for the pollutant so the New Source Review procedures might be avoided.

(f) Consider the questions related to prevention of significant deterioration and nonattainment. If it is found that the facility will be a major source, determine for which areas and pollutants you will have to follow PSD rules. Determine possible "off-sets" if any will be required.

(g) List the tasks and steps required for a permit and estimate the costs and time increments involved in the review process. Coordinate the New Source Review schedule with the facility planning schedule and determine how the New Source Review will affect construction plans, siting, budgetary impact, schedules and the engineering for controls technology.

2.4 MATHEMATICAL MODELING.

2.4.1 MODELING REQUIREMENT. Air quality modeling is necessary to comply with rules for proposed sources in both attaining and nonattaining areas. Modeling is a mathematical technique for predicting pollutant concentrations in ambient air at ground level for the specific site under varying conditions.

2.4.2 MODELING IN ATTAINMENT AREAS. Modeling is used, under PSD rules, to show that emissions from the source will not cause ambient concentrations to exceed either the allowable increments or the NAAQS for the pollutant under study. It may be necessary to model the proposed new source along with others nearby to demonstrate compliance for the one being considered.

2.4.3 MODELING IN NONATTAINMENT AREAS*.* Modeling is used to determine the changes in ambient air concentrations due to the proposed new source emissions and any off-setting decreases which can be arranged through emissions reduction of existing sources. The modeling then verifies the net improvement in air quality which results from subtracting the proposed off-sets from the new source emissions.

2.4.4 MONITORING. Modeling is also used to determine the need for monitoring and, when necessary, to select monitoring sites.

2.4.5 GUIDELINE MODELS. EPA's guideline on air quality recommends several standard models for use in regulatory applications. Selection requires evaluation of the physical characteristics of the source and surrounding area and choice of a model that will best simulate these characteristics mathematically. Selection of the proper model is essential because one that greatly over-predicts may lead to unnecessary control measures. Conversely, one that under-predicts ambient pollution concentration requires expensive retrofit control measures. Because of the subtleties involved, it is usually advisable to consult an expert to help select and apply the model.

2.5 MONITORING. For a New Source Review, monitoring may be required to obtain data which shows actual baseline air quality concentrations. If monitoring is required, prepare a monitoring plan that includes monitor siting, measurement system specifications, and quality assurance program design. Once the plan is ready, it should be reviewed with the relevant agencies.

2.6 PRESENTATION AND HEARINGS. After a New Source Review application is prepared, it must be reviewed with the appropriate agency. Often a public hearing will be necessary and the application will have to be supported with testimony. At the hearing, all phases of work will be subject to public scrutiny and critique.

2.7 FACTORS AFFECTING STACK DESIGN.

a. Design of the stack has a significant effect on the resulting pollutant concentrations in nearby ambient air. Stack emission dispersion analysis is used to determine increases in local air pollution concentrations for specific emission sources. Factors which bear upon the design of stacks include the following:

- Existing ambient pollutant concentrations in the area where the stack will be located
- Meteorological characteristics for the area
- Topography of the surrounding area

b. Specific regulations having to do with stack design have been promulgated by the EPA to assure that the control of air pollutant shall not be impacted by stack height that exceeds "good engineering practice" or by any other dispersion technique. These regulations have a direct bearing on the specific location and height of a stack designed for a new pollution source.

3. MEASURING TECHNIQUES

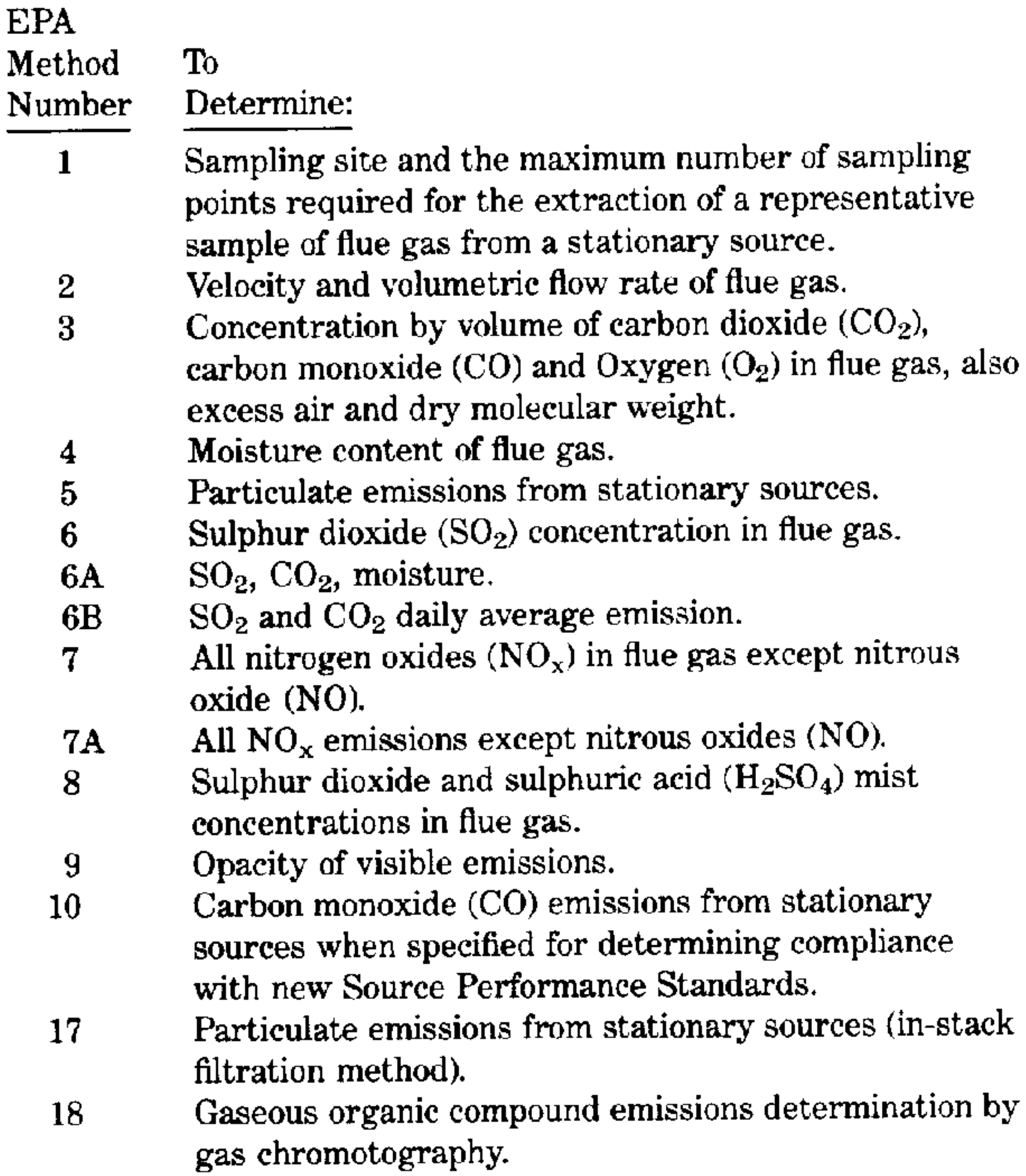
3.1 CRITERIA. In order to evaluate the nature and magnitude of air pollution, establish remedial measures and determine control programs. It is necessary to test for the existence of pollutants. In the upgrading of existing installations, compliance is determined through "point source emission rate tests." Revisions to the regulations regarding air pollution test requirements for federal installations appear in the Federal Register.

3.2 STACK AND SOURCE MEASUREMENT TECHNIQUES. The point source emission rate test methods and requirements are covered under Environmental Protection Agency Regulations on Standards of Performance for the New Stationary Sources, 40 CFR 60 and subsequent revisions. The techniques are listed in Table 5.

3.3 METEOROLOGICAL AND AMBIENT AIR MEASUREMENT.

3.3.1 MEASUREMENTS. Air quality measurements are used to trace emission sources and determine if these sources comply with federal, state, and local air quality standards. For the determination of possible violations of air quality, the continuous monitoring of pollutant concentrations is normally required for a one-year period. Air quality measurements are a function of the sampling site, the local meteorology, the methods used, and the existing pollutant concentration in the atmosphere. Personnel knowledgeable and experienced in meteorology and air quality testing are needed to conduct and evaluate air-quality measurements.

3.3.2 SAMPLING TECHNIQUE. The criteria for instrumentation, calibration, and use of EPA-approved sampling techniques are covered under 40 CFR 53 Environmental Protection Agency Regulations on Ambient Air Monitoring Reference and Equivalent Methods. See Table 6.



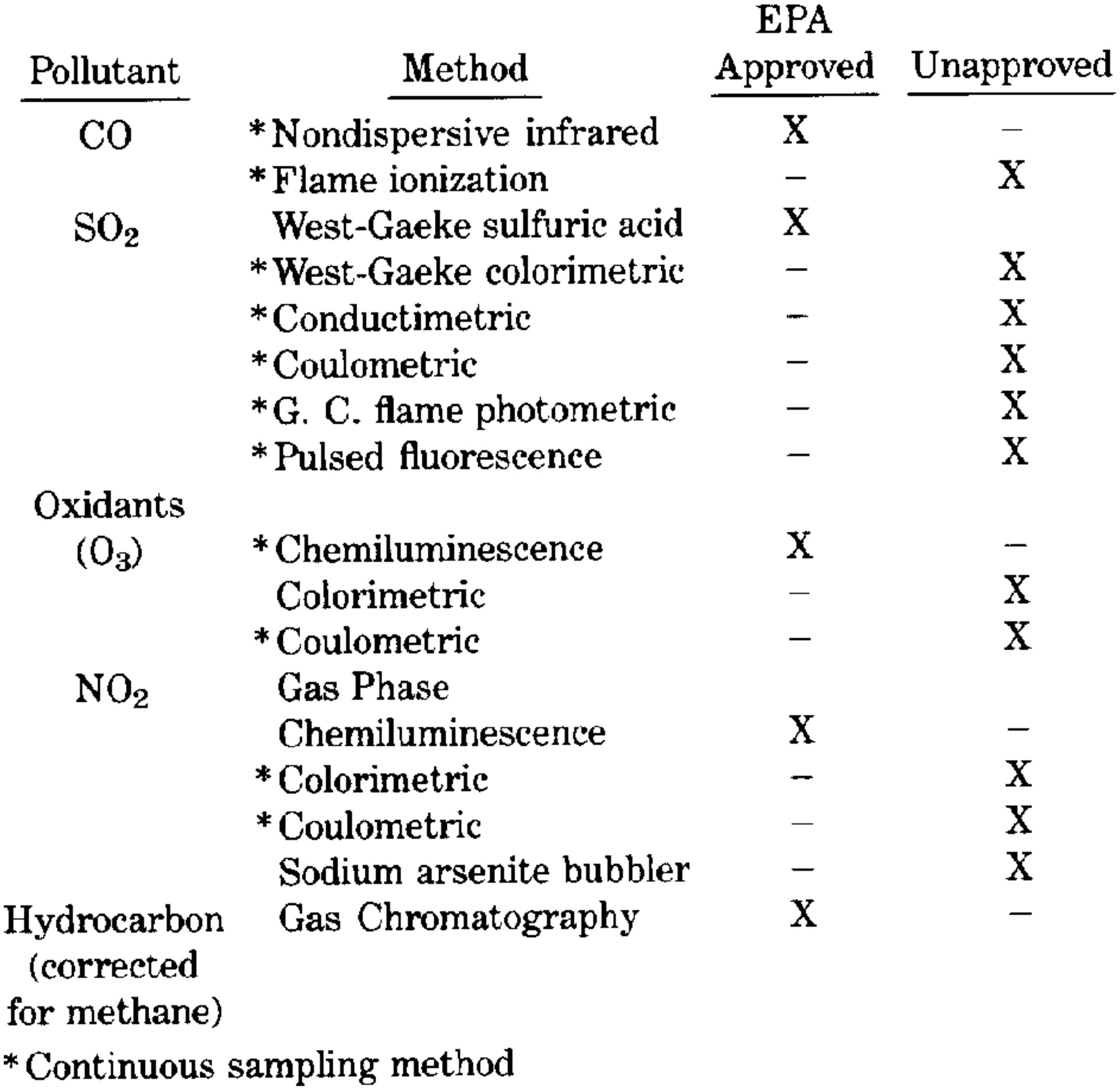
EPA Method Number	To Determine:
1	Sampling site and the maximum number of sampling points required for the extraction of a representative sample of flue gas from a stationary source.
2	Velocity and volumetric flow rate of flue gas.
3	Concentration by volume of carbon dioxide (CO_2), carbon monoxide (CO) and Oxygen (O_2) in flue gas, also excess air and dry molecular weight.
4	Moisture content of flue gas.
5	Particulate emissions from stationary sources.
6	Sulphur dioxide (SO_2) concentration in flue gas.
6A	SO_2, CO_2, moisture.
6B	SO_2 and CO_2 daily average emission.
7	All nitrogen oxides (NO_x) in flue gas except nitrous oxide (NO).
7A	All NO_x emissions except nitrous oxides (NO).
8	Sulphur dioxide and sulphuric acid (H_2SO_4) mist concentrations in flue gas.
9	Opacity of visible emissions.
10	Carbon monoxide (CO) emissions from stationary sources when specified for determining compliance with new Source Performance Standards.
17	Particulate emissions from stationary sources (in-stack filtration method).
18	Gaseous organic compound emissions determination by gas chromotography.

Table 5

EPA emissions sampling techniques

(1) Continuous sampling is the recommended technique for obtaining the most reliable information concerning the variation of pollutant concentration in the real atmosphere. Discrete sampling can be used for plume tracking and random checking. However,

discrete sampling should be used with caution when measuring any of several pollutants that have daily variations. (For example, ozone has very low concentrations at night.) In addition, use of discrete sampling methods will often result in economically unacceptable manpower requirements. In these cases, sampling with continuous instruments and recording on data charts provide a lower cost solution.



Pollutant	Method	EPA Approved	Unapproved
CO	*Nondispersive infrared	X	–
	*Flame ionization	–	X
SO_2	West-Gaeke sulfuric acid	X	
	*West-Gaeke colorimetric	–	X
	*Conductimetric	–	X
	*Coulometric	–	X
	*G. C. flame photometric	–	X
	*Pulsed fluorescence	–	X
Oxidants (O_3)	*Chemiluminescence	X	–
	Colorimetric	–	X
	*Coulometric	–	X
NO_2	Gas Phase Chemiluminescence	X	–
	*Colorimetric	–	X
	*Coulometric	–	X
	Sodium arsenite bubbler	–	X
Hydrocarbon (corrected for methane)	Gas Chromatography	X	–

*Continuous sampling method

Table 6

Air quality sampling method summary

(2) Air quality regulations require the measurement of extremely small pollutant concentrations (1/100 of a part per million by volume). Sensitive instruments capable of detecting small concentrations are needed.

3.3.3 SAMPLING METHOD FOR CARBON MONOXIDE. The federal reference method for measuring carbon monoxide is the instrumental nondispersive infrared technique. A typical instrument consists of a reference cell filled with CO free air, and a sample or detector cell. The difference in transmittance of infrared radiation passing through the sample cell and the reference cell is sensed by a photon detector. The difference is a measure of the optical absorption of the CO in the sample cell and is proportional to the CO concentration in the sample. The signal from the detector is amplified and used to drive an output meter as a direct measure of CO concentration. This method is precise and accurate.

3.3.4 SAMPLING METHOD FOR SULFUR DIOXIDE. The West-Gaeke sulfuric acid method is the Federal reference method for measuring sulfur oxides. The West-Gaeke method is a discrete bubbler technique which involves bubbling ambient air through an impinger for 24 hours. Sulfuric acid is added to the absorber to eliminate interferences from oxides of nitrogen. SO_2 is collected in a tetrachloromercurate solution. When acid bleach pararosaniline is added to the collected SO_2 together with formaldehyde, a red violet compound is formed which is then measured spectrophotometrically. This method is a discrete instrumental sampling method but may be modified for continuous use.

3.3.5 SAMPLING METHOD FOR OXIDANTS AND OZONE. The instrumental-chemiluminescence method is the federal reference method for measuring ozone. Upon mixing ambient air and ethylene in the testing instrument, ozone reacts with the ethylene to emit light. This light is measured by a photomultiplier. If the air and ethylene flow rates are constant, and the proportion of air and ethylene therefore known, the resulting signal can be related to ozone concentration. Analyzers are calibrated with a known ozone concentration.

3.3.6 SAMPLING METHOD FOR NITROGEN DIOXIDE. The federal reference method for NO_2 is the indirect measurement of the concentration of nitrogen dioxide by photometrically measuring the light intensity of wavelengths greater than 600 nanometers resulting from the gas phase chemiluminescent reaction of nitric oxide (NO) with ozone (O_3).

3.3.7 SAMPLING METHOD FOR TOTAL HYDROCARBONS. Gas chromatography flame ionization is the federal reference method of measuring total hydrocarbons.

3.3.8 SAMPLING METHOD FOR PARTICULATES.

3.3.8.1 TOTAL SUSPENDED PARTICULATES*.* The high volume air sample is the federal reference method for measuring total suspended particulates. Air is drawn (at 40 to 60 ft^3/min) through a glass fiber filter by means of a blower, and suspended particles having an aerodynamic diameter between 100 and 1.0 micron are collected. The suspended particulate is calculated by dividing the net weight of the particulate by the total air volume samples and is reported in ug/m^3**.**

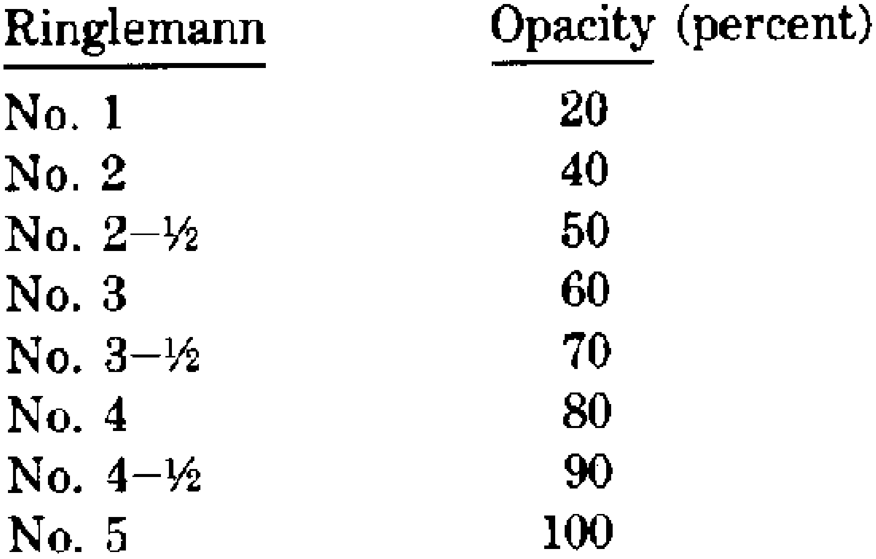
3.3.8.2 COEFFICIENT OF HAZE (C OH). A few states have standards for a particulate measurement called the coefficient of haze. This measurement is reported in units of COH/1000 linear feet of sampled air. In this method, air is drawn through a small spot on a circle of filter paper until the equivalent of a 1000 feet long column of air of the diameter of the spot has passed through the filter paper. Transmittance through this spot then serves as a measurement of particulate material collected on the filter. There are considerable doubts as to the usefulness and true meaning of COH data, since the transmittance recorded is a function of the nature of the particulate as well as the total weight sampled.

3.3.8.3 DUSTFALL (SETTLEABLE PARTICULATES). Several states have standards for the amount of particulate that settles out of the air over a given length of time (one common unit is grams/square meter/30 days). The method of collection is generally the dust bucket. A dust bucket is a 15-inch deep metal or plate container with a 6-inch opening that is exposed to the air generally for a period of one month. Dust buckets should be partially filled with distilled water (or antifreeze) which prevents the transporting of dust out of the buckets by strong winds. This water also acts as a wash at analysis time. After evaporating the water, the remaining material is weighed and the residues are converted to the required units.

3.3.9 TRACEABLE COMPOUNDS. Test methods for compounds other than those for which standards exist are often useful in evaluating stack dispersion. If unusual fuel additives are used, or if incinerators are used to dispose of specialized materials, laboratory chemists can often devise sampling methods to measure these compounds in the atmosphere.

3.3.10 RINGELMANN STANDARDS*.* Particulate matter such as soot, fly ash, and droplets of unburned combustibles present in exhaust gases tend to impart blackness or opacity to a plume. It is assumed that the darker the shade of gray or black, the greater the concentration of particulate matter present in a plume. The Ringelmann Chart offers a set of standards with which to measure the opacity of an effluent plume. By the comparison of the blackness of a plume to the blackness of a series of graduated light diffusers, a Ringelmann number corresponding to a percent opacity can be assigned to the plume (see Table 7). It should be noted that while Ringelmann numbers give a relative indication of plume opacity, they bear no direct relationship to the plume particulate loading. They should supplement but not replace point-source emission tests.

3.4 FLUE GAS SAMPLING PORTS. Sampling ports are approximately 4 inches in diameter, extend out approximately 4 inches from the stack, and have a removable cover. On double wall stacks, sampling ports may consist of a 4-inch diameter pipe extending from 4 inches outside the stack to the inner edge of the inner stack wall. Accessible sampling ports shall be provided and located so that the cross sectional area of the stack or flue can be traversed to sample the flue gas in accordance with the applicable current federal or state regulations for fuel burning equipment.



Ringlemann	Opacity (percent)
No. 1	20
No. 2	40
No. 2–½	50
No. 3	60
No. 3–½	70
No. 4	80
No. 4–½	90
No. 5	100

Table 7

Ringlemann standards