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A Review of Standards of Performance for New Stationary Sources - Incinerators

by

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ABSTRACT

This report reviews the current Standards of Performance for New Stationary Sources: Subpart E - Incinerators. It includes a summary of the current standards, the status of applicable control technology, and the ability of incinerators to meet the current standards. Compliance test results are analyzed and recommendations are made for possible modifications to the standard. Information used in this report is based upon data available as of November 1978.

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1.0 EXECUTIVE SUMMARY

The objective of this report is to review the particulate matter New Source Performance Standard (NSPS) of 0.18 grams/dscm (0.08 grains/dscf) at 12 percent CO_2 from the incineration of municipal solid waste (Subpart E, 40 CFR 60). This review is given in terms of developments in technology and new issues that have developed since the original standard was promulgated in 1971. Possible revisions to the standard are analyzed in the light of compliance test data available since promulgation of the standard. The following paragraphs summarize the results and conclusions of the analysis, as well as recommendations for future action.

1.1 Best Demonstrated Control Technology

Particulate matter is present in the flue gas from incineration of municipal refuse. In modern multichamber incinerators, uncontrolled particulate matter is generated at a rate of 5 to 35 kilograms/metric ton (kg/Mg) or 10 to 70 lb/ton of refuse. The electrostatic precipitator (ESP) is the best demonstrated control technology for particulate emissions from municipal solid waste incinerators. This emission system has become the system of choice for the majority of plants that have become subject to the NSPS or to local regulations as stringent or more stringent than the NSPS.

The use of venturi scrubbers for particulate matter control, has not been as successful in meeting the NSPS and, because of experience with corrosion and increasing energy costs, its use will likely decrease. Only one incinerator operating with a venturi scrubber is meeting the NSPS, and this unit has a new control device operating with a relatively high pressure drop (35 to 40 inches water gauge).

Theoretically, baghouses have the highest removal efficiency potential of any of the devices used to date. However, only one incinerator in the U.S. has operated with a baghouse. The facility met with mixed success due to corrosion problems associated with the bags and baghouse as well as apparent periods of high emissions. An experimental pilot unit was operated successfully. Further experience is required before baghouses can be considered the best adequately demonstrated technology.

1.2 Current Particulate Matter Levels Achievable With Best Demonstrated Control Technology

Test results since 1971 for nine facilities indicate that ESP controlled incinerators have complied with the current standard. In fact, two facilities in Massachusetts and Maryland successfully met emissions standards of 0.11 grams/dscm (0.05 grains/dscf) at 12 percent CO_2 and 0.07 grams/dscm (0.03 grains/dscf) at 12 percent CO_2, respectively. All of the ESP test results were below 0.11 grams/dscm (0.05 grains/dscf) at 12 percent CO_2. Given these results, it is recommended that EPA consider revising the NSPS to a more stringent level with consideration given to a standard of 0.11 grams/dscm (0.05 grains/dscf) at 12 percent CO_2. In developing a revised standard, data should be obtained to assess the need for a specific limitation on lead and cadmium emissions.

1.3 Other Issues

1.3.1 Opacity Standard

Only three states do not have municipal solid waste incineration opacity standards of 20 percent (Ringelmann No. 1). Illinois and Indiana have opacity standards of 30 and 40 percent, respectively, and Delaware has no standard. However, it is unknown how strictly these standards are enforced or whether affected sources are consistently able to comply. The rationale for not including an opacity standard in the NSPS was the poor correlation found between opacity and particulate concentrations from several tested facilities. Based on the utility of opacity standards as an enforcement tool, it is recommended that EPA consider revising the NSPS to include an opacity standard set at a level consistent with the particulate standard.

1.3.2 Resource Recovery

A new development since 1971 is the increase in energy and resource recovery from municipal waste. As a result, solid waste is now being processed to a fuel-like substance and burned either in on-site boilers or as a substitute or addition to traditional fuels in off-site boilers or other processing units. Clarification is required as to whether preprocessed refuse is waste or fuel and what standard, if any, applies. For instance, a facility designed to burn processed refuse derived fuel for power generation would not be subject to the current Subpart D for new sources, since that standard only applies to facilities having the capability to burn greater than 250 x 10^6 Btu/hour of fossil fuel. A revised Subpart D standard has been proposed by EPA. It is unclear at this time how the final revision will affect refuse firing.

1.3.3 Coincineration with Sewage Sludge

Various possibilities exist for incinerating municipal solid waste and sewage sludge. There is currently no explicit statement in either Subpart E or Subpart O (Standards of Performance for Sewage Treatment Plants) that covers the appropriate standard to be used for incinerators jointly burning both types of waste. It is suggested that consideration be given to revising both Subparts E and O to cover this situation.

2.0 INTRODUCTION

In Section 111 of the Clean Air Act, "Standards of Performance for New Stationary Sources," a provision is set forth which requires that "The administrator shall, at least every four years, review and, if appropriate, revise sugh standards following the procedure required by this subsection for promulgation of such standards...." Pursuant to this requirement, the MITRE Corporation, under EPA Contract No. 68-02-2526, is to review 10 of the promulgated NSPS including the standards of emission control from incinerator furnaces burning at least 50 percent municipal solid waste (refuse) with a capacity of at least 45 Mg/day (50 tons/day).

This report reviews the current incinerator standard for particulate matter and assesses the need for revision on the basis of developments that have occurred or are expected in the near future. The following issues are addressed:

1. Definition of the present standard
2. Status of the incinerator industry and applicable control technology
3. Particulate test results over the past several years

Based on the information contained in this report, conclusions are presented and recommendations are made with respect to changes in the NSPS and unresolved issues.

3.0 CURRENT STANDARDS FOR INCINERATORS

3.1 Background Information

Prior to the promulgation of the NSPS in 1971, most municipal solid waste incinerators utilized some form of mechanical settling chamber (wet or dry) to prevent larger fly ash particles from entering the atmosphere. Uncontrolled emissions were on the order of 2.25 grams/dscm (1.0 grains/dscf) at 12 percent CO_2 and increasingly stringent local and Federal regulations required more control. The most common controls included wet spray chambers or wetted baffle walls that were capable of removing the larger particles in the fly ash. This constituted about 20 to 30 percent of the total particulate matter by weight. The mechanical cyclone collector was used extensively to increase collection efficiencies to values as high as 80 percent in order to meet regulations calling for 0.45 to 0.90 grams/dscm (0.2 to 0.4 grains/dscf) at 12 percent CO_2 (Hopper, 1977).

The estimated national particulate emissions from municipal incineration in 1975 were between 60,000 and 100,000 tons or between 0.4 and 0.6 percent of all particulate emissions (EPA, 1978). Between 1971 and 1976, the total national solid waste disposal capacity of incinerators had decreased by 40 percent with a likely proportional decrease in emissions (Hopper, 1977). The effect of the NSPS standard on overall emissions has been minimal due to the limited number of new installations since 1971.

3.2 Facilities Affected

The NSPS regulates incinerators burning at least 50 percent municipal type solid waste (refuse) that were under construction or in the process of modification as of 17 August 1971. Each incinerator furnace is the affected facility. The NSPS does not apply to incinerator furnaces with a design capacity of less than 45 Mg/day (50 tons/day) or to facilities designed to incinerate less than 50 percent municipal solid waste.

An existing incinerator is subject to the promulgated NSPS if: (1) a physical or operational change in an existing facility causes an increase in the emission rate to the atmosphere of any pollutant to which the standard applies, or (2) if in the course of reconstruction of the facility, the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable new facility that meets the NSPS.

3.3 Controlled Pollutant and Emissions Level

The pollutant to be controlled at incinerator facilities by the NSPS is defined by 40 CFR 60, Subpart E as follows:

> On and after the date...no owner or operator subject to the provisions of this part shall cause to be discharged into the atmosphere from any affected facility any gases which contain particulate matter in excess of 0.18 grams/dscm (0.08 grains/dscf) corrected to 12 percent CO_2.

The value for the standard was derived from tests at two domestic incinerators where ESPs were in use. Particulate emissions ranged from 0.16 to 0.20 grams/dscm (0.07 to 0.09 grains/dscf) corrected to 12 percent CO_2. In addition, two European incinerators with ESP controls were tested by EPA personnel. Data from these tests indicated emissions levels of 0.11 to 0.16 grams/dscm (0.05 to 0.07 grains/dscf) at 12 percent CO_2. Limited data available at the time indicated that both baghouses and high energy (venturi) scrubbers could also meet a 0.18 grams/dscm (0.08 grains/dscf) standard (EPA, 1971).

3.4 Testing and Monitoring Requirements

3.4.1 Testing Requirements

Performance tests to verify compliance with the particulate standard for incinerators must be conducted within 60 days after achieving full capacity operation, but not later than 180 days after the initial startup of the facility (40 CFR 60.8). The EPA reference methods to be used in connection with incinerator testing include:

1. Method 5 for concentration of particulate matter and associated moisture content
2. Method 1 for sample and velocity traverses
3. Method 2 for velocity and volumetric flow rate
4. Method 3 for gas analysis and calculation of excess air.

For Method 5, each performance test consists of three separate runs each at least 60 minutes long with a minimum sample volume of 0.85 dscm (30.0 dscf). The arithmetic mean of the three separate runs is the test result to which compliance with the standard applies

(40 CFR 60.8). If one of the runs is invalidated due to weather or equipment failure, the other two runs would be sufficient (upon approval by EPA) for the determination of the arithmetic mean.

To establish a consistent reference point for comparing emission rates, concentrations are adjusted to 12 percent CO_2 by the equation:

$$C_{12} = \frac{12C}{\%\ CO_2}$$

where:

C_{12} is the concentration of particulate matter corrected to 12 percent CO_2

C is the Method 5 particulate concentration

% CO_2 is the percentage of CO_2 as measured by Method 3.

When a wet scrubber is used, the percent CO_2 is measured at the inlet to the scrubber to avoid errors due to CO_2 absorption. Under this condition it is also necessary to correct the CO_2 inlet measurement for dilution air by adjusting the percent CO_2 by the ratio of inlet to outlet volumetric flow rates or inlet to outlet excess air.

Alternative testing equipment or procedures may be used (upon approval by EPA) when the specified procedures cannot be applied (e.g., stack geometry and limited work space require modification of the location of the pollutant sampling trains).

3.4.2 Monitoring Requirements

The only continuous monitoring required of incinerator operators under the NSPS is the recording of daily charging rates and hours of operation.

3.5 Applicability of NSPS to Coincineration of Municipal Solid Waste with Municipal Sewage Sludge*

The coincineration of municipal solid waste and sewage sludge has been practiced in Europe for several years and on a limited scale in the U.S. Where energy resources are scarce and land disposal is economically or technically unfeasible, the recovery of the heat content of dewatered sludge as an energy source will become more desirable. Due to the institutional commonality of these wastes and advances in the preincineration processing of municipal refuse to a waste fuel, many communities may find joint incineration in energy recovery incinerators an economically attractive alternative to their waste disposal problems (see Section 4.1.2).

Coincineration of municipal solid waste and sewage sludge as described above is not currently explicitly covered in 40 CFR 60. The particulate standard for municipal solid waste described in Subpart E (0.18 grams/dscm or 0.08 grains/dscf at 12 percent CO_2) applies to the incineration of municipal solid waste in furnaces with

*This topic is being studied by The MITRE Corporation in its review of NSPS for sewage sludge incinerators.

a capacity of at least 45 Mg/day (50 tons/day). Subpart O, the particulate standard for sewage sludge incineration (0.65 grams/kg dry sludge input or 1.3 lb/ton dry sludge), applies to any incinerator that burns sewage sludge with the exception of small communities practicing coincineration.*

To clarify the situation when coincineration is involved, the EPA Division of Stationary Source Enforcement determined that when an incinerator with a capacity of at least 45 Mg/day (50 tons/day) burns at least 50 percent municipal solid waste, then the Subpart E applies regardless of the amount of sewage sludge burned. When more than 50 percent sewage sludge and more than 45 Mg/day (50 tons) is incinerated, the standard is based upon Subpart O, or alternatively, a proration between Subparts O and E. Table 3-1 summarizes the current rules that apply to solid waste and sewage sludge incineration (Farmer, 1978).

The alternative of prorating the Subparts E and O is not straightforward, since the two standards are stated in different units. The proration scheme requires a transformation of the municipal incineration standard (Subpart E) from grams per dry standard cubic meters (grains per dry standard cubic feet) at 12 percent CO_2 to grams per kilograms (pounds per dry ton) refuse input, or a transformation of the sewage sludge standard (Subpart O) from grams per

*Special rules apply to communities of less than approximately 9000 persons. See the Federal Register (1977).

TABLE 3-1

APPLICABILITY OF 40 CFR 60 FOR
COINCINERATION WITH SEWAGE SLUDGE

Sewage Sludge (percent)	Municipal Refuse (percent)	Incinerator Charging Rate	Applicable Subpart (40 CFR 60)
51-100	0-49	>50 Tons/Day Total Waste	Subpart O or Proration of O and E
0-50	50-100	>50 Tons/Day Total Waste	Subpart E
0	100	≤50 Tons/Day Municipal Refuse	None
100	0	Any Rate	Subpart O
1-99	1-99	≤50 Tons/Day Total Wastes, >1.1 Dry Tons/Day Sewage Sludge	Subpart O
11-99	1-89	≤50 Tons/Day Total Wastes, ≤1.1 Dry Tons/Day Sewage Sludge	Subpart O
0-10	90-100	≤50 Tons/Day Total Wastes ≤1.1 Dry Tons/Day Sewage Sludge	None

Source: Farmer, 1978.

dry kilograms (pounds per dry ton) input to grams per dry standard cubic meters at 12 percent CO_2. Such transformations are dependent on the percent CO_2 in the flue gas stream, the stochiometric air requirements, excess air, the volume of combustion products to required air, the percent moisture in refuse or sludge, and the heat content of the sludge and solid waste.

As shown in Figure 3-1, the proration scheme, as currently determined, has a discontinuity when a municipal incinerator burns 50 percent solid waste. Nominal equivalent values for sludge and refuse emissions appear on the vertical axis for each standard.

3.6 State Regulations

3.6.1 Particulate Standards

Every state has an explicit standard for particulate emissions resulting from incineration of municipal solid waste (Environmental Reporter, 1978). In addition, most states have explicit standards for new incinerators which tend to be more stringent than those for existing incinerators. A survey of state regulations indicates that 23 states have standards that either reference the Subpart E NSPS or have exact copies of Subpart E written into their regulations. Nine states have standards less stringent than the NSPS and do not reference Subpart E. Three states have more stringent regulations Massachusetts and Illinois, 0.11 grams/dscm (0.05 grains/dscf) and Maryland, 0.07 grams/dscm (0.03 grains/dscf) at 12 percent CO_2.

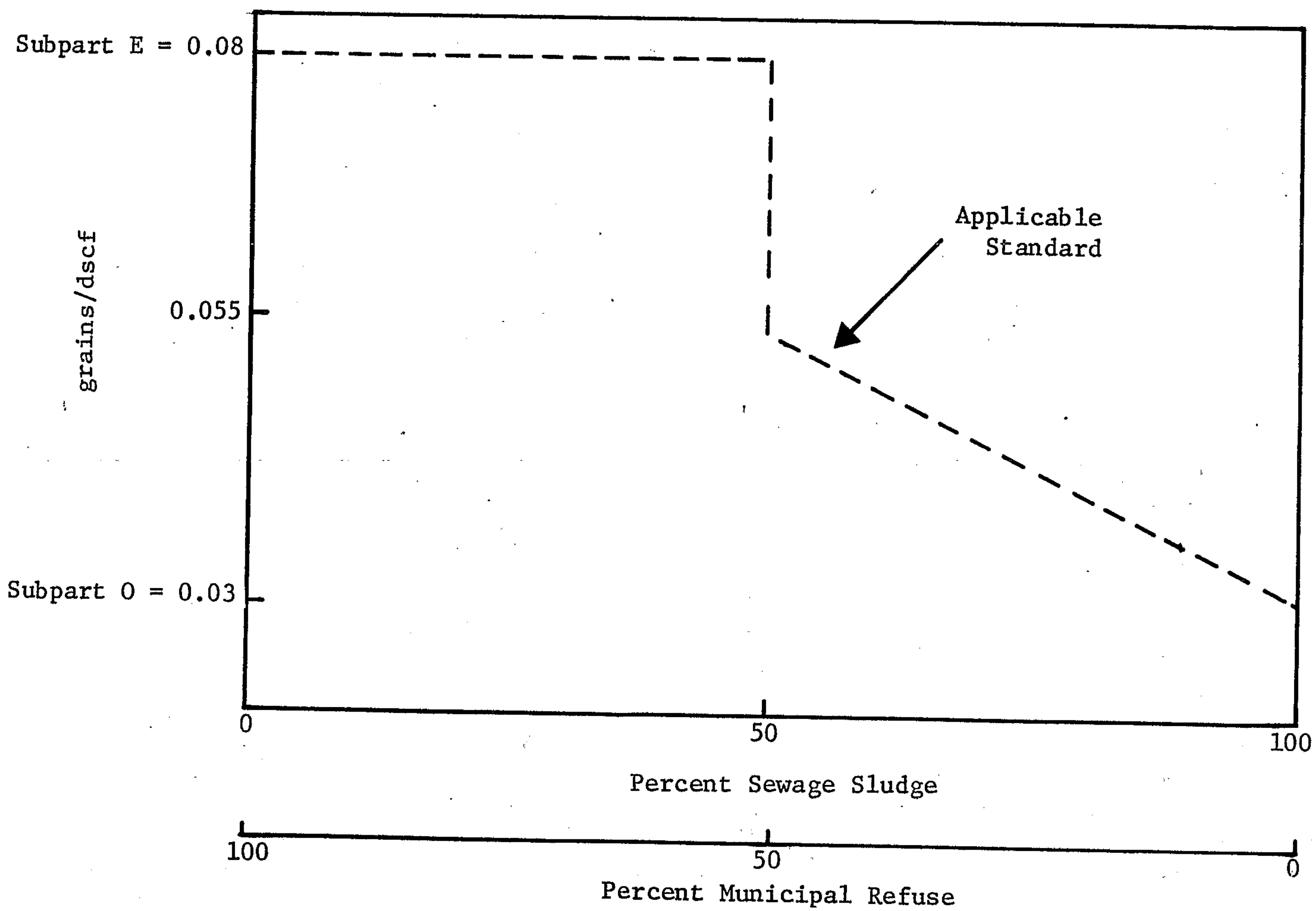


FIGURE 3-1
INTERPRETATION OF COINCINERATION STANDARD WHEN TOTAL WASTE IS GREATER THAN 50 TONS/DAY

New Mexico is the only state to explicitly prohibit incineration. The remaining states have emission standards that are a function of the amount of waste being incinerated. If one assumes a 272-Mg/day (300-ton/day) furnace and 10,350 Joule/Mg (4450 Btu/lb) refuse higher heat value, of the remaining states, 11 would have less stringent standards and Delaware, Nevada and North Carolina would have more stringent standards (Hopper, 1977).

In summary, it appears that the current NSPS is identified by most states as reflecting their most stringent incinerator emission standards. However, the fact that at least six states have more stringent regulations than the NSPS may indicate the possibility of a need for tightening the standard.

3.6.2 Opacity Standards

The current NSPS does not contain a standard for opacity. Testing of incinerators prior to promulgation of the standard in 1971 did not indicate a consistent relationship between emission opacity and concentrations (Trenholm, 1978). Nevertheless, a survey of current state regulations shows that every state has an opacity standard for new incinerators of 20 percent (Ringelmann No. 1) or stricter except Illinois (30 percent), Indiana (40 percent), and Delaware, which has no opacity standard. In fact, Maryland and the District of Columbia have "no visible emissions" standards. (The District of Columbia, however, also has a new source ban on the incineration of municipal waste.) It is unknown how strictly these standards are enforced or whether sources are consistently in compliance.

While data are still limited about the relationship between opacity and particulate emissions from incinerators, it appears that most states find an opacity standard a convenient gross measure of emissions. Based upon the fact that existing opacity standards of 20 percent are currently in force in almost every state, EPA may wish to consider further study of the relationship between opacity and mass emissions, and development of an opacity limit as a possible addition to the current NSPS. An opacity limit would be useful to EPA enforcement personnel in assessing proper operation and maintenance of incinerators and control systems without performing extensive stack testing.

4.0 STATUS OF CONTROL TECHNOLOGY

4.1 Status of Municipal Solid Waste Incinerators Since the Promulgation of the Standard

4.1.1 Geographic Distribution

In 1972 there were 193 incinerator plants* operating in the U.S. (Hopper, 1977). By 1977 the number of plants had been reduced to 103 with 252 furnaces and a total solid waste disposal capacity of about 36,000 Mg/day (40,000 tons/day). Since the standard was originally promulgated, five incinerator units have become operational. Table 4-1 lists the units subject to the NSPS and their design capacity. Table 4-2 presents the new units that are planned or under construction at the current time. Figure 4-1 shows the distribution of incinerators in the U.S. (Hall and Capone, 1978). For the most part, existing units are concentrated in the Northeast and Midwest.

4.1.2 Municipal Incineration Trends

As previously indicated, the number of municipal waste incinerators has been reduced during the past 6 years. Among the possible reasons for this decline are the stricter emission limits that have been placed on emissions from incinerators by Federal, state, and local agencies and the opting by communities for alternative methods of disposal such as sanitary landfills that may be more economical than upgrading incinerator facilities. A second factor that may be affecting use of incineration as a waste disposal

*An incinerator plant may contain more than one NSPS facility, or furnace.

TABLE 4-1

MUNICIPAL SOLID WASTE INCINERATORS
IDENTIFIED AS NEW SOURCES

State	City/Name	No. of Furnaces	Capacity (tons/day)	Particulate Control Method
Massachusetts	East Bridgewater[1]	1	300	FF[3]
Massachusetts	Saugus[1]	2	1200	ESP
Tennessee	Nashville Thermal	2	720	ESP
Utah	Ogden No. 3	1	150	ESP
Maryland	Pulaski No. 4[2]	2	600	ESP

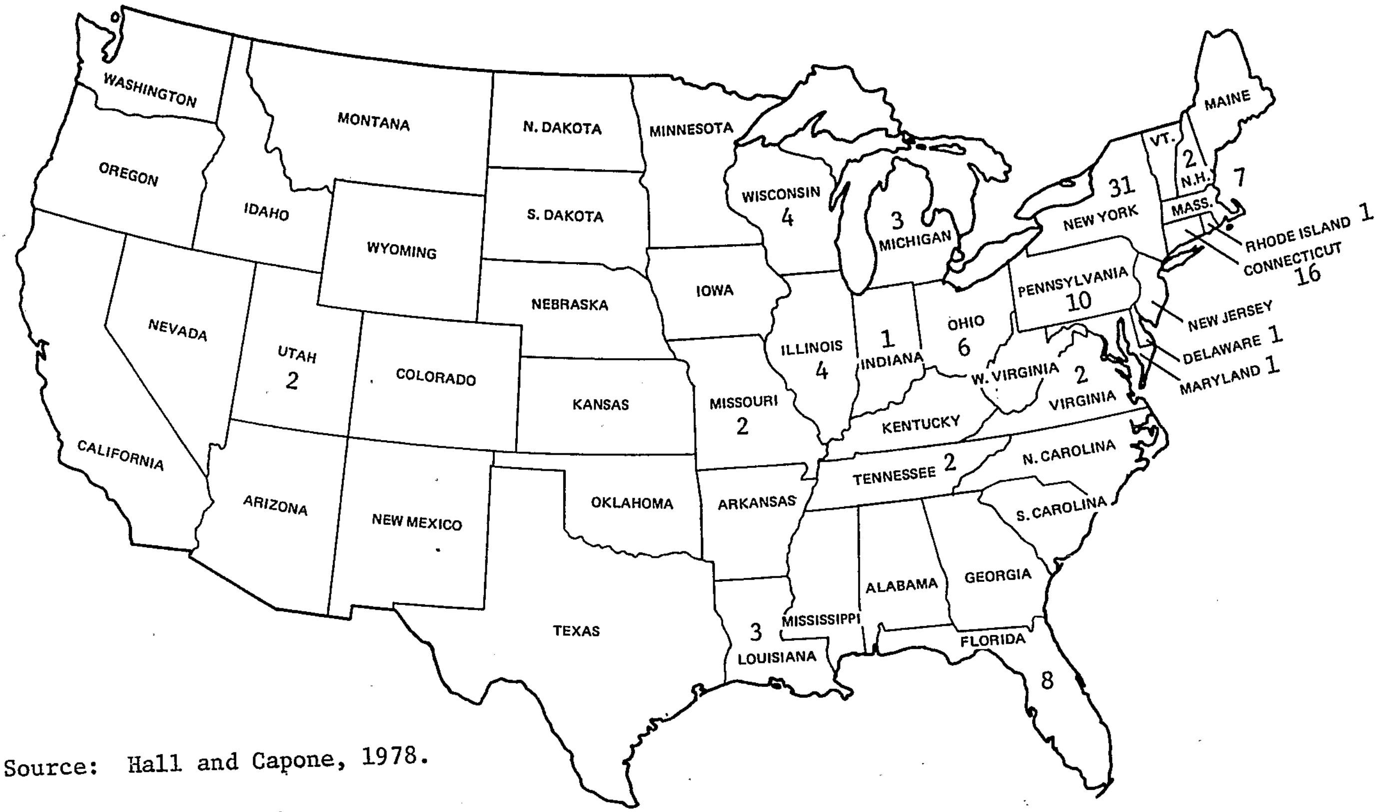
[1] Subject to 0.11 grams/dscm (0.05 grains/dscf) Massachusetts Standard
[2] Subject to 0.07 grams/dscm (0.03 grains/dscf) Maryland Standard
[3] FF: Fabric Filter Baghouse

TABLE 4-2

INCINERATORS PLANNED OR UNDER CONSTRUCTION

Region	City
I	West Warwick, R.I.
II	Albany, N.Y. Glen Cove, N.Y. Hempstead, N.Y. Niagara Falls, N.Y.
III	Wilmington, Del. Hampton Roads, Va. Huntington, W. Va.
IV	Dade County, Fla. Pinellas County, Fla. Kenton County, Ky.
V	Detroit, Mich. Niles, Mich. Owosso, Mich. Duluth, Minn. Akron, Ohio
X	Tacoma, Wash.

Source: EPA Regional Compliance Data Systems and St. Clair, 1978.



Source: Hall and Capone, 1978.

FIGURE 4-1
LOCATION OF MUNICIPAL INCINERATORS IN U.S.

process is the relatively new concept of resource recovery including the recycling of material and the use of the energy content of solid waste as a processed fuel source. A recent survey indicates that there are at least 28 resource recovery systems in operation, under construction, or in the final contract stage (St. Clair, 1978). Total capacity of these operations will be about 27,000 Mg/day (30,000 tons/day), or about three-fourths of the current installed incinerator capacity.

For the most part, these systems are characterized by substantial processing of solid waste into usable recycled material and a homogenous fuel. The homogenous fuel may be in the form of a slurry or a type of "fluff" material that can be transported to other sites for eventual combustion. It is important to note that the phenomena of processing solid waste prior to combustion is a growing trend that has implications in the definition of incineration. For example, when processed refuse derived fuel (RDF) is used in an industrial or utility boiler, are the emission standards for Subpart E in effect or are other standards to be used? If the boiler is located at the new solid waste processing center, is it a boiler or an incinerator? In Duluth there are plans to use RDF to provide fuel for incinerating sewage sludge in a fluidized bed reactor. The solid waste input before processing will be 360 Mg/day (400 tons/day), while the sludge to be incinerated will total about 90 Mg/day (100 tons/day) of dry solids. If the entire facility were considered, Subpart E would apply since more than 50 percent of the waste processed is municipal waste. If only the fluidized bed incinerator is considered, then a proration scheme between Subparts E and O might be necessary (see Section 3.5), since the RDF is solid waste derived and more than 45 Mg/day (50 tons/day) is being incinerated. If the RDF is considered a fuel, then Subpart O alone would apply.

The above areas of ambiguity in definition require clarification. If RDF is considered to be a fuel, then installations burning RDF will not likely be considered incinerators. It is suggested that the incinerator definition be examined in new facilities where electrical or steam generation for commercial use is an integral part of the resource recovery system. To date these locations have been considered incinerators (e.g., Saugas, Massachusetts and Hempstead, New York). Due to improved design and the homogeneity of the fuel and removal of recoverable material, the emission characteristics of these new facilities may be considerably different than those from the traditional refractory wall incinerator with no preprocessing of the solid waste.

4.2 Municipal Incineration Processes*

Solid waste incineration, when carried out under the proper combination of turbulence, time and temperature, can reduce the charge

*Much of the information in this section was extracted from Hopper, 1977.

to a noncombustible residue consisting only of the glass, metal and masonry materials present in the original charge. Figure 4-2 presents a generic view of an incinerator processing system.

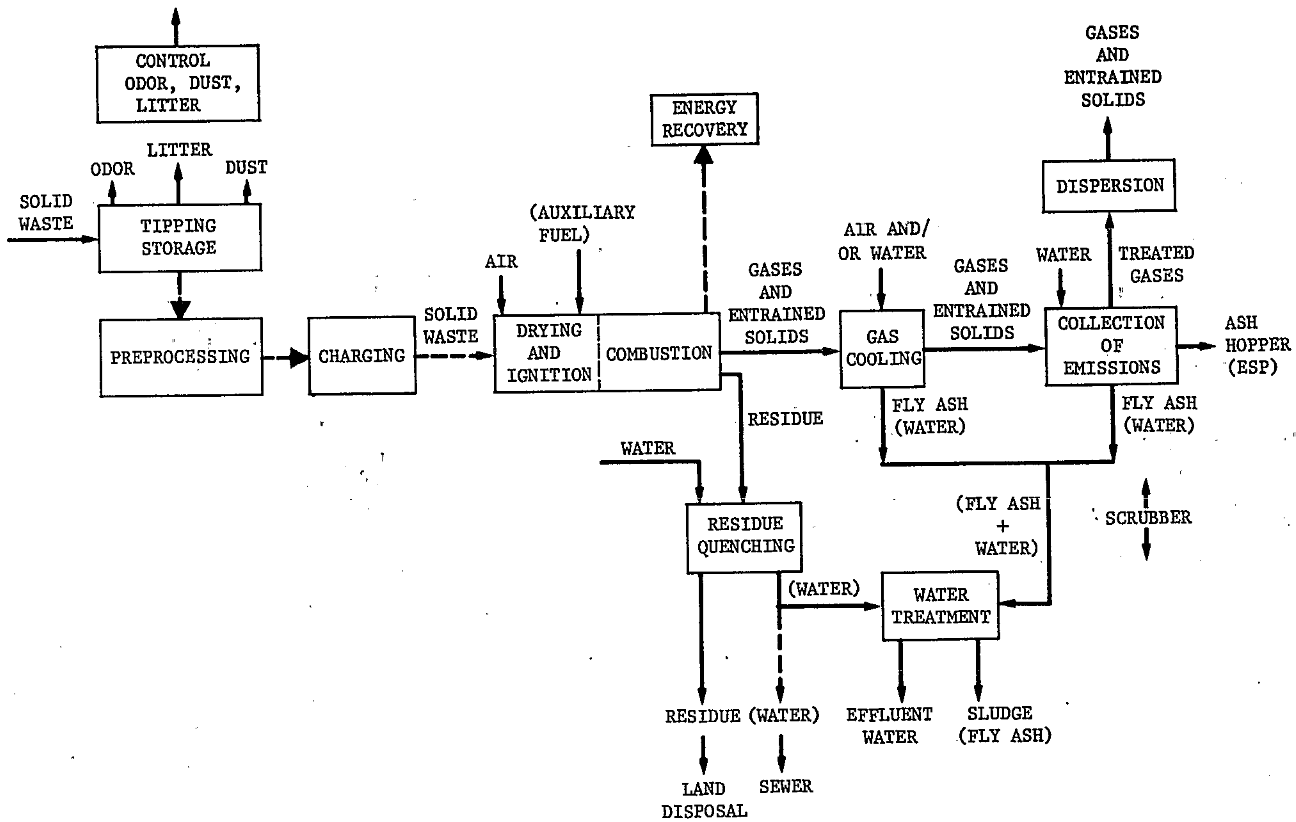
4.2.1 Charging of Solid Waste

Solid waste is charged either continuously or in batches. In the continuous process, solid waste is fed to the furnace directly through a rectangular chute that is kept filled at all times to maintain an air seal. In the batch process, solid waste is fed to the furnace intermittently through a chute, or the furnace may be fed directly by opening the charging gate and dropping the waste directly from a crane bucket, front-end-loader, or bulldozer. A ram can also be used to feed a batch of material directly onto the grate through an opening in the furnace wall. Continuous feed minimizes irregularities in the combustion system. Batch feeding causes fluctuations in the thermal process because of the nonuniform rate of feeding and the intermittent introduction of large quantities of cool air.

4.2.2 Furnaces

The combustion process takes place in the furnace of the incinerator, which includes the grates and combustion chambers. There are numerous designs or configurations of furnaces and grates to accomplish combustion, and presently no one design can be considered the best.

Four types of furnaces are commonly used for the incineration of municipal solid waste: vertical circular, multicell rectangular,



Source: Adapted from J. DeMarco, D.J. Keller, J. Leckman, and J.L. Newton. 1969. "Municipal-Scale Incinerator Design and Operation." U.S. Department of Health, Education, and Welfare, Public Health Service, Bureau of Solid Waste Management, PHS Publication No. 2012 (Reprinted by U.S. Environmental Protection Agency, 1973), p. 47.

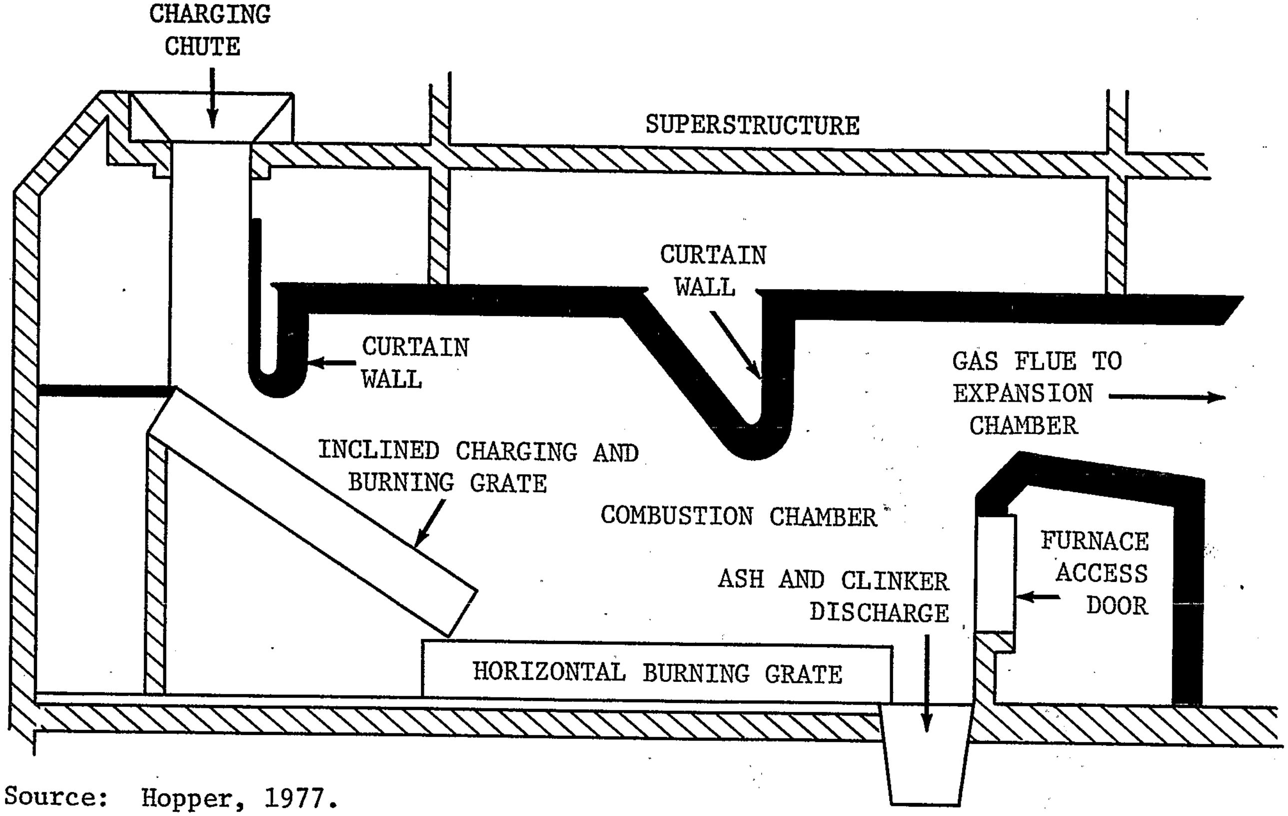
FIGURE 4-2
DIAGRAM OF THE IN-PLANT SYSTEMS WITH FLY-ASH COLLECTION AND CONVEYING FROM COOLING AND COLLECTION OPERATIONS

rectangular, and rotary kiln. Although these furnaces vary in configuration, total space required for each is based on a heat release rate of about 672 MJ/m^3* (18,000 Btu/ft^3) of furnace volume/hour. However, heat release rates can vary from 467 to 934 MJ/m^3 (12,500 to 25,000 Btu/ft^3).

The rectangular furnace is the most common type of recently constructed municipal incinerator (Figure 4-3). Several grate systems are adaptable to this form. Commonly two or more grates are arranged in tiers so that the moving solid waste is agitated as it drops from one level to the next. Each furnace has only one charging chute. Secondary combustion is frequently accomplished in the back end of the furnace which is separated from the front half by a curtain wall. This wall serves to radiate heat energy back towards the charging grate to promote drying and ignition as well as to increase combustion gas velocity and the level of turbulence.

A grate system must transport the solid waste and residue through the furnace and, at the same time, promote combustion by adequate agitation and passage of underfire air. The degree and methods of agitation on the grates are important. The abrupt tumbling encountered when burning solid waste drops from one tier to another promotes combustion. Abrupt tumbling, however, may contribute to entrainment of excessive amounts of particulate matter in the

*MJ/m^3 = 10^6 Joules/cubic meter.



Source: Hopper, 1977.

FIGURE 4-3
RECTANGULAR FURNACE

gas stream. Continuous gentle agitation promotes combustion and limits particulate entrainment. Combustion is largely achieved by air passing through the waste bed from under the grate, but excessive amounts of underfire air contribute to particulate entrainment. Some inert materials such as glass bottles and metal cans aid combustion by increasing the porosity of the fuel bed. Conversely, inert materials inhibit combustion if the materials clog the grate opening.

Mechanical grate systems must withstand high temperatures, thermal shock, abrasion, wedging, clogging and heavy loads. Such severe operating conditions can result in misalignment of moving parts, bearing wear, and warping or cracking of castings.

Grate systems may be classified by function, such as drying, ignition and combustion. Grates for solid waste incineration may also be classified by mechanical type and include traveling, reciprocating, oscillating, and reverse reciprocating grates; multiple rotating drums; rotating cones with arms; and variations or combinations of these types. In the U.S., traveling, reciprocating, rocking, rotary kiln and circular grates are most widely used.

4.2.3 Combustion Parameters

4.2.3.1 Drying and Ignition. Since most municipal solid waste contains substantial quantities of both surface and internal moisture, a drying process is necessary before ignition can occur and the combustion process can proceed. This drying process continues throughout the entire length of the furnace, but proceeds at the greatest rate immediately following charging of the solid waste. Once moisture is removed, the temperature of the substance can be raised to the ignition point.

4.2.3.2 Primary and Secondary Combustion. The incineration combustion process occurs in two overlapping stages, primary combustion and secondary combustion. Primary combustion generally refers to the physicochemical changes occurring in proximity to the fuel bed and consists of drying, volatilization and ignition of the solid waste. Secondary combustion refers to the oxidation of gases and particulate matter released by primary combustion. To promote secondary combustion, a sufficiently high temperature must be maintained, sufficient air must be supplied, and turbulence or mixing should be imparted to the gas stream. This turbulence must be intense and must persist long enough to ensure thorough mixing at the temperatures required for complete combustion.

4.2.3.3 Combustion Air. In the combustion process oxygen is needed to complete the chemical reaction involved in burning. The air necessary to supply the exact quantity of oxygen required for the chemical reactions is termed stoichiometric or theoretical air. Any additional air supplied to the furnace is termed excess air and is expressed as a percentage of the theoretical air.

Air that is purposely supplied to the furnace from beneath the grates is termed underfire air. Overfire air is that air introduced above the fuel bed. Its primary purpose, in addition to supplying oxygen, is to provide turbulence. Infiltration air is the air that enters the gas passages through cracks and openings and is frequently included in the figure for overfire air.

The proportioning of underfire and overfire air depends on incinerator design. Very often the best proportions are determined by trial and error. In general, as the underfire air is decreased, the burning rate is inhibited; but with increasing underfire air, particulate emissions are likely to increase.

To supply adequate air for complete combustion and to promote turbulence, a minimum of 50 percent excess air should be provided. Too much excess air, however, can be detrimental because it lowers furnace temperatures. In general, refractory furnaces require 150 to 200 percent excess air; whereas water wall furnaces require only 50 to 100 percent excess air.

4.2.3.4 Furnace Temperatures. At the air intake, combustion air may be either at ambient temperature or preheated, depending on furnace design. Immediately above the burning waste, the temperature of the gases generally ranges from 1150° to 1370°C (2100° to 2500°F); and for short periods of time, it may reach 1540°C (2800°F) in localized areas. When the gases leave the combustion chamber, the temperature should be between 760° to 980°C (1400° to 1800°F), and the gas temperature entering the stack should be less than 540°C (1000°F). Where induced draft fans, ESPs and other devices requiring lower gas temperatures are used, the gases have to be cooled further to about 260° to 370°C (500° to 700°F).

Regulation of the combustion process through control of furnace and flue gas temperatures is achieved principally through the use of excess air, water evaporation, and heat exchange. Of these, the use of excess air is the most common and, in refractory furnaces, is often the only method of control. Even when another cooling method is available, some excess air is still used but primarily for ensuring turbulence and complete combustion.

Heat exchange through the use of water tube walls and boilers, a well-established European practice, is attracting greater attention in the U.S. A distinct advantage of heat exchangers in cooling gases is that additional gases or vapors are not added to the gas flow to reduce temperature, and a smaller gas volume results. Because gas volume is greatly reduced, the size of collection devices, fans and gas passages can be reduced. Heat recovery and utilization can bring further economies through the sale of steam or the generation of electricity.

4.2.4 Residue Removal

Residue, or all of the solid material remaining after burning, includes ash, clinkers, tin cans, glass, rock, and unburned organic substances. Residue removal can be either a continuous operation or an intermittent batch process. In a continuous feed furnace, the greatest volume of residue comes off the end of the burning grate; and the remainder comes from siftings and fly ash. The residue from the grate must be quenched and removed from the plant.

4.3 Emissions from Municipal Solid Waste Incinerators

4.3.1 Particulate Matter

The uncontrolled particulate emissions from an incinerator plant vary widely and are dependent on the composition of the refuse being incinerated, the design of the preprocessing and charging system, the combustion chamber design, and the operating procedures with respect to air control and burning rates on the grate. Uncontrolled emissions rates cited in the literature range from as low as 5 kg/Mg (10 lb/ton) of refuse to as high as 35 kg/Mg (70 lb/ton) of refuse (Smith, 1974). The EPA handbook of emission factors suggests an uncontrolled emission value of 15 kg/Mg (30 lb/ton) of refuse (EPA, 1977).

Studies indicate that the proper use of overfire and underfire air can have a significant effect in reducing the amount of particulate matter emitted (Hopper, 1977). Too much excess air results in higher velocites that increase carryover of particulates to the stack and lower furnace temperature conditions to below that required for complete combustion. Overfire air, when properly applied, can reduce the carryover of unburned combustible particulate by ensuring complete burnout. Since entrained flyash from the grate increases roughly with the square of the air velocity through the grate, limiting underfire air and, thus, the combustion rate on the grate, can reduce the amount of particulate reaching the stack (and increase the amount leaving as residue from the grate). Thus, the proper control of the underfire and overfire air, as well as grate speed and charging rate, can minimize emissions.

4.3.1.1 Particle Size Distribution. Of critical importance for air pollution control purposes is the particle size distribution entering the stack air pollution control device. Data from three refractory lined incinerators indicated a weight distribution of 23 to 38 percent below 10 microns, and 13 to 23 percent below 2 microns (Smith, 1974). Inlet particulate size data from a waterwall incinerator indicated that 26 to 56 percent were below 10 microns and 14 to 32 percent were below 1 micron (Bozeka, 1976). The fineness of the particle size was further indicated by the fact that 10 to 22 percent of the particulate matter was found to be below 0.3. Data from another continuous feed refractory furnace showed 40 percent of the particulate matter below 2.0 microns (Jacko and Neuendorf, 1977). The differences among the various data may reflect design differences but, it should be pointed out, may also reflect differences in refuse composition and the fact that the waterwall data were taken when the facility was new.

The limited data discussed above indicate that there are substantial quantities of small particles exiting municipal incinerators. This result has led to the general recognition that high efficiency collector systems are necessary to catch the smaller particles so as to minimize overall emissions and, importantly, the respirable particulate emissions.

4.3.1.2 Pre-NSPS Control Techniques. In general, the use of control systems on municipal incinerators has evolved from simply reducing gas velocity in settling chambers to allowing large particles to settle out to the use of sophisticated ESPs that remove up to 99 percent of all particulate matter. Early systems for particulate removal involved the use of wetted baffle walls that provided wetted impingement surfaces and offered low pressure drops to minimize energy losses. Collection efficiencies for the most part were below 50 percent (Hopper, 1977).

Many of the incinerators constructed in the 1955-1965 period utilized mechanical cyclone collectors. Removal efficiencies of these devices ranged from 60 to 80 percent and operated at pressure drops of 2 to 4 inches water guage. Another approach was the use of various scrubber techniques including the submerged entry of gases, the spray wetted-wall cyclone, and the venturi scrubber. For the most part, the cyclone and scrubber techniques, excluding venturi scrubbers, do not have the collection efficiencies required for the current standards, given the nominal particle size distribution described in Section 4.3.1.1.

4.3.1.3 Control Devices for Satisfying the NSPS. Given the suggested EPA uncontrolled emission factor of 15 kg/Mg (30 lb/ton) of refuse and that the NSPS standard of 0.18 grams/dscm (0.08 grains/dscf) at 12 percent CO_2 is roughly equivalent to 0.75 kg/Mg

(1.5 lb/ton) of refuse, the removal efficiency is about 95 percent with a potential range of between 85 and 98 percent. In 1971, when the emission standard was promulgated, the ESP was the only proven technology for this type of efficiency, and that was based primarily on experience on two incinerators in the U.S. and experience with ESPs in Europe. Based mostly on experience with controlling particulate matter in other industries and the expected particle size distribution, venturi scrubbers operating in the range of 15 to 20 inches water guage pressure drop and fabric filter baghouses could also be used to control emissions to the 0.18 grams/dscm (0.08 grains/dscf) at 12 percent CO_2 level (EPA, 1971). The experience with these various devices over the past 7 years is described in Section 5.

4.3.1.4 Incinerator/Device Characteristics. The proper operation of an ESP is dependent on the moisture content, temperature velocity, constituency of the gas stream, and the electrical resistivity properties of the particles. Resistivity is a function of the particle characteristics and the gas stream parameters discussed previously, especially temperature and humidity. Too high a resistivity can cause accumulation on the collector plates and arcing within the collected particle layer, which can reentrain captured particles. Too low a resistivity can cause reentrainment due to loss of charge. It has also been observed that poor combustion in the incinerator will generate large proportions of carbonaceous material in the particulate matter, which causes the particles to rapidly lose charge and be reentrained.

The above characteristics have led to design parameters that call for input exhaust temperatures between 205° to 315°C (400° to 600°F) and, when exhaust is cooled by air dilution or heat exchanger boilers, the addition of proper amounts of moisture. The variability in feed moisture and waste content can affect the overall effectiveness and must be adjusted during operations. The ESPs generally operate with very low pressure drops of 1 to 2 inches water guage.

Venturi scrubbers have met with only limited success with respect to controlling particulate matter at the NSPS level (see Section 5). The removal efficiency of venturi scrubbers is theoretically proportional to the energy input and particle size distribution. The accelerated mixing of gases and scrubbing liquid produce enlarged "wet" particles which are then removed by a cyclonic mist eliminating section. Venturi scrubbers are generally capable of throat variation controls to maintain constant pressure drop over varying air flows or varying pressure drops with constant air flow. Large high pressure induced draft fans are required to maintain exhaust gas flows.

Historically, the principal advantage of the venturi scrubber has been its lower capital investment cost as compared with the ESP, its relative simplicity and its capability to absorb some gaseous emissions. However, with rising energy costs and the need to treat scrubber effluents, the operational disadvantages have caused ESP controls to be used for most incinerator installations (see Section 5).

Baghouse applications for municipal incinerators were considered a feasible control device for meeting the NSPS in 1971, although not demonstrated at the time. Since then, an experimental unit was tested and one incinerator has employed a baghouse with mixed success. The basic premise of baghouse operation is the filtration of particulate matter through impingement, sieving, diffusion, and electrostatic attraction. Draft fans are used to propel the gas through the baghouse to account for a 6 to 10 inch water guage pressure drop. Collected particles are periodically removed from the bags by shaking or other methods and collected in a hopper for disposal.

As with the ESP, baghouse operation is sensitive to temperature and humidity. Too high a gas temperature will burn the bags (e.g., greater than 305°C (550°F) and too low a gas temperature with high moisture content will cause the bags to "blind" or become encrusted with a deposit that cannot easily be removed. Therefore, municipal incinerators with highly variable input refuse heat and moisture content must have a very tight control system to guarantee proper baghouse operation. The additional problem of chemical corrosion and bag disintegration is controllable by special bag coatings or pretreating of the input gas stream with neutralizing chemicals.

4.3.2 Gaseous and Trace Metal Emissions

Gaseous and trace metal emissions are not controlled under the present NSPS. A limited amount of work has been performed in the area of evaluating the magnitude of these emissions from municipal solid waste incinerators. In particular, the emission of hydrochloric acid (HCL) from the increased incineration of polyvinyl chlorides has been studied with mixed results. One recent study at a solid waste incinerator indicated a lower emission level than that generally found in the literature (Jahnke et al., 1977). This study noted that HCL in the gaseous phase is difficult to measure and that higher HCL measurements previously reported may have been due to the inclusion of HCL entrained in moisture droplets as opposed to gaseous HCL.

One study of trace metals was performed at a municipal incinerator downstream of a plate scrubber control device (Jacko and Neuendorf, 1977). This study indicated that respirable particulates accounted for 40 percent of total particulate emissions. Cadmium emissions were on the order of 0.2 percent of all particulate emissions and about 0.4 percent of emissions less than 2 microns. Lead concentrations were about 4 percent of all particulate matter and 11 percent of respirable particulates emitted from the scrubber. Emission factors were $9x10^{-3}$ kg/Mg ($18x10^{-3}$lb/ton) refuse for cadmium and $1.9x10^{-1}$ kg/Mg ($3.8x1010^{-1}$lb/ton) refuse for lead.

There is currently an effort underway within EPA to independently look at the need to regulate cadmium. Separate documents have been prepared which examine emissions, resulting atmospheric concentrations, and population exposure. These documents are part of an overall EPA program to satisfy requirements of the 1977 Clean Air Act to evaluate the need to regulate emissions of cadmium to the air (EPA, 1978a; 1978b; 1978c; 1978d).

5.0 INDICATIONS FROM TEST RESULTS

A survey of the literature and polling of various EPA regional offices was performed to obtain NSPS incinerator compliance test data or data to satisfy local regulations. The number of new incinerators was difficult to determine, since the exact date when construction had begun for new or rebuilt facilities had not been well documented. Since the important factor with respect to the NSPS is technology capability for pollutant removal, data were collected for all sources that have been required to meet standards similar to the NSPS. Of particular value was a study performed by GCA, Inc. for the Division of Stationary Source Enforcement, EPA, which summarized compliance test results as of mid-1978 (Hall and Capone, 1978).

5.1 Analysis of NSPS Test Results

The results of 22 tests of various incinerator facilities are summarized in Tables 5-1 and 5-2. Table 5-1 presents test results reportedly performed according to EPA Reference Method 5 for facilities subject to various regulations as stringent or more stringent than the NSPS. Table 5-2 summarizes 1970 to 1973 ESP test results from facilities for which the test method was not cited and the data not necessarily corrected to 12 percent CO_2 (Bump, 1976).

5.1.1 Electrostatic Precipitator Control Results

Tables 5-1 and 5-2 indicate that ESP control technology is capable of limiting emissions to values below the 0.18 grams/dscm

TABLE 5-1

MUNICIPAL INCINERATOR TEST RESULTS

State	City/Name	Size (tons/day)	Control	Test Results (gr/dscf @ 12% CO_2)		Comments
Mass.	E. Bridgewater	150	F.F.	0.024	1975	Filter bags replaced once, current deterioration problem
Mass.	Saugas	600	ESP	0.049	1976	
Tenn.	Nashville	360	ESP	0.018	1976	Converted from venturi scrubber
Va.	Norfolk (Navy)	280	ESP	0.05	1976	
Utah	Ogden-3	150	ESP	0.045	1974	
D.C.	Washington	200	ESP	0.040/0.06	1973	
Ill.	Chicago NW	400	ESP	0.030/0.050	1971/75	
Md.	Baltimore No 4	300	ESP	0.025	1976	
Penn.	EC Philadelphia	300	ESP	0.047	1977	Converted from low energy scrubber
Penn.	NW Philadelphia	300	ESP	0.048	1976	
Ill.	Calumet	200	VS (15)	0.046/0.049	1974	Deterioration has been visible
Ky.	Louisville	200	VS (15-18)	0.05/0.06 0.11	1976 1977	Prescrubber deteriorated/ retrofit
Wisc.	Sheboygan Falls	30-90	S (7-8)	0.416	1976	
R.I.	Pawtucket	200	VS (35-40)	0.0775	1978	

Source: Watson et al., 1978.

TABLE 5-2

OTHER TEST RESULTS (ESP)

State	City/Name	Size (tons/day)	Test Results	Date
Montreal	Des Carriers	300	0.0133 grains/dscf 0.0799 grains/dscf	1970 1971
New York	So Shore #4	250	0.129 grams/dscm	1971
New York	SW Brooklyn	250	0.03 grains/dscf @ 12% CO_2	1974
Florida	Dade County	300	0.027 grains/dscf	1971
Massachusetts	Braintree	120	0.108 grains/dscf	1971
Pennsylvania	Harrisburg	360	0.09-0.10 grams/dscm	1973
New York	Huntington	200	0.146 grains/acfm	1972
New York	Hamilton Ave	250	0.0346 grains/acfm	1971

Source: Bump, 1976.

(0.08 grains/dscf) at the 12 percent CO_2 level. This technology is capable of very high removal efficiencies above those required for the current NSPS. The Baltimore Pulaski Number 4 incinerator emission control system, for instance, meets the strict Maryland standard for incinerators of 0.07 grams/dscm (0.03 grains/dscf) at 12 percent CO_2. Similarly, the Saugas, Massachusetts facility was designed for the state standard of 0.11 grams/dscm (0.05 grains/dscf) at 12 percent CO_2 and was successfully tested at this level of compliance.

The results of tests to date at facilities with ESPs indicate that the NSPS particulate emission standard could be made more stringent. Based on enforcement experience, several EPA regions made recommendations that a more stringent standard should be considered (Watson et al., 1978). However, limited test data indicate that performance may deteriorate with time due to aging of the combustion facility, aging of the electrostatic precipitator, changes in the refuse mix, or all of these factors (Bump, 1976). For this reason, the newer facilities listed in Table 5-1 should be retested to determine their emission characteristics after several years of operation.

5.1.2 Scrubber Control Results

The use of scrubbers on municipal incinerators has met with mixed results and an overall difficulty in satisfying the 0.18 grams/dscm (0.08 grains/dscf) at the 12 percent CO_2 particulate emission standard. A study to specifically evaluate scrubber performance was completed by GCA, Inc. in mid-1978, and their observations for each scrubber-controlled incinerator listed in Table 5-1 are quoted here (Hall and Capone, 1978).

- Calumet, Illinois

> The Calumet incinerator in Chicago, Illinois is an older system that began operation in 1959. Particulate control equipment originally consisted of settling chambers followed by sprays and impingement baffles. When standards became more strict, a flooded baffle system was installed on furnace No. 1 in 1969. The flooded baffle system, however, failed to meet the standard. In 1971 an Ovitron wet gas scrubber was installed on furnace No. 5. In the period of February 1972 to September 1973 venturi scrubbers manufactured by Combustion Equipment Associates were installed on furnaces Nos. 2, 3, 4 and 6.
>
> Initial investigations indicated that the Calumet incinerator was in compliance but additional evaluations indicate that compliance is doubtful. EPA Region V classifies the test results as inconclusive because of variable results and the test locations. Stack tests were conducted in breachings under very turbulent conditions. New ports are being installed in more suitable locations and additional tests are scheduled for May 1978. The only test results available to GCA are from furnace No. 5. These 1975 test results show an emission rate of 0.2385 gr/dscf or almost five times the standard of 0.05 gr/dscf....

Follow-up conversations with state personnel indicate that the Calumet facility has had opacity problems, and modification to the facility is underway. The 0.046 to 0.049 grains/dscf test result given in Table 5-1 represents initial compliance data tests for the State of Illinois.

- Louisville, Kentucky

> The Louisville, Kentucky incinerators are controlled by venturi scrubbers with 20 to 22 in. W.C. pressure drops. These units also appeared to be in compliance during initial investigations. However, at this time the compliance status is unknown. Tests are conducted by the local agency and formal test reports are not prepared. At GCA's request, a summary of the most recent tests was prepared. During the October 1976 tests on unit No. 2, problems were encountered with the CO_2 measurements (CO_2 results before the scrubber were 2.0, 5.2 and 1.9 percent) contributing to an average particulate emission rate of 0.443 gr/dscf corrected to 12 percent CO_2. If the real CO_2 concentrations were 6 percent, then the average emission rate is 0.22 gr/dscf corrected to 12 percent CO_2. This unit apparently does not comply with 0.08 gr/dscf. New prescrubber(s) are being installed on at least one unit and tests will be conducted in April or May 1978. Earlier test results have been summarized by Environmental Laboratories Inc. September 1975 tests on Louisville No. 2 show an average emission rate of 0.056 gr/dscf. November 1975 tests on unit No. 3 show 0.072 gr/dscf and November 1976 tests on unit No. 4 show 0.066 gr/dscf. These earlier tests indicate compliance....

Discussions with county personnel indicated that a prescrubber located upstream of the venturi scrubber deteriorated quickly after initial startup and is being redesigned. The actual pressure drop in the venturi scrubber has been in the 15- to 18-inch water guage range rather than the 20- to 22-inch design range. Another factor that county personnel noted was a suspected feedback linkage between the gas pressure drop in the scrubber and combustion changes in the furnace.

- Sheboygan Falls, Wisconsin

> The Sheboygan, Wisconsin incinerator is a relatively new facility. It is required to meet a 0.08 gr/dscf state standard. Whether or not it is an NSPS facility depends on its operating schedule. It has been operating only 8 hours per day and incinerating only 30 ton/day of refuse. This unit was designed and built to meet 0.08 gr/dscf. December 1977 test results show an emission rate of 0.15 gr/dscf. The use of a spray chamber with baffles to meet a 0.08 gr/dscf standard seems to be a poor choice of control equipment. The facility has been ordered to close.

This incinerator is presently closed while alternative control techniques are examined. While peripheral to the current discussion, it should be pointed out that the municipality has claimed that this facility was designed with excess capacity and really was only meant to process 27 Mg/day (30 tons/day). Since the NSPS only applies to facilities incinerating at least 47 Mg/day (50 tons/day) the municipality felt that the 0.18 grams/dscm (0.08 grains/dscf) standard should not apply to this facility.

- Pawtucket, Rhode Island

> The Pawtucket incinerator appears to comply with the state particulate emission standard of 0.08 gr/dscf. A venturi scrubber operating at 35 to 40 in W.C. pressure drop is used to achieve compliance. The incinerator consists of two furnaces (one is described below) built in 1965....Environmental Laboratories, Inc. conducted stack tests in 1977. Initial tests in March showed 0.1109, 0.1067 and 0.111 gr/dscf with an average emission rate of 0.1096 gr/dscf, 37 percent above the standard. CE Maguire then made some operating modifications (details are not clear) and the unit was retested in May. Test results were 0.0872, 0.0667, and 0.0780 gr/dscf

with an average of 0.0773 which is 3 percent below the standard. A summary by CE Maguire of the same test results shows 0.0707 gr/dscf.

The use of a scrubber at Pawtucket was based upon easy availability of water facilities, enhanced gas pollutant removal, and low initial capital costs. Another furnace will be equipped with a venturi scrubber designed for 40- to 45-inch water guage pressure drop.

The results discussed in the previous paragraphs indicate that venturi scrubbers for control of municipal waste particulate emissions may involve considerable risk of nonattainment of the current NSPS. The Pawtucket facility venturi scrubber operates at pressure drops higher than original design to barely meet the standard of 0.18 grams/dscm (0.08 grains/dscf) at 12 percent CO_2. One possible factor may be that far more small particles are generated by incineration than originally believed. The amount of particulate matter below 2 microns from tested facilities has been reported to be between 13.5 and 40 percent by weight. The effectiveness of venturi scrubbing is theoretically proportional to the energy or pressure drop, and inversely proportional to particle size. If the standard is made stricter, e.g., 0.11 grams/dscm (0.05 grains/dscf), applications of venturi scrubbers to new incinerators will involve higher capital investment for draft fans and higher operating costs that may make this technology infeasible economically when compared with ESP or baghouse.

5.1.3 Baghouse Results

Since 1971, only the East Bridgewater, Massachusetts facility has been tested with a fabric filter control device. In 1975 that facility tested at 0.054 grams/dscm (0.024 grains/dscf) at 12 percent CO_2, well below the Massachusetts standard of 0.11 grams/dscm (0.05 grains/dscf) at 12 percent CO_2. However, problems of bag and baghouse corrosion and periodic high opacity observations have persisted. A resource recovery system serving the City of Brockton and surrounding towns is currently in the startup mode and may eventually replace the incinerator facility.

A 9000-acfm pilot facility was recently used to evaluate several types of filter bags as control media from a 135,000-lb/hr refuse-fired boiler (Mycock, 1978). Removal efficiencies of greater than 99.8 percent were achieved when operating at air-to-cloth ratios of 6 to 1 or less. For the short testing period, no wear problems were encountered. It should be pointed out that the input particle size distribution was 13 percent less than 2 microns by weight, which is on the low side of the 10 to 40 percent range.

Currently, Framingham, Massachusetts is the only other municipal incinerator facility with a fabric filter control system. The specially coated bags are designed to prevent deterioration and overall design capability is 0.07 grams/dscm (0.03 grains/dscf) at 12 percent CO_2. This facility should be starting up in November 1978.

5.2 Summary of Test Result Implications

The test results to date on existing and new facilities indicate that a standard of 0.11 grams/dscm (0.05 grains/dscf) is technologically feasbile through the use of appropriately designed ESPs. This stringent standard would affect every state except Delaware, Nevada, Massachusetts, Maryland and Illinois where there are standards more stringent than the current 0.08 grains/dscf at 12 percent CO_2 for large incinerators. Such a standard would likely rule out scrubbers as the primary equipment for particulate removal. Due to maintenance problems, fabric filters have not been proven as a viable control system, although they have demonstrated high-efficiency removal on an experimental basis.

6.0 FINDINGS AND RECOMMENDATIONS

The primary objective of this report has been to assess the need for revision of the existing NSPS for municipal solid waste incineration and to describe any new developments that have occurred since the standard was promulgated in 1971. The findings and recommendations developed in these areas are presented below.

6.1 Findings

6.1.1 Incinerator Developments

- Between 1972 and 1977 the number of incinerator facilities has been reduced from 193 to 103 with an accompanying capacity drop of 40 percent to about 36,000 Mg/day (40,000 tons/-day). During that time only five new facilities were identified as being built and operating.

- A new development since 1971 is the increase in energy and resource recovery from municipal waste. As a result, solid waste is now being processed to a fuel-like substance and burned either in on-site boilers or as a substitute or addition to traditional fuels in off-site boilers or other processing units. Installed and under-construction capacity of these units is about 27,000 Mg/day (30,000 tons/day) or about three-fourths of current installed incinerator capacity.

6.1.2 Process Emission Control Technology

- The current best demonstrated control technology, the ESP, has proven performance as well or better than envisioned in 1971 when the standard of 0.18 grams/dscm (0.08 grains/dscf) at 12 percent CO_2 was promulgated.

- Two facilities with ESP control, in Massachusetts and Maryland, successfully met emission standards of 0.11 grams/dscm (0.05 grains/dscf) at 12 percent CO_2 and 0.07 grams/dscm (0.03 grains/dscf) at 12 percent CO_2, respectively. Seven other ESP test results were below 0.11 grams/dscm (0.05 grains/dscf) at 12 percent CO_2.

- The use of venturi scrubbers for particulate matter control, has not been as successful in meeting the NSPS and, because of experience with corrosion and increasing energy costs, use of these scrubbers will likely decrease. Only one incinerator operating with a venturi scrubber is meeting the NSPS, and this unit has a new control device operating with a relatively high pressure drop (35 to 40 inches water guage).

- Theoretically, baghouses have the highest removal efficiency potential of any of the devices used to date. However, only one incinerator in the U.S. has operated with a baghouse. The facility met with mixed success due to corrosion problems associated with the bags and baghouse as well as apparent periods of high emissions. An experimental pilot unit was operated successfully. Further experience is required before baghouses can be considered the best adequately demonstrated technology.

6.1.3 Opacity Standard

- Every state except Illinois, Indiana and Delaware has a municipal solid waste incineration opacity standard of 20 percent (Ringlemann No. 1). Illinois and Indiana have opacity standards of 30 and 40 percent, respectively; and Delaware has no standard. The rationale for not including an opacity standard in the NSPS was the inability to define a correlation between opacity and particulate concentrations from several tested facilities.

6.1.4 Coincineration with Sewage Sludge

- Various possibilities exist for incinerating municipal solid waste and sewage sludge. There is currently no explicit statement in either Subparts E or O that covers the appropriate standard to be used for incinerators jointly burning both types of waste.

6.2 Recommendations

6.2.1 Revision of the Standard

At this time there appears to be sufficient evidence to recommend development of a revised NSPS standard possibly to reflect a more stringent emission level and an opacity standard. In this development, data should be obtained and consideration given to the need for establishing specific limitations on lead and cadmium emissions. The rationale for these changes is based on the following considerations:

- The best demonstrated control technology, the ESP, is being used on most incinerators to meet NSPS and local standards.
- ESPs have been demonstrated to be capable of meeting the Massachusetts and Maryland standards of 0.11 grams/dscm (0.05 grains/dscf) at 12 percent CO_2 and 0.07 grams/dscm (0.03 grains/dscf) at 12 percent CO_2, respectively.
- Opacity standards of 20 percent are currently in force for new incinerators in almost every state. The usefulness of opacity standards is the ability to identify excess emission levels without requiring extensive stack testing to indicate noncompliance.
- Cadmium and lead concentrations are reported to represent 0.4 percent and 11.0 percent, respectively, of the respirable particulate emissions from one scrubber-controlled incinerator.

6.2.2 Definitions

- Clarification is required for defining the applicable NSPS standard when sludge and solid waste are jointly incinerated. A table similar to Table 3-1 would be helpful in defining when 40 CFR 60 Subpart E, Subpart O, or a proration of both is required. It is further suggested that the proration scheme currently employed for joint incineration be avoided, if possible, by explicitly including types of facilities in both Subpart E and Subpart O.
- Solid waste resource recovery systems are becoming increasingly popular and combustible wastes are being processed into a homogeneous type fuel for use in boilers or industrial processes. Whole facilities are being planned and are under construction for the explicit purpose of generating electricity from steam produced by burning processed refuse. These facilities would not be subject to Subpart D which covers electrical generation from fossil fuel. It is recommended that an NSPS be considered to cover this category of refuse disposal.

6.2.3 Research Needs

- Given the relatively poor performance of scrubbers to date and the developing baghouse technology, it is recommended that a research program to investigate the relationships between waste input composition, particle size distributions, and scrubber and baghouse operations be instituted at several facilities to determine more precise design parameters for these control techniques.

- Limited data are available on the metal and gaseous components of emissions. It is recommended that research in this area be continued.

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16. ABSTRACT

This report reviews the current Standards of Performance for New Stationary Sources: Subpart E - Incinerators. It includes a summary of the current standards, the status of applicable control technology, and the ability of incinerators to meet the current standards. Compliance test results are analyzed and recommendations are made for possible modifications to the standard. Information used in this report is based upon data available as of November 1978.

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