EPA Assessment of Technologies for Controlling Emissions from Municipal Waste Combustion

The EPA will soon propose new standards for municipal waste combustion facilities. This article explains background work performed by the agency to arrive at the proposed standards, and indicates emission levels that are estimated to be achievable by various types of facilities.

By James D. Kilgroe and Michael G. Johnston

The U.S. Environmental Protection Agency is developing new emission rules which will apply to new and existing municipal waste combustion facilities (MWCs) under the Clean Air Act. Revised new source performance standards (NSPS) are being developed to control emissions from new sources pursuant to Section 111(b) of the Act. Emission guidelines which are to be used by state authorities to define regulations for control of emissions from existing facilities are being developed under Section 111(d) of the Act. According to EPA's schedule, these will be proposed in November 1989 and promulgated in December 1990. This article examines EPA's technical activities related to this regulatory effort.

James D. Kilgroe is a manager of the Office of Research and Development, Air and Energy Engineering Research Laboratory's Municipal Waste Combustion Program. Michael G. Johnston is an environmental engineer with the Office of Air Quality Planning and Standards, Industrial Studies Branch, which is responsible for the development of technical background information used in the development of air pollution emission control standards.

The EPA's activities include:
—assessments of combustion and flue gas cleaning technologies;
—collection and evaluation of air emission test data;
—development of technical recommendations for good combustion practices;
—development of model plants based on existing and projected MWCs; and
—evaluation of combustion and flue gas cleaning strategies at these model MWCs.

Background

Landfilling is the most common method of municipal solid waste disposal in the U.S. However, since one-third of the nation's landfills will be full by 1991, we will soon need new facilities for the management and disposal of wastes. Despite this mounting problem, efforts to site new MWCs, a technology which can be used to recover energy and reduce the volume and mass of waste which must be landfilled, are met with increasing public opposition. One reason may be the concern about possible health risks from MWC air emissions, primarily trace metals and dioxins.

EPA Decides to Develop New Rules

On July 7, 1987, the EPA published an advance notice of proposed rulemaking in the Federal Register announcing its intention to regulate MWC air emissions under Clean Air Act Section 111.

At the same time, the EPA's Office of Air Quality Planning and Standards issued guidelines (called "operational guidance") to EPA's Regional Offices concerning applications for new incinerator permits. These guidelines recommended that all new incinerators use good combustion practice and the appropriate flue gas cleaning technology to ensure adequate control of air emissions. They defined appropriate flue gas cleaning technology as a dry scrubber in combination with a fabric filter (FF) or electrostatic precipitator (ESP).

Regulatory Procedure

The Office of Air Quality Planning and Standards is responsible for the development of air emission standards for MWCs. The development of standards encompasses a number of activities specified by the Clean Air Act, its amendments, and Agency procedures. Under Section 111 of the

Table 1. Emittants Evaluated for Possible Control.

Trace Organics	Trace Metals	Acid Gasses
Benzo(a)pyrene (BaP)	Arsenic	Hydrogen Chloride
Chlorobenzenes	Beryllium	Hydrogen Flouride
Chlorodibenzodioxins	Cadmium	Sulfur Dioxide
Chlorodibenzofurans	Chromium	
Chlorophenols	Copper	
Formaldehyde	Lead	
Polycyclic Aromatic Hydrocarbons	Mercury	
	Nickel	
Polychlorinated Biphenyls	Selenium	

Act, standards are technology-based rather than risk-based. NSPS for new or modified facilities must reflect the best degree of control available, taking cost, energy, and non-air related environmental impacts into account. Emission guidelines for existing facilities must also take the remaining life of the facility into consideration.

One of the initial steps in setting air emission rules is to select the pollutants to be considered for control. After the pollutants are selected, background information is developed on the emission levels, costs, energy impacts, and non-air environmental impacts for several emission control strategies, known as regulatory alternatives. Each strategy provides a different level of control at a different cost. These regulatory alternatives are considered by EPA, and one option or a combination of options is selected. The EPA announces its selected option as a proposed set of rules and publishes it for public comment. After a period of public comment, the EPA modifies the proposed rules as necessary before they are promulgated.

Controlled Pollutants

MWC facilities emit a mixture of air pollutants. Table 1 lists the pollutants EPA evaluated in preliminary studies for potential control. These pollutants can be grouped into three main categories: trace organics, trace metals, and acid gases.

Pollutants can also be grouped by the methods used to control them. One method to limit emissions of organics is through good combustion practice (GCP). Another is to use flue gas cleaning devices to control pollutants after they leave the combustor. The collection of pollutants in flue gas cleaning devices depends on the differences in the physical, chemical, and electrical properties of pollutants. Many metals condense at stack gas temperatures and are collected as particulate matter (PM). Other metals are adsorbed onto the surfaces of particles, or the flue gas temperature must be low enough for them to condense. In wet scrubbers, pollutants are condensed or chemically react with reagents to form compounds which are removed with the liquid scrubbing medium. In dry scrubbers, acid gases are collected after they react with a sorbent, which converts them to a solid. They are then collected as PM. PM control devices also control organics in varying degrees. Semi-volatile organics are also collected effectively by equipment used to control acid gases. The major control mechanisms include condensation to form particulate, and adsorption or absorption on the surface of PM, followed by PM collection. Volatile organics are difficult to control if they are not destroyed during combustion.

To simplify its study, the EPA designated a number of MWC pollutants for evaluation:

—MWC metals emissions which are measured as PM

—MWC acid gases which include hydrogen chloride (HCl) and sulfur dioxide (SO_2)

—MWC organic emissions which include chlorinated dibenzo-p-dioxins and chlorinated dibenzo-furans (CDD/CDF)

Although nitrogen oxides (NOx) are also a MWC emission of concern, this article does not cover studies relating to NOx control.

MWC Model Plant Studies

When assessing control options, EPA considers reductions in air emissions, costs, economic impacts, energy impacts, and non-air environmental impacts. These factors vary with the size of MWCs, the type of combustor, the pollution control technology, age of the plant, and numerous other factors. Rather than study each existing and projected plant, a model plant study approach was used to provide infor-

Emission Control Terminology "Shorthand"

Discussion of emission control technologies often requires reusing complicated names, making the use of abbreviations convenient. The following abbreviations are used in this article:

CDD/CDF—Chlorinated dibenzo-p-dioxins and chlorinated dibenzo-furans (used by the EPA to represent hazardous organic pollutants).

DSI—Dry sorbent injection, a way of neutralizing acid gases.

ESP—Electrostatic precipitator, used mainly to remove particulate from the flue gas.

FF—Fabric filter baghouse, which traps particulate and other material in a way similar to a vacuum cleaner bag.

GCP—Good combustion practice, the process of ensuring that the equipment burns as efficiently as possible.

gr/dscf—Grains per dry standard cubic foot, a measurement of pollutant concentration.

MWCs—Municipal waste combustors, including but not limited to waste-to-energy plants.

ng/Nm^3—Nanograms per normal cubic meter, another measurement of concentration.

NSPS—New Source Performance Standards, which apply to new facilities ("pollutant sources").

PM—Particulate matter, any solid suspended in the flue gas.

RDF—Refuse-derived fuel, a system that upgrades municipal solid waste into a fuel with lower ash content and higher heating value.

mation needed for development of MWC air pollution emission regulations.

Two sets of model plants were developed—one set for new MWCs, which will be subject to NSPS, and one set for existing MWCs.

1. Information was collected on existing and planned MWCs in the U.S. This information included plant name and location, type of combustor(s), number of combustors, heat recovery provisions, plant size in tons per day, year of start-up, and air pollution control device employed.

2. Projections were made of MWCs to be built during the 5-year period after the NSPS becomes effective. These projections included estimates of the combustor type, number of combustors, heat recovery provisions, plant capacity, and air pollution control devices employed.

3. Model plants were defined for each major type of combustor, and a "retrofit study" was performed for each of several air emission control technologies for each model of existing MWCs. Control technologies evaluated included the use of GCP and flue gas cleaning devices. Flue gas cleaning technologies evaluated included the use of: furnace sorbent injection, duct sorbent injection or spray dryer absorption for acid gas control; and electrostatic precipitators (ESPs) or fabric filters (FFs) for PM control. The costs of implementing these plant modifications were estimated, and the associated air emission performance levels were defined. Similar design, cost, and performance studies were made for selected air pollution control techniques for each type of new plant.

4. Estimates were made of "baseline" levels of emissions that would occur in the absence of new EPA rules for MWCs.

5. A number of regulatory options using the results of the model plant studies were evaluated. These regulatory options included the use of GCP and moderate PM control; GCP and best PM control; GCP, good acid gas control, and best PM control; and GCP, best acid gas control, and best PM control. The evaluations, called regulatory impact assessments, included estimates of emissions, costs, and non-air emission impacts for both the new and existing plants.

Types of Combustors

EPA's 1987 municipal waste combustion study identified four classes of MWC facilities: mass burn incinerators, modular incinerators, refuse-derived fuel (RDF) combustors, and fluidized bed combustors.[1] In subsequent EPA work, these classes have been expanded to additional sub-classes or types of combustors. Types of combustion systems for which model plants were developed include:

—mass burn, refractory, traveling grate
—mass burn, refractory, reciprocating or rocking grate
—mass burn, refractory, rotary kiln
—mass burn, waterwall, reciprocating or rocking or rolling grate
—mass burn, rotary, waterwall
—modular, starved air
—modular, excess air
—refuse-derived fuel, spreader stoker
—(bubbling) fluidized bed
—circulating fluidized bed

The characteristics of the combustion systems and emission control technologies used for the existing and new model plant studies are described in the following sections.

Existing Plants

Approximately 450 individual combustors with combined capacities of 86,000 Mg per day (95,000 tons per day) will be subject to guidelines for existing MWCs. This includes plants that are currently operating and "transitional plants" (plants that were not in operation when the studies were started but which began construction prior to November 1989). A total of 17 model plants were developed to represent the existing and transitional MWC population. These include three mass burn/refractory models, four mass burn/waterwall models, four RDFs, four modular, and two rotary waterwall models.

The existing and transitional models represent each common type of combustor design. Some of the existing designs include GCP, while others do not. It was assumed that all models representing transitional MWCs had GCP, since this is typical of newer units. The models also reflect the size ranges within each design type, the types of air pollution controls at existing and transitional facilities, heat recovery capabilities, and typical operating hours. While these models represent the great majority of existing and transitional combustors, at least four types of combustors are not represented by our models. These types include some batch-fed refractory wall combustors, a pulsating hearth combustor, a refractory wall rotary kiln combustor, and pulverized coal RDF combustors. There are also at least eight facilities with unknown combustor designs.

New Plants

MWCs that begin construction after the NSPS proposal will be considered "new" facilities. Using projections of the growth in combustion of MSW, it is estimated that up to 45,000 Mg/d (50,000 TPD) of new MWC capacity could become subject to the NSPS within 5 years. About 150 new combustors are expected to commence construction within this time period.

To project the distribution of new MWCs to be constructed, the EPA used information on facilities in advanced planning or early construction stages. These facilities were selected because new MWCs are expected to be similar to MWCs that have been recently built or are under construction.

To represent new MWCs, 12 model plants were developed. Models were selected to represent each common MWC design, then typical sizes were chosen within each design. Where there was great size variation within a category (such as mass burn), models were developed for different combustor sizes. Other factors considered included the annual operating hours and heat recovery ability. While most large new MWC plants are expected to operate continuously and produce steam and electricity for sale, some smaller modular and mass burn plants will operate fewer hours or will not produce electricity.

The 12 model plants include three mass burn/waterwall, a mass burn/refractory, a mass burn/rotary combustor, two RDF, a modular excess air, two modular starved air, and two fluidized bed facilities.

Emission Control Technologies

EPA is considering various approaches to controlling emissions from

MWCs. Plant operators can reduce emissions of organics, including chlorinated dibenzo-p-dioxins and chlorinated dibenzo-furans (CDD/CDF), by modifying the combustion process. This is sometimes called combustion control or GCP. Another approach is to add flue gas cleaning equipment. This will control emissions of PM, metals, and acid gases, and obtain additional control of organics. The third approach combines the previous two.

Good combustion practices include the proper design, construction, operation, and maintenance of an MWC. The use of appropriate combustion control techniques can minimize emissions of CDD/CDF by promoting more thorough combustion.

High CDD/CDF emissions are generally associated with poor combustion conditions; low CDD/CDF emissions, with good combustion. MWC design and operating conditions that result in low CDD/CDF emissions are defined as GCP. One major indicator of good combustion is the CO concentration in stack gas. Other combustion conditions necessary to achieve low CDD/CDF emissions are discussed in another paper.[2]

After leaving the furnace, precursors can evolve into additional CDD/CDF in the presence of fly ash at temperatures ranging from approximately 200°C to 400°C (390°F to 750°F). Destruction of precursors and minimizing the amount and residence time of PM in this temperature zone help to limit this secondary formation. Plant operators must keep the inlet temperature to PM control devices below 230°C (450°F) to prevent significant secondary CDD/CDF formation in the PM control device.

The furnace formation of CDD/CDF is related to the design and operating conditions of MWCs. Table 2 summarizes model plant estimates of current "baseline" and achievable emissions of CDD/CDF and CO from the different combustor types now in operation in the U.S. The baseline emissions represent an upper bound for average emissions of all incinerators in a given sub-class. The table provides estimates of emissions which can be achieved through the use of GCP in both existing and new combustors. The emission estimates for existing combustors with GCP represent average performance levels which are believed attainable by combustion retrofits and by operating continuously with good combustion conditions. These emission estimates were derived primarily from short duration compliance tests and parametric tests.

Table 2: Estimates of Model Plant Combustor Emission Performance for CDD/CDF and CO.

(CDD/CDF measurements are in nanograms per dry standard cubic meter. Carbon monoxide measurements are in parts per million by volume.)*

	Existing MWCs Baseline Emission		*Existing MWCs With GCP*		*New MWCs With GCP*	
Combustor type	*CDD/CDF*	*CO*	*CDD/CDF*	*CO*	*CDD/CDF*	*CO*
Mass burn, refractory, traveling grate	4000	500	500	150	NA	NA
Mass burn, refractory, R-grate**	4000	500	500	150	NA	NA
Mass burn, refractory, R-grate**, rotary kiln	4000	500	500	150	300	100
Mass burn, waterwall, R-grate**, large	500	50	500	50	200	50
Mass burn, waterwall, R-grate**, midsize	200	50	200	50	200	50
Mass burn, waterwall, R-grate**, small	2000	400	200	50	200	50
RDF, speader stoker	2000	200	1000	150	1000	100
Modular, starved air	400	100	400	100	300	50
Modular, excess air	200	50	200	50	200	50
Mass burn, rotary combustor, waterwall	2000	100	400	100	300	100

* – flue gas concentration at combustor outlet prior to PM control.

** – reciprocating, rocking, or rolling grate.

Many plants that have begun operation in the past several years employ GCP. In other cases the builders and operators of older plants are working to achieve GCP by improving combustion conditions. The estimates for new units represent performance levels which are believed to be attainable, now or within the next several years.

PM Control

The most frequently used high performance PM control devices in the U.S. are ESPs and FFs. These devices control particulate and fine particulate which may include metals and organics in particulate form. Although other PM control technologies such as cyclones, electrified gravel beds, and venturi scrubbers are used at some MWC plants, they are infrequently applied and are not expected to be widely used at future MWC plants.

Existing plants have PM emissions ranging from 755 mg/dscm (0.33 gr/dscf) to less than 23 mg/dscm (0.01 gr/dscf) at 12 percent CO_2.[3] The 1971 NSPS for MSW incinerators specifies a PM emission limit of 183 mg/dscm (0.08 gr/dscf). MWC plants which must meet standards for new industrial boilers must achieve an emission limit of 114 mg/dscm (0.05 gr/dscf). This level of control (183-114 mg/dscm) [0.08-0.05 gr/dscf] is defined as moderate PM control. Well-designed ESPs and FFs can achieve total PM emission levels of 23 mg/dscm (0.01 gr/dscf) or less. In studies of regulatory alternatives, the best PM control was assumed to range from 34 to 69 mg/dscm (0.015 to 0.03 gr/dscf) depending on specific plant conditions.

Metals of concern emitted from MWC units include arsenic, beryllium, cadmium, chromium, lead, mercury, and nickel. Metals, with the exception of mercury, are normally removed by ESPs or FFs in the form of particulates. Data indicate that well-designed ESPs or FFs operated at 230°C (450°F) or less remove over 97 percent of arsenic, cadmium, and lead, and about 99 percent of beryllium, chromium, and nickel from MWC exhaust gases. Because the metals content of MSW is variable, metals concentrations in the MWC exhaust gases vary from plant to plant. The great variability from plant to plant makes it difficult to specify outlet metals concentration emission limits. However, MWCs can use ESPs or FFs to achieve best PM control. By controlling the flue gas temperature entering the PM control device. MWCs can attain a high removal efficiency of the potentially toxic metals of concern, with the possible exception of mercury.

Mercury has a high vapor pressure and remains as a vapor in flue gas at typical ESP operating temperatures. ESPs appear to provide little mercury control whether used alone or in conjunction with dry acid gas control systems. Initial field tests indicated that moderate to good mercury reduction can be achieved when FFs are used with dry acid gas control systems. However, some conflicting results have since been obtained and further investigations are needed to assess mercury capture in dry acid gas and PM control systems.

Semi-volatile organics, such as CDD/CDF, can be collected by PM control devices if they are adsorbed or condensed on the surface of particulate. However, a number of field tests indicate that CDD/CDF can form in ESPs, granular bed filters, and other PM control devices if they are operated at 200°C to 400°C (390°F to 750°F). Limited data suggest that, under certain conditions, at ESP temperatures below 230°C (450°F), there is a net reduction in CDD/CDF concentrations between the inlet and outlet of PM control devices. Because of the limited data on the effects of PM control device operating temperature on CDD/CDF emissions, it was assumed that the inlet and outlet concentrations of CDD/CDF across PM control devices are equivalent. While FFs will probably not be used without acid gas control, it is believed GCP and PM control with a FF will provide comparable or better performance than GCP with an ESP.

Table 3. Control Scenarios and Corresponding Estimated Emission Levels Associated with 111(d) Regulatory Guideline Alternatives (Existing)

Regulatory Alternative		Control Levels by Plant Capacity: Small Plants (less than 250 tons/day)	Large Plants (more than 250 tons/day)
I.	Control Scenario	GCP + MPM	GCP + BPM
	CDD/CDF, ng/Nm³	500 (1,000)[a]	500 (1,000)
	PM, gr/dscf	0.080	0.030
	HCl,%[b]	NL[c]	NL
	SO_2, %[d]	NL	NL
IIA.	Control Scenario	GCP + MPM	GCP + GAG + BPM
	CDD/CDF, ng/Nm³	500 (1,000)	125 (250)
	PM, gr/dscf	0.080	0.030
	HCl,%	NL	50
	SO_2, %	NL	50
IIB.	Control Scenario	GCP + GAG + BPM	GCP + GAG + BPM
	CDD/CDF, ng/Nm³	125 (250)	125 (250)
	PM, gr/dscf	0.030	0.030
	HCl,%	50	50
	SO_2, %	50	50
III.	Control Scenario	GCP + MPM	GCP + BAG + BPM
	CDD/CDF	50 (1,000)	10
	PM, gr/dscf	0.080	0.015
	HCl,%	NL	95
	SO_2, %	NL	85
IV.	Control Scenario	GCP + GAG + BPM	GCP + BAG + BPM
	CDD/CDF, ng/Nm³	125 (250)	10
	PM, gr/dscf	0.030	0.015
	HCl,%	50	95
	SO_2, %	50	-85

[a] Emission levels in ( ) are for RDF MWCs.

[b] HCl in percent reduction or 25 ppmv whichever provides the higher emission level.

[c] NL no limit.

[d] SO_2 is percent reduction or 30 ppmv whichever is higher.

Good Acid Gas Control

Dry sorbent injection (DSI) is being considered primarily as retrofit technology for use in existing MWC systems which currently use an ESP. MWCs install DSI systems primarily to control acid gas emissions. However, when DSI is combined with flue gas cooling and an ESP, it helps control CDD/CDF, PM, and metal emissions.

There are two main types of DSI systems. Both inject dry alkali sorbents, such as lime or hydrated lime. Duct sorbent injection introduces sorbents into flue gas downstream of the combustor outlet and upstream of the PM control device. Furnace sorbent injection adds sorbent directly into the combustor.

There are limited data on the performance of DSI systems. Existing facilities that have been retrofitted with GCP and then apply DSI/ESP systems are believed capable of CDD/CDF emissions of less than 125 to 250 ng/Nm³ depending on the type of combustor. New plants with DSI/FF systems are believed to be capable of achieving CDD/CDF emissions of less than 75 to 150 ng/Nm³ depending on the type of combustor.

Dry sorbent injection systems have achieved a 50 percent reduction in SO_2 emissions when used with ESPs and FFs. They can also achieve 50 percent HCl emission reduction, when used with ESPs, or 80 percent when used with FFs.

MWCs equipped with DSI followed by ESPs and FFs are believed to be capable of producing PM emissions of less than 23 mg/dscm (0.01 gr/dscf).

Dry sorbent injection/ESP systems achieve 97 percent or greater removal of arsenic, cadmium, and lead, and 99 percent removal of beryllium, chromium, and nickel. DSI/ESP systems do little to control mercury, and no control is assumed for the control strategy studies.

Best Acid Gas Control

Combustor designers initially developed lime spray drying systems followed by FFs to control SO_2, HCl emissions, and PM emissions. However, the systems also control CDD/CDF and metal emissions, including mercury. In the spray drying process, the system injects lime slurry into the spray dryer where it reacts with acid gases. The water in the slurry evaporates, cooling the flue gas, and the acid gases react with the calcium-based reagent during the drying process. The FF removes the fly ash and reaction products. Spray dryer/FF systems represent the best MWC add-on control technology currently used in the U.S.

Spray dryer/FF systems have achieved outlet CDD/CDF concentrations of less than 10 ng/Nm^3. For nominal SO_2 and HCl inlet conditions they can also achieve an 85 percent reduction in SO_2 emissions and a 95 percent reduction in HCl emissions. PM emissions of less than 23 mg/dscm (0.01 gr/dscf) have been achieved by MWCs equipped with SD/FF systems and SD/ESP systems.

Typically, SD/FF systems achieve 99 percent removal of all metals except mercury. Additional studies are needed to determine the levels of mercury control which can be achieved by SD/FF and SD/ESP systems.

Regulatory Alternatives

Cost studies were conducted for each model plant for several pollution control options. Based on these cost studies, a number of regulatory alternatives were formulated to study the national aggregated costs of using different plant emission control options. These regulatory alternatives and corresponding emission levels are summarized in Table 3 for existing plants, and in Table 4 for new plants. The regulatory alternatives in these tables are for two plant size ranges: small plants less than or equal to 225 Mg/d (250 TPD) capacity and large plants greater than 225 Mg/d (250 TPD) capacity. In all but alternative IIB, the control requirements for small plants are less stringent than for large plants. The less stringent requirements for small plants allow partial compensation for higher unit costs of control ($/ton waste burned) which are associated with pollution control technologies on small plants.

Table 4. Control Scenarios and Corresponding Estimated Emission Levels Associated with 111(b) Regulatory Guideline Alternatives (New)

Regulatory Alternative	*Control Levels by Plant Capacity* Small Plants (less than 250 tons/day)	Large Plants (more than 250 tons/day)
I. Control Scenario	GCP + MPM	GCP + BPM
CDD/CDF, ng/Nm^3	300 (1,000)[a]	300 (1,000)
PM, gr/dscf	0.080	0.015
HCl,%[b]	NL[c]	NL
SO_2, %[d]	NL	NL
IIA. Control Scenario	GCP + MPM	GCP + GAG + BPM
CDD/CDF, ng/Nm^3	300 (1,000)	75 (250)
PM, gr/dscf	0.080	0.015
HCl,%	NL	80
SO_2, %	NL	50
IIB. Control Scenario	GCP + GAG + BPM	GCP + GAG + BPM
CDD/CDF	75 (250)	75 (250)
PM, gr/dscf	0.015	0.015
HCl,%	80	80
SO_2, %	50	50
III. Control Scenario	GCP + MPM	GCP + BAG + BPM
CDD/CDF, ng/Nm^3	300 (1,000)	10
PM, gr/dscf	0.080	0.015
HCl,%	NL	95
SO_2, %	NL	85
IV. Control Scenario	GCP + GAG + BPM	GCP + BAG + BPM
CDD/CDF, ng/Nm^3	75 (250 ng/Nm^3)	10
PM, gr/dscf	0.015	0.015
HCl,%	80	95
SO_2, %	50	85

[a] Emission levels in ( ) are for RDF MWCs.

[b] HCl in percent reduction or 25 ppmv whichever is higher.

[c] NL = no limit.

[d] SO_2 is percent reduction or 30 ppmv whichever is higher.

GCP is assumed for all existing and new plants for each regulatory alternative. CO emission levels associated with GCP requirements range from 50 to 150 ppm depending on combustor type (see Table 2). Other control requirements for the various regulatory alternatives include GCP plus moderate PM control (GCP + MPM), GCP plus best PM control (GCP + BPM), GCP plus good acid gas, and best PM control (GCP + GAG + BPM), and GCP plus best acid gas and best PM control (GCP + BAG + BPM). All existing and new plants with GCP + BAG + BPM are assumed to be able to achieve comparable emission limits for all types of combustors. BPM emission limits are assumed to be 69 mg/dscm (0.03 gr/dscf) when ESPs are used and 34 mg/dscm (0.015 gr/dscf) when FFs are used. CDD/CDF emissions for RDF combustors are twice those for other combustors except where GCP + BAG + BPM is used. CDD/CDF emissions for new units are lower than for existing units because of improvement in combustor emissions of CDD/CDF which can be achieved with new combustors.

These, and other MWC regulatory options, are now being reviewed within EPA, and the proposed rules for new and existing sources are to be published later this year. While the specific requirements of the proposed rules have not been finalized, this article has provided information on some of the procedures used in developing the new rules, the technologies which can be employed to control air pollution emissions from MWCs, and the estimated emission levels which can be achieved by application of these technologies. □

James D. Kilgroe can be contacted at the U.S. Environmental Protection Agency; Air and Energy Engineering Research Laboratory; Research Triangle Park, NC 27711; (919) 541-2854. Michael G. Johnston can be contacted at the U.S. Environmental Protection Agency; Office of Air Quality Planning and Standards; Research Triangle Park, NC 27711; (919) 541-5604.

Notes

1 U.S. Environmental Protection Agency, Municipal Waste Combustion Study, Report to Congress, June 1987 [EPA/530-SW-87-021a].

2 Nelson L.P., P. Schindler, J.D. Kilgroe, "Development of Good Combustion Practices to Minimize Air Emissions from Municipal Waste Combustors," Proceedings, International Conference on Municipal Waste Combustion, Hollywood, FL, April 11-14, 1989.

3 PM emission values are corrected to 12 percent CO_2. Dioxin, HCl, and SO_2 emissions are corrected to 7 percent O_2.