MUNICIPAL WASTE COMBUSTOR RETROFITS

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1.0 INTRODUCTION

This paper deals with issues involved in achieving compliance with the U.S. Environmental Protection Agency (EPA) emission guidelines for Municipal Waste Combustors (MWCs) 40 CFR 60.30a-60.39a. Such issues include:

- Potential Revisions to Existing Guidelines
- Applicability of the emission guidelines to a particular facility
- Compliance Schedule
- Factors affecting choice of retrofit technology:
  - Performance of existing emissions controls
  - Performance of potential retrofit controls
  - Feasibility of retrofitting existing facility
  - Impact on facility availability
  - Schedule
  - Potential for further change in requirements
  - Costs
- Retrofit Implementation Process

Decisions on retrofitting a facility involve complex factors and potentially substantial costs. The EPA has evaluated both emission control system performance and costs in arriving at the guideline requirements. However, each facility has its own circumstances and characteristics which will affect what emission control can be achieved and the cost of such control at that facility.

These decisions are further complicated because the EPA is in the process of re-evaluating the emission guidelines based on Clean Air Act Amendments (CAAA) of 1990. These amendments established a new basis for regulatory decision making which differs from the criteria used to arrive at the current guidelines. This new basis is the Maximum Achievable Control Technology (MACT) concept. This concept applies to existing MWCs and is the level of control achieved at the best 12 percent of existing facilities. There are many existing facilities that have scrubber/baghouse emission control systems which achieve fairly stringent emission limitations. Therefore, the revised guidelines may well be significantly more stringent than those already promulgated. EPA must also promulgate specific requirements for lead, cadmium and mercury in addition to the pollutants already regulated. EPA New Source Performance Standards (NSPS) and current Emission Guidelines are summarized in Table 1.

2.0 POTENTIAL REVISIONS TO MWC GUIDELINES

Revisions to the MWC emission guidelines for existing facilities have yet to be proposed. However, in order to meet the CAAA provisions the current requirements are likely to become more stringent. Table 2 outlines potential revisions which may be proposed for existing MWC's.

The new guidelines will not only cover large facilities (plant capacity greater than 250 TPD) but will also contain requirements for small MWC's (plant capacity of 39 TPD to 250 TPD). Emission limits for large MWC's will likely become more stringent since the MACT requirements of the CAAA will tend to drive the requirements toward scrubber/baghouse performance levels. There are sufficient existing MWC's with scrubber/baghouses that those facilities comprise the best controlled 12% of existing facilities which is part of the MACT emissions control basis.

NO_x control is not likely to be required since there are relatively few existing facilities which employ NO_x controls other than combustion type controls.

One of the new requirements will be limits on cadmium, lead and mercury. Large facilities may be given an option to achieve more stringent cadmium and lead limits coupled with a less stringent mercury limit or achieve a higher degree of mercury control with somewhat less stringent requirements for lead and cadmium. This may be intended to provide facilities with an option on adding activated carbon to their emission control system. This choice will be dependent on whether the facilities emissions of lead and cadmium can be controlled sufficiently to meet the more restrictive lead and cadmium limits and whether activated carbon is needed to enhance dioxin removal in order to meet the revised dioxin/furan emission limit.

Another likely new requirement is a 0% opacity requirement for fugitive emissions from ash handling, transfer and loading. This will necessitate that ash handling/loading facilities be enclosed or that ash be kept sufficiently moist to prevent fugitive emissions.

Small MWC's will likely be subject to less stringent control since relatively few small facilities have scrubber/baghouse control systems (see Table 2). The primary focus will likely be control of particulates, organics, trace metals and carbon monoxide.

3.0 APPLICABILITY FACTORS

The first step in dealing with the MWC emission guidelines is to determine whether they apply to your facility and the individual units within the facility.

MWCs are defined in 40 CFR 60.51a and include any device that burns solid, liquid or gasified municipal solid waste (MSW). This does not include devices which burn landfill gas. The definition of MSW in the same section is fairly lengthy and contains exceptions for some wastes which are not MSW. These wastes include wood pallets, construction and demolition wastes, industrial process or manufacturing wastes, motor vehicle fluff and

TABLE 1

EMISSION LIMITS
FEDERAL STANDARDS AND GUIDELINES FOR MUNICIPAL WASTE COMBUSTORS[a]

	NEW MWCs	EXISTING MWCs
Particulates		
Particulate Matter	0.015 gr/dscf	0.015 gr/dscf (Very Large MWC)[b] 0.030 gr/dscf (Large MWC)[c]
Opacity Limits	10% (6-minute average)	10% (6-minute average)
Acid Gases[d]		
HCl	95% or 25 ppmdv	90% or 25 ppmdv (Very Large MWC) 50% or 25 ppmdv (Large MWC)
SO_2	80% or 30 ppmdv (24-hour average)	70% or 30 ppmdv (Very Large MWC) 50% or 30 ppmdv (Large MWC)
NO_x	180 ppmdv (24-hour average)	No limit proposed
Organics		
Total Tetra thru Octachlorinated Dioxins/Furans (mass emissions)	30 ng/dsm³	60 ng/dscm (Very Large MWC) 125 ng/dscm (Large MWC) 250 ng/dscm (RDF Stokers at Large (MWC)

Notes:

a. All emission levels are corrected to 7% O_2 on a dry basis using the following abbreviations:
ng = nanograms
dscf = dry standard cubic foot
dsm³ = dry standard cubic meter
ppmdv = parts per million dry volume
gr = grains

b. Very large MWCs are defined as existing MWCs with aggregate design combustion capacity greater than 1,100 tons MSW/day.

c. Large MWCs are defined as existing MWCs with unit design combustion capacity greater than 250 tons MSW per day but less than or equal to 1,100 tons MSW/day total facility capacity.

d. Percents are removal percent efficiency that apply alternatively to the respective ppmdv emission limits.

TABLE 1 (Continued)

OPERATING REQUIREMENTS
FEDERAL STANDARDS AND GUIDELINES FOR
MUNICIPAL WASTE COMBUSTORS

	NEW MWCs	EXISTING MWCs
CO	50 ppmdv (4-hour average for modular starved and excess air MWCs)	50 ppmdv (4-hour average for modular starved and excess air MWCs)
	100 ppmdv (4-hour average for Mass Burn Waterwall, Refractory & Fluidized Bed MWCs)	100 ppmdv (4-hour average for Mass Burn Waterwall, Mass Burn Refractory, Fluidized Bed MWCs)
	100 ppmdv (24-hour average for Mass Burn Rotary Waterwall MWCs)	250 ppmdv (24-hour average for Rotary Waterwall MWCs)
	150 ppmdv (24-hour average for RDF Stokers)	200 ppmdv (24-hour average for RDF Stoker MWCs)
	150 ppmdv (24-hour average for Coal/RDF mixed fuelfired MWCs)	150 ppmdv (24-hour average for Coal/RDF mixed fuelfired MWCs)
Maximum Operating Load[a]	Not to exceed 110% of the maximum load level	Same as new MWCs
Maximum Flue Gas Temperature[b] at Inlet to PM Control Device	Not to exceed 30°F above maximum 4-hour average temperature	Same as new MWCs
Operator Certification[c]	Supervisors and other MWC personnel	Same as new MWCs

Notes:

a. Maximum load level is defined as the measured steam flow rate, based on a 4-hour average, demonstrated during the most recent dioxin/furan compliance test. Non-steam generating units are temporarily exempt.

b. The maximum flue gas temperature at the final PM control device inlet is site specific and is not to exceed 30°F above the maximum 4-hour average temperature demonstrated during the most recent dioxin/furan compliance test.

c. ASME or State certification is required for MWC supervisors. Operator training and training manual are required for other MWC personnel.

TABLE 1 (Continued)

TESTING AND MONITORING REQUIREMENTS FEDERAL STANDARDS AND GUIDELINES FOR MUNICIPAL WASTE COMBUSTORS

	NEW MWCs	EXISTING MWCs
Dioxin/Furans	Annual Stack Test	Annual Stack Test
NO_x	Initial Stack Test Continuous Monitoring	Not Regulated
Opacity	Continuous Monitoring	Same as new MWCs
Particulates	Annual Stack Tests	Annual Stack Tests
Acid Gases		
SO_2	Initial Stack Test Continuous Monitoring (up/downstream)	Initial Stack Test Continuous Monitoring (up/downstream)
HCl	Annual Stack Test	Annual Stack Test
Operational Standards		
CO Levels	Continuous Monitoring	Continuous Monitoring
Steam Flowrate (Max. Loading)	Continuous Monitoring	Continuous Monitoring
Flue Gas Temperature at PM Inlet	Continuous Monitoring	Continuous Monitoring

TABLE 1 (Continued)

REPORTING REQUIREMENTS
FEDERAL STANDARDS AND GUIDELINES FOR MUNICIPAL WASTE COMBUSTORS

	NEW MWCs	EXISTING MWCs
Quarterly Reports	SO_2, CO, NO_x, Load, Temperature, Opacity CEM Drift Tests and Accuracy Determination	SO_2, CO, Load, Temperature, Opacity CEM Drift Tests and Accuracy Determination
Annual Compliance Reports	Dioxin/Furans, PM, HCl	Dioxin/Furans, PM, HCl

TABLE 2
POTENTIAL REVISED EMISSION LIMITS
FEDERAL GUIDELINES FOR MUNICIPAL WASTE COMBUSTORS [a]

Pollutants	Existing MWCs: Current Guidelines	Existing MWCs: Revised Guidelines	
Particulates			
Particulate Matter	0.015 gr/dscf (Very Large MWC) 0.030 gr/dscf (Large MWC)	0.015 gr/dscf (Large MWC) [b] 0.030 gr/dscf (Small MWC) [c]	
Fugitive Dust (Ash Handling)	----	0% Opacity	
Opacity Limits	10% (6-minute average)	10% (6-minute average)	
Acid Gases[d]			
HCl	90% or 25 ppmdv (Ver Large MWC) 50% or 25 ppmdv (Large MWC)	95% or 25 ppmdv (Large MWC) 1000 ppmdv (Small MWC)	
SO_2	70% or 30 ppmdv (Very Large MWC) 50% or 30 ppmdv (Large MWC)	85% or 30 ppmdv (Large MWC) 700 ppmdv (Small MWC)	
NO_x	No limits proposed	500 ppmdv (All MWCs)	
Organics			
Total Tetra thru Octachlorinated Dioxins/Furans (mass emissions)	60 ng/dscm (Ver Large MWC) 125 ng/dscm (Large MWC) 250 ng/dscm (RDF Stokers at Large (MWC)	30 ng/dscm (Large MWC) 500 ng/dscm (Small MWC)	
MWC Metals (Small MWCs)	No limits included.		
Cadmium		.10 mg/dscm (Small MWCs)	
Lead		1.6 mg/dscm (Small MWCs)	
Mercury		1.5 mg/dscm (Small MWCs)	
MWC Metals (Large MWCs)		Alternatives (Large MWCs)	
		Alt. A	Alt. B
Cadmium		.02 mg/dscm	.04 mg/dscm
Lead		.16 mg/dscm	.50 mg/dscm
Mercur		1.5 mg/dscm	.10 mg/dscm or 80% reduction

TABLE 2 (Continued)
POTENTIAL REVISED EMISSION LIMITS
FEDERAL GUIDELINES FOR MUNICIPAL WASTE COMBUSTORS [a]

Pollutants	Existing MWCs: Current Guidelines	Existing MWCs: Revised Guidelines
CO	50 ppmdv (4-hr average for modular starved and excess air MWCs) 100 ppmdv (4-hr average for mass burn waterwall, mass burn refractory, fluidized bed MWCs) 250 ppmdv (24-hr average for rotary waterwall MWCs) 200 ppmdv (24-hr average for RDF stoker MWCs)	Same as Current Guidelines.
Maximum Operating Load [e]	Not to exceed 110% of maximum load level.	Same as Current Guidelines.
Maximum Flue Gas Temperature [f] at Inlet to PM Control Device	Not to exceed 30°F above maximum 4-hr average temperature	Same as Current Guidelines.
Operator Certification [g]	Required	Required

Notes:

a. All emission levels are corrected to 7% O_2 on a dry basis using the following abbreviations: ng = nanograms; dscf = dry standard cubic foot; dsm^3 = dry standard cubic meter; ppmdv = parts per million dry volume; gr = grains.
b. Large MWCs are now defined as existing MWCs with aggregate design combustion capacity greater than 250 tons MSW/day. (plant capacity)
c. Small MWCs are defined as existing MWCs with aggregate design combustion capacity greater than 39 tons MSW per day but less than or equal to 250 tons MSW/day total facility capacity.
d. Percents are removal percent efficiency that apply alternatively to the respective ppmdv emission limits.
e. Maximum load level is defined as the measured steam flow rate, based on a 4-hour average, demonstrated during the most recent dioxin/furan compliance test. Non-steam generating units are temporarily exempt.
f. The maximum flue gas temperature at the final PM control device inlet is site-specific and is not to exceed 30°F above the maximum 4-hour average temperature demonstrated during the most recent dioxin/furan compliance test.
g. ASME or state certification is required for MWC supervisors. Operator training and training manual are required for other MWC personnel.

segregated medical wastes. Therefore, if a facility only burns materials that are not MSW, it is not subject to these guidelines. Also, exemptions from these guidelines are given to facilities which combust MSW or refuse-derived fuel (RDF). These facilities are allowed to burn MSW or RDF, but only if the amount is less than 30 percent of their total daily combustion capacity.

Only MWC units with a capacity over 250 tpd are subject to the current guidelines. The regulation establishes a 4,500 Btu/lb heating value for MSW. The heat input capacity of a given unit must be divided by 9×10^6 Btu/ton to arrive at the capacity for the facility. This derived capacity identifies which facilities are subject to the regulations. This may not be the same as the rated capacity of the unit as designed. Many units are designed to combust waste which has a greater heating value than 4,500 Btu/lb.

Revised guidelines for existing MWC's will likely distinguish facilities based on total facility capacity greater than 250 TPD. Large facilities over 250 TPD will be subject to the more stringent requirements and an additional class of facilities with capacity between 39 TPD and 250 TPD will be subject to new requirements less stringent than those for large facilities.

Distinctions in control requirements are also made relative to the type of combustion technology used for an MWC. Different limits are established for emissions of CO because different types of combustion equipment have demonstrated different performance levels.

In the revised guidelines the organics limits for different types of combustion facilities may change such that all large facilities must meet the same organic limit and all small facilities will need to meet the same but less stringent organics limits.

Finally, construction of the unit or plant had to begin on or before December 20, 1989, or it is subject to the NSPS rather than the emission guidelines.

4.0 COMPLIANCE SCHEDULE

The MWC emission guidelines are to be implemented by each state. Each state is required to submit a plan for implementation and enforcement of the guideline requirements. States can make their requirements more stringent than the guidelines. EPA has 180 days to approve or disapprove the state plan. Units subject to the guidelines must be in compliance either within three years of approval of the state plan or not later than five years from promulgation of the guidelines. Therefore, retrofits under existing guidelines must be complete and compliance achieved sometime between August 1995 and February 11, 1996. However, due to the revisions, this schedule should shift such that compliance will be necessary by 1997 or 1998 depending on when the revisions are final.

5.0 FACTORS AFFECTING CHOICE OF RETROFIT TECHNOLOGY

5.1 Existing Facility Performance

In order to decide on a retrofit strategy you must have a good base of data on existing facility design parameters and performance. Presumably, facility design data and the original performance specifications are contained in the facility files and operating manuals.

Current facility performance must be identified and evaluated based on operating records and emissions testing and monitoring data. This data should cover fuel feed rates, combustion air flows (overfire and underfire), steam production, boiler efficiency, flue gas volume flows upstream and downstream of the current emission control system, furnace temperature, flue gas temperature upstream and downstream from emission control system, flue gas composition, emissions rates/concentrations upstream and downstream of emission control system and emission control system removal efficiency for the various pollutants.

Facility design data and performance specifications need to be compared to actual operating and emission control data to determine how well the facility is currently doing relative to its initial design. This establishes a baseline for evaluating what further modifications and improvements need to be made to achieve the applicable emission guideline performance levels.

It is possible that sufficient design emissions and performance data is not available to establish this baseline. Without this information, you cannot conduct the analysis of modifications needed to achieve guideline requirements. In this case, such data will need to be acquired. The vendors for the combustion equipment and emission control equipment may have to be contacted to secure detailed design data. Emissions data and emission control system efficiency data may be evaluated as to other similar facilities. However, direct data on the specific facility involved is more accurate and useful because each facility has its own characteristics. Also, emissions data on some pollutants (dioxins, trace elements and carbon monoxide) can vary significantly between facilities.

5.2 Control Equipment/Modifications Performance

The existing facility design, performance and emissions data must be evaluated relative to the MWC guidelines. This will determine the degree of additional control necessary to achieve compliance. This also helps to identify what modifications can be made to the existing facility equipment or operating practices to comply versus what equipment must be replaced to achieve compliance.

This analysis must focus on several aspects of the facility as they relate to the pollutant to be controlled.

5.2.1 Particulate Control — The existing volume flow, temperature and particulate loading for flue gas entering the existing control equipment must be accurately quantified. Many existing units employ electrostatic precipitators (ESPs) to control particulate emissions.

ESP performance is dependent on a number of factors. The ESP is sized to achieve a given removal efficiency based on the volume of gas and particulate loading in the flue gas. This involves determining the specific collection area (ratio of collection surface to volume flow) needed. The specific collection area needed for a given removal efficiency depends on:

- Particle size
- Resistivity of particles
- Discharge electrode and collection electrode parameters
- Internal duct spacing and configuration
- Particle migration velocity
- Flow velocity within the ESP
- Related design factors

While it is not possible to deal with all aspects of ESP design in this paper some issues of particular significance must be considered. Most facilities will need to achieve better SO_2/HCl control and in doing so will alter the volume flow and particulate loading conditions of the flue gas. Whether SO_2/HCl control is achieved by dry lime injection (into furnace or duct) or by use of a spray dry type scrubber, particulate loadings will increase. In addition flue gas temperature and volume flow will decrease. In a spray dry system the lime slurry injected into the scrubber will cool the flue gas. If dry injection is used a heat exchanger or other flue gas temperature reduction device will likely also be employed. This device is used to maximize SO_2/HCl removal and adsorption of trace metals and organics (dioxins and furans) onto particles. It also minimizes the potential residence time for flue gas in the 500-700° temperature range to minimize potential for dioxin/furan formation. A reduction in temperature will reduce volume flow. This will increase the ratio of ESP collection surface to volume flow and tend to improve ESP performance. However, reduction in temperature will also alter particle resistivity. Resistivity values in the range of 10^9-10^{11} ohm-cm are optimum for achieving a good precipitation rate and minimizing spark-over. At lower temperatures (250-500°F) particle resistivity is dominated by chemical composition of particles. At higher temperatures (600-800°F) chemical composition of particles is less significant and resistivity values tend to be in the optimum range. Determining resistivity, precipitation rate and potential for spark-over involves both particle chemical composition and flue gas composition within the lower temperature ranges. This makes predictions of ESP collection efficiency quite complex since there can be many variables acting at once such as: presence of calcium tends to increase resistivity, presence of chlorine tends to decrease resistivity, water vapor tends to decrease resistivity and SO_3 in the flue gas tends to reduce resistivity.

Therefore, these and other variables need to be quantified to determine ESP performance when temperature and volume flow are reduced and particulate loading is increased due to lime injection for SO_2/HCl control. This may well involve having the original ESP vendor evaluate the equipment since they have the most data on the original design. The vendor also knows how that design may be affected by altered conditions. It may also require analysis of fly ash resistivity at the new flue gas temperature resulting from other modifications. These issues must be resolved in order to determine whether the ESP can be retained as is, modified to achieve the necessary performance, or replaced.

ESPs can typically be designed to easily achieve either the .03 gr/dscf limit for small MWCs or the .015 gr/dscf limit for very large facilities. However, it cannot be assumed that a particular ESP will continue to perform at the same level as before once the flue gas conditions and particulate loadings change. Control of other pollutants such as metals or dioxins may well also control the decision on whether to retain, modify or replace an existing ESP. Meeting particulate limits does not necessarily mean that other limits will be met for pollutants which tend to be attached to particulates.

Control of particulates with a baghouse is not subject to as many variables as with an ESP. While collection area and volume flow are also basic elements of baghouse sizing, baghouses are not as sensitive to changing particulate and flue gas conditions. Increased particulate loadings may require more frequent cleaning cycles but collection efficiency is not likely to deteriorate. However, if flue gas is cooled too far so that the dew point is reached bags can be blinded, requiring shutdown of the system. Therefore, while it is beneficial to reduce flue gas temperature to about 300°F for control of metals and dioxins, if the temperature drops into the 250°F or less range risk of condensation and blinding becomes significant.

5.2.2 Acid Gas Control (SO_2/HCl) — While the existing emission guidelines are based on two types of acid gas control concepts. Sorbent injection (lime injected into furnace or duct) to achieve the 50 percent reductions for large MWCs and spray drier scrubbers to achieve the 70 percent (SO_2) and 90 percent (HCl) reductions for very large MWCs the revised guidelines will likely narrow the options for large facilities.

Both furnace sorbent injection (FSI) and duct sorbent injection (DSI) have been utilized at a few facilities to control HCl and SO_2. Both ESPs and baghouses have been used for particulate control. Sorbent injection systems generally use lime and have been demonstrated to achieve 50 percent or better removal for both SO_2 and HCl. Some test data indicates that cooling of the flue gas prior to the particulate control device can be beneficial relative to HCl, metals and dioxins control. Sorbent injection systems using baghouses for particulate control generally perform better than sorbent injection and ESPs.

For large MWCs a spray drier scrubber will likely be needed to reliably achieve the 85 percent SO_2 and 95 percent HCl control levels. While DSI systems with a baghouse have at times demonstrated this level of control, performance has not been consistent enough at these levels to rely on.

5.2.3 Combustion Controls (CO and Organics) — Combustion controls involve a number of factors affecting combustion conditions in the furnace. These conditions include quantity and distribution of combustion air (overfire and underfire), thorough mixing of flue gas in the furnace (turbulence), sufficient temperature and residence time, sufficient oxygen (6-9 percent) and even distribution of fuel on the grate. These conditions can all affect CO and organics emissions. Achieving optimum conditions for all of these factors to minimize CO and organics emissions tends to be very facility-specific. If an existing unit has CO or dioxin/furan emissions substantially above the guideline levels, a detailed analysis of the above variables will have to be made for that facility. This is necessary to determine what changes in equipment or operations will be needed to achieve compliance.

An evaluation can be done by altering each variable to determine the effect on monitored CO emissions. This does not mean that once desired CO levels are achieved that organics emissions will also be met. Therefore, diagnostic dioxin and furan emissions testing will likely be needed to determine the optimum combustion air distribution, fuel feed rates and distribution and other factors which will reduce organic emissions.

Furnace combustion models exist which can be employed to evaluate these factors, however, it is still prudent to confirm the results with actual emission test data.

5.2.4 Organics Control (Dioxins and Furans) — Control of organics emissions is really a combination of control strategies. Combustion controls can help reduce formation and promote destruction of organics in the furnace. Flue gas cooling to minimize the amount of time which flue gas is in the 500-700°F temperature range can minimize potential for formation of dioxins and furans. Further cooling to the 300°F range will tend to promote adsorption of dioxins and furans onto particulates. Therefore, the particulate control device can remove a large percentage (90-99 percent) of the dioxins and furans.

Each facility has its own set of characteristics relative to organics emissions. If emissions of organics exceed the applicable guideline levels an evaluation of combustion control modifications and operating practices will need to be done. This will identify whether these factors can be modified to achieve compliance. Flue gas cooling should be investigated if the facility is designed such that flue gas remains in the 500-700°F range for more than a second.

Facilities with spray driers and fabric filters have demonstrated the greatest organics removal efficiencies. Duct sorbent injection with a fabric filter also has shown high removal efficiencies. Scrubber/ESP systems have shown somewhat lower removal efficiencies as have DSI/ESP systems. FSI/ESP systems have shown little or no effect on organics emissions.

5.2.5 Metals Control (Pb, Cd, Hg) — Since cadmium and lead are less volatile than mercury conventional particulate control technology can be employed to achieve 97-99 percent removal (with a baghouse or ESP). Scrubber/baghouse systems have shown the best control of all three metals although mercury control is the least effective. However, emissions of these substances are directly related to the amount in the waste to begin with. Therefore, the level of control necessary can vary substantially as to any one facility.

Decisions on emission control modifications relative to trace metals will primarily be dependent on existing levels of such emissions. If lead and cadmium emissions are low to begin with the facility may be able to opt for alternative A on Table 2 and be subject to the less stringent mercury limit. However, this decision needs to be based on adequate emission test data for the existing facility. Metals emissions can fluctuate substantially, therefore, several sets of test results over a period of at least a year should be available to provide a reasonable characterization of existing emissions.

If existing lead and cadmium emissions are not consistently below the Alternative A levels or if adequate data is not available then alternative B may be more appropriate. However, due to the low mercury limit of Alternative B, it may be necessary to incorporate activated carbon injection or another mercury control strategy to achieve compliance.

Supplemental mercury control systems have been tested utilizing sodium sulfide or activated carbon injection. Sodium sulfide reacts with mercury to form mercuric sulfide which can then be effectively removed by an efficient particulate control device. Sodium sulfide is injected into the flue gas in a temperature range of about 275-500°F.

Activated carbon injection has also been used to achieve mercury removal through adsorption of mercury by the activated carbon. While both approaches have shown significant mercury reduction potential and are available from a few emission control vendors, they have not actually been utilized much in the United States. Information is still being developed on the effectiveness of these methods and compatibility with other emission control systems.

Existing control systems achieve varying levels of mercury control. Scrubber/baghouse systems have frequently removed 90 percent or more of mercury in the flue gas. Duct sorbent injection and fabric filters have shown comparable removal. Spray dryer/ESP and sorbent injection/ESP systems have shown lesser and more variable control for mercury. Mercury control to meet a specific limit is very dependent on mercury levels which occur at a specific facility. Therefore, it would be worthwhile to develop a good set of test data for mercury and other trace metals at each facility so the current emissions and variability can be quantified.

5.2.6 Fugitive Ash Emissions - The revisions to the MWC guidelines will likely introduce an additional factor to be evaluated relative to ash handling. To meet a 0% opacity requirement ash handling/loading facilities will either need to be enclosed or ash will need to be kept sufficiently moist to eliminate fugitive dust. Some combination of these approaches may be sufficient depending on the existing ash handling system and practices.

5.3 Feasibility of Retrofitting Existing Facility

One of the major variables in terms of cost of retrofits is the space limitations which exist at a facility. If it is decided that an existing ESP must be replaced with a scrubber baghouse or a scrubber is to be added to the existing system, space limitations, existing fan capacity, potential corrosion of ductwork and flues need to be evaluated. This evaluation will determine the extent of modification needed to existing fans, ductwork, stack or other equipment that may have to be modified or relocated.

If space is very limited or the facility configuration is such that construction will be very difficult this can result in substantial additional costs.

5.4 Impact on Facility Availability

Depending on the emission control modifications needed the facility may have to shutdown one or more units for significant periods of time. For example, combustion control may be accomplished by redirecting combustion air with existing equipment and addition of monitoring devices. If this is possible, it may give the operator adequate information on combustion conditions and there may be no downtime. However, if combustion controls necessitate new overfire air ports, modifications to fuel feed systems, grate modifications, new fans or modification of the geometry of the furnace, then downtime for each unit could be weeks or months.

If a scrubber is to be retrofitted upstream of an existing ESP and the existing ESP is determined to be capable of achieving the necessary particulate control, then downtime may be minimal. The scrubber could be constructed while the unit continues to operate and the unit would only have to be shutdown while the new ductwork interconnections are built to tie the scrubber in. However, if the ESP has to be modified as well or replaced with a baghouse then downtime is likely to be several weeks per unit.

5.5 Schedule

Scheduling of retrofits is an important factor and can be complex. The initial evaluation of what modifications need to be made may not be simple. This evaluation can take several months or over a year to complete in some cases. Such cases include facilities where combustion conditions must be evaluated, ESP performance under changed conditions must be evaluated and diagnostic emissions tests must be conducted.

Once a set of emission control modifications has been identified then the scheduling can be estimated for procuring equipment, fabrication of equipment, demolition and site preparation, construction, unit downtime and sequencing of unit modifications. For facilities with multiple units it will usually be preferable to only modify one unit at a time. This strategy maintains as much facility capacity in operation as possible and minimizes bypassing of MSW. Sequencing of modifications can result in an extended construction schedule which could well cover a period of two or three years.

5.6 Costs

Costs for retrofits will be quite facility-specific since the number and type of modifications, site restrictions, construction obstacles and combustion control modifications will likely be significantly different from facility-to-facility. Following are examples of retrofit costs prepared by the EPA for the development of the guidelines (Table 3). This can give an idea of the potential retrofit costs but each facility will need to do a detailed analysis of its own to determine probable costs for them.

Retrofit costs for the Detroit Michigan 3000 TPD RDF fired facility have been reported in excess of 100 million dollars to replace the ESP's with spray drier/fabric filter control systems.

6.0 THE IMPLEMENTATION PROCESS

Implementation of an air pollution control retrofit for MWC facilities will typically include the following major activities:

- a feasibility study to determine state and federal regulatory requirements, analysis of retrofit technology and procurement options;
- procurement of the retrofit vendor(s); or negotiation with existing vendor
- modification of existing permits;
- obtaining the necessary permits for construction;
- financing of the project;
- design of the system;
- fabrication and construction;
- regulatory and acceptance testing of the completed system.

A MWC retrofit project checklist presented in Table 4, summarizes the implementation process and shows the typical duration of each major task. Assuming a number of these tasks will be conducted simultaneously, a typical retrofit project may require from 2½ to 5 years to complete. Some of the major tasks are discussed in the following paragraphs.

6.1 Feasibility Study

The feasibility study will quantify the need to retrofit air pollution control systems, and the appropriate technology to meet the standards and guidelines. A typical feasibility study would address the following aspects:

- regulatory issues, including air emissions guidelines, permits for water usage or discharge, and ash handling and disposal;
- technical feasibility of compliance options to identify those retrofit options which are technically feasible and to perform a conceptual design to the level required to quantify retrofit costs;
- economic comparisons to evaluate life cycle costs for each of the technically feasible options, including downtime and bypass requirements.

TABLE 3

CAPITAL COST AND ADDITIONAL TIP FEE FOR RETROFITTING AIR POLLUTION CONTROL SYSTEMS TO EXISTING MWC FACILITIES

RETROFIT OPTION	Capital Cost	Additional Tip Fee $/ton
Mass Burn, 3 units @ 750 tpd each:		
Dry reagent injection with addition ESP plate area	$10,200,000	6.00
Semi-dry scrubber with fabric filter	34,000,000	14.00
Mass Burn, 3 units @ 360 tpd each:		
Semi-dry scrubber with fabric filter	21,000,000	17.30
RDF, 2 units @ 1000 tpd each:		
Combustion modification	4,330,000	2.70
Semi-dry scrubber with fabric filter	$29,700,000 - 33,600,000	17.70 - 19.20

Tipping Fees were calculated based on annualized capital, operating and downtime costs presented in EPA MWC Background Information Report, August 1989, and an 85% plant availability factor.

TABLE 4

CHECK LIST FOR IMPLEMENTATION OF AIR POLLUTION CONTROL RETROFIT PROJECTS FOR MWC FACILITIES

		Typical Time Frame
A.	**Determine need to Retrofit: Phase I Feasibility Study**	1-2 Months
__	1. Review current and pending Federal and State regulations.	
__	2. Review facility design and existing emissions test data.	
B.	**Determine Retrofit Technology and Implementation Options: Phase II Feasibility Study**	3-6 Months
__	3. Acquire additional emissions and operating data, if necessary.	
__	4. Evaluate technology options and economics.	
__	5. Evaluate solid waste bypass options.	
__	6. Prepare conceptual design and develop performance and environmental specifications.	
	7. Evaluate procurement options.	
C.	**Procure Retrofit Vendor**	
__	8. Review existing facility contracts and site lease agreements to determine: - Ownership and responsibilities (public and private); - Procurement procedures; and - Impact of retrofit on existing guarantees.	
__	9. Issue request for proposal (or bid) considering the following approaches: - A&E; - Turnkey; or - Full Service	
__	10. Evaluate proposal(s) or bids and select vendor(s).	
__	11. Negotiate and finalize vendor contract(s).	

TABLE 4 (Continued)

CHECKLIST FOR IMPLEMENTATION OF AIR POLLUTION CONTROL RETROFIT PROJECTS FOR MWC FACILITIES

		Typical Time Frame
D.	**Obtain Permits**	**6-18 Months**
__	12. Modifications to air quality permits.	
__	13. Obtain other required permits for construction.	
E.	**Finance The Retrofit Construction**	**3 Months**
__	14. Review existing financial documents: - Bond agreements and covenants; - Trust Indentures; - Previous Engineer of Record Reports;and - Annual inspection reports.	
__	15. Select method of financing or refinancing.	
__	16. Prepare financing documents and obtain financing.	
F.	**Design and Construct Retrofit Project**	
__	17. Issue notice to proceed and initiate design of the retrofit project.	
__	18. Complete final design.	
__	19. Fabricate equipment.	
__	20. Complete demolition, site preparation and civil/structural activities.	
__	21. Install equipment.	
__	22. Make modifications and "tie-ins" to existing MWC facility equipment.	
__	23. Start up modified facility.	
__	24. Conduct acceptance and emissions testing.	

6.2 Procurement Options

Procurement encompasses the acquisition of services and equipment related to a project. Issues relating to financing, ownership, and risk allocation must be considered. The selection of the most beneficial approach requires an evaluation of the current facility contracts, financing documents, and ownership and operations responsibility. This decision then impacts the process for design, construction and operation and how these responsibilities are distributed between the public and private sectors. There are three major procurement approaches used in solid waste retrofit projects, namely, architecture/engineering (A&E), turnkey, and full service.

In the A&E approach, a professional engineering firm is retained by a municipality to participate in project planning and design. The engineer prepares equipment and system specifications for public bidding, and is responsible for designing certain aspects of the project. The engineer is retained for bid evaluation, construction monitoring, start-up and testing. This approach is often required by a government owned and operated MWC where a competitive procurement process is desired or necessary.

The turnkey approach is generally used to streamline the process and improve the project schedule. A single contractor is awarded a contract to design, construct and start up the project. The turnkey contractor is responsible for the design and selection of the equipment and material, whether or not they actually perform the work themselves or subcontract portions of it. The engineer's role is to provide technical advice and performance specifications for procurement. Upon the completion of construction and successful testing, the project is accepted by the government entity which then assumes responsibility for the operation.

In the full service approach, the total responsibility for project design, construction, testing operation and possibly ownership is given to a single contractor. This procurement approach usually includes a contract for design and construction and another contract for facility operation. Most full service contracts include provisions for capital improvements where the full service vendor provides the additional design, construction, acceptance testing and operation of the capital improvement project. If the MWC was originally developed under a full service procurement then the contracts between the vendor and local government will govern how the retrofit will be performed. However, this does not mean that the governmental body using the facility has no options. The government entity can take an active role with the following approach:

- evaluate the impact of the retrofit project on the full service contract;
- prepare retrofit proposal requirements, including technical, performance and environmental guarantees, capital and operating and maintenance cost details;
- Solicit proposals from other vendors for comparison to full service vendor;
- evaluate proposals;
- audit costs proposed by the vendor;

- negotiation of contract revisions and costs;
- monitor construction and acceptance testing.

A major capital improvement project, such as an air pollution control retrofit, needs an assessment of possible risk events, the impact of a risk occurrence and methods by which risks can be reduced or mitigated. (Risk is the possibility that an event will occur which has a detrimental impact on the project. Risk posture is defined in the existing contractual arrangements, procurement approach and financing structure for the facility.) This assessment should occur simultaneously with the review of contracts, financing documents, and legal and ownership issues to define the government entity's risk posture and to determine the retrofit implementation strategies that meets the public's needs. For each procurement approach, the guarantees are subject to occurrences beyond the contractor's control, such as strikes. The amount of risk shared with the private sector correlates to the price of the project. Since a full service contractor takes the greatest amount of risk, a full service bid price may be higher than an architecture/engineering bid approach.

6.3 <u>Financing Options</u>

The professional consultant team (engineering, financial, legal) would review financing documents relating to existing facility bond issues. The financial documents may define: specific financing or refinancing procedures; selected procurement procedures; and requirements for an independent consulting engineer to review future capital expenditures. Existing financial structure, financial documents and ownership define the financing approach for capital improvements, such as retrofits. There are four major financing structures generally available for capital improvements, namely, bond sales (new issue or refinancing bonds); private funds; grants; and revenue funding. General obligation bonds pledge the full faith and credit of the government agency as security for payment of the bonds. The bond interest rate reflects the government agency's credit worthiness alone without consideration of the security of the project. Revenue bonds pledge the revenues available from the project as security for the bonds. If available, the project revenues could include solid waste disposal fees, revenues from the sale of energy or recovered material, insurance proceeds and damage payments from contractors. Revenue bonds are limited obligations and the governing body would not be obligated to raise taxes to pay debt service. The governing body would generally be required to covenant that rates charged for solid waste disposal will be maintained at levels adequate to pay bond principal and interest.

Private financing has generally been used in resource recovery projects to pass ownership of the project and the resultant tax benefits to the private sector. There are two mechanisms used in private financing of resource recovery projects, namely, equity participation by the contractor; and leveraged leasing. In an equity participation, the contractor is also the project owner. Generally, the contractor is a limited subsidiary of a large parent corporation that is able to take maximum advantage of available tax benefits.

All or a portion of the project debt may be financed by a private placement method. This type of placement exempts the issuers from security law regulations as long as the offering is not made public and involves institutions which acquire the instruments for investment, not resale. Some of the forms the transaction can assume include senior notes, zero coupon notes, first mortgage bonds and adjustable rate notes. The investors are normally insurance companies, pension funds, thrift institutions, money managers or commercial banks.

The revenue funding options available to the municipality for waste management capital improvement projects are: an enterprise fund, tipping fee adjustments and general fund allocation. An enterprise fund separates the cost of service issued from the tax base by charging users of the fund an appropriate fee for services provided. Funds received from these fees may be used to establish and maintain an enterprise fund. Tipping fees are the charges, commonly referred to as "user fees", to dispose of waste at the MSW facility and are generally set at a level that reflects the cost of operating the facility. The cost of air pollution control retrofits can be funded through an increase in the tipping fee. General fund allocations are distribution of funds by a legislative body for specific projects or services. These funds could be tapped to finance the retrofit project.

6.4 Restructuring Debt Service

Debt service is typically a large component of the tipping fee at a MWC facility. If costs are expected to be incurred for major capital projects, such as air pollution control retrofits, the bond issuer may want to restructure outstanding debt to maintain level annual debt service payments on the combination of refunding bonds and new bonds.

The first step for an issuer considering a refunding should be a thorough analysis of the potential savings, the risks and benefits, and the opportunities to restructure financial and operating controls. Refinancing may also lessen the impacts of increases on tipping fees. This analysis should begin at least one to two years before the planned finance date. If a refunding appears to be beneficial, a financing team should be formed, to include a financial advisor, bond counsel, feasibility engineer, and underwriters.

6.5 Permitting

The permitting process can be a critical task in the implementation schedule. An assessment of the permitting requirements and the regulatory review time frames are essential in the development of a plan to minimize the overall schedule for implementing a retrofit program. Federal MWC guidelines state that changes to the facility to comply with guidelines are not modifications or reconstruction, therefore, full repermitting should not be necessary. However, state requirements may affect the extent of permitting required. Modifications to the air quality permits may require air quality impact analysis, as well as detailed descriptions of the emission control system modifications and performance. An important objective during the permitting process is to obtain permit limits that are consistent with the retrofit vendor's guarantees. Other local, state and federal environmental and construction permit requirements must also be identified and obtained prior to construction.

6.6 Design, Construction and Testing

The final design and construction of the retrofit modifications must conform to the contract requirements for facility performance, environmental guarantees, permit conditions and the minimizing of MWC downtime during the retrofit construction period.

Upon issuance of the notice to proceed to the retrofit vendor, the professional engineering consultant should review the engineering design and begin to monitor construction activities. The review and monitoring must consider the impact of the design and construction of the retrofit system on scheduled downtime and interferences with existing facility operations. The technology chosen, the final design, the facility site size and construction sequencing all have an important role in determining the amount of downtime and interference with operations. For example, an acid gas system retrofit utilizing dry sorbent injection into existing duct work along with modifications to an existing ESP system will generally have less downtime and interferences than an acid gas retrofit installing a semi-dry scrubber and fabric filter baghouse system at a facility that has a limited space available for the new equipment. Also important are the laydown of construction material and equipment; demolition of existing structures; modification of existing facility equipment; and "tie-in" of retrofit equipment into the existing facility.

After construction has been completed, a contractual acceptance test and a regulatory emission test should be conducted to insure that the air pollution control retrofit is meeting both guarantees and permit conditions. Further, other plant performance data such as waste throughput and energy production should be tested to insure that these parameters are still within the limit of the guarantees.

6.7 Impacts of the Retrofit Air Pollution Control System on Waste Disposal

Air pollution control retrofits will necessitate that one or more components of the MWC waste processing train are taken out of service for adjustment, modification, replacement or interconnection with new retrofit equipment. Reduced plant capacity will have to be mitigated and alternative waste transfer and disposal capacity will have to be secured during the period of reduced capacity. Diversion of a portion of the waste stream from the MWC facility is likely during the retrofit construction period. Waste collection, potential waste transfer points and ultimate disposal capacity for the bypass waste must be planned. Waste can continue to be accepted at the facility and the excess can be hauled to another solid waste disposal site (such as a MWC or landfill). Alternately, the excess waste could be diverted prior to entering the MWC facility that is undergoing retrofit construction.

Retrofitting an MWC can involve a complex series of interrelated tasks. Therefore, an early assessment of the tasks, time frames and costs involved will maximize the potential to use the most cost effective approach.

7.0 CONCLUSIONS

Revisions to the MWC emission guidelines for existing facilities will likely narrow the options available for existing facilities to achieve compliance. The combination of more stringent acid gas limits, organics limits and trace metal limits definitely shifts the balance of control approaches toward scrubber/baghouse systems. Mercury limits and organics limits create a potential need for activated carbon injection to assure compliance. For facilities which currently have ESPs or scrubber/ESPs or sorbent injection and ESPs it may not be feasible to achieve the necessary control of all emissions by retaining or modifying the ESP. Even facilities with scrubber/baghouse systems may have to make some modifications to assure compliance with all limitations.

Small facilities will have more options since acid gas controls should not be necessary and organics and trace metals limits are substantially less stringent than for large facilities.

While the revisions have not been proposed yet the time has come to give serious consideration to what course of action must be taken to achieve compliance. For large facilities which have to undertake major retrofits the 5-year compliance time frame does not provide a lot of excess time to conduct the analyses, procure equipment, modify permits and contracts, finance, construct and test the new equipment.

To achieve the most cost effective course of action early planning will be prudent.

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