United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park, NC 27711

EPA-450/3-89-27a
August 1989

Docket No. A-95-41
Item No. II-A-39

Air

EPA

Municipal Waste Combustors-Background Information for Proposed Standards: Cost Procedures

NSPS

MUNICIPAL WASTE COMBUSTORS -- BACKGROUND INFORMATION FOR PROPOSED STANDARDS: COST PROCEDURES

FINAL REPORT

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AUGUST 14, 1989

3.3 HUMIDIFICATION

3.3.1 Overview of Technology

Humidification is used to cool the flue gas entering the particulate matter (PM) control device. Humidification can be used separately or in combination with dry sorbent injection. The primary objective of cooling is to reduce the temperature of the flue gas entering the PM control device to below that at which post-combustion formation of dioxin is suspected to occur (approximately 450°F).

The quantity of water required is a function of the temperature, flowrate, and moisture content of the flue gas at the inlet to the humidification chamber and the temperature reduction required.[1]

$$Q_W = (T_i - T_o) * Q_S * (1 - WTR/100)/940 \qquad (1)$$

where:
- Q_W = water required for flue gas cooling, lb/hr;
- T_i = inlet flue gas temperature, °F;
- T_o = outlet flue gas temperature, °F;
- Q_S = flue gas flowrate, scfm; and
- WTR = moisture content of the inlet flue gas, volume percent.

Flue gas temperatures at the combustor exit for refractory-wall combustors generally ranged from 1,400 to 1,600°F; for waterwall combustors, temperatures ranged from 400 to 600°F.

For units already using quench towers for flue gas cooling (primarily refractory-wall systems without heat recovery), the water feed rate is increased to achieve the additional cooling. For units without an existing flue gas cooling system, a humidification chamber is installed. The humidification chamber diameter is sized for a flue gas velocity of 10 feet/second and a chamber length-to-diameter (L/D) ratio of 3 to 1.[2] To minimize PM fallout and impingement of wetted solids on chamber walls, no baffles or other internals are used. Pressure nozzles are used for water atomization.

A secondary effect of cooling the flue gas entering the PM control device is a reduction in flue gas volume (i.e., acfm) and a corresponding increase in the specific collection area (SCA) thereby enhancing the PM collection efficiency of the ESP. However, because MWC ESP's operate at temperatures above the temperature of maximum particle resistivity (300 to 400°F for most fly ashes), decreasing flue gas temperature may in some instances increase fly ash resistivity enough to create ESP back corona problems and impair PM collection efficiency. Because of the current lack of information on resistivity-temperature relationships for MWC fly ash, this analysis assumes that humidification does not alter particulate resistivity enough to cause ESP operating problems. As a result, the impact of humidification on ESP performance is estimated based solely on the change in SCA due to flue gas volume reduction.

3.3.2 Capital Cost Procedures

Capital costs are estimated for existing facilities without an existing flue gas cooling system. Direct capital costs include the humidification (evaporative cooling) chamber including the vessel and supports, water spray system and controls, and duct modifications. Direct equipment cost for the humidification chamber are based on the flue gas flowrate using the following equation:[3]

$$\text{Equipment Costs (\$)} = 0.372 * Q + 67{,}980 \qquad (2)$$

where: Q is 125 percent of the actual inlet flue gas flowrate (acfm) to accommodate variations in waste composition and operating conditions.[4]

The costs estimated by equation 2 are in December 1987 dollars. Originally, the costs were in December 1977 dollars and were adjusted to December 1987 dollars using the Chemical Engineering Plant Cost Index for all equipment. The equipment costs are then adjusted for retrofit difficulty based on the procedures described in Section 3.7.1.

Costs for instrumentation, taxes, freight, and installation are estimated using indirect cost factors for venturi scrubbers.[5] The resultant procedure for estimating capital cost is summarized in Table 3.3-1.

3.3.3 Operating Cost Procedures

Table 3.3-2 presents procedures for estimating operating and maintenance (O&M) costs for the humidification chamber. Because of the simple design and operating requirements of the system, O&M labor and maintenance materials are assumed to be at the low end of those presented in Reference 6 (i.e., using the wet scrubber labor and materials requirements). Other O&M costs include water and the electricity used by the pumps. All costs are based on December 1987 dollars. An operating labor wage of the $12/hr was used. This wage was the average of the labor wages reported by both the Department of Commerce Survey of Current Business for private nonagricultural payrolls and EPRI's Technical Assessment Guide for utility power plants.[7,8] The labor wage reported by EPRI in January 1985 dollars was updated to December 1987 dollars using the Bureau of Labor Statistics' Producer Price Cost Index for all industrial commodities, prior to averaging. An electricity cost of $0.046/kWh was obtained from the Energy Information Administration Monthly Energy Review.[9] Equipment life is assumed to be 15 years.

TABLE 3.3-1 CAPITAL COST PROCEDURES FOR HUMIDIFICATION[10,11]

Equipment Costs (December 1987 dollars)

1. Humidification Chamber and Pumps:[a]

$$\text{Cost, \$} = 0.372 * Q + 67{,}980$$

2. Ductwork

$$\text{Cost, \$} = 0.981 * L * Q^{0.5}$$

Retrofit Purchase Equipment Costs = 1.18 * Equipment Costs • Retrofit Factor (from Section 3.7)

Installation Direct Costs = 0.56 * Purchased Cost

Indirect Costs[b] = 0.35 * Purchased Cost

Total Capital Costs = Purchased Equipment Costs + Installation Direct Costs + Indirect Costs
= 1.91 * Purchased Costs

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[a]Q = 125 percent of the actual flue gas flowrate, acfm
L = Duct length, feet.

[b]Includes a contingency of 3 percent of the purchased costs.

TABLE 3.3-2 OPERATING AND MAINTENANCE COSTS FOR HUMIDIFICATION

		References
Operating Labor:	0.5 man-hours/shift; wages of $12/hr	6, 8
Supervision:	15% of operating labor costs	12
Maintenance Labor:	0.5 man-hours/shift 10% wage premium over operating labor wages	12
Maintenance Materials:	1% of total capital investment	13
Water:[a]	0.00012 * Q_w * (hours of operation) * (water costs, $/1000 gal) cost of $0.50/1000 gal	14
Electricity:[a,b]	1.587×10^{-4} * Q_w * (hours of operation) * (electricity costs, $/kWh) cost of $0.046/kWh	15
Overhead:	60% of the sum of all labor costs (operating, supervisory, and maintenance) and maintenance materials	15
Taxes, Insurance, and Administrative Charges:	4% of the total capital costs	15
Capital Recovery:	15-year life and 10% interest rate	

[a] Q_w = water injection rate, lb/hr, (from Equation 1 in Section 3.3.1).

[b] Assume 20 feet of pumping height, 100 psi discharge pressure, and 10 ft/sec velocity in pipe.

REFERENCES

1. PEI Associates, Inc. User's Manual for the Integrated Air Pollution Control System Cost and Performance Program (Version 2). Prepared for the U. S. Environmental Protection Agency. Research Triangle Park, NC. Contract No. 68-02-3995. April 1985. p. 4-16.

2. Neveril, R.S. (GARD Inc.) Capital and Operating Costs of Selected Air Pollution Control Systems. Prepared for U. S. Environmental Protection Agency. EPA-450/5-80-002. December 1978. p. 4-40.

3. Reference 2. p. 4-41.

4. Letter from Sedman, C.B., EPA, to Chang, J. Acurex Corporation. July 14, 1986. EPA guidelines for costing flue gas cleaning technologies for municipal waste combustor.

5. Reference 2. p. 3-11.

6. Reference 2. p. 3-14.

7. United States Department of Commerce. Survey of Current Business. Washington, D.C. Volume 68. Number 6. June 1988. p. S-12.

8. Electric Power Research Institute. TAG - Technical Assessment Guide (Volume 1: Electricity Supply - 1986). Palo Alto, CA. Publication No. EPRI P-4463-SR. December 1986. p. B-4.

9. Energy Information Administration. Monthly Energy Review: December 1987. Washington, D.C. Publication No. DOE/EIA-0035 (87/12). March 1988. p. 109.

10. Reference 2. p. 4-41.

11. U. S. Environmental Protection Agency. Municipal Waste Combustion Study: Costs of Flue Gas Cleaning Technologies. Research Triangle Park, NC. Publication No. EPA/530-SW87-021e. June 1987.

12. Reference 2. p. 3-12.

13. Reference 5. p. 4-23.

14. Letter from Solt, J.C., Solar Turbines Incorporated, to Noble, E., EPA. October 19, 1984. Development cost for wet control for stationary gas turbines.

15. U. S. Environmental Protection Agency. EAB Control Cost Manual. Research Triangle Park, NC. Publication No. EPA-450/5-87-001A. February 1987. p. 2-31.

EPA-450/3-76-014

CAPITAL AND OPERATING COSTS OF SELECTED AIR POLLUTION CONTROL SYSTEMS

by

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Office of Air and Waste Management
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May 1976

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Size fans for 54,300 ACFM and 95,100 ACFM for glass and polyester bags respectively. Select 50' high stacks of 50" and 66" respectively. Fifty feet of 9" diameter screw conveyor will be required.

Case B - Electrostatic Precipitator — FOR LIME KILN

Establish overall engineering design as follows:

a. Drift velocity = .25 fps.

b. Insulated precipitator

c. Inlet gas temperature of 700F for good resistivity

d. Spray chamber next to source

Figure 3-2 shows the system layout for an electrostatic precipitator operation. The following discussion outlines how the design parameters are obtained for each stage along the system.

Stage 1. Same as for Case A, Fabric Filter.

Stage 2. Estimate spray chamber outlet temperature of 800F. Water required is about 15 gpm. Chamber length is about 35 feet. New gas volume will be:

$$88{,}300 \text{ ACFM} \times \frac{1260 \text{ R}}{1560 \text{ R}} = 71300 \text{ ACFM}$$

Calculate duct diameter:

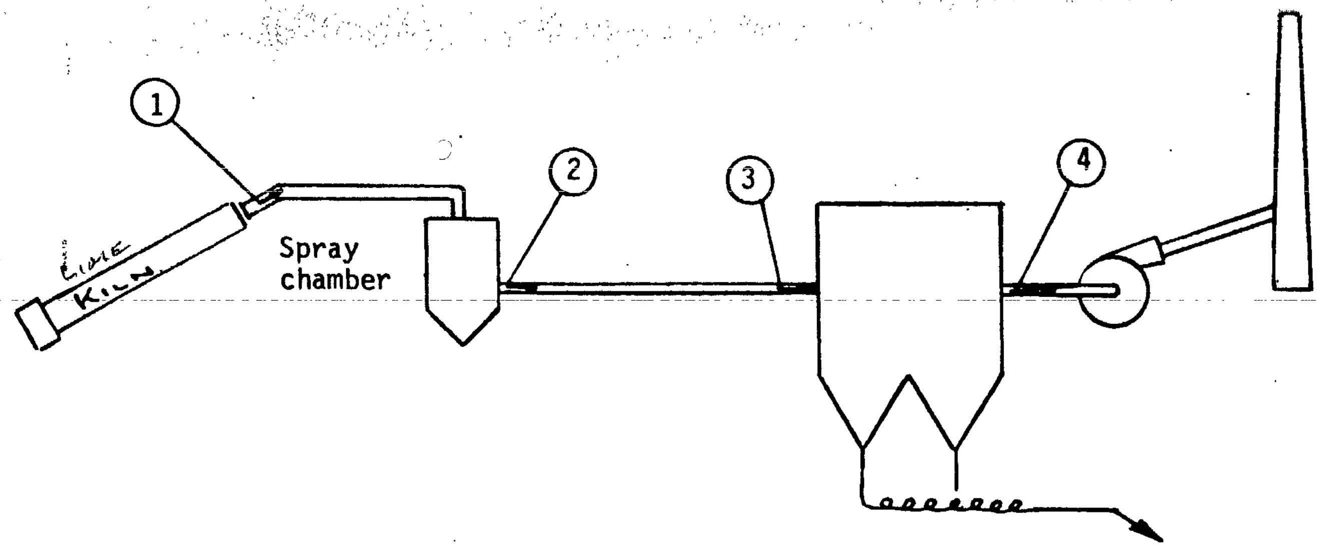
$$\frac{71{,}300 \text{ ACFM}}{4000 \text{ fpm}} = 17.8 \text{ ft}^2$$

Hence 55" duct (16.5 ft^2) may be used, giving:

$$\frac{71{,}300 \text{ ACFM}}{16.5 \text{ ft}^2} = 4300 \text{ fpm}$$

Stage 3. a. Cooling through duct will be about 110F (for 200-35=165 ft). Hence final temperature is 690F and new gas volume is:

$$71300 \text{ ACFM} \times \frac{1150 \text{ R}}{1260 \text{ R}} = 65000 \text{ ACFM}$$



DESIGN PARAMETER	1	2	3	4
SCFM	30,000	30,000	30,000	30,000
TEMPERATURE	1100 F	800 F	690 F	690 F
ACFM	88,300	71,300	65,000	65,000
DUCT DIAMETER	64"	55"	55"	Neglect
STATIC PRES. (" WG)	Kiln Draft		-1.0"	-1.5"

Figure 3-2 ELECTROSTATIC PRECIPITATOR SYSTEM DESIGN