

DRY FLUE GAS CLEANING PROCESSES FOR ACHIEVING AIR POLLUTANT EMISSIONS REQUIREMENTS¹

THEODORE G. BRNA

U. S. Environmental Protection Agency
Air and Energy Engineering Research Laboratory
Research Triangle Park, North Carolina

ABSTRACT

Dry flue gas cleaning (FGC) processes can meet requirements for regulated air pollutants from municipal waste combustors (MWCs): acid gas, trace organic, trace heavy metal, and particulate matter emissions. Rules for controlling these and nitrogen oxides emissions from MWCs with a capacity over 225 tonnes/day (tpd) [250 tons/day (TPD)] were published by the U.S. Environmental Protection Agency (EPA) in early 1991 in compliance with the Clean Air Act Amendments of 1990 (CAAA). The CAAA also require EPA to review these rules; to set emission limits for cadmium, lead, and mercury; and to promulgate air emission rules for MWCs rated at 225 tpd (250 TPD) and less according to a phased schedule.

Following a brief discussion of the MWC rules, basic dry FGC processes are discussed and their performance is compared using field test data. Methods to supplement dry FGC processes for improving the control of mercury and organics are also addressed.

INTRODUCTION

The combustion of municipal solid waste (MSW) reduces the volume of waste requiring disposal, can

thermally destroy toxic organic compounds in MSW, and can recover energy from MSW. Its disadvantages include the generation of air pollutant emissions (acid gases, trace organics, trace metals, and particulate matter), which depend on composition of the waste and combustion conditions. Flue gas cleaning (FGC) processes to control these emissions transfer most of the removed pollutants to liquids or solids, which may require further treatment prior to disposal or beneficial use of these products (residue or ash).

The objectives here are to briefly discuss the federal rules for municipal waste combustors (MWCs) that were published on February 11, 1991, and to describe FGC processes that can be used to comply with these rules. Dry FGC processes will be emphasized since they are used extensively on MWCs larger than 225 tpd (250 TPD) to which the rules given in Table 1 apply. In-furnace processes for the control of acid gases and nitrogen oxides (NO_x) and wet acid gas scrubbing will be noted. The acid gas control processes can satisfy some of the new emissions rules, while an in-furnace process, selective noncatalytic reduction (SNCR), serves as the basis for the NO_x limit in the new source performance standards (NSPS). The disposal of FGC process wastes will not be addressed, as these wastes from many recently built MWCs are disposed of in special landfills, and their reuse is currently limited. Particular attention will be given to mercury (Hg) control.

¹ This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication.

TABLE 1 RULES FOR MUNICIPAL WASTE COMBUSTORS [1]

Good Combustion Practice (GCP)

- Maximum load demonstrated during performance test for polychlorinated dibenzo-p-dioxin and dibenzofuran (PCDD/PCDF) emissions
- Maximum particulate matter (PM) control demonstrated during performance test for PCDD/PCDF
- Carbon monoxide (CO) - emission limit varies from 50 to 150 parts per million by volume (ppmv) depending on type of combustor
- Certification of municipal waste combustor (MWC) supervisor. Training manual and training for MWC operators.

Emission Limits (Referenced to 7% O₂, dry gas)

	NSPS ^a	Emission Guidelines (EG)	
	>225 tonnes/day	>225 tonnes/day ≤1000 tonnes/day	>1000 tonnes/day
•MWC organic emissions PCDD/PCDF, ng/dscm ^b	30	125 ^c	60
•MWC metal emissions PM, mg/dscm ^d	34	69	34
Opacity, % (6-min. avg.)	10	10	10
•MWC acid gas emissions Sulfur dioxide (SO ₂), % removal (ppmv)	80 (30)	50 (30)	70 (30)
Hydrogen chloride (HCl), % removal (ppmv)	95 (25)	50 (25)	90 (25)
•Nitrogen oxides emissions Nitrogen oxides (NO _x), ppmv	180	NA ^e	NA
Monitoring Requirements			
•SO ₂ (CEMS ^f , ≤24-hr geometric mean)	Y ^g	Y	Y
•NO _x (CEMS, 24-hr arithmetic mean)	Y	N ^h	N
•Opacity (CEMS, ≤6-min. average)	Y	Y	Y
•CO, load, temperature (CEMS, 4- or 24-hr average)	Y	Y	Y
•PM, PCDD/PCDF, HCl (annual stack test)	Y	Y	Y

^a NSPS = new source performance standards. 1 tonne/day = 1.1 tons/day.

^b ng/dscm = nanograms/dry standard cubic meter [Standard conditions: 20°C (68°F), 101.3 kPa (14.7 psi)].

^c Limit for refuse-derived fuel (RDF) stoker MWCs is 250 ng/dscm.

^d mg/dscm = milligrams/dry standard cubic meter.

^e NA = not applicable (no limit set).

^f CEMS = continuous emission monitoring system.

^g Y = yes (monitoring required).

^h N = no (monitoring not required).

Good combustion practice (GCP), with the exception of the limit on maximum temperature at the inlet to the main particulate matter (PM) control device, applies primarily to combustor design or operation, while monitoring requirements address compliance with the prescribed emission limits. GCP serves to reduce organic emissions [i.e., products of incomplete combustion (PICs)], and carbon monoxide (CO) serves as a continuously monitorable indicator of good or poor combustion. Thus GCP and monitoring requirements, although listed in Table 1 for completeness, will be discussed only briefly here.

FEDERAL EMISSION RULES

The new federal rules for MWCs, published on February 11, 1991, apply to both new and existing sources [1]. As shown in Table 1, the NSPS apply to units with a capacity to burn over 225 tpd of "residential, commercial, and/or institutional discards," while the emission guidelines (EG) concern two categories: units with capacities over 225 tpd but facilities whose aggregated capacities are below 1000 tpd (1100 TPD) and facilities whose aggregated capacities of units larger than 225 tpd exceed 1000 tpd. Each size unit/facility has rules for GCP, emission limits, and monitoring methods/requirements. The GCP rules include CO emission limits (dependent on combustor type and age), steam load limits, PM collector inlet temperature restrictions, and operator/supervisor certification/training requirements. Emission limits are specified for MWC organics, MWC acid gases, MWC metals (measured as total PM), and NO_x (new units only). Section 129 of the Clean Air Act Amendments of 1990 (CAAA) requires the U.S. Environmental Protection Agency (EPA) to review and revise the NSPS and to set emission limits for cadmium (Cd), lead (Pb), and mercury (Hg) by November 15, 1991 [2]. The CAAA also require EPA to issue emission rules for MWCs with capacities of 225 tpd and less by November 15, 1992.

EMISSIONS REDUCTION DURING COMBUSTION

Organic Control

Furnace and combustion processes for the control of air pollutant emissions are designed to destroy combustible and toxic organic [polychlorinated dibenzo-*p*-dioxin and dibenzofuran (PCDD/PCDF)] compounds or to reduce or remove noxious components (acid gases

and NO_x). As noted earlier, GCP addresses the control of organic pollutants, and CO is a continuously monitored indicator of the combustor's effectiveness in destroying organics in the high temperature regions of the furnace; high CO values suggest high total PCDD/PCDF concentration in flue gases, and low CO values are associated with low total PCDD/PCDF values [3].

Acid Gas Control

Calcium compound injection into the furnace is being used to control acid gases [hydrogen chloride (HCl) and sulfur dioxide (SO₂)] [4, 5]. While limestone (Montgomery County, Ohio), lime, and hydrated lime (Alexandria, Virginia) are being applied, hydrated lime provides the most effective control and limestone the least effective. Use of these compounds through in-furnace injection may achieve 50% or more removal of both HCl and SO₂ as required by the EG in Table 1 for large units (> 225 tpd) and large facilities (≤ 1000 tpd), but it appears unlikely that the in-furnace injection of these sorbents can meet the EG for very large facilities (> 1000 tpd) or the NSPS for large units.

NO_x Control

Table 2 lists technologies for achieving NO_x control in Japan [4]. These technologies are also applicable in the U.S., where uncontrolled NO_x emissions from highly efficient mass burn units may average 300 ppmv, referenced to dry gas with 12% carbon dioxide (CO₂), or about 325 ppmv at 7% oxygen (O₂), compared with the 150 ppmv NO_x at 12% O₂ given in Table 2.

The NO_x limit in Table 1 is based on SNCR which corresponds to (in-furnace) "ammonia injection without catalyst system" in Table 2. Since the ammonia (or urea)/NO_x reactions are temperature sensitive, the injection location must permit the reducing reaction while avoiding excessive ammonia slip (i.e., ammonia which does not react with NO_x to obtain N₂ and O₂). Table 2 suggests that a NO_x reduction of 45–65% can be obtained using SNCR (also called Thermal DeNO_x), and U.S. data confirm this [4]. Seasonal variations in the MSW's nitrogen content, such as that caused by variable amounts of yard waste, affect uncontrolled NO_x emissions and may impact NO_x control.

While the technological basis for the NO_x standard (Table 1) is SNCR, the NSPS does not specify how this limit (or any other pollutant limit) is to be reached. A combination of NO_x control methods, including combustor design, reburning, and exhaust gas recirculation, or post-combustion methods (see last two systems in Table 2) can be used.

TABLE 2 EFFECTIVENESS OF NO_x CONTROL FOR JAPANESE MUNICIPAL WASTE COMBUSTORS
(Courtesy of Hitachi Zosen Corp., Osaka, Japan)

System	Attainable Control Level (ppmv, dry, 12% O ₂)										Remarks
	150	120	100	90	80	70	60	50	40		
Uncontrolled	←→										
Automatic Combustion Control		←→									
Water Spray in Combustion Chamber			←→								used with automatic combustion control
Flue Gas Recirculation					←→						used with automatic combustion control
Ammonia Injection without Catalyst					←→						used with automatic combustion control
Ammonia Injection with Catalyst							←→				
Wet Scrubber with Oxidization							←→				

Note: Concentrations in Japan for municipal waste combustors are normally referenced to 12% O₂ in dry gas.

POST-COMBUSTION EMISSIONS CONTROL

Acid Gas Control

Dry scrubbing systems are used extensively for controlling air pollutant emissions from MWC units in the U.S. Several facilities rated at 180 tpd (200 TPD) or less use in-duct (or duct) injection of powdered hydrated lime followed by a fabric filter (FF), but most recent plants and those being planned use lime spray dryer absorbers (SDAs) followed by FFs or electrostatic precipitators (ESPs). Figures 1, 2, and 3 illustrate these systems. (These figures also show supplemental Hg control options, but these will be discussed later under Metal Emissions Control.) The duct sorbent injection (DSI) system is an all-dry system, while an alkali slurry is injected into the SDA. Although dry solids and unsaturated clean flue gas are discharged from the SDA/PM collection system, this system is often called a semi-dry, rather than a dry, scrubber because the sorbent fed to the SDA is in a slurry (or solution).

The DSI/FF system is the simplest FGC process for removing acid gases from flue gas. When a dry sorbent

[normally calcium hydroxide, Ca(OH)₂] is used, substantial contact time between the sorbent and targeted acid gas (such as SO₂) is needed to obtain high removal. This factor makes a FF preferable to an ESP, and the FF also has unreacted sorbent in its filter cake to counter sudden increases of acid gas concentrations.

The DSI/FF system used to control HCl and SO₂ at MWCs in the U.S. generally use Ca(OH)₂. HCl removals exceeding 90% and SO₂ removals above 75% have been reported for several units in the 90–110 tpd (100–120 TPD) range [4–7]. While these units are too small to be covered by the emission rules presented in Table 1, they would meet the acid gas EG shown, and their FGC systems could be models for upgrading of large units to meet the EG.

Since the approach to saturation temperature achieved with a SDA is usually lower than with DSI, acid gas removal is normally greater with the SDA. Tests on large commercial MWCs have shown HCl removals of 90% or more and SO₂ removals above 70% for both lime SDA/FF and SDA/ESP systems [5]. These units [each with a capacity of 680 tpd (750 TPD)] would meet the EG for large units given in Table 1. The

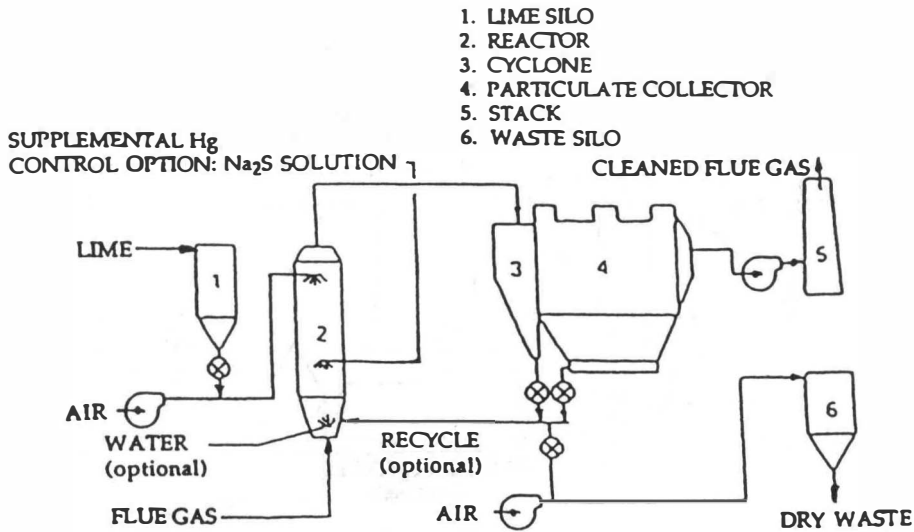


FIG. 1 DRY SORBENT INJECTION INTO FLUID BED REACTOR

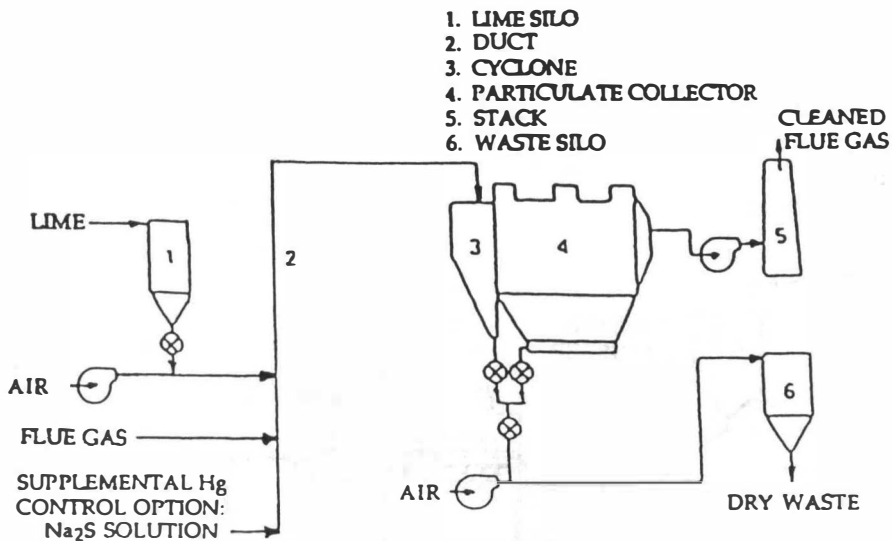


FIG. 2 IN-DUCT DRY SORBENT INJECTION PROCESS

SDA/FF-equipped units would also meet the NSPS in Table 1, as would other SDA/FF-equipped units [8, 9].

While wet acid gas scrubbing systems are not currently used in the U.S. on MWCs, they are used for multipollutant control in Japan and Western Europe. Systems such as those illustrated in Figs. 4 and 5 can remove over 95% HCl, 90% or more SO₂, and high percentages of condensable trace metals and organics (PCDDs/PCDFs). These scrubbers are normally preceded by ESPs and are staged to remove primarily HCl in the first stage and SO₂ (often using caustic soda) in the second stage. Additives can be used to effect

supplemental Hg and NO_x control. For Hg control, sodium hypochlorite (NaClO) has been used in Japan to oxidize Hg to HgCl₂ and to effect HgCl₂ removals of 90–95% [10]. To avoid Hg accumulation in the scrubber effluent and its subsequent recirculation through the scrubber, the addition of trimercapto-s-triazine (TMT) to scrubber effluent has been used as a combined Hg precipitation and flocculation agent with subsequent Hg removals of 99% or more [11]. NaClO had been proposed earlier for NO_x control in Japan, assuming the NO was oxidized to NO₂ first and then removed primarily in the SO₂ scrubbing stage [12]. The

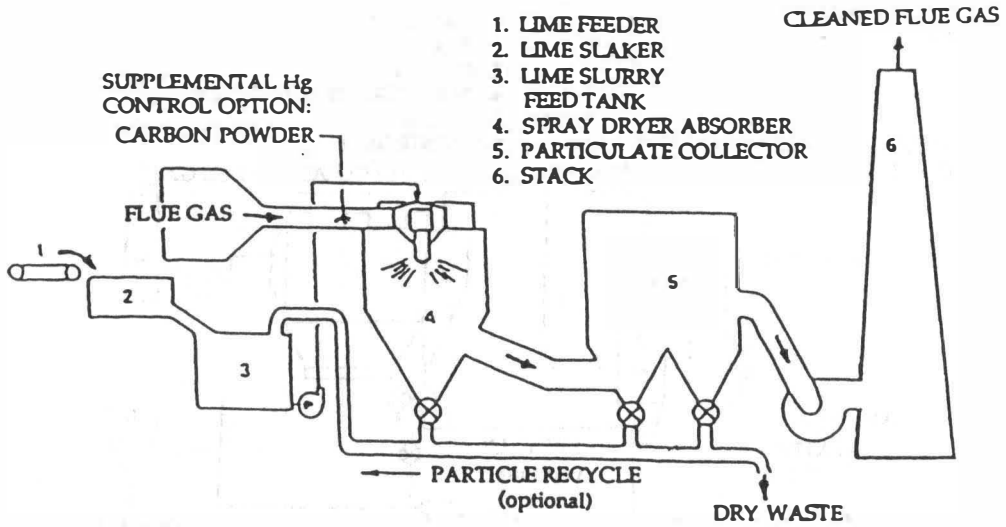


FIG. 3 SPRAY DRYER ABSORPTION (Semi-Dry) PROCESS

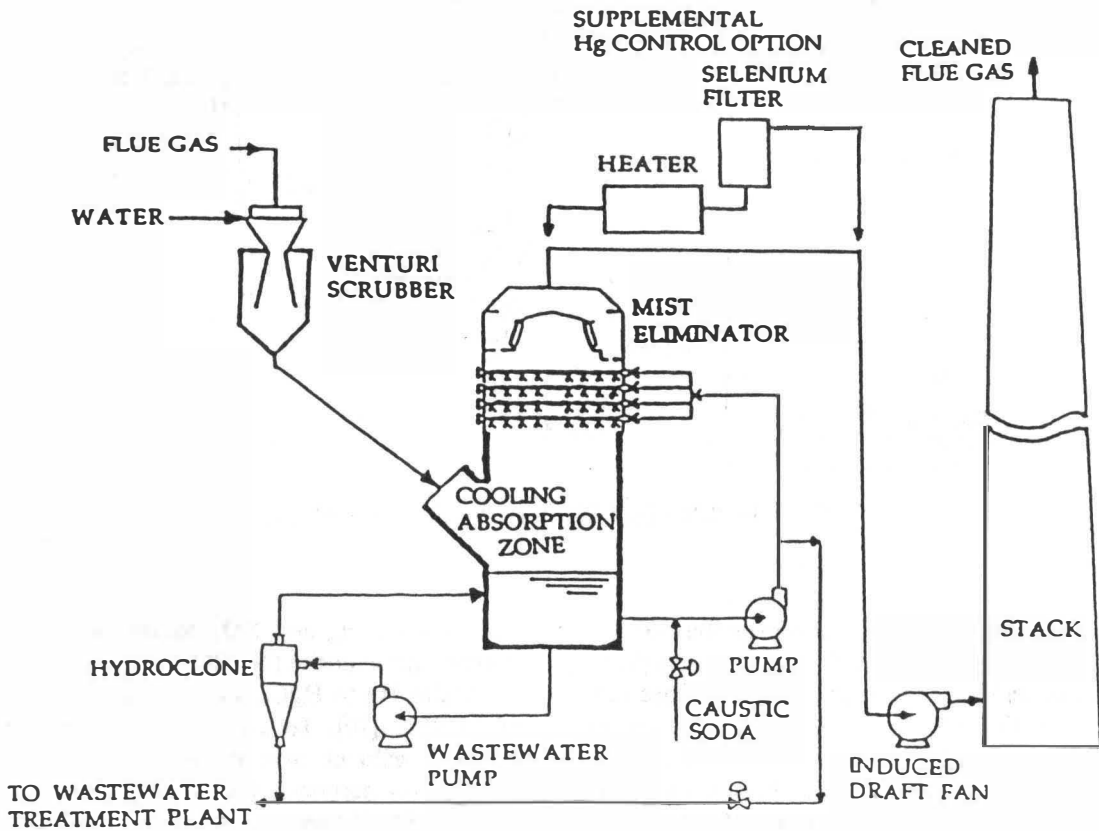


FIG. 4 WET FLUE GAS SCRUBBING SYSTEM

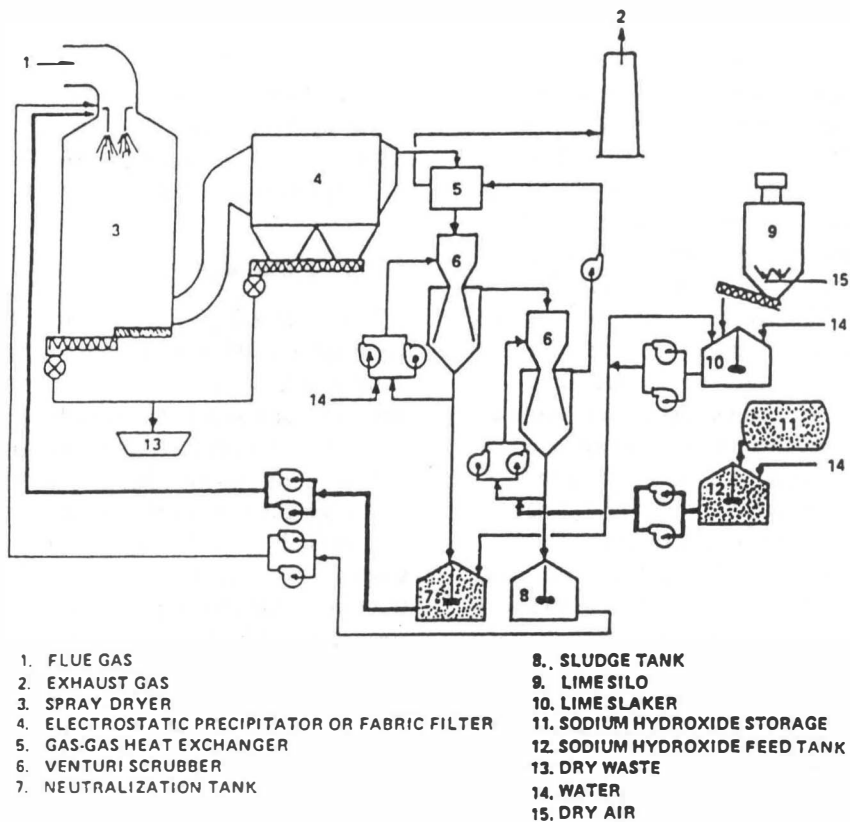


FIG. 5 WET SCRUBBING PROCESS WITH ZERO EFFLUENT DISCHARGE

most recent NO_x control practice now adds bromine plus NaClO to wet scrubbing for Hg control and to reduce NO_x by 30–50% [10].

Particulate Matter (PM) Control

In addition to being a criteria pollutant, PM is used as a surrogate for controlling metals emissions for both the NSPS and EG (see Table 1). Because background information for the development of the MWC emission rules indicated that a PM emission limit of 34 ng/dscm (0.015 gr/dscf) corresponded to 99% removal of all heavy metals of concern, except Hg, and that a PM limit of 69 ng/dscm (0.030 gr/dscf) corresponded to 97% removal of heavy metals, except Hg, PM removal downstream of the furnace/boiler will likely be required to comply with the MWC emission rules. However, as noted earlier, the CAAA require EPA to set emission limits for Cd, Hg, and Pb.

PM control devices (ESPs or FFs) now used on large units and very large facilities can achieve the promulgated PM emission limits. Both the NSPS and EG, however, require that the MWC be operated so that the temperature at the inlet of the final PM control

device does not exceed 17°C (30°F) above the maximum demonstrated temperature during the most recent PCDD/PCDF compliance test. Thus, upgrading of the PM collector may be needed to meet emission rules as a consequence of FGC system operating or equipment changes made to meet acid gas, trace organic, or trace metal emission limits.

Organic Emissions Control

GCP has been formulated to limit PCDD/PCDF emissions and may also be effective in controlling other organic emissions (e.g., chlorophenols, chlorobenzenes, polynuclear aromatic hydrocarbons, or other PICs). However, GCP alone is not expected to permit attaining the required PCDD/PCDF limits (Table 1).

Acid gas scrubbers, while intended mainly for removing HCl and SO_2 , also remove organic pollutants. While the control mechanisms are not well understood, the capture of organics through their condensation on or attachment to particles, and the destruction of organics by caustic attack during scrubbing processes are thought to foster their removal from flue gas. Flue gases enter the air pollution control system at about 200°C

(400°F) and leave a dry system at 140–150°C (285–300°F) and a wet system at 60°C (140°F) or more. Consequently, condensation would seem to be favored in wet scrubbing, but PCDD/PCDF data for SDA/FF systems have shown removals above 95% [4]. PCDD/PCDF removals by wet systems have been about 75%, but a recent report indicates reductions of 95% or more on MWCs in both France and Switzerland [13].

The less effective PCDD/PCDF removal by wet scrubbers relative to dry scrubbers suggests that factors other than flue gas temperature are important to controlling PCDD/PCDF emissions. These factors are believed to include: ash/residue particle size and concentration (adsorption is enhanced by small particles with relatively large surface areas compared with large particles), carbon (C) content of flyash/residue (higher C content appears to promote PCDD/PCDF capture), gas composition [high oxygen (O₂) and moisture contents support formation of PCDD/PCDF via de novo synthesis in the temperature range of about 230–400°C (450–750°F)], and sorbent characteristics (high alkalinity may enhance the destruction of organics while small particles provide condensation nuclei or sites).

The organic emissions limits given in Table 1 are based on SDA/FF systems. While these limits (30–250 ng/dscm) appear high relative to the 0.1 ng/Nm³ 2,3,7,8 tetrachlorinated dioxin (TCDD) equivalent limit of several European countries, conversion of total PCDD/PCDF values to their 2,3,7,8 TCDD toxic equivalents for SDA/FF systems on both mass burn and refuse-derived fuel (RDF) MWCs tested in the U.S. revealed toxic equivalent values below 0.1 ng/Nm³ [14]. It should also be noted that no single factor seems appropriate for converting total PCDD/PCDF values to their 2,3,7,8 TCDD toxic equivalents and that updating of the toxic equivalencies of the various isomers may affect the ratio of total PCDD/PCDF to toxic equivalent values at a given time.

Activated C powder has been injected into the flue gas to improve PCDD/PCDF removal from waste incinerators in Europe. When used to supplement lime DSI/FF systems, activated C permitted attainment of emission limits which were not being achieved with the basic FGC system [15]. Activated C addition ahead of a lime SDA/ESP system also improved total PCDD/PCDF control (as well as Hg removal), but C injection had no effect on PCDD/PCDF control for a lime SDA/FF system when the total PCDD/PCDF was already high (> 95%) [16, 17]. A carbon bed following an acid gas scrubber has also been proposed as the final scrubbing stage to improve multipollutant control and to reduce the concentration of chlorinated dioxin and furan isomers to or near nondetectable values [18].

Tests on a MWC (Hamburg-Stapelfeld) gave the total PCDD/PCDF emission in flue gas leaving the bed as 0.098 ng/Nm³. Assuming the value given to be referenced to 11% O₂ in dry gas, this value is equivalent to 0.14 ng/Nm³ at 7% O₂.

Metals Emissions Control

FGC technologies now used in the U.S. can achieve the required PM emission limits (Table 1) and simultaneously attain high control of metals emissions of concern, except possibly Hg [19]. Most metals are volatilized from the MSW feed during its combustion, and the metallic vapors condense as the flue gases cool following the combustion process. Condensation concentrates the volatile species on fine particles which have high surface areas [20]. Thus, the submicrometer fraction of the PM is enriched with condensed volatile species, and efficient collection of this fraction is essential for their control.

Figure 6 presents saturation curves for selected metals and their compounds. Because the sampling and analytical methods determine the concentration of a metallic species regardless of its chemical form, the saturated vapor concentrations for specific metal species cannot be translated to the measured concentrations. Metals data, except for Hg, indicate that over 90% of the metals analyzed are in the solid phase despite the high volatility of some of their compounds. Elemental arsenic (As), Cd, Hg, and selenium (Se), plus chlorides of As, Hg, Se, and zinc (Zn), may be entirely in the vapor phase as they leave the combustor because of their relatively high volatilities.

Inorganic metal compounds, in contrast to organic compounds, have a low tendency for chemical adsorption on PM. The sampling of flue gas at 205°C (400°F) or lower temperature indicated that most metals were in their less volatile chemical forms because most of the total metallic species were present in the particulate phase [21]. Mercury, however even at stack gas temperatures of 120–150°C (250–300°F), was in the vapor phase as it was collected mostly in the back half of the sampling train.

While acid gas removals of 90% or more for HCl and over 70% for SO₂ are attainable with dry scrubbers, metals removal is also usually high because of the effective collection of both total PM mass and fine particles. If Hg control is inadequate due to Hg not being in the solid phase, it can be improved by injecting sodium sulfide (Na₂S) or activated C into the flue gas prior to Ca(OH)₂ injection or by using a C bed to provide further gas cleaning after acid gas scrubbing. When Na₂S is injected (see Figs. 1 and 2), mercuric sulfide (HgS)

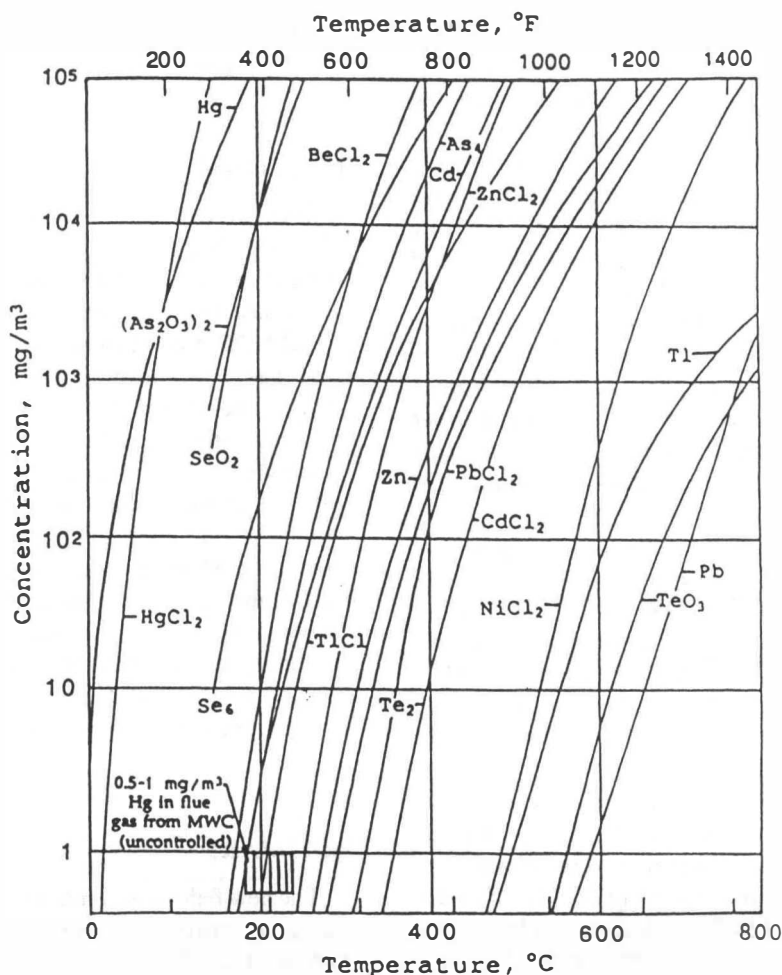


FIG. 6 SATURATION CURVES FOR SELECTED METALS AND COMPOUNDS

is formed in the Na_2S -Hg reaction and removed in the PM collector, while C injection (Fig. 3) leads to the adsorption of Hg vapor on the C particles and its removal in the PM collector. MWCs demonstrating high Hg control have been suspected of having significant unburned C in their flyash, while those showing low or poor Hg capture are believed to have had low C in their fly ash. Thus, RDF units have shown high Hg (and PCDD/PCDF) control, while some high combustion efficiency mass burn units have exhibited poor Hg control.

Both additives, Na_2S and activated C, have been applied in Europe and North America to improve Hg control. Na_2S in conjunction with DSI/FF systems is being used to improve Hg control in Sweden and Germany. Test results at the Högdalen plant during 1988-1990 showed Hg removals normally exceeding 85% when a 10% Na_2S solution was used [22]. Testing with

a similar FGC (DSI/FF) system in Vancouver, except that water quenching was used to reduce flue gas temperature (Fig. 1) rather than a heat exchanger as used at Högdalen, indicated that Hg removal averaged 85% for seven tests (August-September 1989) with the change in Na_2S addition rate [2-6 kg/h (4.4-13.2 lb/hr)] having little, if any, effect on Hg removal for an average inlet Hg concentration of $505 \mu\text{g/dscm}$ at 11% O_2 ($709 \mu\text{g/dscm}$ at 7% O_2) [23]. With sodium hydrosulfide (NaHS), which is less expensive than Na_2S and easier to handle since it is received as a bulk liquid rather than as solid crystals as is Na_2S , the results of six tests (September-October 1989) gave an average Hg removal of 76% when the average uncontrolled Hg concentration was $550 \mu\text{g/dscm}$ at 11% O_2 ($772 \mu\text{g/dscm}$ at 7% O_2). Again the Hg removal showed little sensitivity to the additive feed rate [2-10 kg/h (4.4-22.1 lb/hr)].

Activated C has been used to improve Hg capture at Vancouver (DSI/FF system) and for SDA/ESP and SDA/FF systems. The Vancouver tests on units rated at 240 tpd (265 TPD) averaged 84% Hg removal over 14 tests with an average Hg concentration of 490 $\mu\text{g}/\text{dscm}$ at 11% O_2 (688 $\mu\text{g}/\text{dscm}$ at 7% O_2) at the inlet to the air pollution control system [23]. The C feed rate used for six of the tests was 2.0 kg/h (4.4 lb/hr) and was dictated more by the need to maintain a steady feed rate rather than by the minimum rate for good Hg control. The activated C addition technology has been selected for installation on all three mass burn units at the Burnaby plant in Vancouver. Lower cost and lower health risk to plant employees were cited as factors for choosing C over Na_2S injection as the supplementary Hg control system.

C injection has been used to supplement Hg control in Europe for both SDA/ESP and SDA/FF systems [24]. At a 360-tpd (400-TPD) MWC in Zurich, C injection upstream of the SDA/ESP system improved Hg removal from about 45% to 90%. Reducing the SDA outlet temperature from 140°C to 110°C (284°–230°F) improved Hg capture from about 30% to 45% without C addition. Reducing the SDA outlet temperature and adding C ahead of the SDA/FF system were also effective in improving Hg control in the 275-tpd (300-TPD) unit in Amager, Denmark. Hg removal improved from 43% at 140°C (284°F) and 76% at 127°C (260°F) without C addition to about 95% when C was added to give a flue gas concentration of about 60 mg/Nm^3 .

Both Na_2S and activated C injection upstream of the SDA/FF system were tested for Hg control in one 360-tpd (400-TPD) unit of the Ogden Martin Systems of Stanislaus, Inc. plant in tests completed in August 1991. Since this unit near Modesto, California, has SNCR for NO_x control, one objective of the EPA-sponsored C injection testing was to determine if ammonia affects Hg control. The Institute of Resource Recovery supported the Na_2S injection testing under the direction of Ogden Projects, Inc. Test results are not available at this time.

Conventional wet scrubbing can effectively remove metals from flue gas. However, if supplemental Hg control is required, then the approaches noted earlier (NaClO addition to scrubber slurry/solution, TMT addition to scrubber water, and C beds following scrubbing of flue gas) are available. An additional approach is to use a Se filter after the wet-scrubbed gas has been heated above its dewpoint [20, 25]. This gas is passed through a porous material impregnated with Se so that Hg reacts with Se and the HgSe is retained in the filter (see Fig. 4). The filters are designed for a 5-year lifetime and may be used in parallel to meet capacity require-

ments. The MWC being built in Karlskoga, Sweden, in 1991 will use Se filters.

NO_x Control

Selective catalytic reduction (SCR) and wet scrubbing for NO_x control on MWCs have not yet been applied in the U.S. Of the SCR options shown in Fig. 7, the last two are being applied to MWCs. Conventional SCR [Fig. 7(a)] would subject catalysts to high acid gas concentrations and probably significantly shorten their normally expected 2–3 year lifetime. The SCR arrangement in Fig. 7(b) is being used on units in Japan with low temperature catalysts [190–250°C (375–480° F)] to attain about 50% NO_x control on a space-limited retrofit application and about 80% NO_x reduction on a MWC designed with SCR [26]. The SCR option shown in Fig. 7(c) has been retrofitted to a unit in Germany (Munich South plant) [27]. This system was designed for 90% NO_x removal, but no performance data for the unit which was in start-up in the fall of 1990 are currently available.

SUMMARY

The new federal air emission rules for MWCs require stringent control of pollutants such as acid gases (HCl and SO_2), PCDD/PCDF, and PM. NO_x control will also be necessary for units with capacities over 225 tpd under the revised NSPS. EPA will issue emission limits for Cd, Hg, and Pb and rules for units of 225 tpd or lower capacity according to the phased schedule of the CAAA.

Generally, SDA/FF technology has been the basis for the new rules; however, the DSI/FF system may be appropriate for achieving the EG applicable to units over 225 tpd. These technologies may also require supplemental methods of Hg control because Hg control seems to be a problem for some MWCs, particularly for highly combustion-efficient ones. Both Na_2S and C injection have been used to supplement Hg control by dry scrubbers, with C also having the potential to improve PCDD/PCDF control. While not being currently used on MWCs in the U.S., wet acid gas scrubbing has the potential to meet the new rules and can be augmented for improved PCDD/PCDF and Hg control.

NO_x control can be effected by SNCR, SCR, or wet scrubbing, with SNCR being the basis for the revised NSPS. SCR using low temperature catalysts or flue gas reheating after acid gas and PM removal is being ap-

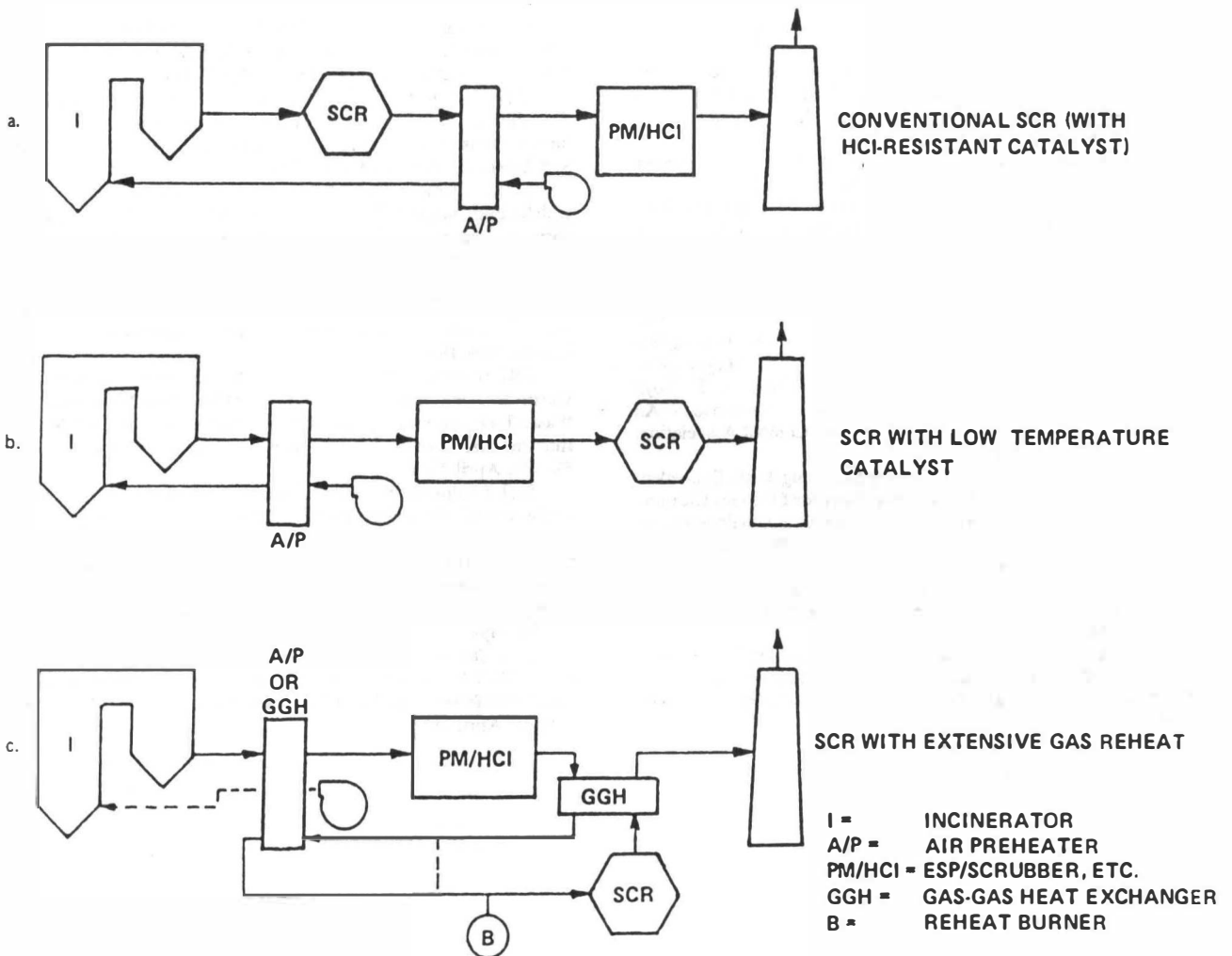


FIG. 7 SELECTIVE CATALYTIC REDUCTION (SCR) OPTIONS FOR MUNICIPAL WASTE COMBUSTORS

plied outside the U.S. to obtain higher NO_x removals than normally achieved with SNCR.

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