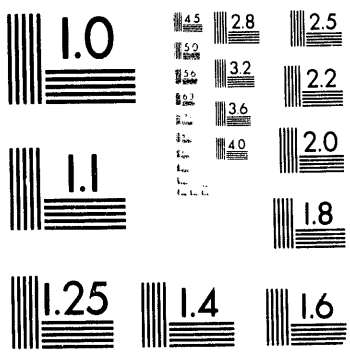
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REGULATION OF HAZARDOUS AIR POLLUTANTS EMITTED FROM FOSSIL-FIRED BOILERS

Paul L. Hendrickson
Keith K. Daellenbach

ABSTRACT

The changes made in §112 of the Clean Air Act by the 1990 Amendments to the Act will affect the regulation of hazardous air pollutants (HAPs) emitted by fossil-fired boilers. The 1990 Amendments designated 189 chemicals/compounds as HAPs. Major and area sources of these pollutants in categories designated by the Environmental Protection Agency (EPA) will be subject to emission standards set by EPA. Industrial and institutional/commercial boilers are two such categories of HAPs designated by EPA for which emission standards will be issued. Fossil-fired boilers can emit a variety of HAPs. All or a portion of such emissions that exceed designated thresholds are likely to be regulated. Source owners have the option of participating in the early reduction program before final standards are issued.

STATUTORY BACKGROUND

Hazardous air pollutants (HAPs) were a significant concern of Congress when it amended the Clean Air Act (CAA) in 1990. According to industry estimates, more than 2.4 billion pounds of HAPs were emitted to the atmosphere in 1988 (EPA 1991, p. 30). HAPs can cause a variety of adverse health effects including cancer, reproductive effects, birth defects, and respiratory illness (EPA 1991, p. 30).

Title III of the 1990 CAA Amendments completely replaced §112 of the CAA which covers HAPs. Before 1990, regulation of HAPs at the federal level was relatively limited. The original §112, enacted as part of the CAA in 1970, required the Environmental Protection Agency (EPA) to identify HAPs "which may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness." Once a HAP was identified, EPA had one year to issue a final emission standard that provided "an ample margin of safety" to the public. By 1990, EPA had issued only seven national emission standards for hazardous air pollutants (NESHAPS). The standards cover mercury, beryllium, radionuclides, asbestos, vinyl chloride, benzene, and inorganic arsenic. These standards apply to both new and existing sources, are still in effect, and are codified in Part 61 of Title 40 of the Code of Federal Regulations (CFR).

1990 CLEAN AIR ACT AMENDMENTS

Congress took a different approach to the regulation of HAPs in the 1990 CAA Amendments. Section 112(b) of the CAA now designates 189 chemicals/compounds including heavy metals and organic compounds as HAPs. Section 112(a) of the CAA defines a "major source" of HAPs to be a stationary source or group of stationary sources that emits 10 or more tons per year of any single HAP or 25 or more tons per year of any combination of HAPs. "Area sources" are defined to be stationary sources of HAPs that are not major sources.

Section 112(c) of the CAA directs EPA to issue a list of categories and subcategories of major and area sources of HAPs. The initial list includes industrial boilers and institutional/commercial boilers as major source categories [57 Federal Register (FR) 31591, July 16, 1992]. Emission standards for the designated categories and subcategories of major and area sources are to be issued according to the schedule in §112(e) of the CAA. EPA's draft schedule for issuing emission standards for categories of HAP-emitting sources

of existing sources will be met [CAA, §112(g)(2)(A)]. If the MACT standard has not yet been issued, an appropriate emission standard is to be determined on a case-by-case basis. A modification is "any physical change in, or change in the method of operation of, a major source which increases the actual emission of any hazardous air pollutant emitted by such source by more than a de minimis amount or which results in the emission of any hazardous air pollutant not previously emitted by more than a de minimis amount." State operating permit programs are likely to become effective beginning in 1995 [CAA, §502(d)]. Owners of sources of HAPs that will be subject to a §112(d) MACT standard will want to consider carefully the implications of any modifications to their facility once the operating permit program becomes effective in their state.

Under §112(l) of the CAA, states can apply to EPA for delegated authority to implement and enforce the requirements in §112 of the CAA. States can apply for complete or partial delegation of EPA authority. State emission standards established under this delegated authority must be at least as stringent as EPA's standards. EPA issued a proposed rule on May 19, 1993 (58 FR 29226) to provide guidance to the states regarding EPA approval of rules or programs that states can implement and enforce in place of certain requirements under §112 of the CAA.

All of the preceding discussion covers regulation of HAPs under the federal CAA. Owners of sources of HAPs must also be aware that many states regulate the emission of HAPs under state laws. Under §116 of the CAA, states can regulate stationary sources of air pollution provided the state requirements are at least as stringent as federal requirements. States have been particularly active in regulating HAP sources because the federal program has been so slow to develop. State programs vary widely in their scope and application. Some states regulate more than the 189 chemicals/compounds designated in §112(b) of the CAA and apply their program to sources that would not be major sources under §112 of the CAA. A common approach to setting standards is for the state to establish maximum acceptable ambient concentrations of particular pollutants (Selmi and Manaster 1992, §17.01). Using this standard as a basis, the state regulatory authority establishes emission limits to be imposed on individual sources.

APPLICATION TO FOSSIL-FIRED BOILERS

A common industrial process with the potential to emit HAPs is operation of fossil-fired boilers. Thirty-seven of the 189 HAPs designated in §112(b) of the CAA have been detected in flue gas from fossil power plants (Boutacoff 1991, p. 10). These 37 HAPs are listed in Table 1. Any of these 37 HAPs could also be present in the emissions from fossil-fired boilers.

There is considerable uncertainty regarding what particular HAPs are emitted from fossil-fired boilers and their rate of emission. Reasons for this uncertainty include 1) lack of universal quality assurance procedures and methodologies during sampling and testing, 2) wide variability in the trace elements found in coal, and 3) variations in boiler design and controls. Also, emissions data for coal-fired utility boilers are largely based on calculations from test burns under carefully controlled conditions (Brown et al. 1991).

Tables 2, 3, and 4 present average emission factors for oil-fired, stoker-fired, and pulverized coal-fired boilers, respectively. The data in the tables should be considered with the limitations noted above in mind. Much of the data in Tables 2, 3, and 4 are from a 1986 report prepared for EPA by the Radian Corporation (Mead et al. 1986; EPA 1992). Because the emission factors for each boiler type are generally independent of capacity (Btu/hr), the emission factors could apply to fossil-fired boilers used for residential, commercial/institutional, industrial, or utility applications. The emission factors indicate the level of emissions for a currently operating plant (pounds of HAPs per 10^{12} Btu of fuel burned) in various operating modes including no control of emissions, i.e., "uncontrolled," as well as selected emission control equipment for the coal-fired boilers. Stoker-fired boilers typically have steam capacities less than 100,000 pounds of steam per hour. Pulverized coal (PC) boilers generally have capacities greater than 100,000 pounds of steam

per hour (Avallone and Baumeister 1978). Average emission factors for stoker and PC coal boilers are shown in Tables 3 and 4, respectively.

The quality of coal varies greatly among geographical areas in the United States. Bituminous, lignite, and anthracite coal are included in Table 4. These coal types have higher heating values (HHV) of 13,770 Btu/lbm; 7,194 Btu/lbm; and 12,700 Btu/lbm, respectively. Tables 3 and 4 break-out average emission factor values for these coal types.

Controlling the emissions shown in Tables 2, 3, and 4 to a MACT emission standard could involve significant expenditures. Emission control equipment to meet MACT standards could include 1) cold-side electrostatic precipitators, 2) fabric filters (conventional and pulse-jet), 3) spray dry and wet lime/limestone flue gas desulfurization scrubbers, 4) low NO_x burners, 5) post-combustion NO_x systems, or 6) emerging technologies such as alumina adsorbents for mercury removal (Chow et al. 1991). Once again, the quality and quantity of data concerning the effectiveness of emissions control equipment is limited. Furthermore, certain of these control technologies may require that a sorbent or other combustion-modifying chemicals be added to the furnace or flue gases. The effect of such additions on the nature and quantity of HAP emissions is not fully known (Brown et al. 1991).

SUMMARY

The federal program for regulating emission of hazardous air pollutants (HAPs) was significantly altered by the 1990 Amendments to the Clean Air Act. Over the next seven years, EPA will be issuing emission standards for a number of source categories of HAPs. These standards will require the application of maximum achievable control technology (MACT) to HAP emissions. Two common source categories which will be subject to MACT standards are industrial and institutional/commercial boilers. Under EPA's proposed schedule, the MACT standards for these categories are to be issued by the end of the year 2000. Owners of industrial and institutional/commercial boilers can take several steps before the final emission standards are issued. First, they can participate in EPA's standard setting process. Second, they can elect to participate in EPA's early reduction program to delay the time when compliance with the MACT standard is required. Third, they should carefully consider any planned modifications to a facility that might subject the facility to a MACT standard set by a state in advance of the EPA-set standard.

ACKNOWLEDGEMENT

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Table 1. HAZARDOUS AIR POLLUTANTS FOUND IN FOSSIL POWER PLANT FLUE GASES

Acetaldehyde
Antimony compounds
Arsenic compounds
Benzo-a-pyrene
Benzene
Beryllium compounds
Biphenyl
Bis-(2-ethylhexyl)-phthalate
Cadmium compounds
Carbon disulfide
Carbon tetrachloride
Carbonyl sulfide
Chlorine
Chlorobenzene
Chloroform
Chromium compounds
Cobalt compounds
Dibenzofurans
1,4-Dichlorobenzene (p)
Formaldehyde
Hexachlorobenzene
Hydrochloric acid
Hydrofluoric acid
Lead compounds
Manganese compounds
Mercury compounds
Naphthalene
Nickel compounds
Pentachlorophenol
Phenol
Phosphorus
Selenium compounds
2,3,7,8-Tetrachlorodibenzo-p-dioxin
Tetrachloroethylene
Toluene
Trichloroethylene
2,4,5-Trichlorophenol

Table 2. AVERAGE EMISSION FACTORS FOR OIL-FIRED BOILERS

Hazardous Air Pollutant		Average Emission Factors ($lbm/10^{12}$ Btu of Heat Input)		
		Residual Oil		Distillate Oil
Arsenic		19		4.2
Beryllium		4.2		2.5
Cadmium		15.7		10.5
Chromium		21		48
Copper		280		280
Mercury		3.2		3.0
Manganese		26		14
Nickel		1260		170
Polycyclic Organic Matter		8.4		22.5
Formaldehyde		405		405

Tables 3 and 4. will be correctly formatted by word processing

Table 3. AVERAGE EMISSION FACTORS FOR STOKER-FIRED BOILERS AND SELECTED EMISSION CONTROL EQUIPMENT

Hazardous Air Pollutant	Average Emission Factors (lbm/10^{12} Btu of Heat Input) for Stoker-Fired Boilers								
	Uncontrolled Emissions			Multicyclone			Electrostatic Precipitator		
	Bitm.	Lign.	Anth.	Bitm.	Lign.	Anth.	Bitm.	Lign.	Anth.
Arsenic	650	1,320	250	320	650	125	80	165	30
Beryllium	75	120	45	30	45	20	6	10	4
Cadmium	50	55	15	30	35	8	15	15	3
Chromium	1,255	1,505	2,975	725	925	1,720	360	460	850
Copper	905	1,590	990	535	940	585	135	240	150
Mercury	15	20	20	15	20	20	10	15	15
Manganese	2,170	11,800	2,230	600	3,290	630	250	1,380	260
Nickel	1,030	930	1,795	520	470	910	280	250	490
Uranium-238[1]	NA[2]	NA	NA	NA	NA	NA	15	15	15
Thorium-232[1]	NA	NA	NA	NA	NA	NA	15	15	15
Polycyclic Organic Matter (POM)	NA	NA	NA	30	30	30	30	30	30
Formaldehyde	710	710	710	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	1,410	220	1,420	50	5	NA

Notes:

(1): Emissions for uranium-238 and thorium-232 are measured in picoCuries per 10^6 Btu of heat input.
(2): NA indicates that emission factor information was not found.

Table 4. AVERAGE EMISSION FACTORS FOR PULVERIZED COAL BOILERS AND SELECTED EMISSION CONTROL EQUIPMENT

Hazardous Air Pollutant	Average Emissions Factors (lbm/10^{12} Btu of Heat Input) for Pulverized Coal Boilers																	
	Uncontrolled Emissions			Multicyclone			Electrostatic Precipitator			Flue Gas Desulf. (Scrubber)		
	Bitm.	Lign.	Anth.	Bitm	Lign.	Anth.	Bitm.	Lign	Anth.	Bitm.	Lign.	Anth.
Arsenic	1,010	2,060	395	500	1,010	195	105	215	40	50	95	20
Beryllium	80	130	50	50	85	30	3	5	2	.1	.2	.1
Cadmium	55	65	15	40	45	10	15	15	3	1	1	.3
Chromium	1,295	1,550	3,070	750	890	1,775	370	440	875	110	130	250
Copper	710	1,250	780	420	740	460	140	100	150	25	40	25
Mercury	15	20	20	15	20	20	10	15	15	4	5	5
Manganese	1,895	10,330	1,950	880	4,815	910	410	2,230	420	35	195	40
Nickel	1,065	660	1,850	540	485	940	290	260	500	40	35	70
Uranium-238[1]	NA[2]	NA	NA	NA	NA	NA	295	295	295	75	75	75

Thorium-232[1]	NA	NA	NA	NA	NA	NA	170	170	170	35	35	35
Polycyclic Organic Matter (POM)	NA	NA	NA	20	20	20	20	20	20	20	20	20
Formaldehyde	110	110	110	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	315	NA	NA	130	155	NA	55	5	90	20	NA	NA

Notes:

(1): Emissions for uranium-238 and thorium-232 are measured in picoCuries per 10^6 Btu of heat input.
(2): NA indicates that the emissions factor information was not found.

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