

Draft Technical Support Document for HWC MACT Standards

**Volume III:
Selection of MACT Standards**

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Acronyms and Abbreviations

ANOVA	Analysis of variance
APCD	Air pollution control device
BIF	Boiler and industrial furnace
CK	Cement kiln
CKD	Cement kiln dust
CO	Carbon monoxide
CoC	Certification of Compliance test
CT	Compliance test
DRE	Destruction and removal efficiency
EPA	United States Environmental Protection Agency
ESP	Electrostatic precipitator
FF	Fabric filter
HAP	Hazardous air pollutant
HC	Hydrocarbons
HCl PF	Hydrochloric acid production furnace
HEPA	High efficiency particulate air
HEWS	High energy wet scrubber
Hg	Mercury
HWC	Hazardous waste combustor
IB	In-between
LEWS	Low energy wet scrubber
LFB	Liquid fuel boiler
LVM	Low volatile metals
LWAK	Lightweight aggregate kiln
MACT	Maximum Achievable Control Technology
MTEC	Maximum theoretical emissions concentration
NA	Not appropriate
PCDD	Polychlorinated dioxins
PCDF	Polychlorinated furans
PIC	Product of incomplete combustion
PM	Particulate matter
RCRA	Resource Conservation and Recovery Act
SAP	Simultaneous achievability for particulates
SE	Emissions mass concentration
SFB	Solid fuel boiler
SRE	System removal efficiency
SVM	Semivolatile metals
TE	Hazardous waste thermal emissions
TEQ	Toxic equivalents
UVF	Universal variability factor for fabric filters
VS	Venturi scrubber
WC	Worst case

WHB Waste heat boiler

1.0 Introduction

The United States Environmental Protection Agency (EPA) is proposing “Maximum Achievable Control Technology” (MACT) standards for hazardous waste combustors. This includes hazardous waste burning incinerators, cement kilns, lightweight aggregate kilns, boilers, and hydrochloric acid production furnaces. The MACT standards for the “Phase I” hazardous waste burning source categories -- incinerators, cement kilns, and lightweight aggregate kilns -- will replace the interim standards promulgated for these sources on February 13 and 14, 2002 (67 FR 6792 and 67 FR 6968). The MACT standards for the “Phase II” hazardous waste burning source categories -- boilers and hydrochloric acid production furnaces - - are being proposed (and promulgated) on the same schedule as the replacement Phase I standards.

This document provides technical support for the determination of the MACT standards. It discusses the approaches and procedures being considered. It contains the following chapters:

Chapter 2 – Presents and discusses hazardous air pollutant emissions data from each source category.

Chapter 3 – Discusses issues related to the selection of hazardous air pollutants.

Chapter 4 – Discusses selection of subcategories.

Chapter 5 – Discusses data handling and data classifications used for setting MACT floors.

Chapter 6 – Discusses formats considered for MACT floors.

Chapters 7 - 15 – Discusses various approaches being considered for setting MACT floors.

Chapters 16 - 22 – Presents results of the approaches for setting MACT floors.

Chapter 23 – Discusses miscellaneous issues, including the mercury content of hazardous waste burned by cement kilns, and comparison of mass emission concentrations and hazardous waste thermal emissions from energy recovery units.

Chapter 24 – Discusses beyond-the-floor controls.

2.0 Source Characterization, Data Availability

There are six general source categories of units covered under the proposed hazardous waste combustion MACT rule:

- Incinerators
- Cement kilns (CK)
- Lightweight aggregate kilns (LWAK)
- Liquid fuel boilers (LFB). Boilers that do not burn solid fuels. These boilers generally burn liquid hazardous waste fuels with natural gas, or less frequently, process gas or fuel oil.
- Solid fuel boilers (SFB). Boilers that burn solid fuels. All solid fuel boilers that burn hazardous waste cofire liquid hazardous waste with coal.
- HCl production furnaces (HCl PF)

The following sections of this chapter present and discuss information used to develop the proposed HWC MACT floors, including: HAP emissions, HAP feedrates, combustor and air pollution control device design and operating parameters, and stack gas conditions (gas flowrate and temperature). The sections are organized by source category and HAP. The information is contained in the “Data Summary Sheets”, taken directly from the hazardous waste combustor database. The Data Summary Sheets are described and contained in Volume II of the HWC MACT technical support documents.

2.1 **Incinerators**

PCDD/PCDF

PCDD/PCDF data are available for over 55 incinerators. Levels range widely from 0.001 to 30 ng TEQ/dscm.

Many of the data were taken during “risk” burn testing conditions where system operations were designed to produce “normal” PCDD/PCDF levels. Many others were taken during compliance testing conditions where conditions were adjusted to attempt to maximize PCDD/PCDF emissions; for example, operating at maximum desirable dry PM air pollution control device temperature, minimum combustion temperature, maximum waste feedrate, maximum copper feedrate, etc.

Numerous factors affect PCDD/PCDF emissions from hazardous waste incinerators. Some of the more important ones include:

- Combustion conditions – Maintaining efficient combustion conditions limits the formation of potential PCDD/PCDF precursors such as polychlorinated biphenyls, benzenes, phenols, and other products of incomplete combustion.

Note that many of the PCDD/PCDF test conditions were conducted under compliance testing situations where conditions were adjusted to simulate “relatively poor” combustion conditions (low temperature, low available oxygen, high waste feed, etc.). However during this same compliance testing, almost all units continued to achieve relatively good combustion conditions, as demonstrated by meeting the current RCRA DRE requirement, as well as having CO and HC levels in almost all test conditions less than 100 and 10 ppmv respectively. Thus, although nominally the conditions were under “compliance” conditions designed to maximize potential PCDD/PCDF formation, the combustion conditions are not considered “poor” based on CO, HC, and DRE performance levels which are generally consistent and representative of good combustion conditions.

- Gas temperature in PM holdup zones – Rapid cooling of the combustion gases and limiting the dry PM air pollution control device (FF or ESP) temperature can help to prevent low-temperature catalytic formation. PCDD/PCDF is known to form through heterogeneous surface catalytic reactions involving PM in the temperature range of about 400 to 700°F. This can occur on waste heat boiler tubes or in dry PM air pollution control devices. Incinerators can be grouped into three main design categories based on trends in PCDD/PCDF performance:
 - Rapid gas cooling to saturation temperature – Many incinerators use water quench cooling of combustion gases to moisture dew point saturation temperatures required for wet scrubbing (around 150°F). PCDD/PCDF emissions from these types of incinerators range from 0.001 to 0.4 ng TEQ/dscm. PCDD/PCDF are suspected to be controlled by preventing low-temperature catalytic formation.
 - Combustion gas cooling in waste heat boilers or heat exchangers – PCDD/PCDF levels from incinerators using waste heat boilers and heat exchangers range from 0.1 to greater than 30 ng TEQ/dscm. The lower levels are from units that use activated carbon for PCDD/PCDF control. PCDD/PCDF levels for units with waste heat boilers without activated carbon are typically greater than 1 ng TEQ/dscm.
 - “Dry” PM air pollution control devices (APCD) – PCDD/PCDF levels from incinerators with dry PM APCDs (such as FF or ESPs) vary depending on the APCD temperature. For units with temperature less than 400°F, levels are less than 0.4 ng TEQ/dscm. For units with temperature above 500°F, PCDD/PCDF can be above 1 ng TEQ/dscm.

- Activated carbon – Four units currently use activated carbon (in beds or injected into the flue gas and captured in an ESP or FF) to collect (absorb) PCDD/PCDF.

PM

PM emissions are available for almost every incinerator. Data range from 0.001 gr/dscf, up to the current RCRA standard of 0.08 gr/dscf.

Most of the data are taken from compliance test conditions, where system operations were designed to produce maximum PM emissions levels and testing was used to set PM-related system operating parameters limits on maximum ash feed, maximum flue gas flowrate, and various PM APCD operating parameters.

PM emissions are controlled in incinerators by:

- Limiting the ash feedrate. A few units meet current RCRA standards solely by limiting the ash feedrate to the system.
- Using a PM air pollution control device (APCD). APCDs include fabric filters, electrostatic precipitators, venturi scrubbers, ionizing wet scrubbers, and other novel scrubber designs such as hydrosonic, free-jet, and collision-type scrubbers.

Hg

Mercury data are available from over 50 incinerators. Levels range widely from less than 1 ug/dscm up to greater than 30,000 ug/dscm.

Some of the data (most of the lower emissions levels) are from tests where the system was operating under “normal” conditions with respect to mercury emissions – including both risk burn tests or compliance tests where compliance with the mercury emission standard is demonstrated using a procedure similar to the RCRA BIF “Tier I” approach. Under the RCRA BIF Tier I option, compliance testing is not used to demonstrate system performance; mercury is limited solely through feedrate control. Incinerators are not subject to the RCRA BIF regulations; however, many incinerators are permitted in a manner identical to that used for BIFs under RCRA omnibus authority to ensure that emissions do not pose a hazard to human health and the environment.

A smaller amount of data (containing most of the higher test conditions) are taken under compliance test conditions where system operating limits were designed to maximize mercury emissions (including maximum mercury feedrate).

Mercury is controlled in incinerators through:

- Limiting the mercury feedrate. Many incinerators meet current RCRA standards solely

by limiting the mercury feedrate to the system.

- Using a mercury air pollution control device:
 - Activated carbon – A few systems use activated carbon. Activated carbon has been demonstrated to achieve greater than 90% mercury control.
 - Wet scrubbing – Most incinerators use some type of wet scrubber, usually primarily intended for chlorine control. Hg control in wet scrubbers varies widely from zero to greater than 90%. Scrubbing efficiency is strongly dependent on: (1) mercury speciation in the gas, which depends on the waste composition (e.g., chlorine in the waste feed enhances formation of soluble mercuric chloride) and flue gas temperature cooling profile; and (2) scrubber liquor composition.

SVM

SVM data are available from over 50 incinerators. Levels range very widely – from 3 to 30,000 ug/dscm.

Similar to mercury, some of the data are taken under compliance test conditions where SVM operating limits are set and operating conditions are designed to maximize SVM emissions. Others tests are taken under normal operating conditions with respect to SVM emissions (where compliance with SVM emissions limit is under a procedure similar to the RCRA BIF Tier I approach).

SVM is controlled in incinerators through both control of the level of SVM contained in the hazardous waste and other feedstreams as well as with the use of SVM air pollution control devices (which are identical to those described above for PM).

LVM

LVM data are available from over 50 incinerators. Levels range very widely – from 1 to 4,000 ug/dscm.

Similar to mercury, some of the data are taken under compliance test conditions where LVM operating limits are set and operating conditions are designed to maximize LVM emissions. Others tests are taken under normal operating conditions with respect to LVM emissions (compliance with LVM requirements under procedures similar to the BIF Tier I approach).

LVM is controlled in incinerators through both feedrate control and LVM air pollution control devices (identical to those described above for PM).

Chlorine

Chlorine data are available from almost all incinerators. Levels range widely – some less than 1 ppmv, a couple over 100 ppmv.

Most of the data are taken from compliance test conditions where system operations were designed to produce maximum chlorine emissions levels (e.g., maximum chlorine feed, maximum flue gas flowrate, and minimum wet scrubber liquid pH, etc.).

Chlorine emissions are controlled by incinerators through limiting the feedrate of chlorine, and the use of wet and dry scrubbers.

The incinerator chlorine data are the result of some similar, but different, stack gas sampling methods:

- Method 26 – The newer data are taken from Method 26, which speciates both HCl and Cl₂ through the use of separate acidic and basic sampling solution impingers. These data are handled directly as reported.
- Modified Method 5 – Prior to Method 26, HCl measurements were taken using a Modified Method 5 sampling train, using impingers with a basic NaOH solution. Results are reported as HCl; however, the basic sampling solution effectively picks up Cl₂ as well. Thus, the reported HCl value is considered equivalent to “total” chlorine (HCl + 2*Cl₂).

2.2 Cement Kilns

PCDD/PCDF

PCDD/PCDF data are available for all but one cement kiln. Levels range widely from 0.004 to 20 ng TEQ/dscm.

Most of the data were taken under compliance test conditions designed to maximize PCDD/PCDF emissions. A few of the test conditions were collected under “normal” operating conditions.

Under current RCRA BIF regulations, PCDD/PCDF is controlled in cement kilns through limiting the FF or ESP operating temperature. Although many system operating factors may effect PCDD/PCDF emissions, the data set as a whole continues to confirm that reducing the flue gas temperature in the dry PM control device consistently has a significant impact on limiting PCDD/PCDF formation.

PM

PM emissions data are available for all cement kilns. PM emissions range from 0.001 to 0.06 gr/dscf.

Most of the data are from compliance testing conditions where PM emissions are maximized. A few conditions are also from “normal” operating conditions.

FFs or ESPs are used for PM emissions control on all cement kilns. Sometimes the FF or ESPs are preceded by cyclones for coarse bulk PM removal.

Hg

Mercury data are available from almost all cement kilns. Levels range from about 2 ug/dscm up to about 120 ug/dscm.

Almost all of the data are from test conditions where the system was operating under “normal” conditions with respect to mercury emissions – tests where compliance with mercury is demonstrated under the RCRA BIF “Tier I” option (where, as described above, testing results are not used to demonstrate system performance; mercury is limited solely through feedrate control).

For kilns that do not use in-line raw mills, Hg is generally regarded as “uncontrolled” once in the CK system. Hg volatilizes and primarily partitions to the stack gas. Mercury is highly volatile at the kiln combustion temperature and is not contained in the cement clinker. Additionally, mercury generally remains volatile at PM APCD temperatures and is not typically contained in the cement kiln dust.

Mercury emissions from CKs using in-line raw mills tend to correlate with the operational status of the raw mill. Mercury emissions appear to be consistently lower when the in-line raw mill is on-line, likely due to the enhanced mercury capture at lower raw mill flue gas temperatures and raw mill dust filtering. Alternatively, when the raw mill is off-line, very little mercury control is observed.

SVM

SVM data are available for all CKs. SVM data range widely from 1 to 3,000 ug/dscm.

Almost all of the data are from compliance tests where the operating conditions were designed to maximize SVM emissions.

SVM are controlled in CKs through both limiting the feedrate of SVM and the use of PM APCDs.

LVM

LVM data are available for all CKs. LVM data range from about 1 to 100 ug/dscm.

Almost all of the data are from compliance tests where the operating conditions were designed to maximize LVM emissions.

LVM are controlled in CKs through both limiting the feedrate of LVM and the use of PM APCDs.

Chlorine

Chlorine data are available for all CKs. Chlorine emissions range from less than 10 to 150 ppmv.

Almost all of the data are from compliance tests where the operating conditions were designed to maximize chlorine emissions (specifically, through maximizing the chlorine feedrate to the system).

Under current RCRA BIF regulations, chlorine emissions are controlled through limiting the chlorine feedrate. No CKs use wet or dry scrubbing control devices that are designed to specifically remove chlorine from the flue gas.

However, chlorine contributed from hazardous wastes is controlled in CKs. Chlorine SREs in CKs range from around 90 to 99+%. CKs perform like dry scrubbers as a result of the need for calcined limestone (lime) to make cement. Lime is a critical ingredient to the cement structure. Large quantities of freshly calcined lime are present midway through the CK. The chlorine generated during combustion of chlorine-containing wastes is highly reactive with the lime and forms calcium chloride salts. The chlorine salts, contained as part of the CKD, are removed from the stack gases in the PM APCD. Very little chlorine is removed with the clinker product.

Although all CKs are demonstrating significant overall chlorine control (as expected based on process chemistry considerations), the chlorine SREs range fairly widely. This is suspected to be a result of various factors including: (1) PM APCD operating temperature; (2) alkalinity (Na and K) content of raw materials; (3) CKD recycle rates; and (4) level of chlorine in raw materials.

Note that the control of chlorine present in raw materials may not be as effective as the control of chlorine from hazardous wastes. As the raw material moves down the kiln and is heated, chlorine in the raw materials is volatilized and carried back with the flue gas. This occurs prior to when the limestone is calcined to lime. At the lower temperatures of the back end of the kiln the Ca is present primarily as limestone, which is not very effective at reacting with chlorine (compared with Ca in the form of lime). The control of chlorine from raw materials is likely significantly effected by the availability of Na and K, both which are much more reactive with chlorine than limestone at the low temperatures at the back end of the kiln.

2.3 Lightweight Aggregate Kilns

PCDD/PCDF

PCDD/PCDF data are available for all LWAKs. Levels range widely from 0.1 to 58 ng TEQ/dscm.

Some of the data are taken under compliance testing operations, designed to maximize PCDD/PCDF emissions. Some of the data are taken under “research” operating conditions, where the impact of the reduction of kiln back end flue gas temperature and PM APCD temperature on PCDD/PCDF emissions was evaluated.

Testing results suggest that the flue gas temperature profile downstream of the kiln back end is directly related to PCDD/PCDF emissions. PCDD/PCDF levels are consistently reduced when the kiln back end gas temperature is reduced with water quench spray cooling. PCDD/PCDF formation is suspected to occur in the flue gas transition ducting between the kiln back end and the FF, where the flue gas temperature is in the critical low-temperature, surface catalyzed PCDD/PCDF formation zone.

PM

PM data are available for all LWAKs. PM emissions range from 0.001 to 0.04 gr/dscf, with most less than 0.02 gr/dscf.

All data are taken under compliance testing operations, designed to maximize PM emissions.

All LWAKs control PM with the use of FFs.

Hg

Hg data are available for all LWAKs.

For all Solite kilns, the RCRA BIF Hg emission standard is complied with under the Tier I option; thus the data are classified as “normal”. Normal emissions data range from 1 to 47 ug/dscm.

For the Norlite kilns, both “normal” and “compliance testing” data are available. For the Norlite kilns, Hg is complied with under Tier III, thus the some data are classified as “compliance testing” where the operations were designed to maximize Hg emissions. Also, some Hg data are available during risk burn testing where it appears Hg operating parameters were “normal”. Hg compliance test data from Norlite are at 1,000 ug/dscm.

For the Solite kilns, Hg control is achieved solely through limiting the Hg feedrate. Mercury is not found in the lightweight aggregate product or the FF dust.

For the Norlite kilns, Hg control is achieved through both limiting the Hg feedrate as well as with the use of a venturi scrubber.

SVM

SVM data are available for all LWAKs. SVM data range very widely from 1 to over 1,600 ug/dscm.

Almost all of the data are from compliance tests where the operating conditions were designed to maximize SVM emissions.

SVM are controlled in CKs through both limiting the feedrate of SVM and the use of PM APCDs.

LVM

LVM data are available for all LWAKs. LVM data range from 16 to 200 ug/dscm.

Almost all of the data are from compliance tests where the operating conditions were designed to maximize LVM emissions.

LVM are controlled in LWAKs through both limiting the feedrate of LVM and the use of PM APCDs.

Chlorine

Chlorine data are available for all LWAKs.

Almost all of the data are from compliance tests where the operating conditions were designed to maximize chlorine emissions.

For the Solite kilns, chlorine control is achieved solely through limiting the chlorine feedrate. Chlorine SREs are essentially zero; chlorine is not found in the lightweight aggregate product or the FF dust. Chlorine emissions range from 500 to 2,400 ppmv.

For the Norlite kilns, chlorine control is achieved through both limiting the chlorine feedrate as well as with the use of a venturi scrubber. Chlorine SREs are greater than 97%. Chlorine emissions range from 14 to 120 ppmv.

2.4 Liquid Fuel Boilers

PCDD/PCDF

PCDD/PCDF data from liquid fuel boilers are available from about 40 test conditions and 35 facilities. Test condition averages range from less than 0.05 ng TEQ/dscm to 0.44 ng TEQ/dscm, with one test condition at 2.4 ng TEQ/dscm. Almost all data are from risk burns, where the system was operating under typical, normal conditions. The test condition with the

highest average of 2.4 ng TEQ/dscm (818C3) is from a boiler that: (1) uses a FF with an operating temperature of 410°F (which is not considered a maximum operating level for the source); and (2) processes a waste catalyst that is very high in Ni – Ni is suspected as a PCDD/PCDF formation catalyst. None of the data are classified as conducted under operating conditions that were designed to maximize PCDD/PCDF emissions.

PCDD/PCDF from liquid feed boilers is being controlled currently under the RCRA BIF Rule through:

- Good combustion practices -- Maintenance of good combustion practices.

Recent PCDD/PCDF evaluation testing at an EPA pilot-scale hazardous waste liquid burning firetube boiler has reinforced the importance of avoiding poor combustion conditions, in particular minimizing the formation of soot. It was shown that PCDD/PCDF can be readily formed through initial operations at poor combustion sooting conditions (during which low PCDD/PCDF was measured), followed by efficient combustion conditions, under which PCDD/PCDF was measured in the range of 10 to 50 ng TEQ/dscm. It is suggested that PCDD/PCDF formation is a result of the sooty tube deposits (left during inefficient combustion) in combination with excess oxygen operating conditions (during efficient combustion).

- Dry PM control device temperature -- Control of the dry PM APCD temperature to below 400°F. Dry PM APCD operating temperature is assumed to have a significant impact on PCDD/PCDF formation, based on the technology transfer of performance of similar systems, including hazardous waste incinerators and medical and municipal waste combustors. There are only a few boilers with dry APCDs. Most boilers do not have any add-on air pollution control device. A few use high and low energy wet scrubbers.
- PM control -- PCDD/PCDF may be controlled to a very limited degree through control of PM which may contain adsorbed PCDD/PCDF.

PM

PM emissions data are available from almost all liquid fuel boilers. PM levels range widely: from less than 0.002 gr/dscf up to the current RCRA BIF emissions standard of 0.08 gr/dscf. Almost all are from compliance test conditions designed to maximum PM emissions and set PM related operating limits (ash feedrate and PM air pollution control device operating limits).

For most of the liquid fuel boilers, PM emissions are controlled solely through limiting the ash content of the hazardous waste (and any other feedstreams). PM emissions are also controlled to a much lesser degree by achieving complete burnout of waste organics, limiting flame sooting, and limiting chlorine feed, which can contribute to solid salt emissions.

Some boilers that burn wastes with higher ash content and/or higher SVM or LVM content use PM APCDs including FFs, ESPs, and various types of high and low energy wet scrubbers to meet RCRA BIF PM and metals emissions limits.

Hg

Hg stack gas measurements from liquid fuel boilers are limited to 11 test conditions, coming from both CoC and risk burn testing.

Hg is controlled in liquid fuel boilers primarily through limiting the mercury feedrate. Hg feedrate MTECs measured during CoC testing range from less than 1 up to 50 ug/dscm, with almost all less than 10 ug/dscm, and 50% less than 1 ug/dscm. Almost all liquid fuel boilers comply under the current RCRA BIF rule through the Tier I approach, where it is conservatively assumed that all Hg that is fed to the boiler is emitted at the stack. No liquid feed boilers actively “spiked” Hg during the testing. All hazardous waste feedrate Hg MTECs are likely more representative of “normal” wastes.

Hg is also controlled in liquid fuel boilers with wet scrubbing. Wet scrubbing is used by 9 of 84 (11%) liquid feed boilers. Wet scrubbers provide variable control of Hg, ranging from 10 to 90+%, likely depending on a variety of factors including Hg speciation in the flue gas and wet scrubber design and operation.

SVM

SVM stack gas emissions measurements are available from 17 test conditions from 16 different sources. Data range from 1 to 40 ug/dscm, with one at 530 ug/dscm.

Most units control SVM solely through SVM feedrate control. These units comply with the RCRA BIF Rule under the “Tier I” approach, since they do not use any active PM air pollution control device. As a result, the CoC testing feedrate data from these units is likely “normal” with respect to SVM hazardous waste content. For almost all of these units, CoC SVM hazardous waste feedrate MTECs are less than 100 ug/dscm, with the majority less than 50 ug/dscm.

Some units additionally control SVM through the use of PM control devices. A couple of these units set SVM operating limits during CoC compliance testing under the RCRA BIF Tier III approach.

LVM

LVM stack gas emissions data are available from 33 test conditions from about 25 different sources. Most are at levels less than 100 ug/dscm; the rest range from 200 to 400, with one at 900 ug/dscm.

LVM, identical to SVM, is controlled solely through feedrate control for most units under the RCRA BIF Tier I approach. Some units also use PM APCDs for additional LVM control. Most of the “normal” unspiked CoC hazardous waste LVM feedrate MTECs are below 100 ug/dscm. A few spiked LVM feedrates range from 500 to 20,000 ug/dscm; most of these are associated with sources that have PM APCDs.

Chlorine

Stack gas chlorine emissions range widely from less than 5 ppmv to over 900 ppmv. Stack gas emissions measurements were taken from about 75 different test conditions from over 40 sources.

All liquid fuel boilers control chlorine emissions in part through limiting the chlorine feedrate. The vast majority of chlorine feedrate MTECs during CoC testing are less than 100 ppmv, and are “unspiked”. A few units have spiked chlorine feedrates from 150 to over 1,000 ppmv. All of these higher chlorine feedrate units also use wet scrubbing.

A number of units also use wet scrubbing for the control of chlorine emissions. Low or high energy wet scrubbers are used on 9 units. Wet scrubber chlorine SREs range typically from 99 to greater than 99.9%. There are a few with SREs of 90 to 99% that are associated with low chlorine stack gas emissions (less than 10 ppmv) and lower chlorine feedrates.

2.5 Solid Fuel Boilers

PCDD/PCDF

PCDD/PCDF data are available from only 3 test conditions from 2 sources at 2 facilities (one of which is no longer burning hazardous waste). All 3 test condition averages are less than 0.1 ng TEQ/dscm. Various factors are suspected to affect PCDD/PCDF emissions from solid fuel boilers:

- Dry PM control device temperature -- All units use either dry ESP or FFs for PM control. Under the current RCRA BIF Rule requirements, dry PM APCD temperature is limited to either less than 450°F, or that demonstrated under a successful CoC test. This is based from the trend that dry PM control device operating temperature has a significant impact on PCDD/PCDF formation -- which has been shown fairly conclusively for municipal waste combustors, medical waste incinerators, hazardous waste incinerators, and cement kilns. Current dry PM APCD operating temperature limits for the solid fuel boiler units are shown in Table 2-1.

However, the available (although somewhat small) data set indicates that for the solid fuel boilers (which all use a combination of coal and liquid hazardous waste co-firing), dry PM APCD operating temperature does not appear to have an strong impact on PCDD/PCDF emissions (at least not in the range of available data up to about 500°F):

- The 3 hazardous waste / coal boiler PCDD/PCDF data sets are all less than 0.1 ng TEQ/dscm. For each of these, the ESP operating temperature was around 500°F, a temperature where it is anticipated that significant PCDD/PCDF formation would occur (based on that observed for hazardous waste incinerators, municipal waste combustors, medical waste incinerators, and cement kilns).
- PCDD/PCDF data from coal-only-fired utility and industrial boilers are all less than 0.3 ng TEQ/dscm, regardless of dry APCD operating temperature. These data are summarized in Table 2-2. Additionally, there is some recent limited EPA-sponsored testing at a coal-fired boiler using a hot-side ESP (operating at ESP temperature greater than 500°F) that further supports that dry PM APCD operating temperature does not have a strong influence of coal fired boiler PCDD/PCDF levels.
- Good combustion practices -- Maintaining efficient combustion conditions limits the generation of potential PCDD/PCDF formation precursors such as PCB, chlorinated benzenes, phenols, and other organic products of incomplete combustion. Good combustion is maintained on a real-time basis through the monitoring and control of hazardous waste feedrate, hazardous waste and other feedstock composition, combustion temperature, CO and/or HC combustion gas levels, etc.
- Sulfur feedrate -- The presence of sulfur in combustor feedstocks has been shown to dramatically inhibit the catalytic formation of PCDD/PCDF in downstream temperature zones of 400 to 700°F. All of the solid fuel boilers co-fire significant amounts of coal, in combination with liquid hazardous wastes (from 5 to 30% liquid hazardous waste by firing input rate; alternatively, 70 to 95% coal). Thus, the sulfur contributed by the coal is likely a significant factor contributing to the generally low PCDD/PCDF levels from coal fired units. Sulfur levels in the coal from solid fuel boilers that fired hazardous waste are not specifically known; however, sulfur levels are likely significant based on the location of the unit and type of coal (bituminous) being used at the four sites which are co-firing coal and hazardous wastes:
 - Arkansas Eastman (ID No. 1009) -- Bituminous coal from Wyoming.
 - Tennessee Eastman (ID Nos. 719, 1011, 1012) -- Bituminous coal from Kentucky and West Virginia.
 - Union Carbide (ID Nos. 907, 908) -- Most likely bituminous coal from West Virginia.
 - Celanese Pampa Texas (1013, 1014) -- Bituminous coal from Wyoming.
- Chlorine feedrate -- There is limited, conflicting evidence on the impact of chlorine feedrate on PCDD/PCDF formation in coal / hazardous waste co-fired boilers. Data from

the three test conditions from the solid fuel hazardous waste boilers indicate that PCDD/PCDF levels can be low at relatively high chlorine feedrates (associated with uncontrolled chlorine in the combustion gas of approximately 700 ppmv).

Alternatively, pilot-scale work by EPA has shown that high levels of PCDD/PCDF (500 ng total PCDD/PCDF / dscm) can be formed during the combustion of coal and doped HCl at a flue gas level of 1,000 ppmv. Even higher PCDD/PCDF levels were observed with the combination of coal combustion gases, doped HCl, and municipal waste combustion fly ash.

- PM control -- The PM control efficiency of the FF or ESPs might be expected to have some role in controlling PCDD/PCDF emissions for solid fuel boilers. This is because coal fired boiler fly ash typically contains unburned carbon, which may act to adsorb organics including PCDD/PCDF. However, due to lack of data, the degree of significance cannot be assessed. Additionally, the adsorptive capability of the fly ash may depend on the type/source of coal (similar to that observed for Hg control).

PM

PM emissions data are available from all solid fuel boilers. Test condition averages range from 0.021 gr/dscf up to 0.036 gr/dscf. The data are all from compliance testing conditions designed to maximize PM emissions.

PM emissions from solid fuel boilers are controlled primarily with the use of ESPs or FFs. FFs or ESPs are used on all units to meet the current RCRA BIF PM requirement of 0.08 gr/dscf, as well as in most cases the LVM and SVM RCRA BIF risk-based standards..

To a lesser degree, PM is also controlled by limiting the ash feedrate. The uncontrolled PM loading in the combustor flue gas is related primarily to the ash feedrate. Total ash feedrate MTECs from solid feed boilers range from 8,000 to 12,000 mg/dscm. Coal contributes the majority (greater than 90%) of the total ash input. Coal provides 70 to 95% of the total heat input to solid feed boilers. Ash contributions from hazardous waste feeds used in the CoC tests are not significant compared to the ash from the coal.

The coal firing mechanism can also have an affect on uncontrolled PM levels. Pulverized coal units generally have higher entrained fractions of “fly ash” contained in the combustion flue gas compared with stoker units (which have larger fractions of “bottom ash”). However, as discussed below, solid fuel boilers are not sub-categorized based on fuel firing type because the dominant control mechanism for PM is the PM APCD.

Hg

Mercury stack gas emissions measurements from solid fuel boilers are available from 5 sources. Test condition averages range from less than 1 to 12 ug/dscm. Feedrate data are

available from all sources.

Mercury is controlled in solid fuel boilers in part by limiting the mercury feedrate. Three units actively spiked Hg during CoC testing, at feedrate MTECs of 50 to 90 ug/dscm. The other units complied with Hg feedrate limits under the RCRA BIF Tier I option. Unspiked “normal” hazardous waste Hg feedrate MTECs were all less than 2 ug/dscm. Hg feedrate MTECs in coal during CoC testing range from less than 1 to 10 ug/dscm.

The ESPs and FFs used by the solid fuel boilers also provide some level of Hg control. ESPs and FFs on solid fuel boilers are achieving, during CoC compliance testing, from 80 to 90+% control of Hg. This is somewhat consistent with the wide (and generally lower) mercury control performance of ESP and FFs observed from recent comprehensive performance on coal-fired utility boilers, summarized in Table 2-3:

- FFs control Hg at rate of 60 to 90%, likely due to bag dustcake filtering effect of collected carbon containing ash.
- ESPs have a wide range of control, from 0 to 80% (with most from 0 to 30%), where efficiency is somewhat dependent on coal type (in order of high to low collection efficiency: bituminous, subbituminous, and lignite), and where hot-side ESPs are on the lower efficiency end.

Mercury control efficiencies in ESP and FFs are suspected to depend on mercury speciation in the flue gas, coal type / quality, sulfur and chlorine levels, fly ash carbon content, etc.

SVM

SVM emissions data from solid fuel boilers are available from 10 of the 12 sources. Data from 4 sources (representing 9 sources) are from compliance testing under operating parameters designed to maximize SVM emissions. Data range from less than 5 to 165 ug/dscm.

SVM are controlled in solid fuel boilers through a combination of:

- Feedrate control. SVM feedrates are limited under the RCRA BIF Rule. SVM feedrate MTECs range widely:
 - Two units complied with SVM under the RCRA BIF Tier I option – the units did not measure SVM in the stack gas and did not spike SVM during the CoC testing. Total SVM feedrate MTECs were less than 500 ug/dscm.
 - Four of the units complied under the RCRA BIF Tier III option. Spiked SVM total feedrate MTECs ranged from about 2,500 to 10,000 ug/dscm, where spiking accounts for 50 to 90% of the total SVM feed.

- One of the units limited spiking and stack gas measurement to Cd only.
- PM air pollution control device of either FF or ESP.

LVM

LVM emissions data are available for all solid fuel boilers. Stack gas data range from 40 to 230 ug/dscm. All are from compliance tests designed with operating conditions to maximize LVM emissions.

LVM, identical to SVM discussed above, is controlled through a combination of feedrate control and the use of PM air pollution control devices. Total LVM feedrate MTECs range from about 3,000 to 22,000 ug/dscm -- with 200 to 5,000 ug/dscm coming from coal; and 800 to 18,000 ug/dscm from spiked waste. All units actively spiked LVM during the CoC testing (all complied with the RCRA BIF Rule under the Tier III approach). The higher emissions levels are generally associated with the higher feedrates.

Chlorine

Total chlorine emissions data are available from all units. All data are from CoC testing. For 2 of the units, compliance was demonstrated under the RCRA BIF Tier I approach; no chlorine spiking was used during testing (chlorine feedrate limits were not set during testing). Alternatively, for the other units, compliance was demonstrated under the Tier III approach, where testing was conducted using spiked, maximum chlorine feedrate limit levels. Emissions levels range widely from less than 5 ppmv (for the two units complying under Tier I, with normal chlorine feedrates), up to 700 ppmv (for the units under Tier III, with maximum chlorine feedrates).

Chlorine emissions from solid fuel boilers are controlled solely through limiting the feedrate of chlorine from the hazardous waste, coal, and other non-hazardous waste feedstreams. The 2 units with the lowest chlorine feedrates (and emissions of less than 1 ppmv) did not “spike” chlorine during CoC testing. The other units spiked varying amounts of chlorine during CoC testing (70% to greater than 95% of the chlorine was from spikes).

Chlorine concentrations in coal can range from less than 20 to over 1,500 ppmw (typically less than 300 ppmw), which project to uncontrolled chlorine stack gas emissions levels of less than 40 ppmv. Chlorine MTECs from coal used during the CoC testing ranged from less than 1 ppmv up to apparently 50 ppmv.

Chlorine air pollution control methods such as dry and wet scrubbing are not used on any solid feed boilers currently burning hazardous waste. This is evident from the near zero total chlorine SREs (0 to 20%, with one at 50%) that are observed during the CoC testing (i.e., there was a very good balance of chlorine that was fed and chlorine that left the stack). Dry scrubbing is used on one boiler (ID No. 717) at the Eastman Tennessee facility that in the past burned

hazardous wastes; however, this unit has recently stopped burning hazardous waste. Chlorine control was greater than 95% for this dry scrubbing unit.

For coal fired units, it is especially appropriate to set a total chlorine emission floor level, compared with separate HCl and Cl₂ floors. Recent bench-scale experiments indicate that EPA Stack Gas Sampling Method 26A cannot be used to accurately speciate HCl and Cl₂ in coal combustion flue gases due to interference from potentially high levels of SO₂.

2.6 HCl Production Furnaces

PCDD/PCDF

PCDD/PCDF levels from HCl Production Furnaces are available from 14 of the 17 sources. Test condition averages range widely from less than 0.1 ng TEQ/dscm, up to 7 ng TEQ/dscm.

PCDD/PCDF data from units with waste heat boilers (or lack of combustion gas cooling water spray quench) appear to be higher than PCDD/PCDF from units that do not have a waste heat boiler (and use rapid water quench cooling of combustion gases). There are two test conditions which fall outside this general behavior, however:

- Cond. ID No. 786C3, with PCDD/PCDF at 1.6 ng TEQ/dscm, is a high outlier within the set of PCDD/PCDF data from units without waste heat boiler. The remainder of the PCDD/PCDF data from units without waste heat boilers are all below 0.2 ng TEQ/dscm.
- Cond. ID No. 2020C3, with PCDD/PCDF at 0.2 ng TEQ/dscm, is a low outlier within the set of PCDD/PCDF data from units with waste heat boilers.

The potential trend where units with waste heat boilers have higher PCDD/PCDF data than those without waste heat boilers would be consistent to that observed for hazardous waste incinerators with and without waste heat boilers. Potential differences in PCDD/PCDF performance between units with waste heat boilers and units with water quenching may be attributed to:

- For waste heat boiler systems, catalytic PCDD/PCDF formation as a result of particulate hold-up on firetube boiler surfaces within a flue gas temperature range (400 to 700°F) that has been implicated for PCDD/PCDF formation; and/or;
- HCl Production Furnaces (as well as many hazardous waste incinerators) can have relatively high chlorine-to-hydrogen ratios, at which the homogeneous (non-catalytic) formation of Cl₂ can be significant. Cl₂ is directly linked to PCDD/PCDF formation. For water quench systems, the addition of cooling water (providing hydrogen) directly into the combustion gases has been suggested to suppress Cl₂ formation compared with Cl₂ levels in waste heat boiler units.

PM

PM emissions are available for all units. All but one of the test conditions is less than 0.015 gr/dscf. Cond ID No. 853C12, with a PM level of 0.045 gr/dscf, appears to be an outlier:

- It has 2 other test conditions with levels less than 0.01 gr/dscf.
- There are many other test conditions from other HAFs with similar or high ash feedrates and with PM levels of less than 0.01 gr/dscf.

PM is controlled through the use of multiple low energy type wet scrubber absorbers designed for acid recovery. Some (5) units additionally use high energy scrubbers, positioned both upstream and downstream of the primary acid absorber towers, for enhanced acid gas and/or metals or PM control. The use of the high energy scrubbers has no observable effect on PM emissions levels or control, however.

PM is also controlled through limiting the ash feedrate. HCl Production Furnace feedstreams tend to have low ash content (feedrate ash MTECs of less than 100 mg/dscm for most units). This may in part be a result of the requirement to recover a non-contaminated acid product with certain specifications on maximum solids/ash content.

Hg

Hg levels from HCl Production Furnaces are all less than 0.2 ug/dscm. Low emissions levels are a result of: high control efficiencies from the use of multiple wet scrubber stages with both acidic and basic wet scrubber solutions; and low mercury feeds (data are all from normal test conditions, where mercury spiking was not used).

SVM

SVM emissions data from HCl Production Furnaces are available from 13 units.

Most of the emissions data are from risk burn testing at “normal” waste feeds (i.e., SVM was not spiked) and are at SVM levels of less than 5 ug/dscm – these sources complied with RCRA BIF rule SVM requirements under the Tier I option.

Alternatively, two units complied with Pb under the RCRA BIF Tier III option (but with Cd under the Tier I option). These units operated under compliance test conditions for Pb (with maximum, spiked Pb feedrates); Pb emissions are 60 and 160 ug/dscm.

LVM

LVM stack gas emissions data are available for 15 sources. Data from most of the

sources is from “normal” operating conditions with respect to LVM. LVM emissions levels from all conditions are less than 45 ug/dscm. LVM feedrates ranged widely from less than 100 ug/dscm, all the way up to 13,000 ug/dscm. The higher feedrates are all from test conditions where LVM was spiked (compliance with LVM under the RCRA BIF Tier III approach).

Chlorine

Total chlorine emissions data from HCl Production Furnaces are available from all units. The data are from compliance tests and range from less than 5 ppmv, up to 150 ppmv, with one at almost 500 ppmv.

All HCl Production Furnaces use a series of multiple primary absorber towers (spray, tray, and packed varieties) for the removal of HCl from the combustion gases. A tail end polishing scrubber is also used for the final cleanup of HCl and Cl₂ that pass through the primary absorber towers. The final cleanup scrubber is operated with a scrubber liquid solution that is maintained at a highly basic pH through the addition of a caustic reagent such as sodium or calcium (or other proprietary) material to ensure the high efficiency capture of Cl₂ (which is typically captured in the primary absorbers with very low efficiency due to the use of acidic scrubbing liquor) and any residual HCl.

As with all other BIF units, HCl Production Furnace chlorine feedrate limits are set based on levels demonstrated in a successful CoC testing program. Moreover, however, for classification as a HAF, hazardous waste feed materials must contain at least 20% chlorine by weight (see 40 CFR 260.10). In effect there is a minimum limit of chlorine that must be fed to the HCl Production Furnace. Because these furnaces produce HCl product from chlorinated feedstocks, MACT floor control does not involve limiting the hazardous waste chlorine feedrate.

Table 2-1. APCD Temperatures for Solid Fuel Boilers

Test Cond	APCD	ESP Inlet Temp (F)	Stack Temp (F)	Comments
717C1	SD/ESP	178	189	Stack temp > ESP temp !? No longer burn haz waste
908C1	ESP	355	330	
719C10	ESP	360	350	
1012C1	ESP	375	330	
1014C10	FF	386	371	
1014C11	FF	330		
1013C10	FF	390	370	
1011C1	ESP	426	350	
907C1	ESP	495	370	D/F measurements made
907C2	ESP	495		D/F measurements made
1009C1	ESP	396	380	
1009C2	ESP	502	475	D/F measurements made

Notes:

Under BIF, required to make PCDD/PCDF measur when desired APCD temp > 450F
If APCD temp < 450F, no PCDD/PCDF measur req

Not a big difference in ESP inlet and stack temperatures for most units

6 of 9 units with ESP/FF inlet temps < 400F

Table 2-2. PCDD/PCDF Data from Non Hazardous Waste Industrial Boilers

Cond ID / Fuel Type / APCS	D/F TEQ ng/dscm Cond Avg	Stack Gas Temp F Cond Avg	Estim APCD Temp F Cond Avg
E200.004c, coal, ESP	0.002	326	401
E204.011, coal, ESP	0.003	337	412
E218.004, coal, ESP	0.005	299	374
E203.003, coal, FF	0.006	331	406
E884.004, coal/industrial sludge/wood, FF/MC/S	0.007	326	401
E200.004u, coal, None	0.008	334	
E207.004, coal, ESP	0.013	291	366
E2.001, coal, LI/FF	0.013	299	374
E202.009, coal, ESP	0.016	127	202
E753.007, coal, None	0.017	298	
E884.003, coal/wood, FF/MC/S	0.019	328	403
E19.002, coal, LI/FF	0.026	308	383
E20.008, coke/natural gas, LI/FF	0.038	329	404
E721.005, coal/liquid waste/wood/other solids, ESP/C	0.043	407	482
E15.001, coal, LI/FF	0.062	316	391
E753.002, coal/tires, None	0.072	291	
E1.008, coal, FF	0.081	354	429
E217.001, coal, DS/FF	0.086	167	242
E91.002, coal/RDF, None	0.103	285	
E1021.005, coal/coke, FF	0.285	307	382
E91.006, coal/RDF, None	0.710	278	

Wood

E676.001, industrial sludge/natural gas/wood, ESP/C	0.001	343	418
E833.003, wood, FF/FGR/LI	0.002	335	410
E778.005, wood, None	0.002	345	
E795.024, tires/wood, FF/DS	0.002	219	294
E833.004, wood, FF/FGR/LI	0.003	337	412
E1024.003, wood, MC/ESP	0.004	333	408
E1026.030, tires/wood, ESP	0.005	341	416
E519.002, tires/wood, ESP	0.005	341	416
E724.013, wood, ESP/MC	0.006	341	416
E518.004, wood, ESP	0.007	355	430
E767.004, fuel oil/industrial sludge/wood, ESP/MC	0.007	366	441
E522.004, wood, ESP	0.008	358	433
E1026.040, wood, ESP	0.010	358	433
E29.001, wood, MC/ESP	0.011	344	419
E27.013, biomass/wood, LI/MC/FF	0.014	363	438
E27.006, biomass/wood, LI/MC/FF	0.014	362	437
E1026.050, wood, ESP	0.017	356	431
E724.004, wood, ESP/MC	0.019	336	411
E521.004, wood, ESP	0.021	356	431
E1026.020, wood, ESP	0.022	355	430
E798a.027, wood, FF/DS	0.022	237	312
E795.016, wood, FF/DS	0.025	250	325
E1026.010, wood, ESP	0.029	348	423

Table 2-2. PCDD/PCDF Data from Non Hazardous Waste Industrial Boilers

Cond ID / Fuel Type / APCS	D/F TEQ ng/dscm Cond Avg	Stack Gas Temp F Cond Avg	Estim APCD Temp F Cond Avg
E795.007, tires/wood, FF/DS	0.036	251	326
E520.002, wood, ESP	0.037	348	423
E798a.013, tires/wood, FF/DS	0.046	235	310
E265.004, wood, ESP	0.066	357	432
E530.003, wood, ESP	0.068	357	432
E28.001, wood, WS	0.075		
E710.003, wood, ESP/C	0.124	316	391
E530.006, wood, ESP	0.152	367	442
E266.006, wood, MC/ESP	0.255	349	424
E529.003, biomass/wood, ESP/MC	0.262	349	424
E797.013, tires/wood, FF/DS	0.266	272	347
E1026.004, wood, ESP	0.274	346	421
E265.002, wood, ESP	0.309	367	442
E614.008, wood, ESP/LI	0.341	291	366
E530.005, wood, ESP	0.355	358	433
E614.009, wood, ESP/LI	0.370	304	379
E625.002, wood, ESP/VS	0.385	145	220
E798b.007, tires/wood, FF/DS	0.390	222	297
E614.007, wood, ESP/LI	0.411	295	370
E710.005, wood, ESP/MC	0.463	358	433
E862.005, RDF/wood, EGB	0.499	346	421
E537.001, RDF/wood, EGB	1.298	325	400
E859.001, RDF/wood, FF/EGB	1.302	336	411
E529.007, E266.005, biomass/wood, MC	1.413	441	516
E613.003, wood, ESP	2.064	313	388
E860.002, RDF/wood, FF/EGB	2.912	351	426
E657.001, RDF, ESP/C	3.331	423	498
E861.001, RDF/wood, EGB	5.157	341	416
<u>Fuel Oil</u>			
E251b.003c, fuel oil, ESP/FGD	0.007	325	400
E22.002, fuel oil, None	0.007	404	
E251b.003u, fuel oil, FGD	0.009	311	
E212.002u, fuel oil, LNB	0.383	325	
E212.002c, fuel oil, ESP/LNB	0.482	344	419
<u>Miscellaneous</u>			
E767.009, industrial sludge, ESP/MC/FGD	0.002	96	171
E507.003, landfill gas, VS/LNB/FGR	0.008	302	
E509.001, landfill gas, FGR	0.029	299	

Source: EPA ICCR Data Base

Table 2-3. Mercury Control From Coal Fired Utility Boilers

APCD	Bituminous			Sub Bituminous			Lignite		
	Eff Range %	Eff Avg %	No. Test Cond	Eff Range %	Eff Avg %	No. Test Cond	Eff Range %	Eff Avg %	No. Test Cond
ESP (cold)	15-80	50	7	0-35	15	6	0-20	10	2
ESP (hot)	0-20	10	4	0-30	10	5			
FF	70-90	80	3	60-80	70	2			

Source: EPA ICR Information Collection on Hg from coal-fired utility boilers

3.0 HAP Selection Issues

3.1 PM as Surrogate for Non-Enumerated Metals and Continuous Indicator for LVM/SVM Performance Assurance

Non-Enumerateds

PM is used as a surrogate for the “non-enumerated” metal HAPs of antimony (Sb), cobalt (Co), manganese (Mn), nickel (Ni), and selenium (Se). PM also controls the RCRA metals of silver, barium, and thallium. Direct “numerated” MACT standards are not set for these non-enumerated metal HAPs due to the lack of emissions test data and/or low risk.

The non-enumerated metals of Co, Mn, Ni, and Sb are classified as low volatile metals (LVMs). For all combustion source types, they are generally contained in the bottom ash or entrained PM, and are well distributed through the various entrained PM size distribution. They are not generally volatile at combustion of APCD temperatures.

Selenium is classified as a semivolatile metal (SVM). It is volatile in the combustor (little remains in the bottom ash), condenses fully in the downstream air pollution control system, and is contained primarily in the enriched, fine-sized entrained PM. Selenium’s enrichment and SRE performance data are similar to the enumerated SVMs of Cd and Pb.

Thus, all of the non-enumerated metals are controlled in part through PM control, as well as directly through feedrate control.

Control Indicator for SVM and LVM

PM control is directly related to SVM and LVM control. Increased PM control leads to lower condensible emissions (such as LVM and SVM) because these condensibles are contained within the overall PM. The vapor phase contribution of LVM and SVM is negligible at the temperature of the air pollution control device.

PM control may also provide additional control of semivolatile organic HAPs (organics that are condensed or adsorbed onto particulates).

3.2 CO/HC and DRE as Surrogates for Non-PCDD/PCDF Organic HAPs

MACT standards for CO or HC and DRE are used as surrogates for the control of non-PCDD/PCDF organic HAPs. CO and HC are widely used and accepted indicators of combustion conditions; and are effectively used to maintain combustion efficiency, overall reaction completeness, and limit the formation and emissions of products of incomplete combustion (PICs):

- CO – CO is a conservative indicator of deteriorating combustion conditions. Generally,

when CO is low, waste destruction is high and PIC and HC emissions are low. When CO increases, increased frequency of lower DRE and high PICs has been observed in numerous types of waste combustion systems.

However, high DRE and low PIC emissions can be achieved at high CO levels, as demonstrated in rapid combustion gas quench design incinerators. It is suggested that insufficient residence time at temperature is available for CO to fully oxidize. Waste organics breakdown to CO; CO oxidation to CO₂ is the slowest (and last) step in the organic waste combustion process.

Thus, an alternative of meeting the HC standard rather than the CO standard is provided.

- HC – HC is a direct indicator of inefficient combustion and PIC emissions.

Note that under efficient combustion conditions (signified by the CO and HC MACT standards), PIC emissions are generally the result of “random” combustion failure modes – thus, there may not be a strong relation between PIC and CO or HC levels – other than PICs are low when CO and HC are low. However, under “gross” combustion failures there is a direct relation between CO/HC and PIC levels.

3.3 Metal Volatility Groupings

HAP metals are grouped according to volatility class because the volatility of the metal affects the control technique or efficiency. The classification is based on various considerations:

- Theoretical thermodynamic modeling.
- Observed metal behavior and partitioning from hazardous waste combustor performance tests. This includes assessments of metal system removal efficiency, fly ash enrichment, and metal partitioning to bottom ash, fly ash, and stack gas.
- Metal behavior from experimental tests on other types of combustor systems.

HAP metals are classified into three “volatility” groupings:

- High volatile metals – Includes Hg. Hg tends to vaporize completely at combustion temperatures. Hg tends to remain volatile at the air pollution control device, and is controlled through adsorption or absorption stack gas control methods.
- Semivolatile metals – Includes Cd and Pb (and non-enumerated Se). Like the high volatile metals, these metals tend to vaporize significantly at typical combustion temperatures; smaller amounts remain in the combustion bottom ash. However, unlike high-volatile metals, they fully recondense at the air pollution control device temperatures on fine particulate matter (enriched in the fine fly ash). Their control is highly dependent on the capture of fine, submicron particulate.

- Low volatile metals – Includes As, Be, and Cr (and nonenumerated metals of Co, Mn, Ni, and Sb). These “refractory” metals do not tend to vaporize at combustion temperatures. They are incorporated primarily into a solid matrix at the combustion temperatures (i.e. they are retained in the bottom ash for incinerators and boilers, and in the clinker and aggregate for industrial kilns). They are not enriched in the fly ash. Although these metals partition primarily to the bottom ash or kilnproduct, a portion is entrained in the combustion gas. Control is dependent on the capture of larger size entrained particulate matter.

3.4 Selection of HAPs for HCl Production Furnaces

For HCl production furnaces, MACT emission standards are set for the following HAP or HAP surrogates: total chlorine, CO/HC, DRE, and PCDD/PCDF.

The total chlorine standard is used as a surrogate for the control of the HAP metals. There are no separate, enumerated floor standards for Hg, SVM, LVM, or PM for HCl Production Furnaces. The use of total chlorine as a surrogate for the control of Hg, SVM, LVM, and PM is appropriate because:

- In order to be classified as an HCl Production Furnace, feeds with relatively high levels of chlorine must be processed. Thus, to meet the total chlorine MACT floor emissions level, the HCl Production Furnace must use a wet scrubber system that has high efficiency chlorine control.
- High efficiency wet scrubber series being used by currently operating HCl Production Furnaces are effective at controlling Hg, SVM, LVM, and PM (which is indicative of control for nonenumerated metals):
 - All PM levels less than 0.015 gr/dscf, with most less than 0.005 gr/dscf. Many have ash SREs of greater than 99%.
 - All LVM levels are less than 30 ug/dscm. For the units that spiked LVM, SREs are greater than 99%.
 - All but two SVM levels are less than 4 ug/dscm. Two conditions are at 60 and 160 ug/dscm. These units actively spiked SVM. SVM SREs are from 90 to 99%.
 - All Hg levels are less than 1 ug/dscm.

3.5 Total Chlorine Standard

The chlorine standard is expressed as “total chlorine” – a combination of hydrogen chloride (HCl) and chlorine gas (Cl₂). The total chlorine format is used because of concerns with the ability of Method 26 to accurately speciate HCl and Cl₂. Various stack gas constituents

(including sulfur, bromine, and iodine) can interfere with the differentiation of HCl and Cl₂ in the Method 26 sampling train – typically biasing HCl high. However, the ability to capture “total chlorine” is not affected¹.

Total chlorine is calculated as:

$$\text{Total chlorine (ppmv)} = \text{HCl (ppmv)} + [2 * \text{Cl}_2 \text{ (ppmv)}]$$

¹ As discussed in the preamble to the proposed rule, however, Method 26 has a low bias for total chlorine for sources that emit alkaline particulate, such as cement kilns. This would not affect compliance with the total chlorine emission standard for those sources because the emissions data used to establish the standard were obtained using Method 26.

4.0 Subcategorization

4.1 Approach

Engineering judgement and statistical analysis are used to determine the appropriateness of subcategories beyond the six primary hazardous waste combustor source categories – incinerators, cement kilns, lightweight aggregate kilns, liquid fuel boilers, solid fuel boilers, and HCl production furnaces. The subcategory evaluation approach has two steps:

- Subcategory selections – Engineering judgement is used to determine potential subcategories. Potential subcategories are considered when unit design and operation differences within the source category could have a substantial impact on the ability to emit and control HAPs.
- Statistical analysis – Analysis of Variance (ANOVA) is used to determine if stack gas emissions from two or more of the potential subcategories are statistically different. The ANOVA procedure is a common statistical test used for determining if the means of different groups of data are different (i.e., if the different groups of data come from distinctly different populations).

Standard ANOVA analysis is used to determine if differences exist in the means of two or more groups (or subcategories) of data. Specifically, the ANOVA approach involves the following procedures:

- Calculate the “variation between subcategories” as:

$$v_B = \sum_{j=1}^a n_j (\bar{x}_j - \bar{x})^2$$

where:

- n_j Number of data points (sources) in each different group (subcategory)
- a Number of different groups
- \bar{x}_j Average all of data points (sources) in each different group
- \bar{x} Global average, average of all data points in all groups

- Calculate the “total variation” for all subcategories as:

$$v_T = \sum_{j=1}^a \sum_{k=1}^{n_k} (x_{jk} - \bar{x})^2$$

- Calculate the “variation within subcategories” (also commonly referred to as the “residual”) as:

$$v_w = v_T - v_B$$

- Calculate the “mean square” of the between and within variations:

$$MS_B = \frac{v_B}{DOF_B}$$

$$MS_W = \frac{v_W}{DOF_W}$$

where:

DOF_B Degrees of freedom between subcategories (equal to the number of subcategories minus 1 (a-1))

DOF_W Degrees of freedom within subcategories, equal to the total number of data sources in all subcategories minus the number of subcategories)

- Calculate the “F” test statistic as:

$$F = \frac{MS_B}{MS_W}$$

- Compare the F test statistic with F_{crit} (where F_{crit} is taken from a one-sided F distribution, evaluated at a 95% confidence level). If the F test statistic is greater than F_{crit} then the means (averages) of the different subcategories are statistically different (i.e., the subcategories belong to different populations of data).

An advantage of the ANOVA test procedure is that it can be used to determine differences between three or more potential subcategories of data (it is not limited to comparing two categories). When considering three or more potential subcategories, the first step is to determine if differences exist when considering all potential categories together. If differences do not exist then the analysis is concluded. If differences are found (i.e., if differences are determined to exist between the three or more categories), engineering judgement is used to select a smaller subset of potential categories to analyze. In this manner, by determining which combination of subcategories are similar, subcategories which are different than the rest are isolated.

Finally, ANOVA statistical analysis results are evaluated for consistency with engineering principles.

4.2 Potential Subcategories Considered

Potential subcategories that are considered based on engineering principles depend on the HAP and source category, and include:

- Solid fuel boilers

PM – Stoker fired vs pulverized coal boiler designs. Pulverized coal boilers have higher levels of fine entrained PM compared with stoker designs. In pulverized coal boilers, due to the small ground pulverized coal form, combustion flame, and boiler design, most ash/PM is entrained with the combustion flue gases out of the combustion chamber; very little bottom ash is collected. In stoker bed boilers, however, much of the ash/PM remains in the stoker bed and is removed in the primary combustion chamber.

- Liquid fuel boilers

PCDD/PCDF – Dry APCDs vs no or wet APCDs. PCDD/PCDF levels from systems with dry APCDs can be higher than those from units without dry APCDs as a result of PCDD/PCDF formation in dry APCDs.

PM, SVM, and LVM – Mixed waste (i.e., waste that is classified both as hazardous and low level radioactive) vs other. One liquid fuel boiler burns mixed waste and uses a HEPA filter due to the treatment of radioactive contaminated wastes. HEPA filters provide the best available control of PM and are used by this source to control radionuclides. PM and PM related emissions from the mixed waste unit with HEPA filters may not be achievable with less sophisticated PM controls that are more appropriate for combustors burning typical (non-radioactive) hazardous wastes.

- HCl production furnaces

PCDD/PCDF – With waste heat boiler vs without waste heat boilers. As discussed in the previous section, the presence of a waste heat boiler is suspected to affect PCDD/PCDF emissions from HCl production furnaces.

- Cement kilns

Hg, chlorine, SVM, PCDD/PCDF – Long kilns (no short, all wet, without in-line raw mills) vs short with in-line raw mill on-line vs short with in-like raw mill off-line. The operating status of the in-line raw mill (on-line vs off-line) is suspected to affect Hg, chlorine, SVM and PCDD/PCDF emissions.

- Lightweight aggregate kilns

Hg and chlorine – Units that feed high levels of chlorine and mercury and use

“back-end” wet scrubbing (Norlite kilns) vs kilns that feed lower levels of mercury and chlorine and do not have any “back-end” add-on chlorine or mercury air pollution control device (Solite kilns).

- Incinerators

PCDD/PCDF – Units with dry APCDs and/or WHB vs others.

PM, SVM, LVM, Hg, Cl

- Units that are limited to firing liquid wastes (liquid waste incinerators) vs units that feed solid wastes (non-liquid waste incinerator designs such as rotary kiln or controlled air incinerator).
- Government owned units vs non-government units. Government owned units currently include those that burn radioactive wastes (Department of Energy at Oak Ridge), chemical weapons (Department of Defense at Tooele Utah, with a couple others in the construction stage), and munitions (various Department of Defense ammunition depots).

4.3 Results of Subcategory Analysis

ANOVA results of the subcategory analyses are summarized in the set of tables in Appendix A (all with titles starting with “ANOVA analysis”).

Subcategories that are selected based on engineering principles and statistical analysis include:

- PCDD/PCDF from liquid boilers – Two subcategories: units that use dry APCD vs others (those that use no APCD or wet APCDs only). ANOVA suggests the emission data sets are statistically different (they are not from the same population). This is consistent with engineering principles based on transfer of behavior from other similar units (municipal waste incinerators, hazardous waste incinerators).
- PCDD/PCDF from incinerators – Two subcategories: units with dry APCD and/or waste heat boilers vs others (units that do not use a waste heat boiler or dry APCD). ANOVA suggests the emission data sets are statistically different (not from the same population). This is consistent with engineering principles. Additionally, there is no statistical difference between data from units with waste heat boilers and units with dry APCDs (and no waste heat boiler), so further subcategorization is not used.

All other potential subcategories are rejected based on the ANOVA statistical analysis and engineering principles. Specifically:

- PM from stoker and pulverized coal boilers – Although uncontrolled PM emissions levels for stoker and pulverized coal fired boilers are expected to be significantly different, controlled stack gas emissions levels are very similar (no statistical difference). In addition, both boiler types can use the same PM control devices – ESPs and FFs.
- PM (and SVM and LVM) emissions from liquid boilers with HEPAs – PM and PM controlled (SVM and LVM) emissions from the liquid boiler with a HEPA filter are not significantly different (lower) than those from other liquid boilers.
- PCDD/PCDF from HCl production furnaces with waste heat boilers – As discussed in the previous sections, there is a general trend that PCDD/PCDF emissions from units with waste heat boilers are higher than units without waste heat boilers. The average of the data set with waste heat boilers is about three times higher than the average of the data set without waste heat boilers; the majority of the data from waste heat boilers are higher than the majority of the data from units without waste heat boilers. This trend is consistent with PCDD/PCDF behavior from various types of incinerators. However, the ANOVA statistical analysis does not confirm a difference at the 95% confidence level. A difference could be stated with 72.5% confidence.
- PCDD/PCDF, SVM, mercury, and chlorine from cement kilns with in-line raw mills – Cement kilns are not subdivided for any HAPs by the use and operating status of in-line raw mills:
 - For PCDD/PCDF, SVM and chlorine, no statistical difference was found between emissions from kilns without in-line raw mills (all wet, long kilns) and kilns with in-line raw mills (short) with and without the in-line raw mill in operation.
 - For Hg, the ANOVA analysis identified a significant statistical difference between the three potential subcategories. Hg emissions from in-line raw mill kilns with the in-line off are higher than those from kilns with the in-line raw mill off-line or kilns without in-line raw mills. Nonetheless, cement kilns are not subcategorized for mercury due to the following concerns: (1) there is a limited amount of data for in-line raw mill kilns; (2) variations in mercury feedrates during raw mill on-line and off-line operations; (3) uncertainty of the degree of equilibrium for mercury that was achieved in the kiln system during the compliance testing; and (4) inability to determine a in-line raw mill time-averaged mercury emissions level.

However, data from in-line raw mill kilns are not used in the MACT floor analyses for mercury, SVM, and chlorine because:

- Mercury stack gas emissions are likely biased low when the in-line raw mill is on-line, and biased high when the in-line raw mill is off-line, as determined from the ANOVA analysis of the limited data, and as discussed in Chapter 2.

- SVM and chlorine emissions are also likely biased during the in-line raw mill off and on modes; i.e., their emissions levels are sensitive to the in-line raw mill operating temperature and scrubbing influence.
- Hg and chlorine from “high feed” and “low-feed” LWAKs –
 - Hg: There is no statistically significant difference between normal Hg emissions levels for the two potential subcategories. Compliance test data are available only for the high Hg feed category, thus a statistical comparison of compliance test data cannot be made.
 - Chlorine: There is a statistically significant difference between compliance test chlorine emissions data from the two potential subcategories. As expected, chlorine from compliance test conditions from the Norlite sources using wet scrubbers is lower than chlorine from Solite kilns which do not use wet scrubbers. Nonetheless, subcategories are not selected because:
 - .. Resulting MACT floors for the two potential subcategories would both be higher than the current applicable chlorine requirement of the HWC Interim Standard Rule of 600 ppmv (for both new and existing sources).
 - .. The LWAK source category has a small number of units.
 - .. Chlorine emissions from the high chlorine feed Norlite kilns are actually lower than chlorine emissions from the lower feed Solite kilns.
 - .. The chlorine MACT floor based on considering all data together is reasonably achievable by the Solite kilns (that do not use wet scrubbing) using feedrate control.
- PM, chlorine, SVM, LVM, and Hg for non-government vs government incinerators – There is no statistically significant difference in PM, chlorine, SVM, LVM, or Hg emissions between government or non-government incinerator groups.
- PM, chlorine, SVM, LVM, and Hg for liquid vs non-liquid incinerators – There is no statistically significant difference in SVM, LVM, or Hg emissions between liquid or non-liquid sources.

For PM, a statistical difference is identified between the liquid and non-liquid subcategories. Nonetheless, subcategorization is not used. The initial rationale for the potential need for subcategorizing is that the consideration of PM emissions achieved by low ash waste, liquid only units would produce a MACT floor that is not achievable by the solid waste, higher ash feeding units. However, PM emissions are actually higher from liquid only incinerators compared with non-liquid units, opposite to what is

expected based on typical, relative liquid vs solid waste ash content. Thus, differences in PM emissions are strongly related to the type and efficiency of back-end air pollution control device, and more weakly related to ash feed. Further, all types of PM control devices (ESP, FF, wet ESP, venturi scrubbers, etc.) are equally applicable to both liquid and non-liquid wastes. Thus, subcategorizing is not appropriate.

For chlorine, a statistical difference is identified between the liquid and non-liquid subcategories. Nonetheless, subcategorization is not used. Chlorine levels from liquid only systems are statistically higher than emissions levels from non-liquid systems. The primary reason the statistical analysis determined that the potential subcategories are different is due to a number of liquid-only incinerators that have high chlorine emissions as a result of very high chlorine feedrates and/or inefficient wet scrubbing. However, numerous liquid-only units use wet scrubbers that are achieving very high chlorine control efficiency and achieving chlorine emissions levels that are as low as the units from the non-liquid category. Also, the chlorine MACT floors based on the potential subcategories would not be significantly different than the MACT floor considering all units.

4.4 Subcategorization of Boilers by Physical Form of Fuel

Hazardous waste combusting boilers are categorized according to the physical form of waste or auxiliary fuel they burn:

- Liquid fuel boilers – Comprised of boilers that burn only pumpable liquid or hazardous wastes and auxiliary fuels. Can include sludges and slurries as long as: (1) they are pumpable; (2) fuel feeding and combustion burner equipment design and operation are intended for liquid fuels (e.g., the combustor is not a stoker or fluidized bed); and (3) combustion occurs in a flame that resembles that of liquid fuel combustion. All liquid fuel boilers burn liquid hazardous waste with natural gas (predominately), process gas, or fuel oil.
- Solid fuel boilers – Includes boilers that burn fuels that are solid. This includes shredded or size reduced solids and non-pumpable sludges. All solid fuel boilers burn liquid hazardous waste with coal.

Boilers are categorized by liquid and solid fuels due to a number of compelling operating and design differences:

- Uncontrolled ash loading – The physical state of the fuel burned by solid fuel vs liquid fuel boilers strongly impacts the uncontrolled emissions of PM and some HAPs associated with PM. Solid fuel boilers have high ash loadings in the flue gas due to the relatively high ash content of solid fuels (e.g., coal) compared with the lower ash content of most fuels burned by liquid fuel boilers (e.g., natural gas, process gas, liquid hazardous waste, fuel oil).

- APCD types – Because of the higher loading of ash in the flue gas, solid boilers all use higher efficiency PM control devices such as FF and ESPs, compared with liquid boilers, most of which use no PM control device (or lower efficiency PM control device).
- Hazardous waste heating value – Solid fuel boilers burn hazardous waste with a wide range of heating values (high energy content solvents, as well as low energy content wet sludges). Liquid fuel boilers burn primarily high energy content liquid wastes.
- RCRA BIF compliance – Solid fuel boilers comply with the RCRA BIF rule under “Tier III” for LVM, SVM, and chlorine; whereas almost all liquid boilers comply with the BIF rule under the Tier I option (primarily because very few use active add-on air pollution control devices)..
- Coal composition – The HAP content of coal, which is used by all solid fuel boilers, is distinctly different than that of natural gas, which is most commonly used as non-hazardous waste fuel used by liquid fuel boilers.
- PCDD/PCDF – PCDD/PCDF emissions from all solid fuel fired boilers are expected to be low because all burn substantial amounts of coal, as discussed previously in Chapter 2. PCDD/PCDF from liquid boilers ranges widely depending on waste composition and air pollution control device design and operation, discussed previously in Chapter 2.

5.0 Data Handling Issues

5.1 Test Condition Classification – Compliance Test vs Normal vs Other

As a first priority, MACT floors are set based on test data that are classified as conducted under “compliance test” (CT) conditions for the specific HAP. A “compliance test” condition is the test condition in a test campaign with the highest emissions for the HAP in question and where: (1) emissions testing is used to document compliance with the emission standard; and (2) operating limits for the HAP are established based on the operations during the test. Compliance test conditions have been classified in the data base previously as “WC” (worst case). Where sufficient quantities of data taken under “normal” operating conditions are also available, MACT floors based on the normal data are also evaluated.

If sufficient “compliance test” data are not available, data that are classified as taken under “normal” operating conditions are used. Source category - HAP combinations where MACT floor analyses are conducted only with “normal” data (cases where sufficient amounts of compliance test data are not available) are limited to:

- Hg for cement kilns, LWAKs, and liquid boilers.
- SVM for liquid boilers.
- PCDD/PCDF for liquid boilers.
- PCDD/PCDF for incinerators.

Data classified as “in-between” (IB) are considered only in the MACT analysis of PM floors to assess variability of fabric filter emissions, as discussed below in Chapter 5.3. An IB test condition is a test condition that is used to document compliance with an emission standard, but where there is another test condition in the test campaign with higher emissions for the HAP in question that is also used to document compliance with the emission standard.

Data with other classifications – such as “not appropriate” (NA) -- are not considered in any of the MACT evaluations.

See “Volume II: HWC Data Base” in this series of technical support documents for a detailed explanation of the basis of the test condition classification.

5.2 Age of Test Data

For floors set using “compliance test” rated conditions, data that are available from the most recent testing campaign are used for evaluating the MACT floors. Compliance test data from older, historical testing periods (previous CoC, trial burn, or other testing programs) are not considered in the MACT floor analysis, except for the analysis of PM floors to assess variability of fabric filter emissions. Data from the latest compliance test are the most representative of current permit limit operating conditions, and are most appropriate for evaluating floor levels -- with the exception, as discussed below in Chapter 5.3, of PM emissions from units with fabric

filters, for which all available historical CT and IB data are considered to adequately assess performance variability.

For floors set using “normal” data, data from all available normal test conditions are used. This is reasonable because normal data, unlike compliance test data, are not the result of spiking the waste or “detuning” the APCD at different levels over time.

5.3 Modeling Particulate Matter Performance From Fabric Filters (Baghouses)

Representing source performance using data from the “most recent, compliance testing” campaign is appropriate where emissions during compliance testing are readily controlled (maximized) by adjusting system operating conditions:

- All metals and chlorine emissions. Emissions can be directly controlled during compliance testing by adjusting (maximizing) the metal and chlorine feedrate.
- PCDD/PCDF from systems with dry air pollution control systems. Emissions can be controlled by adjusting the dry air pollution control device temperature.
- PM emissions from units with scrubbers, ESPs, IWSs, and/or no active air pollution control devices. Emissions can be directly (and effectively) controlled through the adjustment (“detuning”) of the PM air pollution control device operating parameters (power input for ESP, pressure drop for scrubber) and/or system ash feedrate.

In these cases, owners and operators can design the compliance test specifically to capture anticipated long-term variability by adjusting system operating parameters. Thus, the most recent compliance test emissions are fully representative of long term variability in system operations.

Alternatively, for PM emissions from sources with fabric filters, using the most recent compliance testing data (consisting of a one-time “snap-shot” of system performance) may not be sufficient to fully account for long term variability. PM emissions during any single compliance test from sources with fabric filters are not necessarily at the upper range of expected long term operations. This is because it is difficult to maximize PM emissions from units with fabric filters during compliance tests because there are no fabric filter or combustion system operating parameters that are strongly related to PM emissions performance:

- FF gas flowrate and pressure drop have only secondary impacts on PM emissions.
- Ash feedrate also has a secondary impact on emissions from FFs. PM emissions tend to be independent of ash feedrate because emissions from FFs are primarily related to two mechanisms:

-- Seepage. Almost all particles are initially collected in the filter cake. However,

they can migrate (or “seep”) their way through the cake and be emitted through the back of the filter cake. Few are emitted which pass directly through the filter uncollected.

- Leakage. As the cake builds up, uncovered pores (channels or pinholes) develop in the cake, where particles can “leak” through.

These FF particle emissions modes are supported by experimental observations which indicate that the particle size distribution in the gas changes only slightly across the FF. Thus, emissions are not strongly related to inlet ash loading.

To fully capture the long term variability of PM emissions from sources with fabric filters, individual source statistical parameters – average (mean) and variance -- are modeled using:

- Average – Determined as the average of all available “CT” and “IB” test conditions from the source. Because (as discussed above) PM emissions during compliance testing are relatively insensitive to operating conditions, all CT and IB test conditions are pooled together to represent the sources long term average performance. Changes in emissions from different test conditions over time, and within the same campaign, are assumed to be related to uncontrollable, inherent variability in FF performance.
- Standard deviation – The long term variability of each source using a FF is represented using a “universal variability factor” (UVF). The UVF is used in place of the standard deviation from actual test data from the specific source because: (1) many sources have limited compliance test data, thus it is not possible to determine long term variability solely from the actual source data; and (2) the UVF is considering a better estimate of long term variability because, as discussed below, it is based on the long term performance of many sources with FFs.

The UVF models the typical long term variability of PM emissions from hazardous waste combustors that use FFs. The UVF is determined by evaluating the relationship between the long term average and standard deviation, considering the performance of sources (including those from all combustor source categories) with FFs that have two or more compliance tests (those rated with either a CT or IB) for PM. Note that:

- Pooling historical CT and IB test conditions is appropriate because any differences in emission levels (over time or among compliance test results for a test campaign) are indicative of emissions variability given that FFs are constant emission concentration devices that are insensitive to variation in inlet PM loadings (e.g., caused by spiking ash at various levels over time during compliance testing) and are difficult to detune to increase emissions for compliance testing.
- It is reasonable to aggregate the data for sources across all source categories

because the standard deviation/emissions relationship is not expected to be impacted by the source category type (not expected to vary from source category to source category).

- “Non-MACT” sources are not considered for developing the correlation. Non-MACT sources are units with FFs which are not included in the “best-performing” 12% of sources, as discussed in Chapter 9. This includes 2 incinerators and 3 LWAKs, as shown in Table 5-1. Non-MACT sources are not used because they are higher emitting sources that may be indicative of a poorly designed or operated FF that is not representative of MACT control.
- Tests conducted under “normal” operating conditions are not considered in calculating the UVF (or the source average) because there was no attempt to maximize emissions by adjusting the few controllable operating parameters, such as maximum load (maximizing A/C ratio by maximizing gas flow rate), point in cleaning cycle, fabric pressure drop, etc.

Table 5-1 shows the data considered for determining the UVF relationship. As mentioned above, the average and standard deviation for each source are determined by pooling all available CT and IB rated test conditions that are available from the source.

Figure 5-1 shows the relationship between the long term (multi-condition) average and standard deviations. Each point on the plot represents the long term average and standard deviation from a different source.

A power function is used to model the relationship between the long term standard deviation and average. The best fit power function curve is shown in Figure 5-1, as well as the upper and lower 95th %ile confidence intervals (which are projected to bound 95% of the data). “Outlier” sources which fall outside of the confidence intervals are removed from further consideration for developing the UVF relationship; one outlier source is identified.

A replot of the data without the outlier is shown in Figure 5-2. The best fit power function curve used for determining the UVF for hazardous waste combustors with FFs is:

$$\text{UVF} = 0.236 * \text{Avg}^{0.823}$$

The best fit curve has a correlation coefficient (R^2) of 0.83. A degrees of freedom of 8 is used with the UVF because, on average, about 3 test conditions (with 9 associated individual test runs) are associated with each source used to develop the UVF.

Table 5-1. Fabric Filter Variability

Source Category	Source ID	Cond IDs (CT and IB Test Conditions)	PM (gr/dscf)	
			Avg	StDev
MACT sources, combined similar units				
CK	200/201	200C1,4,5,10,11 ; 201C1,10,11	0.0057	0.0049
CK	303	303C2,7	0.0249	0.0019
CK	3031	3031C1,2	0.0010	0.0006
SFB	1013/1014	1013C10 ; 1014C10	0.0214	0.0048
LFB	771	771C1,2	0.0038	0.0012
LFB	901	901C1,2	0.0037	0.0043
LWAK	307	307C1,2,3,4,10,11	0.0115	0.0076
LWAK	Cascade	311C1,10,11 ; 312C1,2,10,11 ; 336C3,5,10 ; 474C1,10,11	0.0052	0.0042
INC	210/211/212	210C1,2 ; 211C1 ; 212C1	0.0115	0.0081
INC	3008	3008C1,2,3	0.0051	0.0031
INC	3010	3010C10,11,12,13	0.0033	0.0018
INC	3015/3011	3011C1,2,3 ; 3015C1	0.0007	0.0006
INC	3012	3012C1,3,4,6,7	0.0192	0.0101
INC	333/612	333C1,2 ; 612C1	0.0012	0.0008
INC	3032	3032C1,2,3,4,5	0.0034	0.0014
INC	327	327C1,2,3,10	0.0013	0.0013
INC	338	338C2,10	0.0009	0.0005
INC	341	341C1,2,10,12	0.0013	0.0013
INC	349	349C1,2,3,11	0.0024	0.0019
Non-MACT Sources				
INC	359	359C1,2,3,4,5	0.0242	0.0181
INC	503	503C1,2,3,4,5,10,11	0.0311	0.0246
LWAK	Arvonía	313C1,10,11,12 ; 314C1,3,10,11 ; 476C1,10,11	0.0199	0.0150
Individual Sources				
CK	200	200C1,4,5	0.0063	0.0047
CK	201	201C1,10,11	0.0048	0.0052
LWAK	311	311C1,10,11	0.0029	0.0023
LWAK	312	312C1,2,10,11	0.0082	0.0049
LWAK	474	474C1,10,11	0.0052	0.0042
LWAK	336	336C3,5,10	0.0034	0.0021
LWAK	313	313C1,10,11,12	0.0191	0.0138
LWAK	314	314C1,3,10,11	0.0217	0.0198
LWAK	476	476C1,10,11	0.0188	0.0094

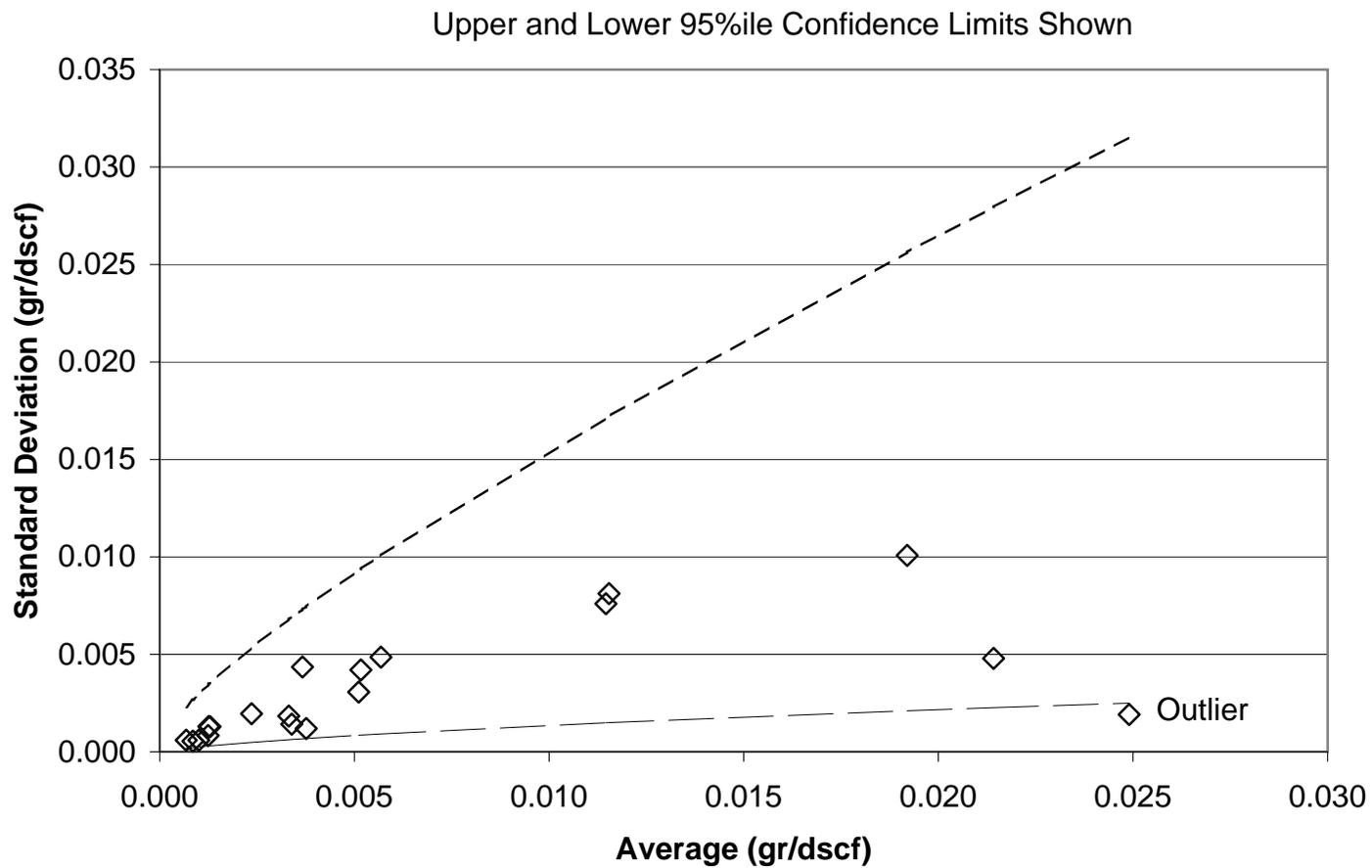


Figure 5-1. "Universal Variability Factor" for fabric filters, all data, upper and lower 95th %ile confidence levels shown.

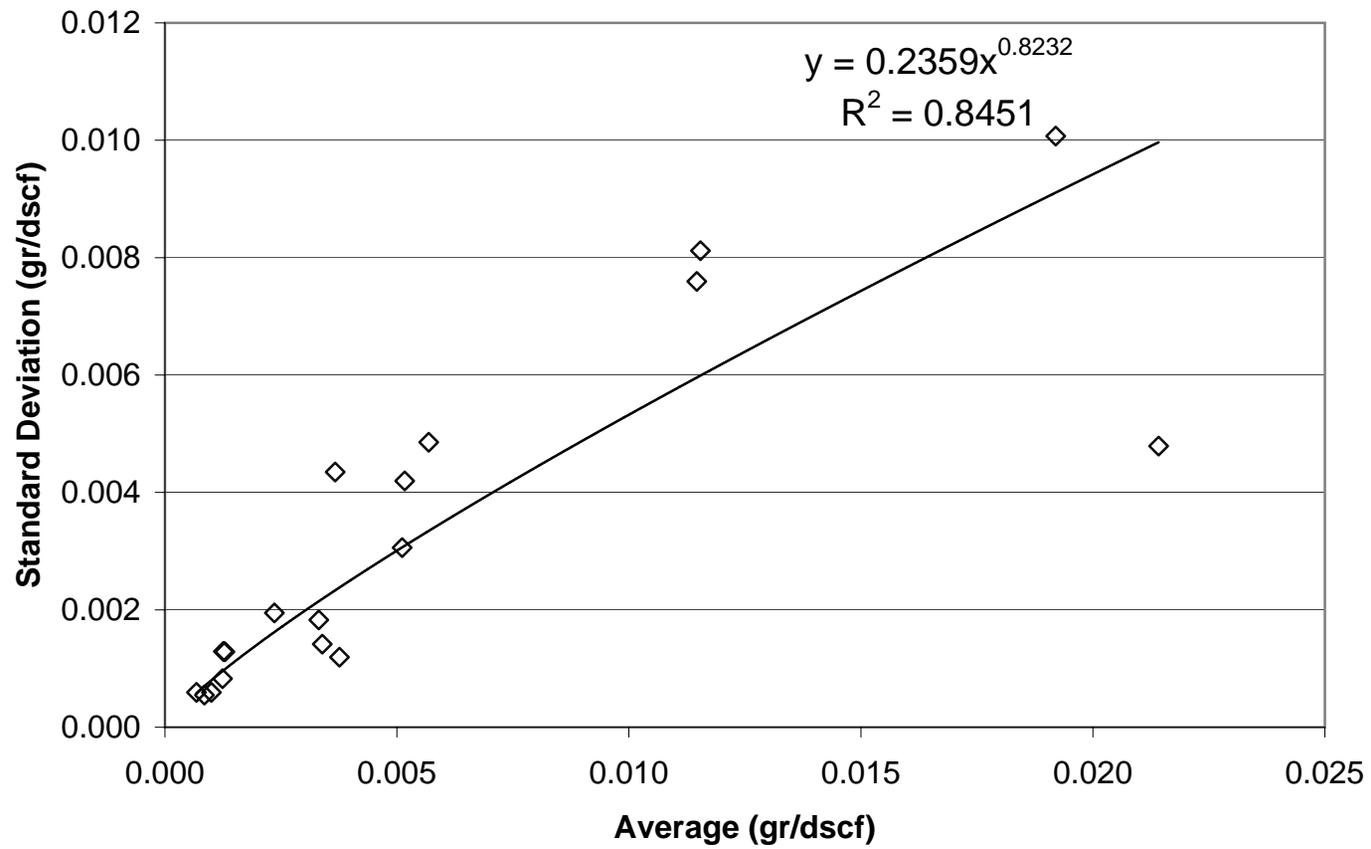


Figure 5-2. "Universal Variability Factor" for fabric filters, best fit curve, without outliers.

6.0 Format of the Standards

Various formats are considered for developing the MACT emissions standards, depending on the HAP and combustor source category characteristics:

- Emission concentration
- Hazardous waste thermal emissions
- System removal efficiency

6.1 Emission Concentration

MACT standards expressed as stack gas mass concentrations (ug/dscm, gr/dscf, ng/dscm, ppmv) are considered (are directly applicable) for all HAPs and all source categories.

6.2 Hazardous Waste Thermal Emissions

Hazardous Waste Thermal Emissions (HWTE) are emissions factors which are expressed as the mass of HAP in the stack gas emissions that are attributable to the hazardous waste per thermal feedrate from hazardous waste (heat input from hazardous waste). Hazardous Waste Thermal Emissions are calculated as the HAP stack gas mass emissions rate attributable to hazardous waste (lb HAP emissions from hazardous waste/hr) divided by the hazardous waste thermal feedrate (million Btu/hr):

$$TE_{HW} = \frac{\dot{m}_{HW}}{TTF_{HW}}$$

where:

TE_{HW} Thermal emissions from hazardous waste (lb HAP emissions / MMBtu)

\dot{m}_{HW} HAP stack gas emissions rate, attributable to hazardous waste (lb HAP/hr)

TTF_{HW} Thermal feedrate from hazardous waste (MMBtu/hr)

HAP stack gas emissions from hazardous waste are projected from the full HAP stack gas emissions measurement and the ratio of the HAP feedrate in the hazardous waste to the total HAP feedrate from all feedstreams, including raw materials and non-hazardous waste fuels. HAP stack gas emissions from hazardous waste feed is calculated as:

$$\dot{m}_{HW} = \dot{m}_{Total} \cdot \frac{F_{HW}}{F_{Total}}$$

where:

\dot{m}_{HW} HAP stack gas emissions rate, attributable to hazardous waste (lb

	HAP/hr)
\dot{m}_{Total}	As measured total HAP stack gas emissions rate (lb HAP/hr)
F_{HW}	HAP feedrate from hazardous waste (lb/hr)
F_{Total}	Total HAP feedrate from all feedstreams (lb/hr)

This estimation assumes that there is a direct relationship between the HAP feedrate and HAP stack gas emissions rate. For liquid fuel boilers, it is assumed that hazardous waste is solely responsible for stack gas emissions because non-hazardous waste fuels include natural gas and light fuel oils which have low HAP content.

The Hazardous Waste Thermal Emissions format is considered for metals and chlorine HAPs for energy recovery units: cement kilns, lightweight aggregate kilns, and liquid boilers. These units burn hazardous wastes with significant heat content, use the heat content for a useful purpose (e.g., make steam that is used for manufacturing or process heating, cement production, or lightweight aggregate production), and displace the requirement for non-hazardous waste fuels (such as coal, oil, or natural gas).

Using Hazardous Waste Thermal Emissions is advantageous because it removes the potential influence that hazardous waste firing rate (percentage of hazardous waste to other non-hazardous waste fuels) has on straight stack gas mass concentrations.

The Hazardous Waste Thermal Emissions format is not appropriate for solid fuel boilers or HCl production furnaces (or incinerators) because:

- A number of the solid fuel boilers burn aqueous sludges with low heating value such that a thermal emission standard may not be achievable.
- HCl production furnaces burn lower heating value chlorinated wastes for the purpose of chlorine recovery. Moreover, the thermal energy in the waste is used to destroy chlorinated organics and to release the chlorine, similar to the use of the thermal energy in wastes fed to incinerators.

The Hazardous Waste Thermal Emissions are analyzed using the same procedures as emissions expressed as a mass concentration under the alternative MACT approaches discussed in the following chapters of this document.

The Hazardous Waste Thermal Emissions format is not used for PM or PCDD/PCDF because there is not a strong relation between hazardous waste feedrate and PM or PCDD/PCDF emissions.

6.3 System Removal Efficiency

For HCl production furnaces, a total chlorine MACT standard based on system removal efficiency (SRE) is proposed. A total chlorine SRE format is used as an alternative to a stack

gas emission concentration because chlorine feedrate control is not an appropriate MACT emissions control technique for these sources. HCl production furnaces are designed to produce hydrochloric acid from chlorinated feedstocks. Limiting the chlorine feedrate means not producing the intended product, a result inconsistent with MACT. As an alternative to the SRE-based standard, a mass emission concentration limit is also proposed; where the straight mass emissions concentration is based on the floor SRE and the highest chlorine feedrate for any HCl production furnace source in the data base.

The SRE format is not considered for any other HAPs or source categories because: (1) for metals and chlorine for other source categories, hazardous waste feed control is an appropriate emission control method; and (2) for PCDD/PCDF, an SRE is not applicable.

6.4 Emission Factor – Mass Emissions per Mass Feed

For cement kilns, the PM standard expressed as an “emissions factor” (mass emissions per mass feed – lb PM / ton dry raw material) is being considered. The emissions factor is essentially an SRE; and is especially appropriate for PM for cement kilns because hazardous waste feed control is not applicable (ash feed to CKs is dominated by raw material feed; hazardous waste generally contributes a small amount to the total ash feed).

7.0 Emissions MACT Approach

The “Emissions” approach involves evaluating source performance based on emissions concentrations expressed as either mass concentrations (e.g., gr/dscf, ppmv, ug/dscm) or hazardous waste thermal emissions (HWTE) (as discussed previously in Chapter 6). The best ranked sources (those with the lowest emissions concentrations) are used to identify the best performing “MACT pool”. The MACT floor level is determined as the emission level achieved by the “average” of the MACT pool sources, considering emissions variability. This approach is applicable to all HAP and source category combinations.

The Emissions approach involves the following steps:

- **Screen and select data** – Test conditions conducted under the appropriate operating conditions are selected for each source, as available, based on the desired data type and test condition classification (e.g., compliance test, normal, most recent, etc.).
- **Estimate upper 99th %iles** -- Using data from the appropriate test conditions, HAP emission “upper 99th %iles” are estimated for each source. The upper 99th %iles are determined using “prediction limits”. The prediction limit is projected to include 99 out of 100 future 3 run averages. The prediction limit (UPL) is calculated as:

$$UPL = \bar{x} + t s \sqrt{\frac{1}{n} + \frac{1}{m}}$$

where:

- n number of individual runs for source
- m number of future runs for compliance, used as 3
- \bar{x} average of individual runs for source
- s standard deviation of individual runs for source
- t Student’s t-factor, evaluated at 99% confidence, and (n-1) degrees of freedom

Data within each source are assumed to be normally distributed, as discussed in more detail in a following section of this document.

- **Rank sources based on 99th %iles** – Sources are ranked from low to high based on their upper 99th %iles.
- **Best performing MACT Pool** – “MACT pool” sources are selected based on the top-ranked (best, lowest emissions) upper 99th %iles. The number of sources included in the MACT pool is equal to the top 12% of sources, but not fewer than 5 sources, for source categories for which data are available for more than 30 sources. For source categories for which data are available for 30 or fewer sources, the MACT pool is the best performing 5 sources.

- MACT floor limit calculation** – MACT floor limit is calculated based on the performance of the MACT pool sources. The MACT floor limit formula is a modified prediction limit, designed to estimate a MACT floor level that is achievable by the average of the best performing sources (i.e., those in the MACT pool). Specifically, the MACT floor limit, UL, is set using the following formulation:

$$UL = \bar{x}_p + t \sqrt{v_T}$$

where:

\bar{x}_p Average of best performing MACT pool source averages.

$$\bar{x}_p = \frac{1}{N} \sum_{i=1}^N \bar{x}_i$$

\bar{x}_i is the individual average for each MACT pool source

v_T Total variance. Determined as the sum of the within-source variance, v_W , and the between-source variance, v_B .

$$v_T = v_B + v_W$$

v_B Between-source variance. Determined as the variance of the average of the best performing source averages. Based on the relationship that the variance of an average is equal to the variance of the population divided by the sample size (number of samples). Variances of each of the best performing MACT pool averages are additive because they are assumed to be independent.

$$v_B = \frac{v_{Averages}}{N} = \frac{\sum_{i=1}^N v_{i, Avg}}{N} = \frac{\sum_{i=1}^N \frac{s_i^2}{n_i}}{N}$$

v_W Within-source variance. Variance of the MACT source average considering “m” number of future individual test runs used to make up the average. Determined as the best performing source MACT pool overall population variance (calculated as the sum of the variances of individual runs within each of the MACT pool best performing sources) divided by the number of future runs in the test condition which are to be used to demonstrate compliance. Based on the relationship that the variance of an average is

equal to the variance of the population divided by the sample size (number of samples). Variances from each best performing source are additive because they are assumed to be independent.

$$v_w = \frac{\sum_{i=1}^N s_i^2}{m}$$

- S_i standard deviation of individual runs for each MACT pool source
- m number of future runs for compliance, used as 3
- t Student's t-factor, evaluated at 99% confidence, and $\sum_{i=1}^N (n_i - 1)$ degrees of freedom
- N Number of sources in best performing MACT pool
- n_i Number of individual test runs per source

so

$$UL = \bar{x}_p + t \sqrt{\frac{\sum_{i=1}^N s_i^2}{n_i N^2} + \frac{\sum_{i=1}^N s_i^2}{m}} = \bar{x}_p + t \sqrt{\sum_{i=1}^N s_i^2 \left(\frac{1}{n_i N^2} + \frac{1}{m} \right)}$$

The first term of the equation is the average of the best performing MACT pool source averages.

The second term accounts for the expected variability in future measurements due to variations resulting from system operation and measurement activities. The term is effectively a “pooled variability factor” based on the observed variance of individual runs within test conditions from the best performing MACT pool sources. The variability factor assumes that variability from the individual best performing source are independent, and thus are additive.

The MACT limit calculation assumes that data across sources are normally distributed. The rationale for this is discussed in more detail in a following section of this document.

8.0 “SRE - Feedrate” MACT Approach

In the “SRE-Feedrate” MACT approach, source performance is evaluated by explicitly considering both “upfront” hazardous waste feedrate control and “back-end” air pollution control device efficiency. “Upfront” feedrate control is assessed based on the feedrate of the HAP from the hazardous waste, expressed as either a “maximum theoretical emission concentration” or “thermal” feedrate. “Back end” air pollution control is assessed based on “system removal efficiency” (SRE).

For each source, hazardous waste feedrate control and SRE are independently ranked. The sources are then ranked based on their relative aggregate rank, where the aggregate rank is the sum of the individual feed control and SRE ranks. Feed control and SRE performance are given equal weights in determining the source performance. The best controlled sources are determined based on the those with the best aggregate rank.

The SRE-Feedrate approach is applicable for feedrate controlled HAPs – metals and chlorine. It is not used for PM or PCDD/PCDF or CO/HC. The approach is not used with “normal” data because SREs from normal operating conditions are not considered sufficiently reliable due to typically low levels in the feed (no spiking) and stack gas.

The SRE-Feedrate approach involves the following steps:

- **Select / screen test condition data** – For each source, the most recent compliance test conditions (as based on emissions concentrations or hazardous waste thermal emissions) are selected that have feedrate measurements. If feedrate measurements are not available for the most recent compliance test condition, then the next most recent compliance test condition for which feedrate measurements are available is selected.
- **Rank Feeds** – For each source, the HAP hazardous waste feedrate (based on either MTECs or thermal feeds) “upper 99th %ile” is estimated as:

$$UPL = \bar{x} + z s$$

where:

- \bar{x} average of individual runs for source
- s standard deviation of individual runs for source
- z Inverse of the standard normal cumulative distribution, evaluated at 99% confidence.

Sources are then ranked from low to high based on the upper 99th %ile feedrate, and assigned a ranking of 1 to N – with a rank of 1 assigned to the source with the lowest upper 99th %ile feedrate, and N given to the source with the highest upper 99th %ile, where N is the number of different sources with SRE and feed data.

- **Rank SREs** – For each source, lower 99th %ile SREs are estimated as:

$$LCL = \beta^{-1} (a, b, p)$$

where:

β^{-1} Inverse of the 2-parameter Beta distribution function
 p Probability of 99% (actually, to estimate the lower 99%, or upper 1%, a probability of 1% (100-99) is used).

$$a = \frac{\bar{x}^2(1 - \bar{x})}{s^2} - \bar{x}$$

$$b = a \left(\frac{1 - \bar{x}}{\bar{x}} \right)$$

\bar{x} Average of individual runs for source
 s Standard deviation (population) of individual runs for source

The two-parameter Beta distribution is used to model the SREs.

Sources are then ranked from low to high based on the lower 99th %ile SRE, and assigned a ranking of 1 to N – again, where a rank of 1 is assigned to the source with the highest lower 99th %ile SRE, and N given to the source with the lowest lower 99th %ile SRE, where N is the number of different sources with SRE and feed data.

- **Rank by Aggregate (Feed Plus SRE) Score** – Individual SRE and Feed ranks are added together to get a total aggregate score for each source. The sources are then ranked by the total aggregate score, from low to high score.
- **Select MACT pool** – The “best performing” MACT pool sources are selected based on those sources with the lowest aggregate score rank. The number of sources included in the MACT pool is determined as 12% of the total number of different sources for which data are available, but not fewer than 5. If there is a tie in the aggregate score between the last ranked source and the next-in-line ranked source(s), then the additional sources with the tied ranked are included in the best performing MACT pool. For example, if the MACT pool should strictly include 5 sources, but there is a tie in the aggregate rank between the fifth, sixth, and seventh ranked sources, then all 7 sources are included in the MACT pool.
- **MACT limit calculation** – The MACT floor is determined using hazardous waste thermal emissions concentrations where appropriate, and mass emissions concentrations for all other cases (except for total chlorine from HCl production furnaces as discussed below), from the best ranked aggregate MACT pool sources. The MACT floor

calculation procedure is identical to the Emissions approach, described in detail in the previous chapter.

- **SRE MACT limit calculation** – For HCl Production Furnaces for total chlorine, SRE only is considered when identifying the best performing sources. This is because it is inappropriate to consider chlorine feedrate given that these furnaces are designed to produce HCl product from chlorinated feedstocks. In addition, the total chlorine standard is expressed as an SRE rather than an emission concentration (i.e., based on the emissions from the best SRE-performing sources) because expressing the limit as a mass concentration would implicitly limit the feedrate of chlorine inappropriately. The MACT SRE limit is calculated in the same manner as the individual source upper 99th %ile SREs, except that the data set is comprised of all test runs from each of the MACT pool sources. This assumes that the MACT pool sources come from the same population.

9.0 Control Technology (Air Pollution Control Device) MACT Approach for PM

The Control Technology (or “APCD”) MACT approach evaluates performance based on the relative HAP control efficiency of “add-on,” back end, air pollution control devices. The APCD approach is appropriate for PM rather than the SRE-Feed approach which would consider ash feedrate explicitly, or the Emissions Approach which would consider ash feedrate implicitly, because ash feedrate is not an effective control parameter for nonenumerated metal HAPs for which PM is a surrogate.

The APCD approach involves the following steps:

- **Identify general type/class of APCDs used within the source category** – List all of the different general classes (and subclasses) of air pollution control devices that control the HAP of interest that are used by at least one source in the source category. This considers all sources in the source category where the type of APCD that is used is known, regardless of whether HAP emissions data are available for the source. The determination of different classes and subclasses is based on control device operating and design characteristics and performance.
- **Rank the APCD classes based on control efficiency** – The general APCD classes are rank-ordered based on their relative HAP control effectiveness, where a low rank is given to the most efficient control class, and higher ranks to the less efficient control classes. Determination of the control efficiency for each class of APCD is based on HAP performance data from HWCs, as well as the demonstrated control efficiency of the APCD class on other similar sources such as municipal waste combustors, medical waste combustors, sewage sludge combustors, coal fired boilers, oil fired boilers, non-hazardous industrial waste combustors, and non-hazardous waste cement kilns.
- **Define MACT control** – Each source for which the APCD is known is assigned an APCD control class and control efficiency rank as determined from the previous steps. Sources are then rank ordered based on the control technology efficiency rating. MACT control is determined as the APCD control class(es) that are used by the top 12%, but not fewer than 5 of the sources for which the APCD is known.

Next, the percentage of all sources with known APCDs that use the MACT control (%MACT_{All}) is determined. This percentage can be greater than 12% because the worst ranked (lowest control efficiency) APCD class that is included as MACT control (in top 12%) may be used by additional sources. For example, ESPs may be the lowest ranked MACT control (they are used by the 12th% source). But within the entire source category, additional sources may use ESPs.

- **Select appropriate emissions data** – For each source, select the appropriate test condition data, for example, conditions classified as most recent, compliance tests.

- **Adjust the total number of sources with emissions data** – The total number of sources with emissions data is adjusted so that the emissions dataset includes a proportion of sources that use MACT control that is identical to that used by the entire set of sources (regardless of whether emissions data are available):

$$N_{Tot\ Adj\ Emiss} = \frac{N_{MACT\ Emiss}}{\% MACT_{All}}$$

- **Determine number of sources with emissions data to be used for the MACT pool** – The number of sources with emissions data to be included in the best performing MACT pool is determined as 12% of the adjusted total number of sources with emissions data ($N_{Tot\ Adj\ Emiss}$), as calculated in the previous step. Fractions are rounded up to the next integer.
- **Select MACT pool sources** – The sources with emissions data are ranked based on their general APCD class control efficiency rating. Within each of the separate classes, sources are ranked from low to high based on their upper 99th %ile emission concentration (as previously described in the Emissions MACT approach section). The best performing MACT pool sources are selected from this ranking.
- **Calculate MACT limit** – The MACT floor limit is calculated from the MACT pool sources using a procedure identical to that discussed above for the Emissions approach.

10.0 “Simultaneous Achievability for Particulates” (SAP) MACT Approach

The “Simultaneous Achievability for Particulates” (SAP) MACT approach involves evaluating performance based on the sources “average” or “aggregate” control performance for HAPs that are controlled by a particulate matter control device: PM, SVM, and LVM. In determining the relative aggregate performance, equal weight is given to each individual HAP.

The SAP approach involves the following steps:

- **Screen and select data** – For each source, PM, SVM and LVM data from test conditions from the appropriate classification (i.e., compliance test or normal) are selected as available.
- **Estimate upper 99th %iles** – For each HAP where data are available, upper 99th %ile emission levels are estimated, as described previously in the Emissions approach.
- **Rank individual HAP upper 99th %iles** – Separately for each HAP, sources are ranked from low to high based on their upper 99th %ile HAP emissions level. For each HAP, a ranking score of 1 is given to the source with the lowest upper 99th %ile, and a score of N is given to the source with the highest upper 99th %ile, where N is the total number of sources with emissions data for the HAP of interest. Sources that do not have data for specific HAPs are not assigned a rank for those HAPs.
- **Average aggregate rank** – For each source, an “aggregate” average score is determined as the average of the individual HAP ranks where available. The average aggregate score is used as an indicator of the overall source performance for HAPs controlled by a particulate matter control device. Sources with lower individual HAP rankings have lower aggregate average scores. Sources are then ranked based on their average aggregate rank score, from low to high.
- **Select best performing MACT pool** – For each of the individual HAPs, the best performing MACT pool sources are selected as those with the best (lowest) aggregate average scores, and that have an emissions measurement for the HAP. The number of sources which are included in the MACT pool is calculated as 12% of the total number of sources for which HAP data are available, but not fewer than 5.
- **Calculate MACT limits** – MACT limits are calculated from the MACT pool sources in a manner identical to that discussed above for the Emissions approach.

11.0 SRE-Only Approach

The SRE-Only approach is identical to that described above for the SRE-Feed Approach, except that sources are ranked solely based on their SRE (i.e., HW feedrate ranking is not considered in the analysis). The emissions from the best SRE sources are used to calculate the floor levels using the same procedures described above.

12.0 Modified ETC Approach

The “Modified ETC” approach involves the following steps:

- Determine “low-MTEC” filter – A lower 99th %ile feedrate MTEC level (LF) is determined for the data set being considered (assumes feeds are normally distributed):

$$LF = \bar{x} - \frac{st}{\sqrt{n}}$$

where:

\bar{x}	Average MTEC feedrate from all sources
s	Standard deviation of all sources
n	number of sources
t	Students t factor, evaluated at n-1 degrees of freedom, and 99% confidence level

For each source in the data set, the test condition with the highest MTEC feedrate is considered. Also, the lower 99th %ile feedrate MTEC is rounded to three significant figures.

(The procedure recommended by ETC is slightly different in that the low MTEC level is always determined considering MTECs from all sources. In contrast, EPA calculates the low MTEC feed screen level based on data only from the category of sources being considered. For example, EPA calculates the low MTEC filter for non-speciality incinerators² using data only from non-speciality incinerators; ETC calculates the low MTEC filter for non-speciality units using all incinerator MTECs.)

- Screen out conditions with low MTECs – Test conditions with feedrate MTECs that are lower than the lower 99th %ile feedrate (LF), as calculated in the previous step, are identified and eliminated from further consideration.
- Rank sources based on lowest compliance test emissions – Sources are ranked based on stack gas mass emissions concentrations using their lowest compliance test condition average – for sources with multiple test conditions rated as compliance test, the lowest is used to represent the source.
- Determine MACT floor – The MACT floor is determined from the best ranked 12% of sources, or not fewer than 5. The MACT floor is calculated as:

² Speciality incinerators are government run radioactive waste, munitions, or chemical weapon incinerators, or other types of munitions or explosives furnaces.

$$MACTFloor = \bar{x}_p + \bar{v}_p$$

where:

\bar{x}_p Average of best performing MACT source test condition averages. Limits are calculated using three different compliance test condition averages:

Most recent compliance test – Data from the most recent compliance test condition are used.

Highest historical compliance test – Data from the compliance test condition with the highest average, considering all historical compliance test conditions, are used.

Average of all compliance test conditions – The average of all available compliance test conditions is used

\bar{v}_p Average of the variabilities of the best performing sources. The variability of each source is determined as the average of the variabilities from each compliance test condition that are available for the source. Variability from each test condition is calculated as:

$$v_i = \frac{s t}{\sqrt{n}}$$

where:

s	Standard deviation of test condition runs
t	Students t, evaluated at n-1 degrees of freedom, and 99% confidence level
n	Number of test runs in the test condition

(Note that this procedure is slightly different than that suggested by ETC (see the ETC procedure in the proposed rule docket). When calculating the Students t factor, ETC uses a degrees of freedom of n instead of the conventional n-1.)

13.0 SRE-High Feed Screen Approach

The SRE-High Feed Screen approach is similar to that described above for the SRE-only Approach. The procedure involves:

- SRE rank – Sources are initially ranked solely based on their SRE.
- Determine SRE floor – Based on the best performing SREs, a MACT SRE floor limit is determined, identical to that described in the SRE-Feed section.
- Determine “high feed” screen – Using HAP feedrates from all sources in the data set being considered, an upper 99th %ile feedrate level is determined in a similar manner to the lower 99th % ile feedrate in the previous described ETC Approach.
- Flag sources with high feedrates – Sources with feedrates (condition average) that are higher than the upper 99th %ile feedrate level are flagged.
- Rank flagged MACT pool sources – Sources in the best performing SRE MACT pool that have been flagged for having high feedrates are rank ordered based on their 99th %ile stack gas emission concentration.
- Select next-in-line source – The next-in-line source that is just outside of the SRE MACT pool is identified; for example, if the MACT pool is comprised of 5 sources, consider the source with the 6th best ranked SRE. If the source is flagged as having a high feedrate, consider the next-in-line source as well; and others if these are flagged, until one is brought it that is not flagged. From this group, choose the source with the lowest emissions level.
- Potentially replace flagged high feedrate MACT pool sources with next-in-line sources that have lower emissions – Begin by comparing the flagged MACT source with the highest emissions level with the next-in-line source (which was selected in the previous step). Replace the flagged MACT pool source with the next-in-line source if emissions from the next-in-line source are lower than emissions from the highest flagged MACT pool source. If no replacement is made, stop the replacement process. If a replacement is made, continue the process with the flagged MACT pool source that has the next lowest emissions. Again, stop the replacement process as soon as a replacement is not made.
- Calculate the MACT floor emissions level using the modified MACT pool – Using the modified, feed-screened, MACT pool, determine the MACT emissions floor level using procedures identical to those described for the straight emissions approach.

14.0 New Source Floors

New source floors are set as the upper 99th %ile from the best performing MACT pool source. Depending on the MACT approach, new source floors are determined as:

- Emissions – Lowest upper 99th %ile of all sources.
- SRE-Feed – Upper 99%ile from the source with the best (lowest) SRE-Feed aggregate score.
- APCD – Lowest upper 99th%ile from sources in the MACT pool using the APCD ranked as having the highest control efficiency.
- Simultaneous Achievability Method – Upper 99th%ile from the source with the best (lowest) average aggregate HAP score.

In some cases, the upper 99th %ile from the best performing MACT pool source happens to be higher than the existing source MACT floor. In these instances, the new source floor is set equal to the existing source floor.

15.0 Miscellaneous Data Handling Considerations

15.1 Data Distributions

Emissions and Feeds

Probability plots, Skewness Coefficient, and Correlation Coefficient / Shapiro-Wilks testing are used to evaluate whether the best performing MACT pool emissions data are better represented by a normal or log-normal distribution. Results are shown in Appendix J.

A normal distribution is used to model the emissions (and feed) data:

- The data are better modeled with a normal distribution. In some cases, the presence of a few high points make the log-normal distribution appear to better model the data. These outlier points are not expected for well design and operated MACT pool sources.
- The probability plots do not suggest that either assumed distribution is significantly or consistently better.
- The data set arithmetic averages tend to be in the neighborhood of the medians, indicating the data sets are not significantly skewed and more closely normal than lognormal.
- In some cases, neither assumed distribution could be statistically rejected.

SRE

For the SRE data, a Beta distribution is used to represent the data. The Beta distribution is particularly suited for modeling SREs because it is not very sensitive to outliers and is appropriately bounded by 1 and 0 (SREs are physically constrained by 0 and 100%).

15.2 Combining Multiple Test Conditions From the Same Source

In some instances it is appropriate to use data from multiple test conditions to represent a single source. For example, cases where there is more than one normal test condition (either during the same campaign, or from multiple campaigns). In these cases, individual runs from each of the test conditions are pooled (grouped) into a single test condition. This single pooled test condition is used represent the source performance; for example, the average of the source is the average of all of the individual tests runs from all of the test conditions with the appropriate rating.

15.3 Test Conditions With One Run or Average Only

For test conditions with useful data from only one test run, or if only a test condition

average is available, standard deviations are estimated from other data from other test conditions with two or more runs as:

Emissions and feeds. Calculated based on a linear relation between the standard deviation and the average:

$$s_{1run} = x_{1run} \frac{\sum_{i=1}^N x_i s_i}{\sum_{i=1}^N x_i^2}$$

SREs. Calculated using a pooled variance approach:

$$s_{1run} = \sqrt{\frac{\sum_{i=1}^N s_i^2}{N}}$$

For sources with emissions from only one test run, or when only a test condition average is available, upper 99th %ile emissions levels are estimated as:

$$UPL_{1run} = \bar{x} + z s_{1run} \sqrt{\frac{1}{n} + \frac{1}{m}}$$

where:

- n number of individual runs for source, equal to 1
- m number of future runs for compliance, used as 3
- \bar{x} average of individual runs for source, as available (in this case, 1 run or 1 condition average)
- s_{1run} standard deviation estimated from other sources and condition average, as determined above
- z Inverse of standard normal distribution, evaluated at 99% confidence

For feedrates where data from only one run or only a test condition average are available, upper 99th %iles are calculated the exact same way as shown previously in the Emissions approach section for cases where more than one run is available.

For SREs where data from only one run or only a test condition average are available, the lower 99th %iles are calculated in a similar manner to that described above for cases with more than one run, with the following modifications:

$$a = \frac{\bar{x}}{1 - \bar{x}}$$

$$b = 1$$

15.4 Sootblowing

Many solid and liquid boilers periodically use “sootblowing” to clean ash and soot deposits from the boiler water tubes. Under current RCRA requirements, boilers that use sootblowing must operate the sootblowing system during one of the RCRA compliance test runs. Runs under which sootblowing was conducted have been identified in the HWC MACT database. The runs with sootblowing are not considered in the HWC MACT floor evaluation. Runs under which sootblowing took place are not used to evaluate the source’s statistical properties (average, variance, 99th %iles) and are not used in setting the MACT floor.

15.5 Cement Kilns With In-Line Raw Mills

As discussed in Chapter 4, data from in-line raw mill kilns are not used in the MACT analyses for mercury, SVM, and chlorine because:

- Mercury stack gas emissions are likely biased low when the in-line raw mill is on-line, and biased high when the in-line raw mill is off-line, as discussed in the Chapter 2.
- SVM and chlorine emissions are also likely biased during the in-line raw mill off and on modes; i.e., their emissions levels are sensitive to the in-line raw mill operating temperature and scrubbing influence.

16.0 Results Using the Emissions MACT Approach

16.1 Mass Emission Concentration Format

Results using the Emissions Approach and the mass concentration format are shown in the tables of Appendix C. The titles of each table have a label that starts with “E”. A list of tables is shown below. Each of the tables has an identical format and contents. The tables summarize information for each source which is used to evaluate the MACT floors. The information includes: (1) source ID No.; (2) test condition IDs which are used for each source; (3) average of the straight emissions for the individual runs of the test conditions; (4) standard deviation of emissions for the individual runs of the test conditions; (5) number of individual test runs of the test conditions³; and (6) the upper 99th %ile emissions estimate for each source. The sources are ranked by upper 99th %ile, from lowest to highest. The best performing MACT pool sources (12% or at least 5) are shown above the horizontal bold line. At the bottom of the table, the following are shown: MACT floor limit for existing sources, average of the best performing MACT pool source averages, the MACT pool “pooled” variability, and the number of sources included in the MACT pool.

As discussed in the previous “Data Hierarchy” section of this document, the data that are used to evaluate the MACT floors are generally limited to test conditions that are classified as “compliance test” and those “compliance test” conditions from the most recent available testing campaign. There are some exceptions, however, where test data classified as “normal” are used instead of “compliance test” due to insufficient “compliance test” conditions: Hg for CK, Hg for LWAKs, Hg for LFBs, and SVM for LFBs. Where normal data are used, all available normal data are considered (i.e., all normal data from the most recent test campaign, and for Phase I sources, normal data from all historical test campaigns). In addition, for those best performing sources equipped with a FF, historical and most recent compliance test conditions (including test condition labeled in the data base as CT (compliance test) and IB (in-between) are used to identify the floor for PM, as discussed in Chapter 5 of this document.

Incinerators

	<u>PCDD/PCDF</u>
E-INC/D+WHB-DF	<u>Dry APCD and/or WHBs</u> . Category includes units with a dry APCD and/or a waste heat boiler (WHB). Compliance test data only are used.
E-INC/allWHB-DF	<u>All WHBs</u> . Category includes all units with WHB (those with or without dry APCDs). Compliance test data are used if available as a first priority. Normal data are considered if compliance test data are not available for the

³ When normal data are used to identify the floor level, all historical normal test conditions (for Phase I sources) are used to represent emissions for the source.

	particular source.
E-INC/D,noWHB-DF	<u>Dry APCDs, no WHBs.</u> Category includes units with dry APCDs that do not have WHBs. Compliance test data only are used.
--	<u>Others.</u> Category includes units that either have no APCD or use rapid flue gas quench cooling and wet scrubbing (and do not use any dry APCDs (such as dry ESP or FFs) or a WHB). No enumerated PCDD/PCDF MACT floor analysis is presented for this category of incinerators because PCDD/PCDF emissions are not readily controlled, adjusted, or replicable from units with these types of air pollution control devices. Specifically, all PCDD/PCDF test condition data from these types of units has been rated as "NA" because: (1) they clearly cannot be categorized as being conducted under operating conditions that could be described as "normal" due to operations during trial burn testing under "stressed" combustion conditions; and (2) in addition to combustion conditions, there are numerous parameters which can have a significant impact PCDD/PCDF emissions that are difficult to quantify, thus the operating conditions cannot be classified as "compliance test".
E-INC-PM	PM. Separate analyses are performed using both compliance test data and normal data.
E-INC-HG	Hg. Separate analyses are performed using both compliance test data and normal data.
E-INC-SVM	SVM. Separate analyses are performed using both compliance test data and normal data.
E-INC-LVM	LVM. Separate analyses are performed using both compliance test data and normal data.
E-INC-CL	Total Chlorine. Compliance test data only.

Cement Kilns

E-CK-DF	PCDD/PCDF. Separate analyses are performed using both compliance test data and normal data.
E-CK-PM	PM. Separate analysis are performed using both compliance test data and normal data.
E-CK-HG	Hg. Normal data only.
E-CK-SVM	SVM. Compliance test data only.
E-CK-LVM	LVM. Compliance test data only.
E-CK-CL	Total Chlorine. Compliance test data only.

Lightweight Aggregate Kilns

E-LWAK-DF	<u>PCDD/PCDF</u> . Compliance test data only.
E-LWAK-PM	<u>PM</u> . Compliance test data only.
E-LWAK-HG	<u>Hg</u> . Compliance test data only.
E-LWAK-SVM	<u>SVM</u> . Compliance test data only.
E-LWAK-LVM	<u>LVM</u> . Compliance test data only.
E-LWAK-CL	<u>Total Chlorine</u> . Compliance test data only.

Liquid Fuel Boilers

E-LFB/Dry-DF	<u>PCDD/PCDF</u> . Units with dry APCDs only. Normal test data only are available. PCDD/PCDF emissions from units with wet scrubbers or no PM APCD are not actively controlled or readily repeatable or adjustable. See above discussed for incinerators without dry APCDs, and discussion of PCDD/PCDF data from LFBs in Chapter 2.
E-LFB-PM	<u>PM</u> . Compliance test data only.
E-LFB-HG	<u>Hg</u> . Normal test data only.
E-LFB-SVM	<u>SVM</u> . Normal test data only.
E-LFB-CR	<u>Chromium</u> . Separate analyses performed using both compliance test data and normal data.
E-LFB-CL	<u>Total Chlorine</u> . Separate analyses performed using both compliance test data and normal data

Solid Fuel Boilers

--	<u>PCDD/PCDF</u> . PCDD/PCDF is not actively controlled in solid fuel boilers. See discussion in Chapter 2.
E-SFB-PM	<u>PM</u> . Compliance test data only.
E-SFB-HG	<u>Hg</u> . Compliance test data only.
E-SFB-SVM	<u>SVM</u> . Compliance test data only.
E-SFB-LVM	<u>LVM</u> . Compliance test data only.
E-SFB-CL	<u>Total Chlorine</u> . Compliance test data only.

HCl Production Furnaces

--	<u>PCDD/PCDF</u> . PCDD/PCDF is not actively controlled in HCl Production Furnaces. See discussion in Chapter 2.
--	<u>PM</u> . Total chlorine used as a surrogate.
--	<u>Hg</u> . Total chlorine used as a surrogate.
--	<u>SVM</u> . Total chlorine used as a surrogate.
--	<u>LVM</u> . Total chlorine used as a surrogate.
E-HCLPF-CL	<u>Total Chlorine</u> . Compliance test data only.

16.2 Hazardous Waste Thermal Emissions Concentration Format

Results using the Emissions approach and the hazardous waste thermal emissions (HWTE) concentration format for energy recovery source categories – CK, LWAK, and liquid

fuel boilers – are shown in the tables of Appendix D. The titles of each table have a label starting with “HWTE”, as listed below. The format of the tables is identical to that discussed above for the mass emissions concentration format tables.

Most of the data used are classified as “compliance test” and come from the most recent available testing campaign. Analyses using “normal” data are not performed for CKs or LWAKs because SREs are required to apportion emissions between hazardous waste and other feed materials. SRE estimates from normal operating conditions are not considered sufficiently accurate for use in differentiating HAP contributions from hazardous waste and other feed materials.

However, normal data from liquid fired boilers for Hg and SVM are used. This is because HAP contributions from non-hazardous waste feeds are assumed to be zero.

Cement Kilns

HWTE-CK-SVM	SVM. Compliance test data only.
HWTE-CK-LVM	LVM. Compliance test data only.
--	Total Chlorine. Thermal emissions are not evaluated. Chlorine SREs in CKs are inconsistent and not controllable.
--	Mercury. Thermal emissions are not evaluated. Hg SREs are not reliable because data are from “normal” operating conditions.

Lightweight Aggregate Kilns

HWTE-LWAK-SVM	SVM. Compliance test data only.
HWTE-LWAK-LVM	LVM. Compliance test data only.
HWTE-LWAK-CL	Total Chlorine. Compliance test data only.
--	Mercury. Thermal emissions are not evaluated. Almost all Hg SREs are not reliable because data are from “normal” operating conditions.

Liquid Boilers

HWTE-LFB-SVM	SVM. Normal data only.
HWTE-LFB-CR	Chromium. Separate analysis are performed using both compliance test data and normal data.
HWTE-LFB-HG	Mercury. Normal data only.
HWTE-LFB-CL	Total Chlorine. Compliance test data only.

17.0 Results Using the SRE-Feed MACT Approach

Results using the SRE-Feed MACT approach are shown in the tables of Appendix E. Each of the tables has a label starting with “SF”, as listed below. All tables are setup in a similar arrangement, and contain the following:

- (1) source ID No.; (2) test condition IDs which are used for each source; (3) number of individual runs in the test conditions;
- For emissions, hazardous waste feeds, and SREs: (1) average of the test condition runs; (2) standard deviation of the test condition runs; and (3) the upper 99th %ile estimate for each source.
- Feed rate rank, SRE rank, and aggregate (sum) of the hazardous waste feed and SRE rank.

The sources are ranked by the aggregate sum feed/SRE rank, from lowest to highest. The best performing MACT pool sources (12% or at least 5) are shown above the horizontal bold line.

Floor levels are shown at the bottom of the table, as discussed above for the Emissions Approach tables. Emission concentrations are presented as hazardous waste thermal emissions where applicable, and as mass emission concentrations in other cases.

Incinerators

--	PCDD/PCDF. SRE-Feed approach is not appropriate for PCDD/PCDF.
SF-INC-PM	PM. Compliance test data only.
SF-INC-HG	Hg. Compliance test data only.
SF-INC-SVM	SVM. Compliance test data only.
SF-INC-LVM	LVM. Compliance test data only.
SF-INC-CL	Total Chlorine. Compliance test data only.

Cement Kilns

--	PCDD/PCDF. SRE-Feed approach is not appropriate for PCDD/PCDF
--	PM. SRE-Feed approach is not appropriate because ash/solid feed is dominated by raw materials and is not controllable through feedrate modifications.
SF-CK-HG	Hg. Hg SREs for all CKs are assumed to be zero. Hg is not effectively removed in CKs, as discussed above. Also, hazardous waste MTECs and mass emission concentrations are used instead of hazardous waste thermal emission concentrations and hazardous waste thermal feedrates because it is difficult to accurately assess

thermal emissions due to the “normal” Hg feed levels. All historical normal data are considered.

SF-CK-SVM	SVM. Compliance test data set only. Hazardous waste thermal emissions and feeds used.
SF-CK-LVM	LVM. Compliance test data set only. Hazardous waste thermal emissions and feeds used.
SF-CK-CL	Total Chlorine. As discussed in Chapter 2, chlorine SREs for CKs are inconsistent, not repeatable, and not readily controllable. Thus, chlorine SREs are not used in the aggregate ranking process. Instead, a “MACT” chlorine hazardous waste feedrate MTEC is determined from the lowest chlorine feeding kilns with the identical procedure used to set the mass emission concentration MACT floor. A chlorine stack gas concentration MACT floor is then determined based on a combination of a reasonably achievable CK chlorine SRE of 90%, and the MACT chlorine feedrate, as shown at the bottom of the table.

Lightweight Aggregate Kilns

--	PCDD/PCDF. SRE-Feed approach is not appropriate for PCDD/PCDF
--	PM. SRE-Feed approach is not appropriate for PM because ash/solid feed is dominated by raw materials and is not controllable through feedrate modifications.
SF-LWAK-HG	Hg. Normal data set only (all historical normal test conditions). SREs from kilns without wet scrubbers are assumed to be 0 (zero); see discussion of mercury behavior in LWAKs in Chapter 2. SREs from the 2 kilns with wet scrubbers are assumed to be equivalent, and better than kilns without scrubbers (SRE > 0).
SF-LWAK-SVM	SVM. Compliance test data only.
SF-LWAK-LVM	LVM. Compliance test data only.
SF-LWAK-CL	Total Chlorine. Compliance test data only. SREs from kilns without wet scrubbers are assumed to be zero; see discussion of chlorine behavior in LWAKs in Chapter 2.

Liquid Boilers

--	PCDD/PCDF. SRE-Feed approach is not appropriate for PCDD/PCDF
SF-LFB-PM	PM Compliance test data only.
--	Hg. The SRE-Feed approach is not appropriate because only “normal” test condition data are available, and SREs determined under “normal” conditions are not considered reliable.
--	SVM. The SRE-Feed approach is not appropriate because only “normal” test condition data are available, and SREs determined under “normal” conditions are not considered reliable.

SF-LFB-LVM
SF-LFB-CL

LVM (Chromium). Compliance test data.
Total Chlorine. Compliance test data.

Solid Fuel Boilers

--

PCDD/PCDF. SRE-Feed approach is not appropriate for PCDD/PCDF

--

PM. SRE-Feed approach is not appropriate for PM because ash feed is dominated by coal and is not controllable through feedrate modifications.

SF-SFB-HG

Hg. Compliance test data only.

SF-SFB-SVM

SVM. Compliance test data only.

SF-SFB-LVM

LVM. Compliance test data only.

SF-SFB-CL

Total Chlorine. Compliance test data only. As discussed in Chapter 2, chlorine SREs for SFBs are generally very low, inconsistent, not repeatable, and not readily controllable – thus in the SRE-Feed analysis, chlorine SREs from SFBs are assumed to all be equivalent and set to 0 (zero).

HCl Production Furnaces

--

PCDD/PCDF. SRE-Feed approach is not appropriate for PCDD/PCDF..

--

PM. Not analyzed. Total chlorine standard is used as a surrogate for metal HAPs.

--

Hg. Not analyzed. Total chlorine standard is used as a surrogate for metal HAPs.

--

SVM. Not analyzed. Total chlorine standard is used as a surrogate for metal HAPs.

--

LVM. Not analyzed. Total chlorine standard is used as a surrogate for metal HAPs.

SF-HCLPF-CL

Total Chlorine. A modified approach is used for chlorine for HCl Production Furnaces. Chlorine feedrate MTECs are not used for the aggregate ranking because chlorine input to HCl Production Furnaces is a necessary part of the process. Chlorine SREs are directly evaluated to determine a MACT floor SRE, as shown in the table. An associated chlorine stack gas mass emissions concentration floor limit is also shown, projected based on the MACT chlorine SRE floor and the highest chlorine feedrate MTEC used by the HCl Production Furnaces:

$$EC_{\text{MACT Limit}} = (1 - \text{SRE}_{\text{MACT Cl}}) \times \text{MTEC}_{\text{HighCl}}$$

where:

$EC_{\text{MACT Limit}}$	Chlorine MACT emissions concentration limit for HCl PF (ppmv)
$SRE_{\text{MACT Cl}}$	MACT Chlorine SRE for HCl PF (%/100)
$MTEC_{\text{HighCl}}$	Highest Chlorine Feedrate MTEC from all HCl PFs (ppmv)

18.0 Results Using the Control Technology (APCD) Approach for PM

The Control Technology (APCD) approach results for PM are shown in the tables of Appendix F. Each table has a label starting with “APCD”, as listed below. All tables are setup in a similar arrangement, and contain the following:

- (1) source ID No.; (2) test condition IDs which are used for each source; (3) number of individual runs in the test conditions; (4) APCD type acronym; (5) APCD general class; and (5) APCD general class control efficiency rank.
- For emissions: (1) average of the test condition runs; (2) standard deviation of the test condition runs; and (3) the upper 99th %ile estimate for each source.

Sources are ranked by APCD general class, and within each general class, ranked by the upper 99th %ile estimate. The best performing MACT pool sources are shown above the horizontal bold line.

As discussed above, the APCD approach is only used for evaluating PM.

Incinerators

APCD-INC-PM

PM

Five “classes” of PM air pollution control devices are identified based on the control systems used by incinerators. They include, listed in order of decreasing PM control efficiency: (1) fabric filters (FF), (2) electrostatic precipitators (ESP) and ionizing wet scrubber, (3) high energy wet scrubbers (HEWS), and (4) low energy wet scrubbers (LEWS), and (5) none. Performance data do not show that systems with multiple types of devices have improved control efficiency compared with the highest rated device by itself. For example, a FF in series with a HEWS does not generally have improved control efficiency compared with a FF only. Thus additional, combined classes are not included.

The class of APCD is known for 98 incinerators. FFs are used by all of the 12 (12% of 103) best ranked, MACT pool sources based on APCD control class efficiency. In all, 19 of the 98 units use FFs (19%). PM CT emissions data are available from all 19 of these sources. (There are a total of 88 sources with PM CT emissions data.) The MACT pool includes the 12 best ranked (low emissions) sources with FFs (# MACT pool = 12% * 19 / 19% = 12.0 = 12 (rounded)).

Cement Kilns

APCD-CK-PM **PM**

Two classes of PM air pollution control devices are identified for CKs, listed in order of decreasing PM control efficiency: (1) fabric filter, and (2) electrostatic precipitator. Four CKs use FFs, and the remainder use ESPs.

The class of APCD is known for all CKs. Both FFs and ESPs are used by the 5 best ranked MACT pool sources, based on APCD class control efficiency. PM CT emissions data are available for all CKs. Thus, the MACT pool consists of all four sources using the top ranked FFs, as well as the one source with the best ranked ESP (source with an ESP with the lowest upper 99%ile PM emissions level).

Analysis is also provided for PM for CKs using the PM expressed as an emissions factor with units of “lb PM emissions per ton of dry raw material feed” (identical to the format used for the PM New Source Performance Standard and MACT standard for Portland Cement Kilns). Results are shown in the table with the “APCD-CK-PM/EF” label.

Lightweight Aggregate Kilns

APCD-LWAK-PM **PM**

One class of PM air pollution control device is identified for LWAKs: (1) fabric filter. All LWAK use FFs. Two LWAKs use a combination of a FF and venturi scrubber (VS); however, their performance is not significantly different than that of other LWAK units with only FFs, thus a separate class (FF and VS) is not used.

The class of APCD is known for all LWAKs – three LWAK “sources” are considered, because all FFs at the same site are similar and are grouped together -- see Chapter 5 discussion on the handling of PM data from FFs. PM CT emissions data are available for all of the LWAKs. Thus, the MACT pool is comprised of all three LWAK sources with FFs.

Liquid Fuel Boilers

APCD-LFB-PM **PM**

Six “classes” of PM air pollution control devices are identified based on the control systems used by LFBs, listed in order of decreasing PM control efficiency: (1) High Efficiency Particulate Air filters (HEPAs), (2) fabric filters (FF), (3) electrostatic precipitators (ESP), (4) high energy wet scrubbers (HEWS), (5) low energy wet scrubbers (LEWS), and (6) none.

The class of APCD is known for 72 LFBs. Of the 9 top ranked MACT pool sources (12% of 72), FF, ESP, HEWS, and LEWSs are used, based on APCD control class efficiency rank. In all, 16 of the 72 units (22.2%) use FF, ESP, HEWS, and LEWSs. PM CT emissions data are available from all 16 of the sources that are known to use MACT control (FF, ESP, HEWS, or LEWS). (From a total of 67 sources with PM CT emissions data.) The MACT pool includes the 9 best ranked (based on control efficiency rank, and emissions) sources with FF, ESP, HEWS, and LEWS (# MACT pool = $12\% * 16 / 22.2\% = 8.6 = 9$ (rounded up)).

Solid Fuel Boilers

APCD-SFB-PM

PM

Two classes of PM air pollution control devices are identified for SFBs, listed in order of decreasing PM control efficiency: (1) fabric filter, and (2) electrostatic precipitator. Two sources use FFs and the remainder use ESPs.

The class of APCD is known for all SFBs. Both FF and ESPs are used by the 5 best ranked MACT pool sources, based on APCD class control efficiency. PM compliance test emissions data are available for all SFBs. Thus, the MACT pool consists of the two sources using the top ranked FFs, as well as the three sources with the best ranked ESPs.

19.0 Results Using the Simultaneous Achievability for Particulates (SAP) MACT Approach

The Simultaneous Achievability for Particulates (SAP) approach is used to identify floor levels for PM, SVM, and LVM.

SAP approach results are shown in Appendix G. Each table has a label beginning with “SAP”. The following tables are included:

Incinerators

SAP-INC	Using sources that have data for at least 1 of the 3 HAPs (PM, SVM, and LVM).
SAP-INC(>1)	Using sources that have data for at least 2 or the 3 HAPs.

Cement Kilns

SAP-CK-E	Mass emission concentration format.
SAP-CK-HWTE	Hazardous waste thermal emissions format.

Lightweight Aggregate Kilns

SAP-LWAK-E	Mass emission concentration format.
SAP-LWAK-HWTE	Hazardous waste thermal emissions format.

Liquid Fuel Boilers

SAP-LFB-E	Mass emission concentration format.
SAP-LFB-HWTE	Hazardous waste thermal emissions format.

Solid Fired Boilers

SAP-SFB

The tables contain the following information for each source for which sufficient HAP data are available: (1) for each HAP, condition ID number, condition average, standard deviation, number of tests runs in condition, upper 99th %ile, and rank of the condition average relative to condition averages for other sources; and (2) the average of the ranks of each HAP for which data are available, and the overall rank of the source based on the average of the ranks of each HAP. At the bottom of the table in the far left column, PM, SVM, and LVM floor levels are shown.

20.0 Results Using the SRE-Only MACT Approach

SRE-Only results are shown in the tables of Appendix H. Each table has a label starting with “SO”, as listed below. All tables are setup in a similar arrangement, and contain the following:

- (1) source ID No.; (2) test condition IDs which are used for each source; (3) number of individual runs in the test condition;
- For emissions, hazardous waste feeds, and SREs: (1) average of the test condition runs; (2) standard deviation of the test condition runs; and (3) the upper 99th %ile estimate for each source.
- SRE rank, and aggregate (sum) of the feed and SRE rank (where the feed ranks are all set to zero). Feed levels are presented, but not used, in the SRE-Only Approach tables.

The sources are ranked by the aggregate sum rank (i.e., SRE rank as a practical matter, because Feed ranks are set to zero), from lowest to highest. The best performing MACT pool sources (12% or at least 5) are shown above the horizontal bold line.

Floor levels are shown at the bottom of the table, as discussed above for the Emissions Approach tables. Emission concentrations are presented as hazardous waste thermal emissions where applicable, and as mass emission concentrations in other cases.

Incinerators

--	<u>PCDD/PCDF</u> . SRE-Only approach is not appropriate for PCDD/PCDF.
SO-INC-PM	<u>PM</u> .
SO-INC-HG	<u>Hg</u> .
SO-INC-SVM	<u>SVM</u> .
SO-INC-LVM	<u>LVM</u> .
SO-INC-CL	<u>Total Chlorine</u> .

Cement Kilns

--	<u>PCDD/PCDF</u> . SRE-Only approach is not appropriate for PCDD/PCDF.
--	<u>PM</u> . CK PM SREs are estimated using the emissions factor format of lb PM emissions per ton of dry raw material feed. Sources are ranked directly based on this “SRE” metric.
--	<u>Hg</u> . The SRE-Only approach is not appropriate for CKs since Hg is not effectively removed in CKs (SREs are not consistent or repeatable), as discussed in Chapter 17 and Chapter 2.
SO-CK-SVM	<u>SVM</u> .
SO-CK-LVM	<u>LVM</u> .

-- **Total Chlorine.** As discussed above, the SRE-Only approach is not appropriate because chlorine control for CKs is attributable to alkalinity in the raw material, and thus, SREs are insistent and not repeatable.

Lightweight Aggregate Kilns

-- **PCDD/PCDF.** SRE-Only approach is not appropriate for PCDD/PCDF

-- **PM.** The SRE-Only approach can not be implemented with available data. LWAK APCD PM SREs cannot be determined because the ash feedrate is attributable primarily to the raw material and raw material ash feedrates are not generally available.

SO-LWAK-HG **Hg**

SO-LWAK-SVM **SVM.**

SO-LWAK-LVM **LVM.**

SO-LWAK-CL **Total Chlorine.**

Liquid Fuel Boilers

-- **PCDD/PCDF.** SRE-Only approach is not appropriate for PCDD/PCDF.

SO-LFB-PM **PM.**

-- **Hg.** The SRE-Only approach is not appropriate because only “normal” test condition data are available, and SREs determined under “normal” conditions are not considered reliable.

-- **SVM.** The SRE-Only approach is not appropriate because only “normal” test condition data are available, and SREs determined under “normal” conditions are not considered reliable.

SO-LFB-CR **Chromium**

SO-LFB-CL **Total Chlorine.**

Solid Fuel Boilers

-- **PCDD/PCDF.** SRE-Only approach is not appropriate for PCDD/PCDF.

-- **PM.** The SRE-Only approach is not appropriate. APCD PM SREs are difficult to accurately determine because the ash feedrate is attributable primarily to the ash in coal and coal ash feedrates are not reliable.

SO-SFB-HG **Hg.**

SO-SFB-SVM **SVM.**

SO-SFB-LVM **LVM.**

-- **Total Chlorine.** No coal boilers are controlling chlorine with back end air pollution control devices. Chlorine SREs very low, and are not replicable.

HCl Production Furnaces

- **PCDD/PCDF**. SRE-Only approach is not appropriate for PCDD/PCDF.
- **PM**. TCl used as a surrogate for PM (i.e., nonenumerated metal HAPs).
- **Hg**. TCl used as a surrogate for Hg.
- **SVM**. TCl used as a surrogate for SVM.
- **LVM**. TCl used as a surrogate for LVM.
- **Total Chlorine**. Identical to the results for the SRE-Feed approach discussed above because chlorine feedrate is not a control measure for HCl Production Furnaces.

21.0 Results Using Modified ETC MACT Approach

Results using the modified ETC MACT approach are shown in the tables of Appendix I. Each table has a label beginning with “ETC”.

Each table contains the same arrangement and contents. It lists all compliance tests conditions that are considered, with information including: (1) condition average, standard deviation, and “variability”; (2) MTEC; and various flags to identify (a) the most recent compliance test condition; (b) the lowest historical compliance test condition; (c) the highest historical compliance test condition; (d) whether the MTEC is less than the low MTEC filter; and (e) the test condition with the highest MTEC.

At the bottom of each table, the floor results for the three options are shown (considering most recent compliance test data, all compliance test data, and the highest compliance test data).

The approach is run for the following HAP and source categories:

Incinerators – Evaluated with two different categories of units: (1) All units, and (2) No “speciality” units (where speciality units are government run radioactive waste, munitions, or chemical waste incinerators, or other types of munitions or explosives furnaces).

ETC-INC/All-PM	PM. All units.
ETC-INC/NS-PM	PM. No speciality units.
ETC-INC/All or NS-HG	Hg. All units or No speciality units (same data set and results for each category).
ETC-INC/All-SVM	SVM. All units.
ETC-INC/NS-SVM	SVM. No speciality units.
ETC-INC/All-LVM	LVM. All units.
ETC-INC/(NS-LVM	LVM. No speciality units.
ETC-INC/All-CL	Chlorine. All units.
ETC-INC/NS-CL	Chlorine. No speciality units.

Cement Kilns

ETC-CK-PM	PM
ETC-CK-HG	Hg. Normal data are used.
ETC-CK-SVM	SVM
ETC-CK-LVM	LVM
ETC-CK-CL	Chlorine

Lightweight Aggregate Kilns

ETC-LWAK-PM	PM
ETC-LWAK-HG	Hg. Normal data are used.
ETC-LWAK-SVM	SVM
ETC-LWAK-LVM	LVM

ETC-LWAK-CL Chlorine

Liquid Fuel Boilers

ETC-LFB-PM PM
ETC-LFB-HG Hg. Normal data are used.
ETC-LFB-SVM SVM. Normal data are used.
ETC-LFB-CR Chromium
ETC-LFB-CL Chlorine

Solid Fuel Boilers

ETC-SFB-PM PM
ETC-SFB-HG Hg
ETC-SFB-SVM SVM
ETC-SFB-LVM LVM
ETC-SFB-CL Chlorine

22.0 SRE-High Feed Screen Results

SRE-High Feed Screen results are shown in the tables of Appendix J. Each of the tables has a label starting with “SRE/FS”. All tables are setup in a similar arrangement, and contain the following:

- (1) source ID No.; (2) test condition IDs which are used for each source; (3) number of individual runs in the test condition(s);
- For emissions, feeds, and SREs: (1) average of the test condition; (2) standard deviation of the test conditions(s); and (3) the upper 99th %ile estimate for each source.
- SRE rank, and aggregate (sum) of the feed and SRE rank (where the feed ranks are all set to zero).
- Identification of sources that have feedrates above the upper 99th %ile feedrate.
- Rank of potential replacement sources that are outside the initial SRE MACT pool.
- Identification of flagged high feedrate MACT pool sources which are replaced with next-in-line sources with lower emissions.

At the bottom of each table, the MACT floor stack gas emissions concentration results are shown three ways: (1) no high feedrate screen and replacement (strictly using the best ranked SRE sources); (2) high feedrate replacement with next-in-line sources (regardless if the next-in-line source has lower emissions); and (3) high feedrate replacement only if the next-in-line ranked source has lower emissions. Following these is the SRE MACT floor level, and the upper 99th %ile feedrate.

The approach is run for the following HAP and source categories:

Incinerators

SREFS-INC-HG	Mercury
SREFS-INC-SVM	SVM
SREFS-INC-LVM	LVM
SREFS-INC-CL	Chlorine

Cement Kilns

SREFS-CK-SVM	SVM. Provided for both straight emissions and thermal emissions.
SREFS-CK-LVM	LVM. Provided for both straight emissions and thermal emissions.

Lightweight Aggregate Kilns

SREFS-LWAK-SVM	SVM. Provided for both straight emissions and thermal emissions.
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SREFS-LWAK-LVM LVM. Provided for both straight emissions and thermal emissions.

Liquid Fuel Boilers

SREFS-LFB-CR Chromium. Provided for both straight emissions and thermal emissions.

SREFS-LFB-CL Chlorine. Provided for both straight emissions and thermal emissions.

Solid Fuel Boilers

SREFS-SFB-HG Hg

SREFS-SFB-SVM SVM

SREFS-SFB-LVM LVM

23.0 Miscellaneous Issues

23.1 **Mercury Content of Hazardous Waste Burned by Cement Kilns**

The Cement Kiln Recycling Coalition⁴ has provided data on the concentration of mercury in actual hazardous wastes from all 14 hazardous waste burning cement kiln plants. Data cover a three year period from 1999 to 2001. The hazardous waste fuel mercury concentration data are available in the docket supporting the proposed rule (see the “ADDRESSES” section of preamble for details on how to view docket materials). Each of the 14 cement plants are represented by an alphabetic letter (A, B, C, ...N). That is, CKRC’s submission did not include the plant name and location. A mercury concentration measurement is generally available for each burn tank over the three year period; however, for two cement plants (plants I and K), mercury concentration data are available only on a monthly-averaged basis.

Table 23-1 shows the distribution of the mercury data -- both in ppmw and Maximum Theoretical Emissions Concentration (MTECs)⁵ (determined using the procedure shown below in Section 23.3). The distribution of the mercury concentration data shown in Table 23-1 exclude measurements from three cement plants because the data were judged to include a significant number of individuals measurements that were reported as not detected at a relatively high detection limit (compared to detection limits achieved by other cement plants). The three cement plants excluded are plants B, D, and F.

Table 23-2 ranks the facilities according to their 99th %ile hazardous waste mercury concentration. Considered as a group, the best 5 ranked facilities (those with the lowest mercury 99th %iles) have a 99th %ile mercury concentration of 2.2 ppmw.

For comparison, Table 23-3 shows mercury concentration data (when available) for hazardous waste burned during trial burn and compliance testing. Note that the information presented in Table 23-3 is based on concentration data in EPA's Hazardous Waste Combustor Data Base (and not on CKRC's submission). The trial burn and compliance test hazardous waste concentration data represent “snap-shot” measurements that were obtained in one-time testing events.

⁴ CKRC is a trade organization that represents cement companies that burn hazardous wastes as a fuel. CKRC also represents companies that manage and market hazardous waste fuels used in cement kilns.

⁵ MTEC is a term to compare metals and chlorine feedrates across sources of different sizes. MTEC is defined as the metals or chlorine feedrate divided by the gas flow rate and is expressed in units of ug/dscm. The MTECs displayed in Table 23-1 do not include contributions to emissions from other mercury-containing feedstocks such as raw materials and fossil fuels.

23.2 Comparison of Hazardous Waste Thermal Emissions and Mass Emissions Concentration for Energy Recovery Units

“F-factors” are used to project “hazardous waste thermal emissions” (in lb/Btu of hazardous waste) to mass emissions concentrations (e.g., ug/dscm) for energy recovery units. The F-factor (in units of ft³/MMBtu) is the ratio of the amount of flue gas that is produced (ft³/hr) per amount of fuel (MMBtu/hr) that is combusted. Thus, mass emissions concentrations are determined by dividing hazardous waste thermal emissions by the F-factor, and further accounting for the hazardous waste fuel firing replacement rate (percentage of heat input in hazardous waste to total heat input in all fuels), as:

$$EC = (HWTE * P) / F$$

where:

EC	Mass emissions concentration (lb/dscf @ 7% O ₂)
HWTE	Hazardous waste thermal emissions (lb/MMBtu)
F	F-factor (dscf/MMBtu @ 7% O ₂)
P	Fraction of total heat input from hazardous waste fuel

Cement Kilns

The F-factor is estimated separately for wet and dry cement kilns based on the following typical cement kiln operating practices (taken from K. Peray, The Rotary Cement Kilns, 1986, p. 171):

CO₂ generation from limestone calcination – 12,881 scf CO₂ produced (evolved) per ton of clinker produced.

Dry kiln energy requirement – 3 to 4 MMBtu/ton of clinker (assumed at 3.5 MMBtu/ton clinker).

Wet kiln energy requirement – 5 MMBtu/ton clinker.

Coal / hazardous waste F-factor – 10,000 dscf of combustion products per MMBtu fuel input @ 0% flue gas O₂. Or equivalent to 15,000 dscf/MMBtu @ 7% O₂.

So for:

Wet kilns – F-factor = 17,756 dscf/MMBtu (@ 7% O₂).

Determined as the sum of the combustion flue gas products (15,000 dscf/MMBtu) and the calcination products (12,881/5 = 2,576 dscf/MMBtu).

Dry kilns – F-factor = 18,686 dscf/MMBtu (@ 7% O₂).

Determined as the sum of the combustion flue gas products (15,000 dscf/MMBtu) and the calcination products ($12,881/3.5 = 3,680$ dscf/MMBtu).

Table 23-4 shows F-factors for cement kilns calculated from hazardous waste burning CoC test conditions. They generally compare very well with the theoretical estimates.

LWAKs

An F-factor of 9,500 dscf/MMBtu @ 0% O₂ is used for LWAKs. This is based on fuel oil; most LWAKs fire very high percentages of hazardous waste organic liquids that are expected to behave similarly to fuel oil. Assumes that LWAK raw materials do not generate significant amounts of off-gases when they are heated to form aggregate product.

Solid Fuel Boilers

An F-factor of 9,500 dscf/MMBtu @ 0% O₂ is used for solid fuel boilers. This is based on a coal F-factor of 10,000 dscf/MMBtu @ 0% O₂ and a liquid hazardous waste F-factor of 9,200 dscf/MMBtu @ 0% O₂.

Liquid Fuel Boilers

An F-factor of 8,900 dscf/MMBtu @ 7% O₂ is used for liquid fuel boilers. This is based on a natural gas F-factor of 8,800 dscf/MMBtu @ 0% O₂ and a liquid hazardous waste F-factor of 9,200 dscf/MMBtu @ 0% O₂.

Table 23-5 shows projections of CK and LWAK hazardous waste thermal emissions concentration MACT floors using the SRE-Feed approach to equivalent total mass emissions concentrations, as a function of hazardous waste fuel input fraction.

23.3 Conversion of HAP Fuel Feedrate to Maximum Theoretical Emissions Concentration

Feeds of chlorine and metals from fuels are converted to “maximum theoretical emissions concentrations” (MTECs) by:

$$\text{MTEC} = \text{FC} * \text{HV} * \text{F} * \text{P}$$

where:

MTEC	Maximum theoretical emissions concentration (lb/dscf @ 7% O ₂)
FC	Concentration of HAP in fuel (lb HAP/lb waste)
HV	Heating value of waste (Btu/lb)
F	F-factor (dscf/MMBtu @ 7% O ₂)
P	Fraction of total heat input from hazardous waste fuel

Projections of Hg concentrations is hazardous waste to MTECs for cement kilns are shown in Table 23-6.

23.4 Solid Fuel Boiler Floor Notes

For solid fuel boilers for Hg, SVM, and LVM, the SRE-Feed Approach floor levels shown in Appendix E of this Technical Support Document are slightly different than those cited in the preamble:

	<u>Preamble</u>	<u>Technical Supp Document</u>
Hg	10	11
SVM	170	175
LVM	210	230

The difference is due to the procedures used to determine standard deviations from test conditions which have only one test run. See Chapter 15.3 for the preferred procedures which are used to determine the floors shown in this Technical Support Document.

Table 23-1. Hg Concentration in Normal Hazardous Wastes for Cement Kilns

Percentile	Hg Conc in Haz Waste ppmw	Hg Haz Waste MTEC ug/dscm
0.05	0.130	2.3
0.10	0.179	4.4
0.15	0.240	5.8
0.20	0.278	6.7
0.25	0.320	8.3
0.30	0.352	9.9
0.35	0.408	11.1
0.40	0.480	12.1
0.45	0.525	13.8
0.50	0.600	15.8
0.55	0.670	17.6
0.60	0.740	20.1
0.65	0.844	22.8
0.70	0.971	26.4
0.75	1.100	30.9
0.80	1.326	37.0
0.85	1.661	47.9
0.88	1.950	60.3
0.90	2.200	73.8
0.95	3.360	130.1
0.97	4.509	169.2
0.99	9.114	268.5

Table 23-2. Hg Concentration in Normal Hazardous Wastes for CKs

Facility	Minimum	Average	Maximum	StDev	99%ile	# Data Points	# NDs
A	0.050	0.547	4.120	0.425	1.890	1964	135
J	0.000	0.520	5.600	0.479	2.100	600	4
K	0.020	0.427	9.538	0.660	2.500	486	12
E	0.100	0.497	8.100	0.613	3.100	795	28
I	0.458	1.119	3.298	0.601	3.100	36	
L	1.489	2.237	4.724	0.745	4.400	36	
C	0.020	0.861	35.660	1.624	6.800	795	59
M	0.020	1.301	47.280	2.374	10.600	1072	34
H	0.011	2.470	32.194	2.265	11.300	679	1
G	0.012	1.630	49.309	3.685	12.600	792	53
N	0.050	1.438	20.978	2.274	13.300	2021	5
D	0.040	0.609	15.000	0.901	5.700	9848	7920
F	3.000	4.729	137.000	4.648	12.000	4069	3771
B	0.090	2.653	139.000	7.019	41.600	1783	818

Average of Best 5 sources 99th %iles 2.5 ppmw
 99th %ile of Pool of all data from Best 5 sources 2.2 ppmw

Table 23-3. Hg in Hazardous Waste Used During CoCs from Cement Kilns

Cond ID	Mercury Concentration (ppmw)												
	Liquid Hazardous Waste					Solid Hazardous Waste							
	R1	R2	R3	R4	Cond Avg	R1	R2	R3	R4	CA			
200C10	0.04	0.06	0.07		0.06								
200C11	0.04	0.10	0.08		0.07								
200C4	0.95	0.91	0.81		0.89								
200C5	0.65	0.87			0.76								
201C10	0.07	0.04	0.05		0.05								
201C11	0.03	0.05	0.10		0.06								
203C10	0.11	0.13	0.47		0.24								
203C1	0.47	0.11	0.24		0.27								
204C1	nd	0.10	nd	0.10	0.10								
205C10	0.10	0.10	0.10		0.10								
205C1	0.19	0.25	0.25		0.23								
206C10	0.33	0.30	0.36		0.33								
206C1	0.53	0.47	0.33		0.44								
207C12	0.04	0.03	0.42		0.16								
207C10	0.05	0.05	0.04		0.05								
207C2	0.12	0.12	0.12		0.12								
208C10	0.03	0.06	0.30		0.13								
208C1	0.10	0.10	0.18		0.12								
300C11	5.97	6.00	5.95		5.97								
300C3	0.84	nd	0.03	0.84	0.57	2.11	0.18	2.82					
302C10	0.26	0.21	0.27		0.25								
302C3	0.50	0.51	0.49		0.50								
302C4	0.50	0.51	0.51		0.50								
303C7					0.93								
303C9					0.36								
303C3	1.84	1.42	1.86		1.71	9.70	9.85	11.51					
319D6	0.22	0.18	0.16		0.19		1.27	1.44		1.36			
319D9	0.15	0.13	0.19		0.16			0.27		0.27			
319C1				nd	0.10				nd	0.10			
322C8	0.81	0.89	0.89		0.87								
322C1	0.20	0.42	0.82		0.48								
323B3	1.30	1.43	1.28		1.34								
323B2	1.08	1.60	0.92		1.20								
323C9	0.34	0.44	0.23		0.34								
323C1	0.06	0.10	0.34		0.17	0.09	2.79	2.03		1.64			
403C10	0.46	0.14	0.10	0.13	0.21								
403C3	0.24	0.40	0.40	0.35	0.35	3.50	5.72	2.50	7.78	4.88			
404C10	0.10	0.10	0.10	0.10	0.10								
404C1	0.60	0.70	0.90	0.20	0.60	nd	0.20	0.50	nd	0.20	1.80	0.68	
404C4	0.15	0.16	0.13	0.27	0.18	6.20	7.20	5.20	4.80	5.85			
473C1	6.01	6.01	6.16		6.06								
491C1	4.00	8.40	5.60	9.70	6.93	nd	2.00	nd	2.00	nd	2.00	2.00	2.00
3029C11	0.16	0.19	0.20		0.18	0.73	0.60	0.04		0.46			
3031C10	0.07	0.18	nd	0.07	nd	0.06	0.10	0.23	0.19	0.09	0.56	0.27	
3031C11	0.07	0.09	NA	0.17	0.11	2.73	0.09	NA	nd	0.07	0.96		

Table 23-4. F-Factors from Cement Kilns

Cond ID	Dry Gas Flowrate dscfm	O2	Dry Gas Flowrate dscm @ 7% O2	Total Heat Input MMBtu/hr	F-Factor	
					dscm/MMBtu	dscf/MMBtu
303C7	216000	9.7	174343	618.2	478.9	16,921
303C9	279000	11.4	191314	562.0	578.0	20,425
303C1	261101	10.3	199556	639.2	530.1	18,732
303C3	237714	9.3	198095	550.04	611.5	21,609
303C2	266453	10.8	194130	542.48	607.6	21,471
303C9	280567	11.5	189717	561.7	573.5	20,265
200C1	45096	10.2	34788	119.2	495.6	17,511
200C10	69523	11.4	47673	185.84	435.6	15,392
200C11	37376	10.1	29011	68.14	722.9	25,545
200C4	65444	10.4	49550	177.88	473.0	16,714
200C5	34621	7.8	32643	99	559.9	19,783
201C1	59254	10.4	44969	149.94	509.3	17,995
201C10	66756	8.0	62146	176.93	596.4	21,075
201C11	40330	7.5	38986	142.47	464.6	16,419
203C1	106472	8.0	98613	284.67	588.2	20,785
203C10	96126	8.5	85758	405.54	359.1	12,688
203C11	87863	8.0	81378	334.97	412.5	14,576
203C5	118267	8.1	108580	349.89	526.9	18,620
204B3	302327	3.3	382227	1436.6	451.8	15,964
204C1	243828	9.7	197385	1159.59	289.0	10,213
204C2	255336	4.4	302756	1194.67	430.3	15,205
204C9	329483	8.0	306733	998.44	521.6	18,433
205C1	115675	9.3	96396	247.19	662.2	23,398
205C10	92700	6.0	99321	204.94	822.9	29,078
205C5	82820	6.0	88736	309.33	487.1	17,212
206C1	144905	7.4	140765	458.75	521.0	18,411
206C10	172100	7.1	170871	582.65	498.0	17,596
206C11	175867	7.1	174192	575.4	514.0	18,164
206C5	162667	6.9	164216	529	527.1	18,626
207C1	46975	12.5	28604	109.15	445.0	15,724
207C10	48595	12.0	31240	81	654.9	23,141
207C12	61581	12.9	35776	92.33	657.9	23,249
207C2	46400	12.0	29829	143	354.2	12,515
208C1	154750	11.7	102522	289.33	601.7	21,261
208C10	140098	8.8	122086	410.4	505.1	17,849
208C2	148675	11.9	97170	286.62	575.7	20,341
228C2	73415	8.8	64238	297.62	366.5	12,950
300C1	86168	11.9	56009	148.86	638.9	22,575
300C10	66045	6.2	69661	189.03	625.7	22,111
300C11	80013	8.9	68964	220.53	531.0	18,763
300C12	67736	6.8	68543	173.68	670.1	23,679
300C13	79348	9.0	67824	213.67	539.0	19,045
300C2	87849	12.1	55847	171.43	553.2	19,546
3029C10	220333	5.7	241317	792.47	517.1	18,271
3029C11	234933	4.8	272411	772.17	599.0	21,167
302C1	44301	7.0	44301	179.51	419.0	14,807
302C10	61029	7.3	59620	190.67	530.9	18,761
302C11	58862	6.7	60067	188.58	540.9	19,111

Table 23-4. F-Factors from Cement Kilns

Cond ID	Dry Gas Flowrate dscfm	O2	Dry Gas Flowrate dscm @ 7% O2	Total Heat Input MMBtu/hr	F-Factor	
					dscm/MMBtu	dscf/MMBtu
302C12	60657	7.3	59357	184.33	546.8	19,321
302C3	42457	10.3	32348	165.29	332.3	11,742
318C1	59882	5.7	65442	200.41	554.5	19,593
318C2	58690	6.8	59640	200.75	504.5	17,825
319C1	135267	4.4	160388	419.99	648.4	22,913
319C2	132067	4.7	154078	418.63	625.0	22,083
319C6	114449	4.2	137747	533.88	438.1	15,481
319D6	126833	4.2	152200	466.66	553.8	19,569
319D9	120833	4.6	141548	460.19	522.3	18,455
322C1	43389	5.5	48038	141.81	575.2	20,325
322C8	44047	9.1	37440	130.33	487.8	17,236
323B1	63076	9.4	52413	110.4	806.1	28,485
323B2	54420	8.7	47682	166.67	485.8	17,165
323B3	57686	7.5	55626	200.33	471.5	16,660
323C1	54432	5.6	59875	204.02	498.3	17,609
323C9	57736	8.4	51893	170	518.3	18,315
403C1	69385	5.6	76447	329.1	394.4	13,938
403C10	84269	9.1	71930	317.75	384.4	13,582
403C2	65036	7.6	62132	298.33	353.6	12,496
403C3	70979	6.6	72869	465.06	266.1	9,401
404C1	91255	5.8	99076	417.42	403.0	14,241
404C10	108170	7.8	101931	384.39	450.3	15,911
404C2	92567	6.8	94220	434.53	368.2	13,010
404C4	99086	5.9	107225	401.96	453.0	16,005
473C1	54351	5.6	59657	207.49	488.2	17,251
473C3	57531	8.0	53422	190.49	476.2	16,827
491C1	67736	6.8	68543	242.33	480.3	16,971
					average	18,215
					median	18,271

Table 23-5. Comparison of Hazardous Waste Thermal Emissions and Mass Emission Concentrations

Source Category	HAP	HW Thermal Input Fraction (%)	Replacement Rule SRE-Feed Approach MACT Floor				HWC Interim Standards Rule (ug/dscm)
			Hazardous Waste Thermal Emissions (lb/MMBtu)	Mass Emissions Concentration (ug/dscm ¹)			
				Haz Waste ³	Non-HW ²	Total	
CK	SVM	50	4.0E-04	171.7	20.0	191.7	330
		75	4.0E-04	257.6	20.0	277.6	330
		90	4.0E-04	309.1	20.0	329.1	330
CK	LVM	50	1.4E-05	6.0	15.0	21.0	56
		75	1.4E-05	9.0	15.0	24.0	56
		90	1.4E-05	10.8	15.0	25.8	56
CK	Chlorine ⁴	50	2.4E-01	68.7	35.0	103.7	130
		75	2.4E-01	103.0	35.0	138.0	130
		90	2.4E-01	123.6	35.0	158.6	130
LWAK	SVM	90	3.1E-04	314.1	20	334.1	250
LWAK	LVM	90	9.5E-05	96.3	50.0	146.3	110
LWAK	Chlorine	90	3.0E+00	2,026.4	50.0	2,076.4	600

1: For chlorine, units are in ppmv

2: Maximum projected contribution from non-hazardous waste feedstreams (including coal, raw materials, non-hazardous fuels). Based on the range of non-hazardous waste feedrate MTECs observed during CoC testing (see Data Summary Sheets) and replacement rule MACT SRE.

3: For cement kilns, dry kiln F-factor (18,686 dscf/MMBtu) used; for wet kilns with lower F-factor of 17,756 dscf/MMBtu, projected emissions concentration will be lower than shown.

4: For chlorine for cement kilns, an alternative MACT floor is being considered as a chlorine feedrate limit in the hazardous waste of 2.4 lb/MMBtu. The hazardous waste chlorine feedrate limit is projected to a stack gas emissions concentration based on a 90% SRE for chlorine for cement kilns (0.24 lb/MMBtu).

Table 23-6. Projected Hg Emissions Due to Mercury From Hazardous Waste for Cement Kilns

Concentration of Hg in Hazardous Waste ppmw	Mass Emission Concentrations from Hazardous Waste (ug/dscm)			
	Hazardous Waste Thermal Feedrate Fraction of Total			
	25%	50%	75%	90%
0.25	4.9	9.8	14.6	17.6
0.5	9.8	19.5	29.3	35.1
0.6	11.7	23.4	35.1	42.1
1.0	19.5	39.0	58.5	70.2
1.1	21.5	42.9	64.4	77.3
1.5	29.3	58.5	87.8	105.4
2.0	39.0	78.0	117.1	140.5
2.2	42.9	85.9	128.8	154.5
2.5	48.8	97.6	146.3	175.6
3.0	58.5	117.1	175.6	210.7
3.5	68.3	136.6	204.9	245.9
4.0	78.0	156.1	234.1	281.0
4.5	87.8	175.6	263.4	316.1
5.0	97.6	195.1	292.7	351.2

Assumptions:

- 18686 F-Factor (dscf/MMBtu)
- 11000 Hazardous waste heating value (Btu/lb)
- 0% Cement kiln Hg SRE
- Projected emissions are due to hazardous waste only
- No contributions from coal or raw materials

24.0 Beyond-the-Floor Controls

EPA is proposing beyond-the-floor standards for dioxin/furan for lightweight aggregate kilns, liquid fuel boilers equipped with dry particulate matter control devices, and HCl production furnaces, as well as a beyond-the-floor standard for PM for solid fuel boilers. In addition, EPA is requesting comment on beyond-the-floor standards for total chlorine for lightweight aggregate kilns and solid fuel boilers.

The information on the applicability of beyond-the-floor control techniques presented in US EPA, “Technical Support Document for HWC MACT Standards, Vol. III: Selection of MACT Standards and Technologies,” July 1999, is applicable to the beyond-the-floor discussions for the proposed Phase I replacement standards and Phase II standards.

Also, for more discussion on the technologies considered for beyond-the-floor selections, see Chapter 4.6 of the “Technical Support Document for HWCs, Vol. V: Cost and Emissions Estimates for MACT Standards,” March 2004.