United States Environmental Protection Agency	Solid Waste and Emergency Response (5305W)	EPA530-R-01-001 July 2001 www.epa.gov/osw

EPA

Risk Burn Guidance for Hazardous Waste Combustion Facilities

ACKNOWLEDGMENTS

This document was developed by the U.S. Environmental Protection Agency (EPA) Region 4 and the Office of Solid Waste. Beth Antley (EPA Region 4), the primary author/editor of this document, coordinated the technical approach. Andrew O'Palko (Office of Solid Waste) provided overall direction. TetraTech EM Inc. contributed significantly to Chapter 2 and provided other technical support. Dr. Joan Bursey and Eastern Research Group, under subcontract to Hazardous and Medical Waste Services, Inc. (HAZMED), deserve special recognition for the final revision of Appendix B.

EPA530-R-01-001
July 2001
www.epa.gov/osw

RISK BURN GUIDANCE FOR HAZARDOUS WASTE COMBUSTION FACILITIES

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ACRONYM LIST (Continued)

RTI	Research Triangle Institute
SCC	Secondary combustion chamber
SQL	Sample quantitation limit
SRE	System removal efficiency
TCO	Total chromatographable organics
TEQ	Toxic equivalents
TIC	Tentatively identified compound
TOE	Total organic emissions
U/BK	Uptake/biokinetic
WESP	Wet electrostatic precipitator

CHAPTER 1

INTRODUCTION

This document contains the U.S. Environmental Protection Agency (EPA) Office of Solid Waste's (OSW's) recommendations regarding stack emissions tests which may be performed at hazardous waste combustion facilities for the purpose of supporting multi-pathway, site-specific risk assessments, where such a risk assessment has been determined to be necessary by the permit authority. When a site-specific risk assessment will be performed as part of the Resource Conservation and Recovery Act (RCRA) permit decision for a hazardous waste combustion facility, the supporting emissions data may be collected in conjunction with a RCRA trial burn. The emissions data may also be collected during a test event separate from the RCRA trial burn, such as a Maximum Achievable Control Technology (MACT) performance test or other test. This guidance identifies the types of emissions data that EPA OSW recommends be collected to support site-specific risk assessments. The guidance recommends combustor operating and feed conditions that should generally be demonstrated during the testing, and identifies stack sampling and analytical techniques for collection of the emissions data. In addition, the relationship between test conditions and potential RCRA permit conditions is discussed.

Hazardous waste combustors include hazardous waste incinerators, as well as boilers and industrial furnaces (BIFs) that burn hazardous waste for energy or material recovery. Portions of this guidance may also be useful for emissions test efforts at thermal treatment facilities (other than incinerators and BIFs) conducting multi-pathway, site-specific risk assessments, as determined appropriate under 40 Code of Federal Regulations (CFR) Sections 264.601 and 264.602.

Multi-pathway human health and ecological risk assessments may be performed for hazardous waste combustion facilities to assess potential risks associated with direct and indirect exposures to:

guidance for how to conduct a multi-pathway human health and ecological risk assessment is available in peer review draft form (EPA 1998a, 1999a, 1999b). And, EPA OSW's recommended risk and hazard targets that may be used when making risk management decisions are provided in an earlier guidance (EPA 1994a). Additional risk target information is also available (EPA 1998b). Many of the recommendations included in the MACT rule preamble and the human health/ecological risk assessment documents are also identified in this document for the convenience of the reader. However, this document is not intended to update, revise or replace the information contained in those documents. Revisions to the human health and ecological risk assessment documents are in progress, and more recent versions should be consulted when available. Other combustion risk assessment guidance (e.g., Research Triangle Institute [RTI] 1997) may also be consulted.

This document updates and replaces the following guidance documents related to emissions testing which may be performed for the purpose of supporting multi-pathway, site-specific risk assessments:

- U.S. EPA. *Guidance on Trial Burns.* June 2, 1994 Draft.
- U.S. EPA. *Guidance on Structuring RCRA Trial Burns for Collection of Risk Assessment Data.* May 2, 1997 and September 1997 Drafts.
- U.S. EPA. *Guidance on Collection of Emissions Data to Support Site-Specific Risk Assessments at Hazardous Waste Combustion Facilities*. Peer Review Draft. EPA530-D-98-002. August 1998.

This guidance is not intended to update, revise or replace any RCRA or MACT regulatory requirements pertaining to stack emissions testing, or the guidance documents which have been developed to support implementation of those requirements. Examples of guidance documents which are not superseded include:

- U.S. EPA. *Handbook: Guidance on Setting Permit Conditions and Reporting Trial Burn Results. Volume II of the Hazardous Waste Incineration Guidance Series.* Office of Research and Development. EPA/625/6-89/019. January 1989.
- U.S. EPA. *Handbook: Hazardous Waste Incineration Measurement Guidance Manual. Volume III of the Hazardous Waste Incineration Guidance Series.* Office of Solid Waste and Emergency Response. EPA/625/6-89/021. June 1989.

- U.S. EPA. *Handbook: Quality Assurance/Quality Control (QA/QC) Procedures for Hazardous Waste Incineration.* Office of Research and Development. EPA/625/6-89/023. January 1990.

- U.S. EPA. *Technical Implementation Document for EPA's Boiler and Industrial Furnace Regulations.* Office of Solid Waste and Emergency Response. EPA-530-R-92-011. March 1992.

- U.S. EPA. *Final Technical Support Document for Hazardous Waste Combustor MACT Standards, Volume IV: Compliance with the MACT Standards.*

notice. EPA OSW welcomes public comments on this document at any time and will consider those comments in any future revision of this document.

1.2 OBJECTIVES

The objectives of this guidance are to:

1. **Provide recommendations to ensure the collection of adequate data to support completion of technically sound human health and ecological risk assessments.** Specific risk assessment data needs generally include: (1) D/F emission rates, (2) emission rates for organics other than D/Fs, (3) metals emission rates, (4) site-specific particle-size distribution data, and (5) emission rates for HCl and Cl_2. These data needs are discussed in detail in Chapter 2, and sampling and analytical

through 9, and are illustrated by the examples in Appendix A.

Although general guidelines are provided, this guidance cannot encompass every potential situation. Permit writers are encouraged to consider facility-specific circumstances that may not be fully addressed.

1.3 REGULATORY REVIEW

This section provides summary information to explain how emissions tests and risk assessments factor into the RCRA regulatory framework for hazardous waste combustion facilities. First, background information on RCRA performance standards and trial burns is provided. Potential limitations of the RCRA regulations are identified, and the use of site-specific risk assessments to supplement those regulations is discussed. Finally, MACT standards for hazardous waste combustion facilities (EPA 1999c) are introduced briefly, and the relationship between the MACT standards and site-specific risk assessments is explained. This review is minimal and provided only for the convenience of the reader. Cited references should be consulted. Terms are defined in Section 1.4.

1.3.1 RCRA Performance Standards and Trial Burns

Performance standards for hazardous waste incinerators are described in Title 40 of the Code of Federal Regulations (CFR) Part 264, Subpart O. These standards were promulgated on January 23, 1981, and have been subsequently amended. The performance standards consist of the following: (1) a destruction and removal efficiency (DRE) of principal organic hazardous constituents (POHCs) of 99.99 percent, or 99.9999 percent for dioxin-listed wastes; (2) particulate matter emissions not to exceed 180 milligrams per dry standard cubic meter (mg/dscm) or 0.08 grains per dry standard cubic foot (grains/dscf), corrected to 7 percent oxygen; and (3) gaseous HCl emissions not to exceed 1.8 kilograms per hour or a removal efficiency of 99 percent. Compliance with these performance standards is generally established through a carefully designed trial burn (see 40 CFR § 270.62). Trial burns are typically conducted at extreme "worst-case" operating conditions of the unit in order to define the maximum operating range (or operating envelope) that assures compliance. Testing at “worst-case” conditions generally involves at least one performance test condition conducted at a minimum combustion temperature to demonstrate DRE. Additional test conditions may be necessary to resolve potential conflicts between operating parameters. As long as the incinerator continues to operate within the operating envelope demonstrated during a successful trial burn, it is presumed to be in compliance with the regulatory performance standards.

Ongoing compliance with the three performance standards is generally assured by developing limits for the following control parameters, as specified in 40 CFR § 264.345:

C Minimum combustion temperature in the primary combustion chamber (PCC) and secondary combustion chamber (SCC), to assure sufficient temperatures for destruction of organics;

C Maximum flue gas flow rate (or velocity) and maximum waste feed rate, to assure sufficient hydrocarbons. The February 21, 1991 rule also subjected BIFs to the general permitting provisions applicable to incinerators, including the requirement to submit a RCRA Part B permit application.

The BIF standards for 10 metals (antimony, arsenic, barium, beryllium, cadmium, chromium, lead, mercury, silver, and thallium), as well as for HCl and Cl_2, were developed to limit risks from the inhalation exposure pathway. Standards for the carcinogenic metals arsenic, beryllium, cadmium, and hexavalent chromium are based on an aggregate (all carcinogenic metals) maximum potential excess lifetime carcinogenic risk for an individual of no greater than 1 in 100,000 (1E-5) from the direct inhalation exposure pathway. BIF standards for metals causing health effects other than cancer are based on oral reference doses (RfDs) converted to reference air concentrations (RACs) or published reference concentrations (RfCs) in air. Standards for lead are based on 10 percent of the National Ambient Air Quality Standard (NAAQS). HCl and Cl_2 emission rate limits are based on RfCs and RACs. RACs are also available for nickel and selenium, and these metals have sometimes been limited in addition to the BIF metals as necessary to protect human health and the environment (EPA 1992a).

Organic emissions from BIFs are controlled using a DRE standard (the same standard as for incinerators) and by limiting carbon monoxide (and in some cases total hydrocarbon) concentrations in stack gas (40 CFR Part 266 Subpart H; EPA 1992b). The BIF rule also recognizes that hazardous waste combustors equipped with dry APCDs operating between 450 and 750 EF may emit higher concentrations of D/Fs than units equipped with other types of APCDs. 40 CFR Part 266 Subpart H requires risk evaluations for BIFs equipped with dry APCDs operating at 450 to 750 metal and chlorine feed rates be established using one of the following approaches: Tier I (assuming zero SRE without site-specific air dispersion modeling), Adjusted Tier I (assuming zero SRE with site-specific air dispersion modeling), Tier II (based on emissions data without site-specific air dispersion modeling), or Tier III (based on emissions data with site-specific air dispersion modeling). Owners and operators of BIFs may choose to spike the wastes used during the SRE test with metals and chlorine to demonstrate performance at maximum feed rates. Spiking helps to ensure that sufficiently flexible metal and chlorine feed rate limits are established. Similar provisions have been applied at hazardous waste incinerators as necessary to protect human health and the environment.

EPA trial burn and technical guidance documents for incinerators and BIFs (EPA 1983, 1989 and 1992b) describe control parameters typically monitored during trial burn testing. The 1989 document categorizes these control parameters (monitored during DRE or SRE conditions) as Group A, B, or C. Short-term limits, such as hourly rolling averages (HRAs) and instantaneous limits, are typically established for these parameters in the facility's RCRA permit. The Group A, B, and C designations are reviewed below.

Group A control parameters are generally continuously monitored while hazardous waste is being fed to the unit and are generally linked with automatic waste feed cutoff (AWFCO) limits to ensure that waste feed is automatically cut off when specified limits are exceeded. Examples of Group A parameters include maximum and minimum PCC and SCC temperatures, maximum combustion gas velocity, maximum waste feed rate, maximum carbon monoxide concentration, maximum combustion chamber pressure, minimum venturi scrubber differential pressure, minimum scrubber liquid-to-gas ratio and pH, minimum fabric filter differential pressure, minimum wet/dry ESP power input, and minimum wet electrostatic precipitator (WESP) liquid flow rate.

Group B control parameters generally do not involve continuous monitoring and may not be interlocked with the AWFCO system. However, detailed operating records are generally maintained to demonstrate compliance with permitted operating conditions. Examples of Group B parameters include maximum batch size for containerized waste and minimum scrubber blow-down. Some Group B operating parameters, including metal and chlorine feed rates, may be continuously monitored once the supporting analytical data have been entered into a data system.

the RCRA standards would be protective of human health and the environment (EPA 1998a). In those cases where a RCRA permitting authority identified a potentially significant risk, it could invoke Section 3005(c)(3) of RCRA (which is commonly referred to as the “omnibus authority” or “omnibus provision”) to augment the RCRA permit with additional conditions as necessary to protect human health and the environment (EPA 1998a). As discussed in Section 1.3.3, EPA has recently revised its original recommendation in light of the new hazardous waste combustor MACT standards (EPA 1999c).

Section 3005(c)(3) of RCRA, codified in 40 CFR Section 270.32(b)(2), provides EPA with both the authority and responsibility to include additional terms and conditions in each RCRA facility permit as necessary to protect human health and the environment (EPA 1998a). Under 40 CFR Section 270.10(k), EPA may require a permit applicant to submit the information necessary to establish protective permit conditions under the omnibus authority (40 CFR Section 270.10(k); EPA 1998a). For hazardous waste combustors, the information required to establish permit conditions could include a site-specific risk assessment or the supporting information to conduct a site-specific risk assessment (EPA 1999c). Any decision to add permit conditions based on a site-specific risk assessment must be documented in the administrative record for each facility, and the implementing agency must explain the basis for the additional conditions (40 CFR Sections 124.7 through 124.9; EPA 1998a).

1.3.3 Hazardous Waste Combustor MACT Standards

Final MACT standards for certain hazardous waste combustion facilities were promulgated on September 30, 1999, and establish technology-based limits for D/Fs, mercury, semivolatile and low-volatile metals, HCl and Cl_2, hydrocarbons or carbon monoxide, particulate matter, and DRE (EPA 1999c). These standards were promulgated under joint authority of RCRA and the Clean Air Act. The MACT standards apply to several categories of hazardous waste combustion facilities including incinerators, hazardous waste burning cement kilns, and hazardous waste burning lightweight aggregate kilns. The MACT rule requires that these sources achieve compliance with the standards within three years of the rule effective date and begin performance testing for stack emissions within three years and six months of the rule effective date in accordance with 40 CFR §§63.1206(a) and 63.7(a)(2). MACT emission standards for hazardous waste burning boilers and additional industrial furnaces are anticipated in a future rulemaking.

The MACT standards are viewed as more stringent than RCRA Subpart O and Subpart H standards for incinerators and BIFs (EPA 1999c). A national risk assessment was performed to determine if the MACT standards satisfy the RCRA mandate to protect human health and the environment (RTI 1999). The national assessment was a multi-media, multi-pathway analysis addressing both human health and ecological risk. The assessment was predicated on the assumption that sources whose emissions were above the MACT standards would reduce their emissions to MACT levels, and that sources whose emissions were below the standards would maintain emissions at the existing levels. Based on this national assessment, EPA determined that sources complying with the MACT standards are *generally* not anticipated to pose an unacceptable risk to human health and the environment. However, a definitive finding could not be made (RTI 1999; EPA 1999c). Uncertainties remain, especially related to non-dioxin PICs (which were not evaluated in the national risk assessment), mercury (where bioaccumulation is very dependent on local conditions), and other site-specific factors that could vary from those evaluated in the national assessment. Given these uncertainties, EPA continues to believe that site-specific risk assessments may be warranted in some cases (EPA 1999c).

EPA recommends that permit writers evaluate the need for site-specific risk assessments on a case-by-case basis (EPA 1999c). The recommendation that the need for a site-specific risk assessment be evaluated on a case-by-case basis represents a modification to the site-specific risk assessment policy recommendation that EPA made prior to the publication of the MACT standards in 1993 and 1994, when EPA recommended that site-specific risk assessments be completed as part of the RCRA permitting process for all hazardous waste combustors (EPA 1993 and 1994b). The MACT rule preamble provides a list of qualitative factors to assist in the determination regarding the need for a site-specific risk assessment (EPA 1999c). EPA recommends that the decision be made prior to approval of the MACT comprehensive performance test protocol, to the extent possible (EPA 1999c). Therefore, if risk emissions data have not already been collected during a RCRA trial burn or other test, the necessary data can be collected during MACT performance testing (as appropriate).

In summary, promulgation of the MACT standards does not duplicate, supersede, or otherwise modify the omnibus authority or its applicability to hazardous waste combustors (EPA 1999c). Pursuant to the omnibus authority, the RCRA permitting authority has the responsibility to supplement the MACT standards as necessary, on a site-specific basis, to ensure adequate protection under RCRA. Site-specific risk assessments provide a quantitative basis for making omnibus determinations at hazardous waste combustors (EPA 1999c). The results of site-specific risk assessments provide numerical information which can be compared to the MACT standards to determine whether risk-based limits are appropriate for a particular source in addition to the MACT requirements (EPA 1999c).

1.4 RISK BURN NOMENCLATURE

Key terms are summarized below. These terms are defined strictly for the purpose of supporting the concepts presented in this guidance and do not supersede regulatory definitions.

Control Parameters	Combustor operations are defined by **control parameters** such as temperature, pressure, flow rates, and feed characteristics. The terms "control parameters" and "feed and operating parameters" are used interchangeably in this guidance.
Emissions Testing	**Emissions testing** refers to the manual collection of stack gas sample(s), followed by chemical analysis to determine pollutant concentrations.
Normal Test	A **normal test** can generally be described as a test where each **control parameter** is maintained either near the historical mean, or between the historical mean and the minimum or maximum (as appropriate) set point, while burning representative, but challenging, feeds. A normal test may be conducted for the purpose of generating emissions data for subsequent evaluation in a site-specific risk assessment and may be used as the basis for establishing permit terms. A normal test includes a minimum of one **test condition**, but may include more.
Operating Envelope	The term **operating envelope** refers to the entire range of operation allowed for a combustor, as bounded by either physical or regulatory constraints.
Performance Test	A **performance test** is a test performed for the purpose of demonstrating compliance with a specific regulatory emission limit or performance standard. Allowable operating limits are established based on the operation demonstrated during the performance test. Thus, the tests are usually conducted under **worst-case** operating conditions. RCRA trial burns and MACT performance tests are both performance tests. For hazardous waste combustors, performance testing may include a low-temperature **test condition** to demonstrate DRE for POHCs and a high-temperature **test**

	condition to demonstrate SRE for metals. Additional test conditions may be necessary to resolve potential conflicts between targeted operating parameters.
Risk Burn	A **risk burn** is any **emissions testing** performed for the purpose of collecting emissions data for subsequent evaluation in a site-specific risk assessment. The testing may occur in conjunction with a RCRA trial burn or MACT performance test, or the risk burn may consist of a completely separate test effort. A risk burn includes a minimum of one **test condition**, but may include more.
Run	A **run** is the period of time needed to collect a stack gas sample of sufficient volume for subsequent analysis. During a run, control parameters are typically maintained at the same target set point. A minimum of three runs constitutes a **test condition**

CHAPTER 2

RISK ASSESSMENT STACK EMISSION DATA NEEDS

The categories of emissions data that are generally necessary for completing a site-specific risk assessment include: (1) D/F emission rates, (2) organic emission rates other than those for D/Fs, (3) metals emission rates, (4) particle-size distribution, and (5) emission rates of HCl and Cl_2. This chapter introduces these data needs and briefly summarizes their significance with respect to protection of human health and the environment.

EPA OSW recognizes that, for many compounds, only limited information is available regarding health effects (EPA 1998a). However, this does not imply that targeted sampling for a limited number of compounds should be conducted for the risk burn (EPA 1998a). Stack emissions should generally be characterized as completely as possible during a risk burn, regardless of availability of toxicological data. Although some compounds may eventually be eliminated from quantitative risk evaluation as suggested by the compound-of-potential-concern (COPC) selection process provided in the EPA OSW risk assessment guidance (EPA 1998a), it is important that all compounds initially be identified and quantified. New toxicological data may become available after the risk burn, or the risk assessor may consider provisional toxicity data or surrogate toxicity data from a similar compound in deciding whether to retain the compound as a COPC (EPA 1998a). Alternatively, a qualitative risk evaluation may be performed for any detected compound and presented as an uncertainty in the risk assessment (EPA 1998a).

2.1 DIOXINS AND FURANS

D/Fs are addressed in Chapter 4 of this guidance. D/Fs can pose significant risks through both direct and indirect exposure pathways. Their propensity to partition to adipose (fat) tissue and to bioaccumulate can make potential food chain effects particularly significant. According to the dioxin reassessment review (EPA 1995a), the air-to-plant-to-animal exposure pathway is a primary exposure route for humans. Other significant exposure pathways include source-to-surface water-to-fish. Human exposures result from ingestion of contaminated milk, beef, fish, and other foods. D/Fs are believed to promote cancer and other harmful health effects in humans and other receptors, and the potential potency of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin as a carcinogen is currently being re-evaluated by EPA.

D/Fs are a group of anthropogenic chemical compounds created as unintended by-products during combustion and industrial activities (EPA 1995a). As described in Chapter 4, the formation of D/Fs in hazardous waste combustion units is highly dependent on post-combustion temperature, time, and the presence of a reaction surface. In general, D/Fs addressed in this document contain at least four chlorine atoms and can assume a planar configuration that allows for specific biological effects. D/Fs are generally quantified in terms of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin toxic equivalents (TEQ), as discussed in the EPA OSW risk assessment guidance (EPA 1998a). EPA OSW recommends that emissions testing for the tetra- through octa- D/F congeners be performed to support site-specific risk assessments.

Even though the primary focus in this document and in the EPA OSW risk assessment guidance is on the tetra- through octa- D/F congeners, analytical standards have been developed for certain mono- through tri-chloro D/F congeners. EPA encourages stack gas analysis for these mono- through tri-chloro congeners

2.2 ORGANICS OTHER THAN DIOXINS AND FURANS

Organic compounds other than D/Fs are addressed in Chapter 5 of this guidance. Organics can result in increased risks from both direct and indirect exposures. Hazardous waste combustors can emit a variety of trace-level organics. As discussed in Chapter 5 of this document, organic emissions from hazardous waste combustion facilities typically include compounds such as volatile and semivolatile organics, aromatics, polyaromatics, D/Fs, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), phthalates, nitrogenated and sulfonated organics, and short-chain alkanes (such as methane and propane). Both PAHs and PCBs are considered to be potential human carcinogens (EPA 2000), and are considered to be toxic, persistent, and bioaccumulative. PAHs are frequently associated with particulate matter emitted from combustion facilities. Combustion units have also been identified as major contributors to overall PCB emissions (Alcock and others 1999; EPA 1997b), and an increasing body of information supports the likelihood that PCBs may be formed in combustion systems regardless of PCB contamination in the feed (Lemieux and others 1999). PCBs may be formed by mechanisms similar to those described in Chapter 4 for D/Fs.

Target analyte lists for specific organics recommended for identification during a risk burn are provided in Appendix B. However, the total identification and quantification of all organics is frequently not possible, c095 Tn Cs 's BIF ruh a(40 CDreo, til, Subdocuul, uiadd22 Tc 0.2 Tw (17) TuL.ile,wPCBsdolatcs, able, cadmium, chromium, lead, mercury, silver, and thallium. A number of these metals also pose human health risks via the indirect pathways. Mercury, in particular, has significant potential to biotransfer up the food chain through water and sediments to fish and human receptors. Table A-1, “Information on Compounds of Potential Interest,” of Appendix A of the EPA OSW human health risk assessment guidance (EPA1998a) and Table A-1, "Chemicals for Consideration as Compounds of Potential Concern," of Appendix A of the EPA OSW ecological assessment guidance (EPA1999b) identify eight additional metals as compounds of potential concern for evaluation of human and ecological risks. These eight additional metals are aluminum, copper, cobalt, manganese, nickel, selenium, vanadium, and zinc.

EPA OSW recommends that a facility conducting a site-specific risk assessment perform stack testing or develop emission estimates based on other information for the eighteen metals listed above. Although some metals may be subsequently eliminated from the risk assessment during the compound of potential concern (COPC) selection process, it is recommended that all eighteen metals be quantified during the test to prevent the need for additional testing later. Potential human cancer risks based on carcinogenic slope factors (CSFs) are typically evaluated for arsenic, beryllium, cadmium, hexavalent chromium, and certain species of nickel. Health effects other than cancer are based on RfDs and/or RfCs for antimony, barium, trivalent chromium, copper, manganese, mercury, certain species of nickel, selenium, silver, thallium, vanadium, and zinc. As explained in Section 2.3.2 of this document, EPA OSW has recommended that potential health effects from lead be modeled using an alternative approach (EPA 1998a).

EPA OSW's ecological risk assessment guidance (EPA 1999b) describes ecological toxicity reference values for a number of ecosystems and receptors including freshwater quality, freshwater sediment, marine and estuarine water quality, marine and estuarine sediment, and specific receptors including earthworms, terrestrial plants, mammals, and birds. Ecological toxicity reference values have been developed for aluminum, antimony, arsenic, barium, beryllium, cadmium, copper, hexavalent chromium, total chromium, lead, mercury, methyl mercury, nickel, selenium, silver, thallium, and zinc. EPA OSW has recommended that these metals be considered during the COPC selection process for ecological risk assessments (EPA 1999b).

EPA OSW’s human health and ecological risk assessment guidance (EPA 1998a and 1999b) generally recommend addressing metals in the elemental form, with the exception of mercury, chromium, and nickel.

For mercury, chromium, and nickel, the guidance recommends assumptions regarding valence state or chemical form. Based on the conservative nature of the recommended assumptions, a facility may want to perform speciation sampling during the risk burn or present other information to replace the default assumptions with site-specific data. This is discussed further in Section 6.4 and Appendix B.

2.3.1 Human Health and Ecological Concerns for Specific Metals

The following paragraphs discuss human health and ecological significance of the metals aluminum, cobalt, copper, manganese, nickel, selenium, vanadium, and zinc. This information is provided in the EPA OSW risk assessment guidance, as well as other references, and is summarized here because these metals were
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Cobalt

been associated with toxic effects in livestock (blind staggers syndrome). Soils containing high levels of selenium (seleniferous soils) can lead to high concentrations of selenium in certain plants, which then pose a hazard to livestock and other species. In humans, selenium partitions to the kidneys and liver and is excreted through the urine and feces. Toxic effects in humans include central nervous system and gastrointestinal effects (Doull and others 1991). Aquatic birds are extremely sensitive to selenium; toxic effects include teratogenesis. Ecological toxicity reference values have been developed for selenium.

Vanadium

Vanadium is found in several ores, is associated with petroleum products, and is commonly found in food oils. It is unclear whether or not vanadium has any essential role in human metabolism. Toxic effects of vanadium are usually associated with the inhalation exposure route. Effects of chronic exposure to airborne vanadium compounds in workers include bronchitis, bronchopneumonia, and kidney damage (Doull and others 1991). Animal experiments have confirmed effects on the lungs and kidneys. Ecological toxicity reference values for vanadium have not been developed.

Zinc

Zinc is an essential trace element that is involved with many enzymatic reactions in humans and other species (Doull and others 1991). It generally occurs in the divalent oxidation state. Zinc does bioaccumulate, specifically through the indirect soil-to-vegetable exposure pathway. The most common observed human health effect from zinc would be depression of enzyme production, resulting in copper deficiency. Ecological effects include a tendency to bioaccumulate and toxic effects to vegetation and aquatic organisms (Paasivirta 1991). Ecological toxicity reference values have been developed for zinc.

2.3.2 Risk Characterization for Lead

Information on estimating threshold levels of lead exposure is provided in the EPA OSW human health risk assessment guidance (EPA 1998a). Toxicity factors (CSFs and RfDs) are not available for lead. Therefore, EPA OSW has recommended that adverse health effects for lead be characterized through a direct comparison with media-specific health-based levels, adjusted for background exposure (EPA 1998a).

Under the BIF regulations, emissions and feed rate limits for lead are based on a RAC equivalent to 10 percent of the NAAQS for lead converted to an annual average, or 0.09 micrograms per cubic meter (µg/m^3). However, this standard only addresses the direct inhalation exposure pathway. Lead can also be deposited to soils, where it can be ingested. Therefore, EPA OSW has recommended that soil lead levels also be evaluated as part of a site-specific risk assessment (EPA 1998a). The fate and transport equations in the EPA OSW risk assessment guidance (EPA 1998a) can be used to estimate soil concentrations from stack emissions.

The neurobiological effects observed in children are used as the sensitive endpoint for evaluating lead toxicity from ingestion. EPA has recommended a maximum lead concentration in blood of 10 micrograms per deciliter (µg/dL), which is at the low end of the range of concern for adverse health effects in children (EPA 1998a). Potential risks from lead are evaluated based on the application of an uptake/biokinetic
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measurements to determine particle-size distribution. Measurements for particle-size distribution will reflect site-specific combustion characteristics and the efficiency of the APCD. Site-specific particle-size measurements are discussed in more detail in Chapter 7 and in Appendix B of this document.

2.5 HYDROGEN CHLORIDE AND CHLORINE

HCl and Cl_2 are addressed in Section 7.1 of this guidance. Potential risks from HCl and Cl_2 are limited to the inhalation pathway. 40 CFR Part 266 Subpart H already requires BIF facilities to sample stack emissions for HCl and Cl_2, and to limit emissions as necessary to meet direct inhalation RACs specified in

CHAPTER 3

RISK BURNS

In this guidance, the term "risk burn" refers to any testing performed to collect emissions data for subsequent evaluation in a site-specific risk assessment. The testing may occur in conjunction with a RCRA trial burn or a MACT performance test, or the risk burn may consist of a completely separate test effort.

The objectives of a risk burn are to (1) collect appropriate emissions and feed characterization information for evaluation in a site-specific risk assessment, and (2) demonstrate the feed and operating conditions which correspond to measured emission levels. Feed and operating parameters (i.e., control parameters) may be limited and monitored after the risk burn to provide assurance on an ongoing basis that emissions remain at or below the measured levels.

Since EPA may consider the results of a risk assessment and use such information to establish risk-based permit limits under the omnibus authority of RCRA as described in 40 CFR § 270.32(b)(2), the risk burn should generally be integrated with trial burn or performance testing to the extent necessary to produce a final permit decision.

Collection of appropriate emissions and feed characterization information is a fundamental objective of the risk burn. EPA's recommended data quality objective (DQO) process (EPA 1998c) promotes collection of "the right data the first time." The EPA OSW risk assessment guidance (EPA 1998a) and this document support that objective by identifying and discussing data needs and measurement options. However, project-specific measurement goals should generally be established for each data collection effort. For example, some facilities may decide to achieve lower detection limits for certain constituents to demonstrate that risks are below target levels. Preliminary risk modeling can assist in determining the quantitative targets for the measurement design.

Advance planning is also important in choosing the risk burn operating mode. The risk burn operating mode affects the outcome of the risk assessment, and may also affect the final permit terms. Some hazardous waste combustors operate over a wide range of conditions and emission levels. However, the outcome of the risk assessment is linked to specific emission rates measured while operating under specific operating mode(s). To assure that the combustor continues to operate within the range where emissions have been found to be protective, the RCRA permit may limit control parameters based on the risk burn. Ultimately, the risk burn generally should strike a balance between operating modes which achieve desired permit flexibility, while also achieving protective emissions levels. Early communication between the permit writer and facility is important. A clear understanding of how the permit terms will be derived can assist in determining the risk burn operating modes. Preliminary risk modeling and preliminary emissions testing may also be helpful in planning the risk burn.

PHASE 2: DEMONSTRATION

2. **A risk burn is performed to gather stack emissions data and define the operating envelope that corresponds to the risk assessment.** The recommended control parameters for defining the operating envelope that corresponds to the risk burn and risk assessment are identified in Chapters 4 through 7 of this document. In some cases, these parameters may need to be limited in the permit to ensure (on an ongoing basis) that emissions remain below the levels that were measured during the risk burn and found to be protective. Many of the control parameters identified in Chapters 4 through 7 are identical to control parameters which are limited to ensure compliance with regulatory performance standards. Therefore, few (if any) additional permit limitations based on the risk burn may be necessary when the risk burn can be performed in conjunction with a RCRA trial burn or MACT performance test, and when emissions are already controlled to risk burn levels by regulatory limits on key control parameters. A greater number of permit limitations may be necessary when the risk burn and performance tests reflect different operating modes.

3. **A risk assessment is performed to verify that the demonstrated operation does not present significant risk to human health or the environment.** The site-specific risk assessment may either be performed using the actual data from the risk burn, or using a combination of risk burn data and other information. For example, a regulatory standard or allowable permit limit for metals might be evaluated in combination with actual emissions data for specific organics.

   Additional iterations of the risk assessment may be performed if the initial evaluation indicates potentially unacceptable risks. Subsequent iterations might consider additional site-specific information that is more representative of the exposure setting, or reduced emissions (EPA 1998a). However, in most cases, the need for emissions reductions should generally be identified as part of the risk burn planning process, well in advance of performing the risk assessment.

4. **A permit decision is made, either to issue or deny**.

PHASE 3: VERIFICATION

5. **Conditions in addition to those specifically required by regulation may be included in the RCRA permit as necessary to protect human health and the environment**. The final permit represents an important and integral conclusion to the risk-based permitting process. The risk burn and risk assessment are merely tools; it is the final permit that defines what operational conditions are necessary to protect human health and the environment and how that will be assured on an ongoing basis (i.e., risk-based permit limitations). Depending on site-specific considerations, risk-based permit limitations may be necessary to prevent operation at conditions which could result in higher emissions than those represented by the risk burn and risk assessment.

   Risk-based permit terms must be justified on a site-specific basis as limitations that are necessary to protect human health and the environment. EPA OSW recommends that the permitting authority consider a number of factors including, but not limited to, the operating mode(s) demonstrated during the risk burn, the emission levels evaluated in the risk assessment, the conservatism of the risk assessment assumptions, the outcome of the risk assessment, and the extent to which emissions are already controlled by regulatory standards or other limitations. Potential risk-based permit limitations include:

   - ***Emissions limits and stack testing.*** Specific emission limitations may be cited in the permit for certain pollutants. Since most emissions can only be verified by manual stack measurements, the permit may include a schedule for periodic stack testing to confirm that emissions remain below levels that may present a significant risk to human health and the environment.

   - ***Feed restrictions, operating limits and monitoring.*** Emission levels generally cannot be verified continuously. However, feed restrictions and operating limits may be established based on the risk burn as surrogate indicators of emissions. The feed and operating control parameters can then be continuously monitored to assure that emissions remain below the measured levels on an ongoing basis.

   - ***Other limitations.*** Other permit limitations may be established to control potential risks as necessary to protect human health and the environment. For example, environmental sampling may be specified to confirm that ambient concentrations of certain pollutants do not reach levels that may present a significant risk to human health and the environment.

As evident from this risk-based permitting overview, EPA OSW believes that the risk burn, risk assessment, and final permit terms will be closely linked for situations where the RCRA permitting authority has determined that a site-specific risk assessment is necessary. The risk burn plays a key role in the process. Operation during the risk burn may affect whether the measured emissions are found to present potential risk to human health and the environment. In addition, operation during the risk burn can define an operating envelope that establishes the working assumptions for the risk assessment and final permit terms. Within the bounds of the operating envelope demonstrated during the risk burn, emissions are characterized and evaluated for potential risk by the risk assessment. Outside of those bounds (unless additional information is available), emissions and risks may be unknown.

3.2 RISK BURN OBJECTIVES

This section discusses risk burn objectives in more detail. The objectives of the risk burn are to (1) collect appropriate emissions and feed characterization information for evaluation in a site-specific risk assessment, and (2) demonstrate the feed and operating conditions which correspond to emission levels that do not present a significant risk to human health or the environment.

3.2.1 Collection of Appropriate Emissions and Feed Characterization Information

As discussed in Chapters 1 and 2, collection of site-specific risk assessment data at hazardous waste combustion facilities generally involves stack sampling and analysis for D/Fs, non-D/F organics, metals, particle-size distribution, and HCl and Cl_2. Prior to data collection, EPA OSW recommends that specific measurement objectives be developed for the risk burn plan and associated quality assurance project plan (QAPP) to assure collection of complete and useable data.

EPA guidance on quality assurance project plans (EPA1998c and 1998d) describe recommended information to be included in a QAPP. The QAPP identifies a project’s technical and quality objectives and documents how quality assurance and quality control will be applied to assure that the data support technically sound decision-making. In addition, the QAPP may identify potential limitations regarding use of the data.

EPA OSW recommends that, whenever possible, project-specific measurement objectives be defined considering information from a preliminary risk assessment . High detection or quantitation limits, presence of common laboratory contaminants, and sampling artifacts can artificially inflate risks. A preliminary risk assessment can provide information regarding the necessary detection or quantitation limits and constituent concentrations for demonstrating that risks are below levels of concern. If a proposed measurement option will not attain the quantitative objectives, the measurement design may need to be modified. For example, if lower detection or quantitation limits are needed, a longer sampling duration or use of a high resolution analytical finish might be considered. Conversely, if a facility can tolerate higher detection or quantitation limits, more economical measurement options might be selected. As an example, a single semivolatile sampling train might be used to sample for D/Fs, PCBs, PAHs and semivolatile organics (when a single train is used for multiple determinations, the train components are split and detection limits for the semivolatile organics increase). Detection and quantitation limits are discussed in more detail in Appendix B.

The recommended detection or quantitation limits that should generally be reported when constituents are not detected in a stack gas emissions sample are discussed in Section 8.1.1 of this document. It is also recommended that a facility inform the laboratory of preferred reporting conventions prior to development of the risk burn QAPP and analysis of the risk burn samples.

EPA OSW recommends that the risk burn plan and QAPP also address complete characterization of the feed materials to be burned during the risk burn, including wastes, fuels, raw materials, and spike materials. Data equivalent to the following should generally be generated for each feed material:

- Proximate analysis, or a comparable evaluation, to determine physical properties including moisture, percent solids, heating value, ash, and viscosity or physical form, as well as to determine approximate chemical properties including total organic carbon, total chlorine, total organic halogens, and elemental composition;

- Quantification of total metals feed rates for aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc;

- Survey analysis or a comparable evaluation to provide an overall description of the chemistry of the sample in terms of the major quantities and types of organic compounds that are

> present, as well as identification and quantitation of trace quantities of persistent, bioaccumulative, and toxic constituents based on analysis for volatile organics, semivolatile organics, PCBs, PAHs, and facility-specific compounds.

These data typically define a facility's baseline with respect to long-term impacts and potential effects on human health and the environment. When constituents are not detected in a feed matrix, it is recommended that the Sample Quantitation Limit (SQL) as described in *Guidance for Data Useability in Risk Assessment* (EPA 1992c) be reported, with appropriate consideration of the level of dilution necessary to perform the analysis.

EPA OSW recommends that the implications of different measurement options be fully considered during the initial planning stages of the risk burn. Risk burn measurement issues and data analysis are discussed further in the EPA OSW risk assessment guidance (EPA 1998a), and in Section 8.1 and Appendix B of this document.

3.2.2 Demonstration of Operating Modes

The second objective of a risk burn is to determine the feed and operating conditions which will ensure that emission levels do not present a significant risk to human health and the environment. The operating mode during the risk burn may affect the outcome of the risk assessment and, subsequently, the final permit decision. For this reason, EPA OSW recommends that preliminary information regarding potential emission rates and anticipated permit limitations be obtained early in the risk burn planning process.

Useful information regarding potential emissions and risks can be obtained by performing mini-burns and preliminary risk evaluations. Mini-burns involve stack sampling to collect limited emissions data prior to full scale testing. Emissions can also be estimated based upon data gathered at a similar facility, or by performing conservative engineering calculations. A preliminary risk evaluation indicates the degree of potential risk associated with the emissions levels that are anticipated for the risk burn. If the preliminary risk assessment indicates that anticipated emissions are likely to present a significant risk to human health and the environment, a facility may choose to reduce the emissions of certain compounds prior to

Emissions during normal operations (as compared to emissions during DRE or SRE conditions) may better represent the average emissions and risks posed by the combustion facility over its operating life.

When "worst-case" emissions from the DRE/SRE test conditions are not projected to pose a significant risk to human health and the environment, then a facility may choose to minimize the number of test conditions and resulting permit limitations by combining the risk burn and performance tests. Otherwise, the facility and permit authority might explore the possibility of performing the risk burn (or a portion of the risk burn) under normal operating conditions as a separate test effort. The option of collecting data under normal conditions is discussed further in Section 3.3.2.1.

It is important to keep in mind that different approaches may be chosen for different constituents (D/nt approaches may be c

Risk Burn Guidance for

3.3.2 Separate Testing

Section 3.3.2 identifies circumstances where it may be appropriate to perform the risk burn independently from the DRE/SRE performance tests. In some situations, a facility may prefer to perform all or part of the risk burn under normal operating conditions to better represent the average emission levels expected over the operating life of the unit. Testing at normal conditions is discussed in Sections 3.3.2.1 and 3.3.2.2. Alternatively, separate testing may be appropriate because of logistical conflicts, such as timing, or to resolve a conflict between the risk burn and DRE/SRE waste feed or operating targets. Separate testing to resolve a conflict is discussed in Section 3.3.2.3.

3.3.2.1 Testing at Normal Conditions

As explained in Section 3.3.1.1, it may be appropriate in certain circumstances to perform the risk assessment using emissions data generated during normal operation of the combustion unit. If a facility requests that emissions data collected under normal operating conditions be evaluated in the risk assessment, then an additional test condition (separate from the DRE/SRE test conditions) may be suggested in the risk burn plan. This additional condition is optional and is performed by the facility on a voluntary basis.

The permitting authority should generally consider proposals for use of emissions data generated under normal operating conditions in the risk assessment (in conjunction with or instead of data generated during a DRE or SRE test) on a case-by-case basis. Additional permit limitations may be needed to ensure that conditions represented as normal during the test are, in fact, normal over the long-term operation of the facility.

Some facilities may view the prospect of extra permit limitations as a disincentive to performing the risk burn (or a portion of the risk burn) under normal operating conditions. However, the “verification” phase of risk-based permitting has been explained in Section 3.1, and the logic is repeated here for emphasis. The permit endeavors to prevent operation at conditions which could result in higher emissions than those evaluated in the risk assessment and found to pose an insignificant risk to human health and the environment. If emissions data from testing at normal conditions are evaluated in the risk assessment (in lieu of emissions data from “worst-case” DRE/SRE testing) and it is determined that such emissions do not present a significant risk to human health and the environment, then the permit should generally ensure that those emissions, on average, are not exceeded over the long term. Operating limitations from the DRE/SRE test conditions may not offer this assurance, because they represent operating extremes and elevated emissions. Thus, additional operating limitations may be needed to assure protection of human health and the environment. Although these extra permit limitations may indeed be viewed by some facilities as a disincentive to performing a risk burn under normal operating conditions, the decision to pursue testing at normal conditions rests completely with the facility.

It is important to mention that data from testing under normal conditions and data from testing under “worst-case” DRE/SRE conditions may sometimes be evaluated in a risk assessment as two completely separate risk scenarios (for example, to support a more informative risk communication strategy). Provided that “worst-case” emissions from DRE/SRE test conditions are evaluated in the risk assessment and it is determined that they do not present a significant risk to human health and the environment, then extra permit conditions to assure normal operation should not be necessary. Under these circumstances, the regulatory and permit limitations associated with the DRE/SRE testing would ensure that ongoing emissions remain below levels that may present a significant risk to human health and the environment.

3.3.2.2 Defining and Verifying Normal Conditions

Emissions data collected under normal operating conditions may reflect lower emission rates and lower, but more representative, potential risks. However, it may not be appropriate for every facility to use emissions data collected under normal conditions in the risk assessment. EPA OSW recommends that the following be considered when determining whether to test at normal conditions:

1. ***Can the facility provide sufficient information to define normal feed and operating conditions?***

   To use emissions data generated during testing at normal conditions in the risk assessment (in lieu of data generated during a DRE or SRE test), a facility should be able to characterize “normal” for their operations. This characterization could involve plotting control parameters over time, assessing typical variation, determining means and standard deviations, characterizing feed variability, or a combination of these and other approaches. For the feed characterization, EPA OSW recommends that both the hazardous and non-hazardous inputs (including fossil fuels, raw materials, and non-hazardous wastes) be considered. For example, mercury in coal can contribute to potential risks and should be considered in the feed characterization.

Successful characterization of “normal” may be more probable when a facility burns wastes that have little temporal variation in chemical and physical properties, at relatively constant rates, and under operating conditions that do not fluctuate widely. Facilities that do not operate within these

The facility should propose a permitting approach for ensuring that, over the long term, the unit does not operate in excess of the conditions represented as normal during the test. Most likely, the approach will closely mirror the approach used to define "normal" in the first place. It should generally not be necessary for the permit approach to be so conservative that operation during the "normal" test is driven towards the extreme edges of the operating envelope (thereby negating the point of the normal test). On the other hand, if testing near an operating extreme seems necessary to reflect variations in everyday operation, then it may be appropriate to reconsider whether "normal" can truly be defined for that operation.

3. ***Are there additional site-specific considerations?***

It may be appropriate to use emissions data collected under DRE and/or SRE conditions in the risk assessment because of other circumstances, such as acute risk concerns. For some constituents, direct inhalation may cause short-term or acute effects. In these situations, EPA OSW has recommended that a maximum, 1-hour emission rate be evaluated in the risk assessment (EPA 1998a). Maximum emission rates are generally achieved under DRE and/or SRE conditions.

One example of a situation where it may be appropriate to use emissions data collected under normal operating conditions in the risk assessment is a BIF facility that wishes to perform testing for metals at normal conditions. If the facility can provide historical data to characterize normal metal feed rates (consistent with the recommendations in Section 3.3.2.2) and if monthly-average metal feed rate permit limits could be established based on the risk burn to assure that ongoing operation remains within the range represented as normal during the test (consistent with the recommendations in Section 3.3.2.2), then it might be appropriate to use emissions data collected under normal operating conditions in the risk assessment. The recommended testing and permitting approach for this situation follows:

- ***SRE Test:*** The SRE test is conducted at *maximum metals feed rates*, and could involve metals spiking. Emissions from the SRE test are required to be below allowable BIF emission limits (which are based only on inhalation risks) pursuant to 40 CFR § 266.106. *Hourly rolling average metal feed rate limits* are established in the permit based upon this test.

- ***Normal Test:*** This test is conducted at *normal metals feed rates*, without metals spiking. Emissions data from the normal test are evaluated in the risk assessment to determine potential risks from both direct and indirect exposures. *Monthly-average metal feed rate limits* are established in the permit based upon this test.

An example of a situation where it may not be appropriate to use emissions data collected under normal

C Additional operating condition(s) to set limits on the conflicting control parameters. To the maximum extent practicable, only the conflicting parameters should be varied from the first set of operating conditions. All non-conflicting parameters should be maintained as constant as possible during all operating conditions.

As discussed in Sections 3.3.1.2 and 3.3.1.3, it is recommended that the risk burn (or a portion of the risk burn) be performed independently of DRE/SRE testing when actual wastes are not utilized for the DRE/SRE test, or when there is a conflict between the risk burn and DRE/SRE feed or operating targets.

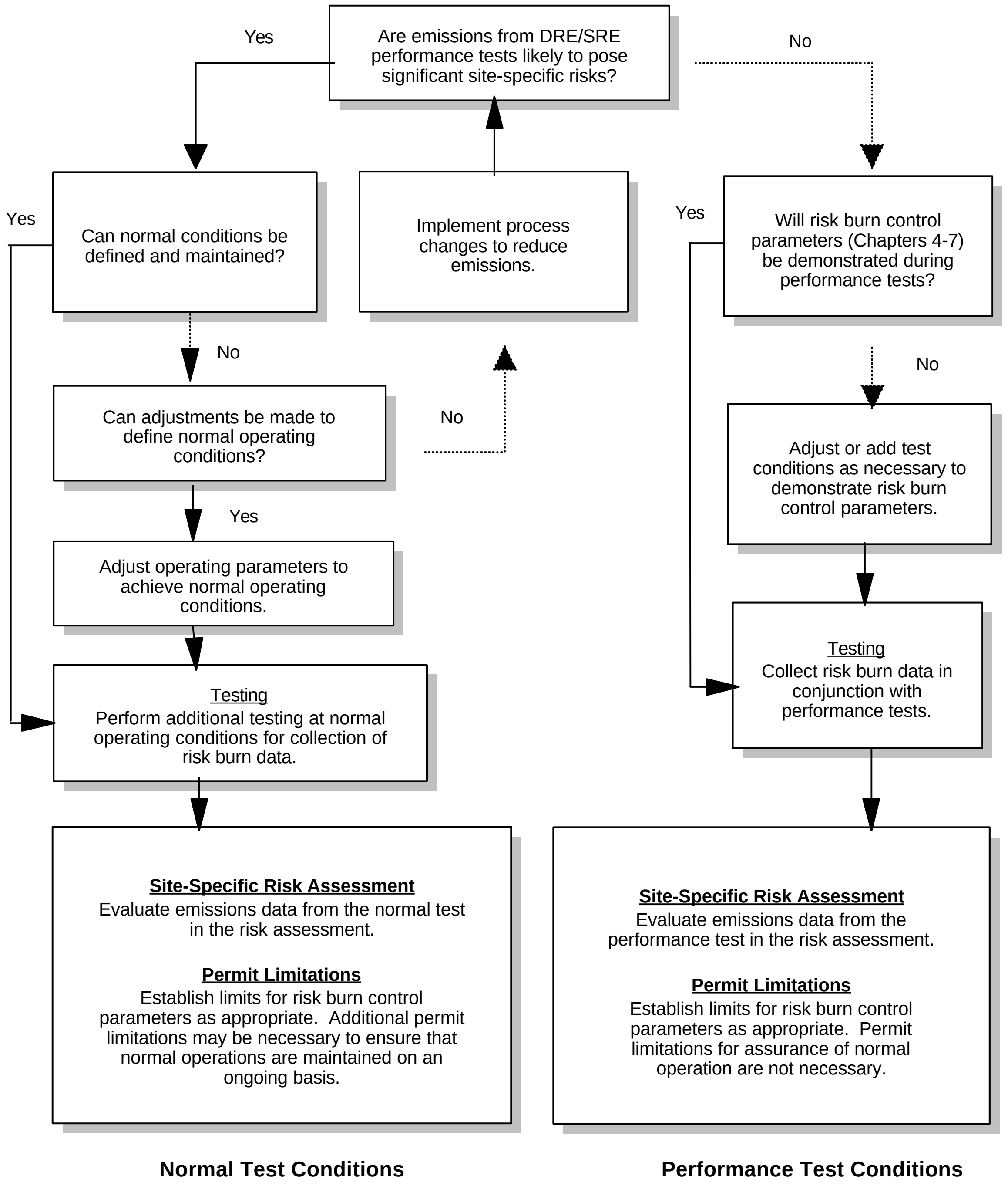
3.4 RISK-BASED DATA COLLECTION, EXAMPLE LOGIC

Figure 3-1 provides example logic (based on the recommendations discussed throughout this chapter) for permit writers and facility personnel to consider in determining appropriate test conditions for the risk burn. The first step involves determining whether emissions demonstrated under DRE and SRE conditions are anticipated to present a significant risk to human health and the environment, considering target risk levels as specified by the regulatory agency. EPA OSW recommends that this question be answered by evaluating existing emissions data, by conducting "mini-burns" (as allowed by existing permit or interim status conditions), or by evaluating data from similar facilities in a preliminary risk assessment.

Based on preliminary data analysis, a facility may anticipate that emissions data collected during perm wmetertest,workditrinied

FIGURE 3-1

RECOMMENDED SITE-SPECIFIC RISK ASSESSMENT DATA COLLECTION FLOW CHART



In some cases, the control parameters identified in Chapters 4 through 7 of this document may not be targeted for demonstration during the DRE or SRE test conditions. In these circumstances, it may be appropriate to adjust the DRE/SRE test conditions to demonstrate appropriate control parameters from Chapters 4 through 7, or add extra test conditions as described in Section 3.3.2.3. An example is a hazardous waste boiler that is equipped with a dry APCD for particulate control, but whose waste feeds contain no metals. Since the waste feed does not contain metals at detectable levels, the facility is not required (pursuant to 40 CFR §§ 266.102 and 266.106) to perform a maximum temperature SRE test or to establish maximum inlet temperature limit for the dry APCD to control metals. However, Section 4.2.1.3 recommends maximum inlet temperature to a dry APCD as a primary control parameter related to D/F emissions. If the boiler cannot demonstrate maximum APCD inlet temperature during the DRE test facility. These terms can include long-term average permit limitations for waste feed rates, temperatures, and other appropriate control parameters, use of control charts, and/or waste tracking and record keeping. These facilities may also be asked to submit a compliance monitoring plan to demonstrate how compliance with the permit terms will be maintained and documented.

3.5 TEST PLAN SUMMARY INFORMATION

A common understanding regarding how the final permit limits will be developed is integral to the design of the test protocol, and early communication and coordination between the permit writer and facility is essential. The permit writer is responsible for identifying control parameters which may be limited in the permit, and for explaining how specific permit terms may be established based on the test results. The permit writer should generally rely on the facility owner/operator to ensure that risk burn operating conditions are targeted in a manner that supports permit terms that are acceptable to the facility. EPA OSW recommends that the following specific types of information generally be included in the test plan to facilitate this process:

C For each type of emissions data to be evaluated in the risk assessment (D/Fs, no1 /Fc 0.Rs process:

the control parameters that will be demonstrated during trial burn or performance testing for DRE, SRE, particulate matter, and HCl and Cl_2.

C A list of conflicting parameters (key control parameters that cannot be maximized or minimized simultaneously), along with a detailed explanation of the reasons for the conflict. The two or more test conditions that will be performed to resolve the conflict should be described, and changes in other control parameters that may be necessary to resolve the conflict should be identified.

C A complete list of control parameters which are expected to be limited in the permit. This list should be consistent with the proposed test conditions and the following information should be included for each control parameter:

  S The anticipated permit limit, assuming that all test conditions are executed as planned;

  S An indication of whether the permit limit will be based on the trial burn or other information (such as a zero SRE assumption for metals);

  S Specific information on how each permit limit will be established based on trial burn results. This information includes specifying the test condition that will be used to establish the numerical limit and how the numerical limit will be calculated (such as the average over all test runs).

  S Specific information on how each control parameter will be monitored and recorded to demonstrate compliance with the permit limit (i.e., whether the control parameter will be continuously monitored, the type of record to be maintained and the recording frequency, and what averaging period will be used for the compliance determination).

  S Statements as to whether the parameter will be interlocked with the AWFCO system, and the corresponding proposed set point.

EPA OSW recommends that the risk burn be integrated with DRE/SRE performance testing as necessary to produce a consistent set of enforceable permit conditions. When permit terms will be established from multiple test conditions, the complete list of anticipated limitations should be reviewed for internal consistency and potential conflicts.

CHAPTER 4

DIOXIN AND FURAN EMISSIONS

D/Fs can pose significant risks through both direct and indirect exposure pathways. This chapter reviews EPA OSW's recommendations for specific operating and feed parameters to be considered for demonstration during collection of D/F emissions data for risk burns. Depending on site-specific considerations, it may be necessary to limit certain of these control parameters in the RCRA permit to protect human health and the environment by ensuring that D/F emissions remain within the levels

Lustenhouwer originally advanced three theories to explain the presence of D/Fs (Lustenhouwer and others 1980). The theories may now be described as:

1. Survival of trace D/Fs in the fuel.
2. D/F formation from gas-phase precursors which are chemically similar to D/Fs, such as chloro-aromatics, via
   a. homogeneous (gas-gas phase) reactions, or
   b. heterogeneous (gas-solid phase) condensation reactions between gas-phase precursors and a catalytic particle surface.
3. *De novo* synthesis of D/Fs from carbon sources that are chemically quite different from the dioxin and furan ring structures. *De novo* synthesis involves heterogeneous, surface-catalyzed reactions between carbonaceous particulate and an organic or inorganic chlorine donor.

It is now generally accepted that Theory (1) cannot explain the levels of D/F emissions which have been measured from combustors. Most combustion units do not burn D/F contaminated wastes, and Schaub and Tsang have noted that the gas-phase thermal destruction efficiency for D/Fs is high at the flame temperatures typically achieved in a combustion unit (Schaub and Tsang 1983). D/Fs have been found to decompose rapidly at temperatures above 1700 EF (Schaub and Tsang 1983).

Theory (2a) is also believed to play a relatively minor role in the D/F emissions from combustion facilities. An early kinetic model developed by Schaub and Tsang suggested that the homogeneous gas-phase rate of formation could not account for observed yields of D/Fs (Schaub and Tsang 1983). At the high temperatures in a combustion zone, the multi-step process necessary for D/F formation cannot compete with destruction. Although Sidhu and others have subsequently demonstrated pure gas-phase formation of D/Fs (Sidhu and others 1994), the minor role of homogeneous gas-phase formation is evidenced by numerous field measurements which show higher D/Fs downstream of the combustion chamber than in the flue gases immediately exiting the combustion chamber (Gullett and Lemieux 1994).

D/F emissions from combustion devices are now believed to result primarily from heterogeneous, surface-catalyzed reactions in the post-furnace regions of the unit (Theories 2b and 3). Experimental evidence suggests that these reactions occur within a temperature range of approximately 390 to 750 EF (200 to

400 EC) or wider, with maximum formation occurring near 570 EF (300 EC) (Kilgroe and others 1990).

Theories (2b) and (3) are both characterized by heterogeneous, surface-catalyzed reactions. Dickson summarizes the distinctions between the two heterogeneous formation pathways (Dickson and others 1992). Theory (2b) can be distinguished by reactions involving gas-phase chloro-aromatic precursors which might already be present in the fuel, or which could be formed as products of incomplete combustion (Karasek and Dickson 1987; Dickson and Karasek 1987). Theory 3 does not require that chloro-aromatic precursors be present on fly ash or in the gas stream. Instead, both the chloro-aromatic precursors and D/Fs may be synthesized *de novo* from gas-solid and solid-solid reactions between carbon particulates, air, moisture and inorganic chlorides in the presence of a metal catalyst, primarily divalent copper (Stieglitz and others 1989a and 1989b). Activated carbon has also been implicated as a catalyst (Dickson and others 1992).

Dickson has performed studies to quantitatively determine the relative predominance of the two heterogeneous formation pathways (Dickson and others 1992). Yields of polychlorinated dibenzo-*p*-dioxin from the precursor compound pentachlorophenol were 72-99,000 times greater than yields formed from reactions of activated charcoal, air, inorganic chloride and divalent copper catalyst under identical reaction conditions. Citing the kinetic work of Altwicker (Altwicker and others 1990a), Dickson postulated the following:

C fast reactions involving chloro-aromatic precursors may be expected to predominate in the post-combustion and heat exchanger sections of a combustor, where the temperatures range from 600 to 250 EC and the residence time of the gas stream and entrained particulates is on the order of 1 second, and

C 62Tc 00as 9i Tc 0 Tw (C.strer 0 TD /F6 11.0456 I48activo22Tc 00as 9i Tc 0 Tw (C.t144Tj 34.56 64 TD greater with Cl_2 than with HCl (Gullett and others 1990). Although HCl does not directly participate in precursor chlorination to a significant degree, it can produce molecular chlorine via the Deacon reaction (Griffin 1986; Gullett and others1990):

$2HCl + ½ O_2$ <==> $Cl_2 + H_2O$, with copper or other metals serving as catalysts (Equation 1)

where:

HCl = hydrogen chloride

O_2 = oxygen

Cl_2 = chlorine

H_2O =

2

prefromlcoal-fctld poweraplantsan witfromlmunpate l we Comcustionors, eveT aDh HClcoal-fctld u

downstream of the combustion chamber. Conditions conducive to downstream formation include (1) presence of particulates, which allow for solid-catalyzed reactions, (2) post-furnace particulate residence time in the critical temperature window (approximately 400 to 750 °F), (3) presence of Cl and organic precursors, including chloro-aromatics, and (4) a shortage of formation inhibitors, such as sulfur. Poor combustion can substantially increase D/F formation, possibly through increased soot formation (providing more catalytic reaction sites for D/F formation), increased formation of PICs (which can serve as D/F precursors), and increased gas-phase formation of D/Fs, although sufficient oxygen also appears to be necessary (Gullett and others, in press). Approaches that have been successfully demonstrated in full scale systems for controlling D/F emissions include:

- Maintenance of good combustion conditions to limit organic precursors and soot;
- Rapid flue gas quenching or other measures to minimize post-furnace particulate residence time in the critical temperature zone;
- Use of formation inhibitors;
- End-of-pipe flue gas cleaning techniques for D/F removal or catalytic decomposition.

4.2 CONTROL PARAMETERS TO BE CONSIDERED FOR RISK BURNS

As explained in Section 4.1, researchers have concluded that D/F formation mechanisms in combustion systems are extremely complex. D/F emissions cannot be predicted accurately with kinetic models or surrogate monitoring parameters such as carbon monoxide or total hydrocarbons (Santoleri 1995). Even in systems achieving good combustion (with low carbon monoxide concentrations), D/F formation may occur in cooler zones downstream of the combustion chamber (Santoleri 1995). Almost any combination of carbon, hydrogen, oxygen, and chlorine can yield some D/Fs, given the proper time and temperature (Altwicker and others 1990b; Santoleri 1995). Factors such as non-detect levels of chlorine in feed streams, lack of dry APCD systems, presence of D/F inhibitors (such as sulfur), lack of D/F catalysts (such as copper), and lack of D/F precursors (such as chloro-aromatics) may lead to reduced or low emissions of D/Fs. However, because mechanisms of D/F formation are extremely complex and are not well understood, it is not possible to predict with certainty whether a given facility will have significant D/F emissions.

Since D/F emissions cannot be predicted, it is recommended that D/F emissions testing be performed to develop the emissions data for site-specific risk assessments. This section recommends key control parameters to be considered in establishing D/F test conditions. After the risk burn, these parameters may need to be limited in the permit to protect human health and the environment by ensuring that D/F emissions remain below measured levels on an ongoing basis.

Several of the control parameters identified in this section may already be limited in association with the DRE standard, and a number of the control parameters will be limited pursuant to the requirements of the hazardous waste combustor MACT rule. To the extent that risks from D/Fs are already adequately controlled by regulatory limits on key control parameters, then fewer risk-based limits may be needed in the RCRA permit. However, if regulatory controls are not applicable or sufficiently comprehensive, then additional risk-based limits may be warranted. A greater number of risk-based permit limitations may be necessary when the risk burn and RCRA or MACT performance tests reflect different operating modes.

In formulating the recommendations in Section 4.2, a conservative approach has been taken. It is important that D/F emissions not be underestimated for risk assessments. However, a facility is not precluded from showing, on a site-specific basis, why a less conservative approach may be warranted, or from following the procedures in Section 3.3.2.1 to show that D/F testing should be performed at normal conditions to better represent the risk over the facility's operating life. Conservative recommendations are appropriate for this guidance because the option of testing at normal conditions may not be appropriate for every facility. EPA OSW recommends that conditions conducive to D/F formation first be reviewed to ensure that high-emitting operating modes at a facility are not under-represented by the risk assessment. In addition, the option of testing at normal conditions depends on whether a permit approach can be developed to ensure that emissions remain at or below measured levels. It may be difficult to ensure that "normal" D/F emissions will be maintained on an ongoing basis after the risk burn because of the non-linear relationship between D/F emissions and certain control parameters, such as particulate hold-up temperature (i.e., short-term perturbations outside of a certain operating range can cause high emissions which cannot be offset during periods of more normal operations). Finally, some level of conservatism in the D/F testing and permitting approach may be warranted to compensate for the continuing uncertainty regarding D/F formation mechanisms in general.

Although Section 4.2 presents each control parameter individually, the relative importance of the parameters with respect to one another should generally also be considered. When one or two control parameters are clearly dominant for a particular system, there may be little benefit to demonstrating and limiting additional parameters. The hierarchical ranking at the end of this section (Section 4.2.6) provides information to be considered in addressing this issue.

Control parameters are categorized according to post-combustion conditions (Section 4.2.1), combustion conditions (Section 4.2.2), feed composition (Section 4.2.3), hysteresis/memory effects (Section 4.2.4), and D/F control technologies (Section 4.2.5). All parameters may not be relevant for all systems, and the information in Section 4.2 should be considered in conjunction with the industry-specific information provided in Sections 4.3 through 4.6, as appropriate, as well as facility-specific information.

4.2.1 Post-Combustion Conditions

The flue gas temperature profile through the D/F formation region (approximately 400 to 750 EF)The fdowtingeamhe

> *APCD systems perform risk burn testing for D/Fs in conjunction with the DRE test conditions, whenever possible. If D/F testing during the DRE test is not feasible (for example, due to timing) consideration may be given to testing at normal conditions, where appropriate (see Section 3.3.2.2).*
>
> *During the risk burn, demonstration of specific control parameters associated with the rapid quench system should generally not be necessary. Consequently, permit limits for the rapid wet quench system based on the test are not expected to be needed. However, controls based on design specifications may be appropriate in some cases to assure that the quench continues to function properly.*

A rapid quench system involves rapid liquid quenching (on the order of milliseconds) from combustion temperatures to saturation temperatures. Facilities with “wet” APCD trains, such as venturi and packed bed scrubbers, utilize rapid wet quench. Wet scrubbers by design operate at stack gas dew point temperatures, which typically range from 170 to 200 EF. Thus, a flue gas exit temperature limit for the quench column or wet scrubbing device is not necessary to ensure that particulates are not held up in the critical 400 to 750 EF temperature window. (Note: This discussion applies to facilities with completely “wet” APCD trains. Temperature limits may be needed for facilities with “dry” APCD components that only perform a partial wet quench prior to a dry APCD, or that initially perform a full quench, but then reheat flue gases downstream of the wet scrubbing system and prior to a dry APCD. Sections 4.2.1.2 and 4.2.1.3 address these situations.)

In systems that perform rapid flue gas cooling from combustion temperatures to saturation (below 200 EF), surface-catalyzed D/F formation reactions are effectively precluded. Hazardous waste combustion facilities utilizing wet APCD systems are among the lowest-emitting sources of D/Fs (EPA 1999d; Santoleri 1998). A database containing more than 40 test conditions indicates that D/F emissions from these facilities are almost always less than 0.4 nanograms (ng) TEQ per dry standard cubic meter (dscm), and are often less than 0.1 ng TEQ/dscm (EPA 1999d). Ullrich describes reductions in D/F emissions which can be achieved through the use of a rapid liquid quench (Ullrich and others 1996).

A notable exception to the low D/F emissions trend for rapid wet quench systems is documented for one source (Source ID No. 330) where two test conditions showed average D/F emissions of 33 and 39 ng

TEQ/dscm, and an individual test run reached a maximum of 76 ng TEQ/dscm (EPA 1999d; Santoleri 1998). This source was burning waste oils with high levels of PCBs (30%). Although other PCB-burning sources have demonstrated low D/F emissions (EPA 1999d), it is possible that the PCBs or PCB combustion breakdown products could be responsible for significant gas-phase precursor formation of D/Fs at Source ID No.330.

The anomalous nature of the high D/F emissions at Source ID No. 330 emphasizes the inherent uncertainty in attempting to predict D/F emissions trends in lieu of actual emissions testing. Even in rapid wet quench systems where post-furnace D/F formation reactions are effectively precluded, the possibility of high D/F emissions cannot be ruled out. Incomplete combustion due to mixing inhomogeneities or cold pockets may generate D/F precursors, and D/Fs may be formed via gas-phase precursor formation mechanisms in regions of the combustion chamber where temperatures are below flame temperatures. These concerns lead to the recommendation for performing D/F testing at DRE test conditions (which usually represent challenging combustion conditions) for rapid wet quench systems whenever possible. Further information regarding the relationship between combustion conditions and D/F emissions is provided in Section 4.2.2.

4.2.1.2 Partial Wet Quench Temperatures

> ***Recommendation*** *-- EPA OSW recommends that facilities that partially quench flue gases to between 570 and 800 EF prior to a dry air pollution control device perform risk burn testing for D/Fs at a maximum post-partial quench flue gas temperature (i.e., at the highest temperature within the 570 to 800 EF range that the facility wishes to achieve during post-risk burn operation). For some facilities, this condition may occur in conjunction with the high temperature SRE test. Unless historical operating data are provided to indicate little variation in post-partial quench temperature, EPA OSW recommends against performing D/F testing at normal or average hold-up temperatures. A permit limit on maximum post-partial quench temperature based on the risk burn may be necessary to protect human health and the environment by assuring that the measured D/F emissions are maintained on an ongoing basis.*

Facilities with “dry” APCD components, such as fabric filters and ESPs, often utilize a wet quench for flue gas cooling prior to the APCD. However, unlike the rapid wet quench situation where flue gases are quenched to saturation, the flue gas upstream of a dry APCD is only partially quenched, and APCD inlet temperatures are maintained well above the dew point.

As explained in Section 4.2.1.1, facilities that rapidly quench flue gases to below saturation temperatures generally have low D/F emissions. However, this may not necessarily be the case for facilities that perform only a partial quench. Waterland and Ghorishi observed significant increases in D/F levels in the flue gas (more than 2 orders of magnitude) as post-partial-quench temperatures increased from 711 to 795 EF (Waterland and Ghorishi 1997). The observed residence time was approximately 0.5 seconds. This phenomenon, termed rapid high-temperature D/F formation, appears to be active in a post-partial-quench temperature range of 570 to 800 EF (Waterland and Ghorishi 1997).

Based on this information, it appears that post-quench temperatures from partial quench systems can be important. Therefore, risk burn testing for D/Fs should generally be performed during a maximum post-partial quench flue gas temperature condition. For some facilities, this condition may occur in conjunction with the maximum temperature SRE test. A permit limit on post-partial quench temperature based on the risk burn may be necessary to protect human health and the environment by assuring that measured D/F emissions are maintained on an ongoing basis.

Unless historical operating data are provided to indicate little variation in post-partial quench temperature, EPA OSW recommends against performing D/F testing at normal or average hold-up temperatures. The exponential relationship observed between the quench temperature and D/F emissions makes it difficult to ensure that “normal” D/F emissions will be maintained on a ongoing basis after the risk burn (i.e., the D/F emissions from one minute of operation at 100 EF above normal cannot be offset by one minute of operation at 100 EF below normal). It is important that D/F emissions not be underestimated for risk assessments. However, a facility is not precluded from showing, on a site-specific basis, why a less conservative approach may be warranted, or from following the procedures in Section 3.3.2.2 to show why D/F testing should be performed at “normal” quench temperatures. If testing at normal temperatures is proposed, the facility should be prepared to explain how a monitoring scheme can be developed to reliably ensure that D/Fs will be maintained at “normal” levels on an ongoing basis.

approximately 400 to 750 EF, D/F formation can increase exponentially with increases in APCD inlet temperature. Thus, dry APCD inlet temperature is a critical control parameter.

Heat exchangers also provide the conditions necessary for surface-catalyzed D/F formation. When flue gas cooling involves a heat exchanger (a waste heat boiler is a type of heat exchanger), the gas is cooled slowly through the catalytic D/F formation temperature region. In addition, particulates may be held up on the heat exchanger tubes. Outlet temperatures from waste heat boilers typically range from 400 to 600 EF (EPA 1999d). Santoleri, citing numerous studies in Germany and the United States, notes that facilities with heat recovery boilers have been found to have higher emissions of D/Fs than facilities without heat recovery (Santoleri 1995). The D/F emissions trend for waste heat recovery boilers is further supported by data collected in support of the hazardous waste combustor MACT rule which indicates that incinerators equipped with recovery boilers have significantly higher D/F emissions than other incinerators (EPA 1997d and 1999d). Acharya has hypothesized that D/Fs in a boiler may be minimized by only cooling combustion gases to about 800 EF (Acharya and others 1991). Although energy recovery might be reduced, the gas temperatures would be maintained outside of the 400 to 750 EF range. Based on this information, the outlet temperature of a heat exchanger is a critical control parameter.

Data collected in support of the hazardous waste combustor MACT rule also document elevated D/F emission rates at some lightweight aggregate kilns, where formation apparently occurred in extensive runs of un-insulated ductwork connecting the kilns to the fabric filters (EPA 1997d and 1999d). Convective cooling in un-insulated ductwork can result in slow gas cooling through the catalytic D/F formation temperature region, and the ductwork provides surface area for particulate hold-up. EPA noted that reductions of D/F emission rates could likely be achieved simply by rapidly quenching gases at the exit of the kiln to less than 400 EF and insulating the ductwork to maintain gas temperatures above the dew point prior to the fabric filter. This information indicates that the temperature at the inlet to extensive runs of un-insulated ductwork at lightweight aggregate kilns (where flue gas can cool through the 400 to 750 EF temperature range) is a critical control parameter.

In summary, the relatively low temperature (approximately 400 to 750 EF) "dry" areas of particulate hold-up downstream of the combustion zone should generally be emphasized for D/F testing. These areas are conducive to surface-catalyzed D/F formation via precursor condensation and *de novo* synthesis mechanisms. Available data indicate that particulate matter provides the substrate to act as a chemical reactor, given the appropriate temperature, time, and presence of Cl. Thus, any particulate hold-up area (including fabric filters, ESPs, HEPA filters, heat exchangers, and extensive runs of ductwork at aggregate kilns) operating in the critical temperature range can promote D/F formation.

Particulate hold-up temperatures should be considered very carefully in determining the appropriate test condition for D/F testing. In most instances, it is recommended that facilities perform risk burn testing for D/Fs at a maximum particulate hold-up temperature (i.e., at the highest temperature within the 400 to 750 EF range that the facility wishes to achieve during post-risk burn operation). For some facilities, this condition may occur in conjunction with the high temperature SRE test. The locations where temperatures should generally be maximized include: 1) the inlet to dry APCD equipment; 2) the outlet of a heat exchanger; and 3) the inlet to an extensive run of un-insulated ductwork at lightweight aggregate kilns where substantial convective cooling occurs. Permit limits on maximum temperatures at these locations based on the risk burn may be necessary to protect human health and the environment by ensuring that D/F emissions are maintained at or below the measured levels on an ongoing basis. (Note: If the device is maintained *above* the critical temperature range to prevent D/F formation, for example, above 800 EF, a minimum temperature limit may be appropriate instead.)

Unless historical operating data are provided to indicate little variation in the inlet (or outlet, as appropriate) temperature to a particulate hold-up device, EPA OSW recommends against performing D/F testing at normal or average hold-up temperatures. D/F formation has been observed to increase exponentially with increases in temperature over the range of approximately 400 to 750 EF (Harris and others 1994; Lanier and others 1996; Kilgroe 1996; EPA 1999e). This non-linear relationship makes it difficult to ensure that "normal" D/F emissions will be maintained on a ongoing basis after the risk burn (i.e., the D/F emissions from one minute of operation at 100 EF above normal cannot be offset by one minute of operation at 100 EF below normal). It is important that D/F emissions not be underestimated for risk assessments. However, a facility is not precluded from showing, on a site-specific basis, why a less conservative approach may be warranted, or from following the procedures in Section 3.3.2.2 to show why D/F testing should be performed at "normal" temperatures. If testing at normal temperatures is proposed, the facility should be prepared to explain how a monitoring scheme can be developed to reliably ensure that D/Fs will be maintained at "normal" levels on an ongoing basis.

A final consideration involves the use of a reheater in a flue gas cleaning train. One source utilizing a rapid wet quench and wet scrubbing system (EPA 1999d, Source ID No. 602) has reported somewhat higher D/F emissions than those observed from most rapid wet quench systems. This source uses a coil-tube reheater downstream of the wet scrubbing system to reheat flue gases to above saturation temperatures prior to HEPA filtration. The gases are reheated to approximately 250 EF. Although this flue gas temperature is outside of the 400-750 EF range, the reheater tubes provide surface area for particulate hold-up and are estimated to be about 500 EF (EPA 1999d). These tube surface temperatures may promote surface-catalyzed D/F formation. During a risk burn, specific temperature targets for a reheater should generally not be necessary (operation of a reheater is expected to be fairly constant). However, it is recommended that the permit writer ensure that emissions sampling for D/Fs occurs downstream (rather than upstream) of the reheater.

4.2.2 Combustion Conditions

Although D/Fs are primarily the [illegible]

be less critical for steady-state operations. In lieu of specific permit limits for the parameters listed in Section 4.2.2.2, periodic reporting to confirm continued absence of transients may be appropriate. When D/F testing cannot be performed in conjunction with the DRE test, caution should be exercised to ensure that targets during the D/F testing for the combustion parameters listed in Section 4.2.2.2 are not substantially different from the levels demonstrated during the DRE test.

Combustion conditions can play a key role in minimizing the formation of D/F precursors, and thus, in potentially minimizing D/F emissions. Maintenance of good combustion conditions to limit organic precursors and soot is repeatedly cited as a prerequisite necessary for achieving low D/Fs (Hasselriis 1987; Kilgroe and others 1990; Kilgroe 1996; Prescott 1996; Berger and others 1996; Gullett and Raghunathan 1997; EPA 1999e).

Substantial information exists to indicate that D/F emissions can be quite high when combustion parameters are not optimized. A majority of the work documenting the influence of combustion quality has been performed on municipal waste combustor systems. Gullett and Raghunathan observed substantial increases in D/F emissions under conditions of poor combustion and carbon monoxide levels greater than 2,000 parts per million (ppm) (Gullett and Raghunathan 1997). Buekens and Huang cite studies where poor combustion situations caused order-of-magnitude D/F increases over those observed during normal combustion (Buekens and Huang 1998). Berger describes a correlation between high D/F emissions and high total hydrocarbon emissions (Berger and others 1996). Prescott documents order-of-magnitude reductions in D/Fs through the use of good combustion control (Prescott 1996), and Hasselriis found that the optimum combustion conditions for minimizing dioxins and furans are closely related to those which minimize carbon monoxide emissions (Hasselriis1987).

Because order-of-magnitude increases in D/F emissions have been observed under certain combustion situations, it is important to ensure that potentially high-emitting operating modes are not overlooked when planning the risk burn. Therefore, the recommendations in this section focus on identifying and demonstrating challenging combustion situations for D/F testing. However, a facility is not precluded from showing, on a site-specific basis, why a less conservative approach may be warranted, or from following the procedures in Section 3.3.2.2 to show that D/F testing should be performed at normal conditions to better represent the risk over a facility's operating life.

Targeting specific combustion conditions for D/F testing can be extremely challenging, because the relationship between individual combustion parameters and D/F emissions is not necessarily intuitive or readily demonstrated. Buekens and Huang explain that D/F formation in combustion processes is influenced by a number of combustion parameters simultaneously, and is therefore regarded as a multi-variate process (Buekens and Huang 1998). Key parameters are likely to vary by facility, and the key parameters may or may not be those identified in this guidance. For example, oxygen concentration is not specifically addressed during many trial burns, and often varies considerably between test conditions if excess air is used to simultaneously achieve minimum combustion temperature and maximum combustion gas velocity. Although studies show that D/F emissions may be affected by oxygen levels, contradictory conclusions have been reached regarding the specific relationship (Buekens and Huang 1998). Buekens and Huang postulate that different combustors may exhibit different behaviors with varying oxygen, and that there may not be a universally applicable correlation. The uncertain relationship between oxygen and D/Fs is just one example of the difficulty in predicting how different operating scenarios may affect D/F emissions.

Because of the inherent uncertainties involved in correlating D/F emissions and individual combustion parameters, it is recommended that D/F emissions be determined during *all* planned test conditions (e.g., DRE and SRE conditions) whenever possible. By characterizing D/Fs over the entire range of combustion conditions, a facility can minimize the possibility of inadvertently omitting combustion situations that may play a key role in D/F formation. In addition, the data collected during multiple conditions can be analyzed for trends to determine which combustion parameters may need to be limited in the RCRA permit to control D/F emissions. EPA OSW recommends that the challenging combustion scenarios discussed later in Section 4.2.2.3 be represented during the testing (if applicable). The challenging combustion situations described in Section 4.2.2.3 include: 1) transient conditions; 2) operation with containerized or batch feeds; and 3) high carbon monoxide situations. The combustion parameters identified in Section 4.2.2.2 should automatically be addressed when D/F testing is performed during all planned test conditions, since these limitations on waste feed composition and batch feeds; and 5) maximum flue gas carbon monoxide and/or total hydrocarbon concentrations.

At the beginning of Section 4.2.2.1, several situations were identified where it may not be possible (or even

It is important to keep in mind that the most influential combustion parameters may not always be the ones listed above. EPA OSW recommends that a facility-specific review of test burn and historical operating data be performed to determine the potential significance of other operating or feed parameters, especially for the challenging combustion scenarios described in Section 4.2.2.3. If other potentially significant parameters are identified, then it is recommended that they be demonstrated during D/F testing and possibly limited in the permit in addition to, or possibly in lieu of, the parameters listed in this section as necessary to protect human health and the environment.

The importance of a facility-specific review to determine the significant parameters affecting combustion quality is illustrated by a situation documented by Branter (Branter and others 1999). In an initial test effort involving containerized waste feeds, the facility did not adequately control downstream D/F formation (i.e., the heat exchanger outlet temperature was not maintained as low as possible). For the two test conditions conducted at a high heat exchanger outlet temperature, the D/F yields were substantially greater at

Section 4.2.2.3 Challenging Combustion Scenarios

Section 4.2.2.1 recommends D/F sampling during *all* test conditions whenever possible (or during the DRE hydrocarbons. Routine spikes should generally be emphasized for the risk burn (i.e., spikes which may occur as often as several times per hour on an ongoing basis). Upsets are not encompassed by the term “transient,” and are generally not represented during the risk burn unless there is a specific agreement reached between the facility and permit writer.

Transient spikes indicate potential changes in combustion quality that may increase D/F emissions. Raghunathan documented an order-of-magnitude D/F increase during a test run where a few significant CO spikes occurred, even though the average CO concentration for the 3-hour test run was maintained well below 100 ppm (Raghunathan and others 1997a). Berger describes a correlation between high D/F emissions and total hydrocarbon spikes (Berger and others 1996).

If a combustion unit normally operates under transient conditions, then it is recommended that this form of operation be represented during D/F testing. The permit writer should review historical operating data to determine whether a facility experiences routine transients. rattsdxmallc 0.2338 Tw (detl OSWhis form os Tj   0 -1reas .23

- Highly chlorinated wastes;
- Low heating value solids and sludges;
- Wastes with a high moisture content; and
- Batch feeds with high moisture, volatility, or instantaneous oxygen demand.

necessary to assure that good combustion practice is maintained. Preventive controls may be needed if operating extremes for the batch feed system cannot be adequately represented during the risk burn, or if the facility has historically experienced frequent operational upsets or waste cutoffs due to batch feeds.

If preventive controls are needed, other permit limitations which might be considered include: 1) maximum batch size; 2) maximum batch charge heat content; 3) maximum batch feeding frequency; 4) minimum oxygen concentration at the location where the batch is fed; 5) maximum kiln temperature; 6) maximum kiln rotational speed; and 7) limitations on waste volatility, composition, or heat content.

Overcharging conditions can occur when containerized or batch wastes are fed to a combustion unit, especially if waste parameters and feeding practices are not closely matched to the unit design. When highly combustible or volatile wastes are exposed to the high temperatures in a combustion chamber, a surge of waste vapors rapidly evolves from the batch. This surge can deplete local oxygen, causing formation of fuel rich gas pockets that may escape the combustor without being adequately oxidized. This situation is often described as “puffing.” Stack emissions may be affected, depending on whether the organics are destroyed elsewhere (such as in an afterburner).

Transient puffs arising from batch feed operations are well documented based on measurements conducted scale facility (see the discussion in Section 4.2.2.2).

Because the soot and chlorinated organic precursors from transient puffs can affect D/F emissions, this guidance recommends that the risk burn be performed while operating under simulated “worst-case” batch feeding conditions (i.e., conditions that maximize precursor generation) to ensure that D/F emissions are not under-estimated for the risk assessment. Historical information on operating trends and AWFCO events should generally be reviewed in an effort to determine which batch characteristics are most likely to cause transients for a particular facility. Some batch-charged and containerized wastes can volatilize rapidly, causing an instantaneous release of heat and gases that completely consume the available oxygen. This rapid volatilization results in a momentary oxygen-deficient condition that can result in poor combustion. Conversely, if too large a batch of aqueous waste or wet soil is fed, there is danger that the batch can instantaneously quench temperature.

During the risk burn, EPA OSW recommends that actual wastes be spiked as necessary to maximize the volatility and oxygen demand of each batch charge. This maximization can be achieved by spiking with low boiling point/low latent heat of vaporization organics (preferably chlorinated), together with high heating value organics that have a high stoichiometric oxygen demand (Linak and others 1987; Wendt and others 1990; Cundy and others 1991). In rotary kilns, spiking compounds may be fed in bottles placed within the batch (instead of sorbed onto a solid matrix) to maximize the rate of volatilization.

The individual batch size and feeding frequency to be targeted for the risk burn should generally be based on the feeding practices at a particular facility. The “total waste feed rate” for the batch feed system (e.g., lb/hr) is a target combustion parameter (see Section 4.2.2.2) and should generally be maximized anyway. However, risk burn goals for individual batch size and feeding frequency may conflict (i.e., a facility may not be able to simultaneously feed their largest batch at their highest frequency). For the most part, the work of Lemieux suggests that larger batches fed less frequently will be worse than smaller batches fed more frequently at a given total feed rate (Lemieux and others 1991). In defining maximum batch size, the “maximum batch charge heat content” (maximum Btu/charge) is just as important as (and perhaps more important than) total mass.

The test plan for a batch-fed facility should generally include a description of the procedures used to maintain adequate oxygen while feeding batch or containerized wastes. During the risk burn, the air flow to the combustion unit should generally be adjusted to minimize excess oxygen at the location in the combustion chamber where the batch is fed. In addition, the testing should generally be performed at higher kiln temperatures and rotation speeds, since these parameters have been shown to exhibit a strong correlation with puff intensity. Demonstration of high kiln rotation speed may be less imperative if spiking compounds are added in bottles to the batch instead of sorbed to a solid matrix, since this spiking method should generally assure a high volatilization rate. Multiple test conditions may be necessary to demonstrate high kiln temperatures, as well as the minimum temperatures recommended in Section 4.2.2.2. For some incinerators, a worst-case test may involve maximum PCC temperatures demonstrated in conjunction with minimum SCC temperatures.

The effect of transient puffs on stack emissions may vary substantially from facility to facility. Variations may depend on: 1) unit design and operation (including size, presence of an afterburner or SCC, and fuel-maximum batch size may be limited by the physical constraints of the batch feed system). However, in some cases, it may be preferable to augment a pound-per-hour feed rate limit with additional restrictions on maximum batch size or maximum batch charge heat content.

Carbon monoxide/total hydrocarbon levels have routinely been used to characterize combustion perturbations associated with batch feeds (Linak and others 1987; Cundy and others 1991; Lemieux and others 1991). Establishing limits for these parameters in conjunction with a "worst-case" batch feed test may be sufficient for assuring that ongoing operations are protective at some facilities. However, carbon monoxide or total hydrocarbon monitoring alone may not be adequate for all batch feed operations. Because oxygen depletion can occur very rapidly due to batch overcharging, carbon monoxide/total hydrocarbon levels may exceed the permit limit before corrective action can be initiated. For some operations, additional preventive measures may be necessary to protect human health and the environment by assuring that good combustion practice is maintained.

Other permit limitations which might be considered if preventive measures are needed include: 1) maximum

4.2.2.3.3 High Carbon Monoxide

> ***Recommendation*** *-- EPA OSW recommends that units with carbon monoxide limits greater than 100 ppm perform D/F emissions testing while carbon monoxide levels are maximized.*

When D/F emissions data are evaluated by normalizing the data based on APCD inlet temperature and carbon monoxide, low carbon monoxide levels (less than 100 ppm) are found to be associated with very low D/F emissions (less than 1 ng/dscm on a total basis) (EPA 1994c; Harris and others 1994). For carbon monoxide levels greater than 100 ppm, temperature-normalized dioxin emissions are found to be significantly higher (in the range of 10 to 100 ng/dscm on a total basis). This observation suggests that units with carbon monoxide limits *greater than* 100 ppm should generally perform D/F testing under conditions that maximize carbon monoxide levels.

4.2.3 Feed Composition

In addition to the physical waste characteristics described in Sections 4.2.2.3.1 and 4.2.2.3.2 that may contribute to poor combustion, there are several chemical feed characteristics that have been evaluated with respect to their potential influence on D/F emissions. These characteristics include chlorine concentration, the presence of metals (such as copper, iron, and nickel) that can act as catalysts for D/F formation, the presence of D/F precursors (such as chlorobenzenes and chlorophenols), and the presence of D/F inhibitors (such as sulfur, calcium hydroxide, and ammonia). Each of these is discussed below.

4.2.3.1 Chlorine

> ***Recommendation*** *-- For D/F testing, EPA OSW recommends that chlorine feed rates be maintained at normal levels (i.e., chlorine should not be biased low). Permit limits on total chlorine feed rate generally should not need to be established based on the risk burn.*

While the presence of chlorine is a necessary prerequisite for D/F formation, there does not appear to be a direct correlation between the level of chlorine in the feed and the level of D/Fs in the flue gas at full-scale combustion facilities. The American Society of Mechanical Engineers (ASME) (Rigo and others 1995)

destruction. Luijk and others hypothesize that $CuCl_2$ levels in the ppm range (no greater than the levels normally observed in municipal waste combustion fly ash) may offer optimum conditions for the formation of D/Fs.

Based on this information, there does not appear to be a need to spike copper during the D/F testing, or to establish specific permit limits on copper (or other catalytic metals). However, EPA OSW recommends the use of wastes or other feed materials containing copper over feeds without copper, where the choice exists.

4.2.3.3 D/F Precursors

> ***Recommendation*** -- *If a facility burns wastes containing significant quantities of D/F precursors, EPA OSW recommends that these wastes be used for D/F testing, rather than wastes without precursors. Although specific D/F precursor feed rate limits in the permit are not anticipated to be necessary to protect human health and the environment, it may be appropriate to consider a permit condition requiring waste profile tracking to determine whether increased quantities of precursor wastes warrant retesting.*

The role of organic precursors with respect to D/F formation is discussed in Section 4.1. Some waste combustors that burn wastes containing D/F precursors, including chlorobenzenes, chlorophenols, and PCBs, have been shown to have high D/F emissions (for example, see the discussion regarding Source ID No. 330 in Section 4.2.1.1). EPA has compared a limited number of facilities that feed known D/F

4.2.3.4 D/F Inhibitors

> ***Recommendation** -- In reviewing the D/F test protocol, EPA OSW recommends that the permit writer verify that the facility will not burn a high sulfur waste or fuel in quantities that bias the S/Cl feed ratio above normal. At S/Cl molar feed ratios approaching 0.3 or greater, it may be appropriate for protection of human health and the environment after the risk burn to require waste and fossil fuel tracking to ensure that a minimum S/Cl ratio is maintained on an ongoing basis. If sulfur or other D/F inhibitors are intentionally added to the system to achieve D/F control, then EPA OSW suggests that the recommendations in Section 4.2.5 be followed.*

The role of SO_2 in suppressing D/F formation is discussed in Section 4.1. D/F inhibitors, such as sulfur, have been commercially marketed as feed stream additives to control D/F emissions. These same compounds may naturally be present in fossil fuels (such as coal) or hazardous waste fuels.

Numerous pilot-scale and full-scale tests on municipal solid waste combustors have proven that D/F emissions reductions can be achieved via coal co-firing to increase SO_2 or SO_2 injection (Raghunathan and Gullett 1996; Gullett and Raghunathan 1997; Raghunathan and others 1997a; Buekens and Huang 1998; Gullett and others 2000b). The suppression effect is well documented when sulfur is present at levels nearly stoichiometric to the chlorine in the feed (i.e., S/Cl molar feed ratio of approximately 1:1). Ullrich has also shown that sulfur levels well below stoichiometric ratios with chlorine can reduce dioxin formation measurably in a full-scale hazardous waste incinerator (Ullrich and others 1996). Significant decreases in D/F emission rates were observed at sulfur-to-chlorine molar ratios as low as 0.3 in the feed (Ullrich and others 1996).

In reviewing the D/F test protocol, EPA OSW recommends that the permit writer verify that the facility will not burn a high sulfur waste or fuel in quantities that bias the S/Cl feed ratio above normal. The particular S/Cl ratio that begins to cause a D/F suppression effect is likely to be system specific, and D/F suppression may be influenced by other, more significant facility-specific variables (Gullett and others, 2000b). However, the results from Ullrich suggest that S/Cl molar feed ratios above approximately 0.3, considering both waste and fossil fuel inputs, should generally be viewed with caution (Ullrich and others 1996). If S/Cl molar ratios approach 0.3 or greater during the risk burn, then waste and fossil fuel tracking conditions in the permit may be necessary to protect human health and the environment by ensuring that a minimum S/Cl ratio is maintained on an ongoing basis.

This discussion primarily applies to situations where naturally-occurring sulfur may be introduced to the combustor with fossil fuels, or when sulfur is normally present in the waste fuel. In some cases, sulfur or other D/F inhibitors are intentionally added to the combustion system to achieve D/F control. For these situations, EPA OSW suggests that the recommendations in Section 4.2.5 be followed.

4.2.3.5 Dioxin-Containing Wastes

> ***Recommendation** -- If a facility burns dioxin-containing wastes (such as F020, F021, F022, F023, F026, F027, F032, F039 or K099), EPA OSW recommends that those wastes be represented during D/F testing. Specific permit limits on D/F contributions from these wastes may be necessary to protect human health and the environment by ensuring that dioxin/furans are not being burned in higher amounts than those represented during the risk burn and found to be protective.*

For many combustion units, D/F emissions are primarily influenced by formation within the combustion system. However, a few hazardous waste combustors burn dioxin-containing wastes (such as F020, F021, F022, F023, F026, F027, F032, F039 or K099), and D/F emissions from those units may be significantly affected by survival of trace D/Fs introduced with the waste feed (even at an adequate level of DRE). When a facility burns these dioxin-containing wastes, the potential waste feed D/F contribution to total D/F emissions should generally be accounted for in the risk burn and risk assessment.

Ideally, the waste feed D/F contribution to total D/F emissions can be accounted for by feeding dioxin-containing wastes during the risk burn to achieve a maximum D/F input. After the risk burn, specific permit limits on waste feed D/F contributions from F020, F021, F022, F023, F026, F027, F032, F039 or K099 wastes may be necessary to protect human health and the environment by ensuring that D/Fs are not subsequently burned in higher amounts than those represented during the risk burn and found to be protective.

If dioxin-containing wastes are not available for the risk burn, then the D/F emissions measured during the

affected by sulfur dioxide can act to suppress ongoing D/F emissions, whereas deposits that serve as a sink removed in the stack gas by a factor of 50.

4.2.6 Control Parameter Summary

Although Section 4.2 presents each control parameter individually, EPA OSW recommends that the relative importance of the parameters with respect to one another also be considered. When one or two control parameters are clearly dominant for a particular system, there may be little benefit to limiting additional parameters in the permit.

Based on a review of existing information, this guidance prioritizes control parameters and conditions associated with D/F formation as primary, secondary, or tertiary. These hierarchical designations should not be considered absolute, but are intended to emphasize the relative importance of demonstrating various control parameters during D/F testing and limiting those parameters in the final RCRA permit. A summary of primary, secondary, and tertiary control parameters follows.

1. <u>Primary control parameters</u> are those which have shown the highest correlation with D/F emissions in full-scale tests, and which are therefore expected to dominate D/F formation and removal. EPA OSW recommends that these parameters be demonstrated during the D/F testing, and that permit writers consider whether specific quantitative limits on these parameters are necessary to protect human health and the environment. The primary control parameters are focused on surface-catalyzed D/F formation downstream of the combustion chamber, survival of trace D/Fs from waste feeds, and the use of specific D/F control technologies. Primary control parameters include:

    - Partial wet quench temperatures;
    - Dry particulate hold-up temperatures;
    - Combustion parameters listed in Section 4.2.2.2, for systems that operate under the challenging combustion scenarios discussed in Section 4.2.2.3;
    - Sulfur-to-chlorine molar feed ratio, unless the S/Cl ratio is well below 0.3;
    - D/F contributions from dioxin-containing wastes;
    - Key control parameters for specific D/F control technologies, including the intentional addition of sulfur as a D/F inhibitor.

2. <u>Secondary control parameters</u> are those that may influence D/F emissions under certain circumstances. However, there is less information indicating a direct correlation between these parameters and D/F emission rates. These parameters may or may not be appropriate to demonstrate during the D/F test, and corresponding permit terms may or may not be necessary to protect human health and the environment, depending on the significance of these parameters for a given system configuration and the presence or absence of dominant primary parameters. Secondary control

parameters include:

- Combustion parameters listed in Section 4.2.2.2, for steady-state systems that routinely maintain good combustion and are equipped with rapid wet quench/wet APCDs;
- Conditions other than combustion quality that may produce organic precursors (such as organics from raw materials in cement kilns and lightweight aggregate kilns, as discussed later in Section 4.5).

3. <u>Tertiary control parameters</u> pertain to feed composition. These control parameters have been the subject of fundamental and pilot-scale research on D/F formation, but have not routinely been correlated with D/F emissions during full-scale testing. These parameters may influence the selection of feeds for D/F testing and subsequent waste profile tracking, but it is generally not expected that specific feed rate limits in the permit will be necessary to protect human health and the environment. Tertiary control parameters include:

    - Chlorine feed rates;
    - Presence of D/F catalysts (such as copper);
    - Presence of D/F precursors (such as chlorinated aromatics);
    - Presence of naturally-occurring D/F inhibitors (such as sulfur), provided that the S/Cl molar feed ratio is well below 0.3.

4.3 D/F EMISSIONS FROM INCINERATORS

Hazardous waste incinerator designs include rotary kiln, liquid injection, fluidized bed, and fixed hearth. Incinerator designs are described in detail in a technical support document to the hazardous waste combustor MACT rule (EPA 1999f). Commercial incineration facilities typically accept hazardous wastes from a variety of generators, and the wastes fed to commercial units can be highly variable. Wastes may range from low- and high-Btu liquids, to laboratory packs, to soils contaminated with low levels of RCRA hazardous wastes. Large chemical facilities sometimes operate “captive” incinerators that treat on-site wastes, as well as wastes generated off-site by corporate affiliates. Wastes fed to a captive unit may also be highly variable, especially if the facility burns a number of wastes from different production operations without the capability to blend the wastes to a consistent specification. Some facilities operate small on-site incinerators that treat only one or two waste streams. The wastes fed to small on-site incinerators can sometimes be more predictable and/or homogeneous than those fed to commercial or captive units.

Air pollution control for hazardous waste incinerators typically involves an exhaust gas cooling step, followed by particulate matter and acid gas control. A few incinerators treat low-ash, low-halogen wastes and do not utilize any air pollution control. Exhaust gas cooling can be performed using a waste heat boiler or heat exchanger, mixing with ambient air, or injection of water into the exhaust gas. As discussed in Section 4.2.1 of this document, the procedures used for exhaust gas cooling can have a significant affect on D/F emissions.

Particulate matter and acid gas control systems for hazardous waste incinerators can generally be grouped into three categories: 1) “wet” systems; 2) “dry” systems; and 3) “hybrid wet/dry” systems (EPA 1999f). In wet systems, wet scrubbers are used for both particulate and acid gas control. These scrubbers may include venturi scrubbers, packed bed scrubbers, ionizing wet scrubbers, wet ESPs, innovative high efficiency scrubbers, or some combination of these. In dry systems, a fabric filter or ESP is used for particulate matter control. Dry scrubbing may also be utilized upstream of the dry APCD to achieve acid gas control. In hybrid systems, a dry technique (i.e., ESP or fabric filter) is used to control particulate matter (possibly in combination with dry scrubbing for acid gas control), followed by wet scrubbing for acid gas control. Some new technologies are being developed, and several facilities are injecting activated carbon for control of D/Fs, non-D/F organics, and mercury.

D/F emissions data are available from a variety of hazardous waste incinerators. Units equipped with rapid wet quench and wet APCD systems are among the lowest-emitting sources and generally have D/F emissions below 0.4 ng TEQ/dscm. D/F emissions from units equipped with dry air pollution control components range from 0.15 to 20 ng TEQ/dscm. Systems equipped with waste heat boilers or other types of heat exchangers have D/F emissions ranging from about 1 to 40 ng TEQ/dscm (EPA 1999d).

The level of D/F emissions from incinerators may be dependent on incinerator design, APCD type, particulate hold-up temperatures, type of quench or presence of a heat recovery unit, combustion conditions, and feed composition. In summary, all of the considerations discussed previously in Section 4.2 apply to hazardous waste incinerators. The most predominant factors influencing D/F emissions from incinerators seem to be the presence of a heat recovery unit and the temperature profile of dry APCD systems.

Table 4-1 summarizes potential control parameters associated with D/F emissions from incinerators. If dry APCD equipment or heat recovery devices are present in the downstream control system, the temperature profile across these devices is recognized as a primary control parameter directly related to D/F formation (see Section 4.2.1). Demonstration of maximum post-combustion temperature is likely to coincide with SRE testing (unless the facility can adjust inlet temperature to obtain the requisite temperature profiles during DRE testing). Combustion efficiency is also a primary control parameter for D/F formation, especially for transient operations, units burning containerized wastes, or high carbon monoxide situations as discussed in Section 4.2.2. Demonstration of control parameters affecting combustion efficiency will most likely coincide with the DRE test conditions.

Facilities with more predictable, homogeneous waste feeds, few operating fluctuations, and no particulate hold-up devices may prefer to collect D/F emissions data during a risk burn conducted under normal operating conditions, as appropriate (see Section 3.3.2.2). Waste feed selection should generally be based on representative waste streams, with a preference for D/F precursors such as chlorophenols and minimal amounts of D/F inhibitors (such as sulfur).

TABLE 4-1

POTENTIAL CONTROL PARAMETERS ASSOCIATED WITH D/F EMISSIONS FROM INCINERATORS AND BOILERS

	Control Parameter	Most Likely Achieved During	Parameter Type/Example Averaging Period*	How Limit May Be Established*	Other Considerations
PRIMARY CONTROL PARAMETERS					
Post-Combustion Conditions: See Section 4.2.1	Maximum post-partial wet quench temperature (within the range of 570-800 EF)	SRE test, unless a variable quench is used	Group A: 1 hour rolling average	Average of the test run averages	See Section 4.2.1.2
	Maximum dry ESP inlet temperature (within the range of 400-750 EF)	SRE test, unless a variable quench is used	Group A: 1 hour rolling average	Average of the test run averages	See Section 4.2.1.3
	Maximum fabric filter inlet temperature (within the range of 400-750 EF)				
	Maximum HEPA filter inlet temperature (within the range of 400-750 EF)				
	Maximum heat exchanger exit temperature (within the range of 400-750 EF)	Any test that achieves the critical temperature window	Group A: 1 hour rolling average	Average of the test run averages	See Section 4.2.1.3 Establish a *minimum* limit if the device is operated *above* the critical temperature range to prevent formation

TABLE 4-1 (continued)

POTENTIAL CONTROL PARAMETERS ASSOCIATED WITH D/F EMISSIONS FROM INCINERATORS AND BOILERS

	Control Parameter	Most Likely Achieved During	Parameter Type/Example Averaging Period*	How Limit May Be Established*	Other Considerations
PRIMARY CONTROL PARAMETERS (Continued)					
Combustion Conditions: (*It is recommended that these parameters also be limited to control non-D/F organics, see Section 5.3*) See Sections 4.2.2 and 4.2.6 Combustion parameters are most critical for challenging combustion scenarios including: - transient operations - batch operations - high carbon monoxide operations Combustion parameters may be less critical for steady-state systems. Although demonstration of these control parameters during DRE conditions is preferred whenever possible, D/F testing at normal combustion conditions may be considered for some steady-state units.	Minimum combustion temperature, each chamber	DRE	<u>Group A</u>: 1 hour rolling average Record keeping and periodic reporting to confirm continued absence of transients may be appropriate in lieu of hourly average limits for some steady-state systems.	Average of the test run averages	See Section 4.2.2.2
	Maximum combustion gas velocity	DRE/SRE			
	Maximum waste feed rate, each location	DRE			Consider limits for: - maximum organic liquids to PCC - maximum aqueous liquids to PCC - maximum slud14nNto :CC maximum slolds to PCC - maximum organic liquids to PSC - maximum aqueous liquids to PSC

TABLE 4-1 (continued)

POTENTIAL CONTROL PARAMETERS ASSOCIATED WITH D/F EMISSIONS FROM INCINERATORS AND BOILERS

	Control Parameter	Most Likely Achieved During	Parameter Type/Example Averaging Period*	How Limit May Be Established*	Other Considerations
PRIMARY CONTROL PARAMETERS (Continued)					
Combustion Conditions: (Continued):	Waste variability that could cause transients	DRE	This is not a continuously monitored parameter, but pertains to selection of wastes for testing. Conditions for waste profile tracking may be specified by the permit writer.		See Section 4.2.2.3.1 Wastes with physical properties that can cause combustion transients should be selected.
	Batch feed conditions: - see "Maximum waste feed rate, each location" - see "Maximum carbon monoxide and/or total hydrocarbons"	DRE			See Section 4.2.2.3.2 Test wastes with high volatility and oxygen demand. Other parameters that may be necessary to limit are listed in Section 4.2.2.3.2
	Maximum carbon monoxide and/or total hydrocarbons	DRE	Group A: 1 hour rolling average	Establish per applicable regulations	See Section 4.2.2.3.3
Feed Composition: See Section 4.2.3	Minimum sulfur-to-chlorine feed ratio (unless the S/Cl molar feed ratio during the test is well below 0.3)	Any test condition where a S/Cl feed ratio ≥ 0.3 is used	Group B: Feed stream analyses may be specified to monitor sulfur-to-chlorine feed ratios	Average of the test run averages	See Section 4.2.3.4
	D/F contributions from dioxin-containing wastes	Any test with dioxin-containing wastes	Group B: Feed stream analyses may be specified to monitor dioxin input	Average of the test run averages	See Section 4.2.3.5

TABLE 4-1 (continued)

POTENTIAL CONTROL PARAMETERS ASSOCIATED WITH D/F EMISSIONS FROM INCINERATORS AND BOILERS

	Control Parameter	Most Likely Achieved During	Parameter Type/Example Averaging Period*	How Limit May Be Established*	Other Considerations
PRIMARY CONTROL PARAMETERS (Continued)					
D/F Control Technologies: See Section 4.2.5	D/F-specific control technologies include carbon injection, carbon bed, catalytic oxidizers and D/F inhibitor technologies. If one of these control technologies is used to limit D/F emissions, permit limits on key control parameters as described in a technical support document to the hazardous waste combustor MACT rule (EPA 1999e) may be appropriate.				
TERTIARY CONTROL PARAMETERS					
Feed Composition: See Section 4.2.3	Total Chlorine D/F Catalysts D/F Precursors D/F Inhibitors				

4.4 D/F EMISSIONS FROM BOILERS

Boilers recover thermal energy from combustion of hazardous waste and export the energy in the form of steam, heated fluids, or heated gases. General boiler designs are discussed in *Combustion Emissions Technical Resource Document* (EPA 1994c), and requirements for boilers burning hazardous waste are defined in 40 CFR Part 266.100 et seq. The following characteristics of a boiler are prescribed by 40 CFR Part 260 for RCRA regulatory purposes: 1) the combustion chamber and primary energy recovery section must be of integral design; 2) thermal recovery efficiency must be at least 60%; and 3) at least 75% of the recovered energy must be exported (i.e., not for internal boiler use). Hazardous waste is most commonly burned in firetube boilers, although watertube boilers are used in some cases. Most boilers treating hazardous waste are on-site units at chemical production facilities. Many oil- and gas-fired boilers burn low-ash, low-halogen wastes and are not equipped with any air pollution control. Some boilers utilize wet scrubbing or fabric filtration, and a few units (primarily coal-fired devices) are equipped with ESPs.

The database of D/F emissions from hazardous waste burning boilers is not as extensive as for incinerators and cement kilns (EPA 1994c). EPA provides data on two boilers equipped with ESPs indicating average D/F emissions less than 0.03 ng TEQ/dscm (EPA1994c). Handrich summarizes data from testing at 21 boilers in Louisiana (Handrich 1999). D/F emissions range from less than 0.008 ng TEQ/dscm to as high as 0.88 ng TEQ/dscm for a unit equipped with a fabric filter. Finally, Gullett and others (in press) provide data from a firetube boiler where the boiler was intentionally operated under poor combustion conditions to assess the maximum potential for D/F formation. After a period of flame wall impingement and soot formation on the boiler tubes, combustion conditions were improved and D/F emissions increased to as high as 49 ng TEQ/dscm.

D/F emissions from boilers are expected to be dependent on boiler design, APCD type, particulate hold-up temperatures, combustion conditions, and feed composition. Table 4-1 summarizes control parameters associated with D/F and other organic emissions from boilers. Depending on the system configuration, demonstration of control parameters associated with D/F formation in boilers may coincide with both the DRE and SRE test conditions.

As explained in Section 4.2.1.3, boiler tubes may serve as particulate hold-up areas and lead to D/F emissions. Because boilers typically have no rapid quench, the flue gas time and temperature window may be suitable for D/F formation. This premise is supported by data for incineration systems equipped with waste heat boilers or other types of heat exchangers, where D/F emissions ranging from about 1 to 40 ng TEQ/dscm have been measured (EPA 1999d). Heat exchanger exit temperature (measured at the exit of the last heat exchanger section) is considered a primary control parameter for D/F formation and control. Collection of D/F emissions data for boilers is recommended during conditions that achieve heat exchanger exit temperatures in the upper end of (but well within) the 400 to 750 EF range. For example, for a facility with heat exchanger exit temperatures ranging from 350 to 550 EF, D/F testing at the exit temperature of 550 EF would be preferred over testing at the exit temperature of 350 EF. Heat exchanger exit temperatures may fall in the upper end of the D/F formation window during either DRE or SRE conditions, depending on the facility-specific operating envelope. (Note: If the heat exchanger outlet temperature is maintained *above* the critical temperature range to prevent D/F formation, for example, above 800 EF, a *minimum* temperature limit may be appropriate instead. However, this situation is not expected to be likely, since the thermal recovery efficiency for the boiler would be compromised.) For boilers equipped with a dry APCD, the inlet temperature to the dry APCD is also considered a primary control parameter.

Demonstration of parameters related to combustion quality (see Section 4.2.2) can also be a consideration, especially for boilers that burn wastes resulting in combustion transients. Some boilers at chemical facilities burn different production run wastes in campaigns. These conditions should generally be evaluated by the permit writer prior to trial burn to determine the potential for transients. Demonstration of control parameters affecting combustion efficiency will most likely coincide with the DRE test condition.

Demonstrating key control parameters related to combustion quality may be problematic for some boilers based on potential test condition conflicts (Schofield and others 1997). For example, depending on the capacity of the forced draft fan, a facility burning a single high-Btu waste stream may be unable to add

control parameters aelated to combustion

as a fuel supplement in the production of Portland cement. Liquid wastes are typically injected into the hot end of the kiln. Solid wastes may be introduced into the calcining zone at some facilities. For long kilns, this means that the solid waste is introduced mid-kiln, and for preheater/precalciner kilns it is introduced onto the feed shelf. Containerized solid wastes may also be projected into the calcining zone by an air cannon mounted to the kiln hood. According to a technical support document to the hazardous waste combustor MACT rule (EPA 1999f), all cement kilns are equipped with either ESPs or fabric filters for particulate matter control. In some cases, the flue gases are cooled prior to the dry APCD. Add-on acid gas pollution control devices are not used at cement kilns, since the raw materials are highly alkaline and provide some degree of acid gas control.

D/F emissions data are available for most hazardous waste burning cement kilns. Test condition averages are highly variable, ranging from 0.004 to nearly 50 ng TEQ/dscm (EPA 1999d). The level of D/F emissions from a cement kiln may potentially be affected by a number of factors. However, the inlet temperature to the particulate matter control device is one factor that has been shown to consistently affect D/F formation (EPA 1999d).

Table 4-2 summarizes potential control parameters associated with D/F and other organic emissions from cement kilns. Data presented in numerous documents (Harris and others 1994; Lanier and others 1996; EPA 1999d and 1999e) demonstrate that D/F emissions from cement kilns increase exponentially with increases in inlet temperatures to the dry APCD within the D/F formation window (400 to 750 EF). A number of kilns have recently added flue gas quenching units upstream of the APCD to reduce inlet APCD temperature, and these additions have significantly reduced D/F emissions (EPA 1999d). This information suggests that maximum inlet temperature to the dry APCD system, as discussed previously in Section 4.2.1.3, is the primary control parameter related to D/F emissions for cement kilns. Collection of D/F emissions data should generally occur during a test condition that achieves maximum APCD inlet temperatures (for example, the SRE test condition, which is performed at a maximum APCD inlet temperature).

Parameters related to combustion quality (as described in Section 4.2.2) are generally less relevant for cement kilns than for incinerators and boilers. The operating envelope of cement kilns is dictated largely by the American Society for Testing and Materials specifications for their final product. Cement kilns operate

TABLE 4-2

POTENTIAL CONTROL PARAMETERS ASSOCIATED WITH D/F EMISSIONS FROM CEMENT KILNS AND AGGREGATE KILNS

	Control Parameter	**Most Likely Achieved During**	**Parameter Type/Example Averaging Period***	**How Limit May Be Established***	**Other Considerations**
PRIMARY CONTROL PARAMETERS					
Post-Combustion Conditions: See Sections 4.2.1, 4.5 and 4.6	Maximum dry ESP inlet temperature (within the range of 400-750 EF)	SRE	Group A:		
			E168 2.4.56 0 TD /F3 9.12 Tf2 Tc (F)) Tj 34.08 21.12 TD -0.055 7TcAl27 4.60 -18.2F 4 Tc 0		

TABLE 4-2

POTENTIAL CONTROL PARAMETERS ASSOCIATED WITH D/F EMISSIONS FROM CEMENT KILNS AND AGGREGATE KILNS (Continued)

	Control Parameter	Most Likely Achieved During	Parameter Type/Example Averaging Period*	How Limit May Be Established*	Other Considerations
PRIMARY CONTROL PARAMETERS (Continued)					
Feed Composition: See Sections 4.2.3, 4.5 and 4.6	Minimum sulfur-to-chlorine ratio at the stack (unless the S/Cl molar ratio during the test is well below 0.3)	Any test condition where a S/Cl ratio $\geq$ 0.3 is used	Group B: Feed stream analyses may be specified to monitor sulfur input	Average of the test run averages	See Sections 4.2.3.4, 4.5 and 4.6
	D/F contributions from dioxin-containing wastes	Any test with dioxin-containing wastes	Group B: Feed stream analyses may be specified to monitor dioxin input	Average of the test run averages	See Section 4.2.3.5
D/F Control Technologies: See Section 4.2.5	D/F-specific control technologies include carbon injection, carbon bed, catalytic oxidizers and D/F inhibitor technologies. If one of these control technologies is used to limit D/F emissions, permit limits on key control parameters as described in a technical support document to the hazardous waste combustor MACT rule (EPA 1999e) may be appropriate .				
SECONDARY CONTROL PARAMETERS					
Control of Precursors from Raw Material Organics: *(It is recommended that these parameters also be limited to control non-D/F organics, see Section 5.4)* See Sections 4.5 and 4.6	Maximum total hydrocarbons, as measured at both the main and bypass stacks, not to exceed regulatory limits	SRE	Group A: 1 hour rolling average	Establish per applicable regulations. Limits in addition to those specifically prescribed by regulation may be considered based on the results of the risk assessment.	Temporary total hydrocarbon monitors may be needed if the facility does not normally measure total hydrocarbons in both stacks.

TABLE 4-2

POTENTIAL CONTROL PARAMETERS ASSOCIATED WITH D/F EMISSIONS FROM CEMENT KILNS AND AGGREGATE KILNS (Continued)

	Control Parameter	Most Likely Achieved During	Parameter Type/Example Averaging Period*	How Limit May Be Established*	Other Considerations
TERTIARY CONTROL PARAMETERS					
Feed Composition: See Sections 4.2.3, 4.5 and 4.6	Total Chlorine D/F Inhibitors	These are not continuously monitored parameters, but pertain to selection of wastes and fuels for testing. Conditions for waste profile tracking may be specified by the permit writer.			Considerations are discussed in Sections 4.2.3, 4.5 and 4.6

Notes:

D/F = dioxins and furans

EPA = U.S. Environmental Protection Agency

ESP = electrostatic precipitator

SRE = system removal efficiency

* = See Section 1.3.1 for a description of the Group A, B and C designations. Hourly rolling averaging periods are specified as examples, but other averaging periods and techniques may be considered. By establishing operating limits from the test as “the average of the test run averages,” the permit writer can better ensure consistency between the manual emissions measurements and the permit. It is less desirable to establish an operating limit as “the average of the minimum (or maximum) hourly rolling averages from the three test runs,” because the minimum or maximum operating extremes may only be demonstrated during a minor portion of the total stack sampling period.

at high temperatures (approaching 3,500 °F) to achieve material temperatures of at least 2,700 EF, with typical gas residence times from 4 seconds to as high as 16 seconds. These conditions are conducive to highly efficient organic destruction. Although some cement kilns operate at elevated carbon monoxide levels, these levels are not necessarily indicative of poor combustion. A portion of the carbon monoxide in cement kilns is due to the calcination process. The calcination process releases large quantities of carbon dioxide, which can subsequently decompose into carbon monoxide at the extremely high temperatures in the kiln. In addition, carbon monoxide may be formed at the kiln exit where total hydrocarbons are volatilized from the raw materials and are partially oxidized.

Results from both kinetic modeling and field studies suggest that organics are efficiently destroyed when fed at the hot end of cement kilns (Dellinger and others 1993). DRE results seem to confirm this. DRE failures at cement kilns are extremely limited, and can generally be explained by high blank or baseline (non-hazardous waste) levels of POHCs. In one instance, DRE failure has been attributed to poor atomizer design (Dellinger and others 1993). However, facility-specific DRE testing should generally be sufficient to reveal design problems. For these reasons, Table 4-2 does not recommend control parameters related to combustion of liquid hazardous wastes introduced to the hot end of cement kilns.

Table 4-2 does recommend limiting combustion control parameters when kilns feed batch waste at mid- or feeat the kiln eg comocss rese rBat mid- ord tojectot end 0 -19. iln eg comocss resmed and cy harefrom 4of sn k68 TD -0.1

In cement kilns, main stack emissions of total hydrocarbons are dominated by organics that are volatilized from the raw materials prior to entering the high temperature regions of the kiln (Schreiber and Strubberg 1994). The chlorination of these hydrocarbons is a potential source of D/F precursors, such as monochlorobenzene (Dellinger and others 1993). Bench-scale, as well as full-scale, tests by the industry have confirmed that hydrocarbons from raw materials play a significant role in governing the production of D/Fs (Sidhu and Dellinger 1997; Schreiber undated). In addition, D/Fs may actually be present in the raw materials and may volatilize once the raw materials reach sufficient temperatures, although the significance of these contributions to total D/F stack emissions is still under debate (EPA 1999d). Considering this information, EPA OSW recommends that D/F testing be performed at the upper end of the operating range for total hydrocarbons, as measured in both the main and bypass stacks, not to exceed applicable regulatory limits.

Although the operating conditions necessary for achieving high total hydrocarbon emissions may vary by facility, maximum total hydrocarbon levels are likely to be achieved by some combination of high production rate, high gas temperatures at the raw material feed end of the kiln, and low oxygen at the raw material feed end of the kiln. Dellinger observed an inverse relationship between total hydrocarbons and stack oxygen concentrations (Dellinger and others 1993), and Schreiber and Strubberg observed that raw-material-generated hydrocarbons decrease as kiln oxygen increases (Schreiber and Strubberg 1994). The organic content of the raw material can also significantly influence hydrocarbon levels. However, raw material characteristics are largely dictated by quarry location, and are not easily controlled for the purpose of testing. If total hydrocarbon levels increase substantially after the risk burn because of changes in raw materials, then re-testing may be necessary.

In the context of D/F and other organic testing, total hydrocarbon levels are recommended for use as a control parameter indicating levels of organics within raw materials that may be chlorinated from the hazardous waste fuel. In this case, total hydrocarbons are not being used strictly as an indicator of waste fuel combustion efficiency. EPA OSW recommends that site-specific risk assessments quantify risks from hazardous waste combustor emissions, regardless of source. Therefore, it may be appropriate for cement kilns that only monitor carbon monoxide, or that only monitor carbon monoxide or total hydrocarbons in a bypass stack, to install temporary total hydrocarbon monitors in the main and bypass stacks prior to and

suppliers. Section 4.2.3.4 suggests that, if S/Cl molar feed ratios approach 0.3 or greater, waste and fossil fuel tracking conditions in the permit may be necessary after the risk burn to protect human health and the environment by ensuring that a minimum S/Cl ratio is maintained on an ongoing basis. In cement kilns, where the alkali raw materials provide some control of acid gases, the S/Cl molar ratio in the stack may be more relevant than the ratio in the feed. Other potential D/F inhibitors, such as calcium, may already be present in the raw materials.

In some cases, sulfur or other D/F inhibitors are intentionally added to a cement kiln to achieve D/F control. Schreiber has documented D/F emissions reductions after sulfur was added to the raw materials to increase the stack concentrations of SO_x from less than 20 ppm to above 300 ppm (Schreiber and others 1995). Schreiber also documented D/F emissions reductions when Na_2CO_3 was injected at the fuel feed

D/F emissions data are available for only a few hazardous waste burning lightweight aggregate kilns. Test temporary total hydrocarbon monitors for the testing.

Feed composition is discussed in Section 4.2.3. Recommendations regarding feed characteristics that can potentially influence D/F emissions are similar to those discussed in Section 4.5 for cement kilns.

Kearney 1997; Lemieux and others 1999). These research efforts indicate frequent detection of volatile and semivolatile organics including chloro-, bromo-, and mixed bromochloro-alkanes, alkenes, alkynes, aromatics, and polyaromatics, D/Fs, PAHs, PCBs, phthalates, nitrogenated and sulfonated organics, and short-chain alkanes (such as methane and propane). EPA reports frequent detection of chlorinated and brominated alkanes and alkenes (such as chlorinated ethenes), and suggests that chlorinated ethenes can

5.1.1 Target Analyte Lists

The first recommended objective of organics testing is to identify and quantify specific toxic organic compounds to assess their contribution to the total potential risk posed by the facility. Recommended target analyte lists for organics are provided in Appendix B of this document. Standard EPA methods (EPA 1996b) can be used to identify and quantify many organics that are potentially toxic, persistent, and bioaccumulative. For volatile and semivolatile organic compounds, SW-846 Methods 8260 and 8270 gas chromatography/mass spectrometry (GC/MS) procedures are preferred (EPA 1996b). The EPA methods, as written, are intended as guidance and are recommended as starting points for the development of standard operating procedures that will actually be used. Guidance on appropriate method modifications is provided in SW-846 (refer to Chapter 2 of SW-846 [EPA 1996b] and the applicable methods.) However, the facility should be able to demonstrate and document that the modified methods meet the DQOs for the particular application. Other methods not found in SW-846 may also be used if the user can demonstrate and document that the methods will generate data that meet the appropriate DQOs.

Stack determinations for PCBs are also recommended, based on evidence that PCBs can be emitted from combustion sources regardless of PCB contamination in the feed . An increasing body of information supports the likelihood that PCBs may be emitted as by-products of the combustion process. It is possible that PCBs are formed by the same reactions that produce D/Fs, discussed previously in Section 4.1. Lemieux hypothesized that, if PCBs and D/Fs are formed by similar mechanisms, then emissions of PCBs should correlate with emissions of D/Fs (Lemieux and others 1999). This hypothesis was tested by reviewing data where both PCBs and D/Fs were measured. An apparent trend was indeed found showing increased PCB emissions with increased D/F emissions. In most cases, PCBs were found in the stack even when there were no PCBs in the feed. Overall, PCB emissions exceeded D/F emissions by approximately a factor of 20, and this trend appeared to hold over five orders of magnitude in D/F emissions.

Alcock (Alcock and others 1999) and EPA (EPA 1997b) have established that waste combustion units contribute significantly to total emission inventories of PCBs. In addition, PCBs can be important from a risk standpoint. In the United Kingdom, where a TEQ is used to assess the potential toxicity of complex mixtures of D/Fs *and* PCBs, the PCBs contributed up to 60% of the TEQ for a cement kiln facility. For other sources, the PCB contribution was more minimal.

The current toxicity approach for PCBs (EPA 1996c; Van den Berg and others 1998) calls for data on:

- Total PCB concentration; and
- Congener-specific analysis for the 12 toxic dioxin-like coplanar and mono-ortho-substituted PCBs listed in Table B.5-1.

The 12 dioxin-like PCBs are important because the rings can rotate into the same plane, similar to that of a D/F molecule. Studies have shown that these dioxin-like congeners can react with the aryl hydrocarbon receptor. This is the same reaction that is believed to initiate the adverse effects of D/Fs. The World Health Organization has derived interim toxicity equivalency factors (TEFs) for these coplanar PCBs (Van den Berg and others 1998). The TEFs are applied to congener-specific concentrations to evaluate dioxin-like toxicity. Risks from the dioxin-like congeners (evaluated using the slope factor for dioxins) are then added to risks from the rest of the mixture (evaluated using the slope factor for PCBs applied to total PCBs reduced by the amount of dioxin-like congeners). With proper planning, the PCB determination can be

5.1.2 Tentatively Identified Compounds

One simple way to quantify non-toxic volatile hydrocarbons without expanding the sampling effort is to utilize information already available as part of the Total Organic Emissions determination (discussed in available.

EPA OSW has recommended that the final result from the Total Organic Emissions determination be used to compute a total organic emissions (TOE) factor, defined as total organic emissions divided by the sum of the identified organics (EPA 1998a). The TOE factor is typically presented in the uncertainty section of the risk assessment report to clearly qualify how much of the stack emissions have been evaluated for risk. Permitting authorities can evaluate the TOE factor and assess to what extent actual risks may be greater than estimated risks (EPA 1998a). TOE factors ranging from 2 to 40 have been computed (EPA 1998a). Lower TOE factors can be achieved by more complete characterization of stack emissions (i.e., more "identified" compounds in the denominator), and facilities should consider this in determining appropriate stack measurements for the risk burn (Sections 5.1.1 through 5.1.3).

The importance of the Total Organic Emissions determination for site-specific risk assessments cannot be over-emphasized. Studies (EPA 1976; Pellizzari and others 1980) have shown that analyses based strictly on target analyte lists may account for less than 20% of the total organic material in an emission sample. Without a Total Organic Emissions determination, a final risk assessment report cannot explain how much of the total stack emissions have been evaluated for risk, significantly complicating the risk management decision.

5.2 CONTROL PARAMETERS TO BE CONSIDERED FOR RISK BURNS

This section identifies key control parameters that are expected to affect organic emissions, and that EPA OSW recommends be considered in establishing the risk burn test conditions. Depending on site-specific considerations, these control parameters may need to be limited in the RCRA permit after the risk burn to protect human health and the environment by ensuring that organic emissions remain within the measured levels on an ongoing basis.

Most of the control parameters listed in this section pertain to combustion conditions that have already been discussed in Section 4.2.2. Information from Section 4.2.2 is referenced, as appropriate, instead of repeating the information here.

Several of the control parameters identified in this section may currently be limited in association with the DRE standard, or will soon be limited pursuant to the requirements of the hazardous waste combustor *parameters listed in Section 4.2.2.2 include: 1) minimum primary and secondary combustion chamber exit temperatures; 2) maximum combustion gas velocity; 3) maximum waste feed rate at each feed location; 4) limitations on waste feed composition and batch feeds; and 5) maximum flue gas carbon monoxide and/or total hydrocarbon concentrations.*

The recommendation for organics sampling during the DRE test is a general guideline. Some facilities and permit writers may be faced with situations where this general guideline is not appropriate. For example, DRE testing may already have been conducted in advance of the risk burn, or the use of surrogate waste for the DRE test might conflict with the objective to use actual wastes during the non-D/F organic testing. These and other situations call for decisions regarding the specific combustion conditions to be demonstrated. Therefore, this guidance recommends that the challenging combustion scenarios described in Section 4.2.2.3 (if applicable) be preferentially targeted for organics testing. As appropriate, it is recommended that permit limits for the Section 4.2.2.2 combustion parameters be established based on organics testing conducted under these challenging combustion scenarios. In addition, a facility-specific review of trial burn and historical operating data should generally be performed to determine whether the challenging combustion scenarios correlate with other operating or feed parameters. If so, it is recommended that the correlating parameters be demonstrated during the testing and limited in the permit as necessary to protect human health and the environment in addition to, or possibly in lieu of, the combustion parameters listed in Section 4.2.2.2. Caution should be exercised to ensure that targets during the organics testing for the Section 4.2.2.2 combustion parameters are not substantially different from those demonstrated during the DRE test.

Finally, it is important to recognize that some combustion units operate under extremely steady-state conditions, at temperatures and residence times that should routinely ensure good combustion. Challenging combustion situations, such as those described in Section 4.2.2.3, do not occur. Combustion conditions may not fluctuate at all, and carbon monoxide may be near zero. Ideally, logistics will favor combining the organics testing with the DRE test. If so, then the combustion parameters listed in Section 4.2.2.2 should automatically be addressed, since

> *they are typically demonstrated and limited as part of the DRE determination. However, if combined testing is not possible, then consideration may be given to testing under normal combustion conditions, as appropriate (see Section 3.3.2.2). Historical operating data for the appropriate combustion parameters should generally be reviewed to verify that the facility maintains steady-state operations with very few fluctuations. Demonstration of absolute maximum or minimum values for the combustion parameters listed in Section 4.2.2.2 during organics testing may be less critical for steady-state operations. In lieu of specific permit limits for the parameters listed in Section 4.2.2.2, periodic reporting to confirm continued absence of transients may be appropriate. When organics testing cannot be performed in conjunction with the DRE test, caution should be exercised to ensure that targets during the organics testing for the combustion parameters listed in Section 4.2.2.2 are not substantially different from the levels demonstrated during the DRE test.*

For most incineration and boiler systems, the generation of organic products of incomplete combustion is typically associated with poor combustion situations (organic emissions from cement kilns and lightweight aggregate kilns are typically dominated by organics that are volatilized from the raw materials, but this is discussed later in Section 5.4). Berger has documented the effects of inefficient burner operation and oxygen control (Berger and others 1996). These conditions led to incomplete combustion and subsequent increases in fly ash and carbon monoxide and total hydrocarbon concentrations. Linak has documented PCC exit total hydrocarbon levels in excess of 10,000 ppm during very intense transient puffs arising from batch feed operations at a pilot-scale unit, and has performed chemical analysis to show that the puffs can contain numerous hazardous compounds, even though adequate DREs (>99.99%) may be achieved (Linak and others 1987). Historically, levels of oxygen, carbon monoxide, and total hydrocarbons have been used as surrogate indicators of good combustion to minimize PIC emissions.

Examples of operating conditions that may lead to increased PIC formation include:

- Insufficient temperatures in either the PCC or SCC, leading to incomplete combustion.
- Excess flue gas velocity or flow leading to shorter residence times in the combustion unit and incomplete combustion;
- Batch-fed containers with high oxygen demand that can lead to transient, low oxygen

these challenging combustion scenarios. In addition, a facility-specific review of trial burn and historical operating data should generally be performed to determine whether the challenging combustion scenarios correlate with other operating or feed parameters. If so, it is recommended that the correlating parameters be demonstrated during the testing and limited in the permit as necessary to protect human health and the environment in addition to, or possibly in lieu of, the combustion parameters listed in Section 4.2.2.2.

At some facilities, the challenging combustion scenarios identified in Section 4.2.2.3 may not occur. For steady-state systems, demonstration of absolute minimum or maximum values for the Section 4.2.2.2 combustion parameters during organics testing may be less critical. Although demonstration of these control parameters can ideally be accomplished by combining the organics testing with the DRE demonstration (which is preferred whenever possible), consideration may be given for some steady-state systems to performing the organics testing under normal conditions. As discussed in Section 3.3.2.2, testing at normal conditions may be appropriate where the facility can establish a monitoring plan and permit conditions can be developed as necessary to protect human health and the environment to ensure that the test conditions are representative of long-term operations. A permit writer generally should consider the extent to which normal conditions represent potential emissions and risks over the permitted operating range in determining whether testing at normal conditions is appropriate. If organic emissions data are collected under normal conditions, caution should be exercised with respect to operating parameters where the average value is significantly different than operating extremes.

5.2.2 Feed Composition

> ***Recommendation --*** *EPA OSW recommends that, whenever possible, actual wastes (rather than surrogate wastes synthesized from pure compounds) be burned during the non-D/F organics testing, and that representative, but challenging, feeds be selected for the test. High quantity, routine and recurring waste streams are generally preferred, with special emphasis on wastes that may cause combustion transients (Section 4.2.2.3.1) and wastes containing highly toxic, persistent and bioaccumulative constituents.*

Waste selection for non-D/F organic testing can be very important, because the types of organic PICs may

5.3 ORGANIC EMISSIONS FROM INCINERATORS AND BOILERS

Hazardous waste incineration and boiler systems are described briefly in Sections 4.3 and 4.4. Non-D/F organic emissions from incinerators and boilers are likely to be dependent on both combustion conditions and feed composition. In summary, all of the considerations discussed in Section 5.2 are also appropriate to consider with respect to incinerators and boilers. Key control parameters are summarized in Table 4-1.

materials, the recommended focus during the risk burn is to maximize total hydrocarbon emissions in the main and bypass stacks, not to exceed applicable regulatory limits. Although the operating conditions necessary for achieving high total hydrocarbon emissions may vary by facility, maximum total hydrocarbon levels are likely to be achieved by some combination of high production rate, high gas temperatures at the raw material feed end of the kiln, and low oxygen at the raw material feed end of the kiln. These conditions are most likely to be achieved during a high temperature or SRE test. The recommendation to maximize total hydrocarbon emissions is discussed further in Section 4.5.

Control parameters associated with organic emissions from lightweight aggregate kilns are identified in Table 4-2. For lightweight aggregate kilns, EPA OSW recommends that demonstration of combustion parameters be considered on a case-by-case basis. Lightweight aggregate kilns do not operate at combustion temperatures as high as those in cement kilns. However, the potential for poor combustion situations may be minimized, because aggregate kilns typically only burn high-Btu, liquid wastes in the flame zone. Historical operating data should generally be reviewed to determine whether a facility frequently experiences operating transients, as discussed in Section 4.2.2.3.1. If so, it is recommended that the transient operations be represented during the organic emissions testing and permit limitations on the combustion parameters listed in Section 4.2.2.2 (or other parameters as appropriate) may be necessary to protect human health and the environment. However, if a facility maintains steady-state operations with very few fluctuations, demonstration of absolute minimum or maximum values for the Section 4.2.2.2 combustion parameters may be less critical. As discussed for cement kilns, raw materials may contribute to elevated organic emissions at lightweight aggregate kilns, and it is recommended that organics testing be performed at the upper end of the operating range for total hydrocarbons.

The recommendations in Section 5.2.2 regarding feed composition are generally appropriate for cement kilns and lightweight aggregate kilns. Although organic emissions may be influenced more by the raw materials than the waste feeds, it is reasonable to expect that representative, actual wastes should be burned than the hot end of the kiln. For blended fuel, it may not be possible to perform a characterization by top percentage of waste receipts. In this case, EPA OSW recommends that an alternate ranking scheme be developed to reflect the chemical and physical characteristics of the blended fuel.

CHAPTER 6

METAL EMISSIONS

EPA OSW has recommended that metal emissions be evaluated in site-specific risk assessments because they can pose potential human and ecological risks (EPA 1998a and 1999b). Since most facilities are either controlling metals emissions or will soon control metals emissions pursuant to the requirements of the hazardous waste combustor MACT rule, the primary consideration for the risk burn is whether additional control beyond applicable regulatory standards may be warranted at a particular site (see also Sections 1.3.2 and 1.3.3). This chapter reviews emissions and operating data that may need to be gathered during the risk burn to assist in this determination.

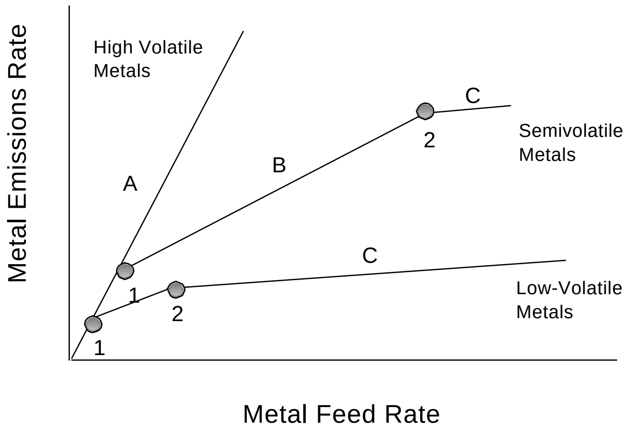
Metal emissions from hazardous waste combustors are highly dependent on metal volatility, metal feed rates, and air pollution control efficiency. Section 6.1 provides information on metals volatility. Section

This section reviews the general characteristics of each volatility group and graphically depicts the relative volatility of the eighteen potentially toxic metals identified in Section 2.3. The discussion in this section is intended to be a general discussion encompassing all of the metals that may be addressed in a risk assessment. For six metals specifically regulated under the MACT rule, volatility groupings are defined by regulation, and the MACT rule volatility designations are reviewed later in Section 6.2.

Volatile metals are defined by EPA as metals that have high vapor pressures (and are typically in vapor form) in the combustion chamber as well as in the cooler downstream APCD components of the combustion system (EPA 1997e). Emissions of volatile metals are highly dependent on feed rate and the

FIGURE 6-1

METAL VOLATILITY REGIMES



A - Metal in vapor phase
B - Metal condensed on fine particulate
C - Metal entrained as larger particulate

1 - Saturated vapor at APCD temperature
2 - Saturated vapor at combustion temperature

Reproduced from EPA (1997e)

metal vapor at the APCD temperature becomes saturated (Point 1). In Region B, the metal begins to condense at the APCD temperatures, primarily onto fine particulate matter. The slope of the line in Region B is determined by the APCD removal efficiency for fine particulate matter.

Low-volatile metals vaporize to a lesser extent at combustion temperatures and partition to a greater extent to bottom ash, other residue, cement kiln clinker, or entrained particulate matter in the flue gas (EPA 1996a, 1997e and 1999d). Low-volatile metal emissions are more strongly related to the operation of the APCD than to feed rate. Evaluations conducted by Springsteen (Springsteen and others 1997) and EPA

among kilns, liquid injection, and controlled air designs), combustion stoichiometry and flue gas flow rates (higher gas velocities can lead to higher particle/metal entrainment), operating temperatures (metal volatility typically increases with increasing temperature), the physical form and species of the metal, the presence of mineral species which may preferentially bind with metals (these may be contained in the raw emissions standards are superseded (however, any RCRA permit requirements or conditions related to the combustor remain in effect until that permit is either modified to remove the conditions or the permit is terminated or expires). Technology-based standards for hazardous waste burning boilers are anticipated in a future MACT rulemaking.

This section reviews the key control parameters influencing metal emissions, with emphasis on the control parameters identified in the hazardous waste combustor MACT rule. The MACT control parameters for metals are similar to BIF control parameters. However, the MACT parameters have been reviewed more recently against an extensive metals emissions database.

The purpose of reviewing MACT control parameters is not to suggest that MACT emissions standards should necessarily be imposed within the context of risk-based permitting, or to imply that any facility will be required to achieve early compliance with MACT emissions standards. Rather, the purpose of reviewing the MACT control parameters in this guidance is to identify the feed and operating conditions that influence metals emissions, as well as to highlight the controls which will be implemented at most hazardous waste combustors in accordance with the requirements of the MACT rule. To the extent that risks from metals are already adequately controlled by regulatory limits on key control parameters, then fewer site-specific risk-based limits may be needed in the RCRA permit. However, if regulatory controls are not applicable or sufficiently comprehensive, then additional site-specific risk-based limits may be necessary to ensure protection of human health and the environment. A greater number of risk-based permit limitations may be necessary when the risk burn and RCRA or MACT performance tests reflect different operating modes.

6.2.1 Volatile Metals (Mercury)

The MACT rule regulates mercury as a volatile metal. EPA considers mercury to be a high priority hazardous air pollutant with the potential to cause significant human health and environmental effects (EPA 1996a, 1997a and 1999c). Mercury is the most volatile regulated metal, is the most difficult metal to control, and has been the subject of many detailed studies, including the *Mercury Study Report to Congress* (EPA 1997a).

At temperatures found in hazardous waste combustion devices, nearly all mercury volatilizes to form gaseous mercury that includes both elemental (reduced) and divalent (oxidized) forms (EPA 1999d). Partitioning between elemental and divalent mercury is critical, because it directly affects the ability to control mercury in the APCD system (EPA 1999d). In general, the divalent form of mercury is more likely to be removed in the APCD.

Mercury speciation is dependent on both the fuel and physical characteristics of the combustor, and may vary for an individual unit as feed and operating conditions change. Mercury speciation in the flue gas depends on factors such as waste composition (in particular, chlorine and sulfur levels), the flue gas temperature profile, and the type of air pollution control (EPA 1999d). If chlorine is not present or if sulfur levels are high, elemental mercury can comprise a significant fraction of the total mercury. Elemental mercury is not soluble in water, and is usually not well controlled by wet scrubbers. Control of elemental mercury may involve the use of an adsorption technology, such as carbon injection.

In the presence of chlorine, formation of divalent mercuric chloride is thermodynamically favored in combustion systems. Mercuric chloride is soluble in water and is readily captured by wet scrubbers. Slow gas cooling (instead of rapid quenching) has been shown to maximize the levels of soluble mercuric chloride and increase wet scrubber performance.

Mercury emissions are primarily controlled by limiting feed rate and through the use of air pollution control techniques involving adsorption or absorption (e.g., carbon technologies and wet scrubbers). MACT control parameters related to mercury emissions from hazardous waste combustion facilities include the following (EPA 1999e):

- Mercury emissions increase with increasing mercury feed rate. The MACT rule (EPA 1999c) requires that limits be established for total maximum mercury feed rate to the unit (including hazardous waste, raw materials, and fossil fuels). A separate limit for pumpable feed streams is not necessary, since mercury is highly volatile in any form.

- Chlorine feed rate may affect mercury emissions when wet scrubbers are used as APCDs. In the case of mercury, the presence of chlorine is expected to decrease emissions through conversion to the soluble divalent species. However, because only *de minimis* levels of chlorine are necessary for mercury conversion to the soluble salt, minimum chlorine limits are not recommended. A maximum chlorine limit is typically established for most metals (because increased levels of chlorine can increase metal volatility). However, a maximum chlorine limit is not necessary for mercury, since mercury is already volatile.

C Combustion chamber temperature is not believed to be a critical operating parameter. At typical mercury feed rates and combustion temperatures, all mercury vaporizes in the combustion chamber.

C Wet scrubbers have been demonstrated to be effective at controlling water soluble forms of mercury. The MACT rule (EPA 1999c) requires that limits be established for operating parameters associated with wet scrubbers (such as minimum pressure drop across the scrubber, minimum liquid feed pressure, and minimum liquid-to-flue-gas ratio). Gaspar and others have observed that rapid quenching of hot flue gases from municipal waste incinerators reduces mercury removal in wet scrubbers (Gaspar and others 1997). They believe that rapid quenching does not allow sufficient residence time for elemental mercury (which is favored at typical incineration temperatures) to shift to soluble mercuric chloride (which is favored at temperatures below approximately 600 EC in the presence of chlorine). This concern is reiterated in a technical support document to the MACT rule (EPA 1999d).

C Carbon injection and carbon bed technologies may also be used for mercury control.
When carbon technologies are used, the MACT rule (EPA 1999c) requires that limits be Tj 36 0 TD /F3 1
incinerationsyastrmsuping 90ng 9 tpecnchichlorine ae). e Tj 36 38.644 TD -0.469 Tc 0.269 Tw Clemen kiln

dust has an elevated carbon content, which is unlikely (EPA 1999d). The mercury SREs which have been reported for cement kilns and lightweight aggregate kilns may be due to measurement uncertainties associated with the very low levels of mercury in the stack gas or feed streams (EPA 1999d).

6.2.2 Semivolatile Metals

MACT regulates lead and cadmium as semivolatile metals. Emissions of semivolatile metals are a function of both feed rate and APCD removal efficiency for fine, submicron particulate matter (Springsteen and others 1997; EPA 1996a, 1997e and 1999d). Wet scrubbers are generally considered more effective at controlling larger particulates, whereas fabric filters, ESPs and ionizing wet scrubber (IWS) devices are considered most effective in removing smaller particulates (Clarke and Sloss 1992; EER 1991; EPA 1999d). MACT control parameters for semivolatile metal emissions from hazardous waste combustion facilities include the following (EPA 1999e):

- Semivolatile metal emission rates increase as the metal feed rates increase. The MACT rule (EPA 1999c) requires that limits be established for total maximum semivolatile feed rate to the unit (including hazardous waste, raw materials, and fossil fuels). A separate limit for pumpable feed streams is not necessary, because partitioning between the combustion flue gas and bottom ash or product does not appear to be affected by physical state.

- Chlorine increases metal volatility. The MACT rule (EPA 1999c) requires that a limit be established for maximum chlorine feed rate to the unit. The limit is based on total chlorine from all sources, including organic and inorganic chlorine sources.

- Higher combustor gas flow rates can increase particulate and metals entrainment. The MACT rule (EPA 1999c) requires that a limit be established on maximum gas flow rate or kiln production rate.

- Maximum combustion chamber temperature has traditionally been established under the BIF rule to control metal volatility. However, maximum combustion chamber temperature is less important than other operating parameters when considering metal emissions from most hazardous waste combustion facilities. For semivolatile metals, typical combustion temperatures are generally high enough to volatilize most of the metals in the combustion chamber, and evaluation of emissions data does not provide any support for a relationship between combustion chamber temperature and semivolatile metals emissions levels (EPA 1999e).

- APCD type and operating parameters are recognized as critical to the control of

6.2.3 Low-Volatile Metals

MACT regulates arsenic, beryllium and total chromium as low-volatile metals. Emissions of low-volatile metals are a function of both feed rate and APCD efficiency for particulate matter (EPA 1997e and 1999d). MACT control parameters associated with the low-volatile metals are consistent with those for the semivolatile metals described in Section 6.2.2, with the following exceptions (EPA 1999e):

- The MACT rule (EPA 1999c) requires that a separate limit be established for low-volatile metals in pumpable feed streams, since these may partition at a higher rate to the combustion flue gas. However, if a facility wants to base their total feed rate limit only on the feed rate of the pumpable waste feed streams during the test, then separate feed rate limits for total and pumpable feed streams are not needed.
- Low-volatile metals are less apt to vaporize completely at typical combustion temperatures. Thus, a limit on maximum combustion temperature could theoretically be more important for low-volatile metals than for semivolatile metals. However, the amount of additional vaporization at slightly higher temperatures could be negligible compared to the amount of metals contained in entrained flue gas particulate matter, especially for kilns and pulverized coal boilers. Thus, maximum combustion chamber temperature is most likely less important than APCD operating parameters. In addition, analysis of emissions data does not indicate a strong relationship between combustion chamber temperature and low-volatile metal emissions levels (EPA 1999e).

MACT control parameters for low-volatile metals are summarized in Table 6-1. If a facility bases compliance on an assumption of zero SRE, then only total low-volatile metal feed rate is limited.

Similar to the semivolatile metals, operation of the APCD is critical to removal of low-volatile metals. In metaliance on a26mivolatil46metals,o removaltem12.t453tio (EPA 1999e).

TABLE 6-1

MACT CONTROL PARAMETERS ASSOCIATED WITH METALS EMISSIONS

	Control Parameter	**Limits From**	**AveraginarSOCIATE4 236.88 Wp4070.16 -25.44 TD 0.0077 eterParameter**		

TABLE 6-1

MACT CONTROL PARAMETERS ASSOCIATED WITH METALS EMISSIONS (Continued)

	Control Parameter	Limits From	Averaging Period	How Limit Is Established	Other Considerations

TABLE 6-1

MACT CONTROL PARAMETERS ASSOCIATED WITH METALS EMISSIONS (Continued)

	Control Parameter	**Limits From**	**Averaging Period**	**How Limit Is Established**	**Other Considerations**
VOLATILE METAL CONTROL PARAMETERS (MERCURY)					
Activated Carbon Bed (continued)	Identification of carbon brand and type or adsorption properties	Comprehensive performance test	N/A	Same properties based on manufacturer specifications	
	Maximum gas temperature at the inlet or exit of the bed	Comprehensive performance test	1 hour	Average of the test run averages	
	Good particulate matter control	Same as for activated carbon injection			
SEMIVOLATILE METAL CONTROL PARAMETERS (Pb, Cd)					
Feed Rate	Maximum total semivolatile metal feed rates from all feed streams [1]	Comprehensive performance test	12 hour	Average of the test run averages	
Chlorine	Maximum total chlorine feed rate from all feed streams [1]	Comprehensive performance test	12 hour	Average of the test run averages	
Gas Flow Rate	Maximum flue gas flow rate or kiln production rate	Comprehensive performance test	1 hour	Average of the maximum hourly rolling averages for each run	
Inlet Temperature to Dry Particulate Matter Control Device	Maximum temperature	Comprehensive performance test	1 hour	Average of the test run averages	

TABLE 6-1

MACT CONTROL PARAMETERS ASSOCIATED WITH METALS EMISSIONS (Continued)

	Control Parameter	Limits From	Averaging Period	How Limit Is	

TABLE 6-1

MACT CONTROL PARAMETERS ASSOCIATED WITH METALS EMISSIONS (Continued)

	Control Parameter	Limits From	Averaging Period	How Limit Is Established	Other Considerations
SEMIVOLATILE METAL CONTROL PARAMETERS (Pb, Cd)					
Fabric Filter	Maximum flue gas flow rate or kiln production rate	Comprehensive performance test	1 hour	Average of the maximum hourly rolling averages for each run	
	Minimum pressure drop and maximum pressure drop across each cell	Manufacturer specifications	1 hour	N/A	
Electrostatic Precipitator and Ionizing Wet Scrubber	Maximum flue gas flow rate or kiln production rate	Comprehensive performance test	1 hour	Average of the maximum hourly rolling averages for each run	
	Minimum power input (kVA) based on secondary voltage and current to each field	Comprehensive performance test	1 hour	Average of the test run averages	
LOW-VOLATILE METAL CONTROL PARAMETERS (As, Be, Cr)					
Feed Rate	Maximum total low-volatile metal feed rates from all feed streams [1]	Comprehensive performance test	12 hour	Average of the test run averages	
	Maximum total low-volatile metal feed rates from all pumpable feed streams [1]	Comprehensive performance test	12 hour	Average of the test run averages	See Section 6.2.2
Chlorine	Same as semivolatile metals				

TABLE 6-1

MACT CONTROL PARAMETERS ASSOCIATED WITH METALS EMISSIONS (Continued)

	Control Parameter	Limits From	Averaging Period	How Limit Is Established	Other Considerations
LOW-VOLATILE METAL CONTROL PARAMETERS (As, Be, Cr)					

6.3 RISK-BASED LIMITATIONS

The MACT control parameters discussed in Section 6.2, or similar parameters under the BIF rule, either apply or will apply to most hazardous waste combustors. However, risk-based limitations beyond these regulatory requirements may be necessary to protect human health and the environment for some facilities. This section addresses potential site-specific risk-based controls beyond BIF or MACT, with emphasis on metal feed rate and emissions restrictions. Since there is generally a strong relationship between metals emissions and feed rates, feed rate reduction is expected to be the primary means of achieving a more stringent risk-based metal emissions level if necessary.

Several topics are addressed in this section. Site-specific risk-based emissions and feed rate limitations for regulated metals (i.e., metals specifically controlled under either BIF or MACT) are discussed in Section 6.3.1. Restrictions for other potentially toxic metals which are not specifically enumerated in the BIF or MACT regulations, but which may be COPCs for site-specific risk assessments, are discussed in Section 6.3.2. Special considerations related to acute risks are discussed in Section 6.3.3. Finally, the use of extrapolation and metals surrogates for establishing site-specific risk-based feed rate limits is discussed in Sections 6.3.4 and 6.3.5, respectively.

Although the metal control parameters discussed in Section 6.2 were presented in terms of metal volatility groups, this guidance does not recommend that risk-based permit limits be established for metal volatility groups (rather than individual metals). The divisions between volatility groups are not absolute. More importantly, EPA OSW has recommended that individual metals be modeled separately for risk assessments using the fate and transport parameters and toxicity information specific to each metal (EPA 1998a and 1999b). The use of volatility groupings for risk-based permitting should generally be limited to the metal extrapolation and surrogate applications discussed later in Sections 6.3.4 and 6.3.5.

6.3.1 Regulated Metals

As noted at the beginning of Section 6.2, the metals emissions standards that apply to hazardous waste combustors vary considerably, depending on the type of combustion device and the time frame being

standards cannot be achieved because of metals in the raw materials. The alternative standards represent another scenario where MACT may need to be supplemented with site-specific risk-based limits to ensure that a facility does not pose an unacceptable risk (EPA 1999c).

A preliminary risk assessment can provide information to determine whether operation within regulatory emissions limits (either BIF or MACT) may present a significant risk to human health and the environment. As discussed in Section 3.2, EPA OSW recommends that the preliminary risk assessment be performed prior to the risk burn to better define the risk burn data needs. If a regulatory limit applies for a particular metal and is sufficiently protective, additional risk-based limits should generally not be needed. However, if the regulatory limit for a particular metal is not sufficiently protective, a lower, site-specific risk-based emissions limit for that metal may need to be established in the RCRA permit to assure protection of human health and the environment.

In addition to providing information on whether operation within a regulatory emissions limit may present a significant risk to human health and the environment, the preliminary risk assessment can also indicate the extent of emissions reduction necessary to assure protection of human health and the environment. After a protective emissions limit has been defined, a correspondingly lower metal feed rate limit can be determined. A variety of methodologies can be used to establish a risk-based feed rate limit from a risk-based emissions limit. Several approaches are outlined below, and a combination of methodologies may be appropriate in some cases:

- Zero SRE: A facility may choose to establish a risk-based feed rate limit from the risk-based emissions limit for a particular metal by assuming zero SRE (i.e., the feed rate limit is the same as the risk-based emissions rate limit).

- Existing SRE: A facility may have data from an existing SRE test performed for BIF or MACT documenting that the lower, risk-based emissions limit is already being achieved. In this case, the risk-based metal feed rate limit is the same as the feed rate during the SRE test where the risk-based emissions limit was demonstrated.

- New SRE: With careful planning, a future SRE test may serve as the vehicle for determining risk-based feed rate limits. For example, a facility may be due for BIF re-certification testing, or may be about to perform the initial MACT performance test. If the facility has performed a preliminary risk assessment which indicates the need for risk-based controls, the facility may be able to reduce (or eliminate) metals spiking, as well as perform sampling for additional non-regulated metals, to meet the objectives of both the performance test and the risk burn. In this case, the risk-based metal feed rate limit is established as the feed rate during the SRE test where the risk-based emissions limit is demonstrated.

- Normal Test: Where appropriate (see Section 3.3.2.2), a separate test conducted at normal metal feed rates may be considered for establishing risk-based metal feed rate limits. When metals emissions data collected during a normal test are utilized for the site-specific risk assessment, a dual testing and permitting scheme such as the following is recommended:

    - An SRE test is performed to demonstrate that maximum emissions meet applicable BIF or MACT limits, and to establish maximum hourly or 12-hour feed rate limits

    - A normal test is performed to generate emissions data for evaluation in the site-specific risk assessment, and to establish long-term average feed rate limits

- Extrapolated Feed Rate: The use of extrapolation to establish risk-based feed rate limits is discussed further in Section 6.3.4. Opportunities for using extrapolation to establish risk-based feed rate limits may be somewhat limited, since only upward extrapolation is recommended (whereas risk-based permitting involves *lowering* feed rates). However, some situations may be amenable to extrapolation. For example, a facility may have collected data for the entire suite of metals during a previous SRE test (even though only a few metals were spiked). Upward extrapolation for the unspiked metals could be considered.

- Surrogate SRE: The use of surrogates to establish risk-based feed rate limits is discussed further in Section 6.3.5. If existing metals emissions data are available, but data on a certain metal were not collected, or if the data for a particular metal are not useful (i.e., an SRE cannot be determined because of non-detects for the feed inputs), use of data for a surrogate metal based on volatility groupings may be considered.

The approach selected to establish risk-based metal feed rate limits from risk-based emissions limits will affect the scope of the risk burn. For example, if a facility chooses the “Zero SRE” approach for all metals where risk-based limits are needed, then metal emissions measurements may not be needed during the risk burn. However, if a facility chooses the “Normal Test” approach, the risk burn may involve extra test conditions.

Under any of these options, EPA OSW recommends that an averaging period for the risk-based feed rate limit be specified. A facility may choose to comply using the same feed rate averaging periods as specified by BIF or MACT (1 hour or 12 hours) to minimize need for extra monitoring. On the other hand, if these

potential risks associated with the metals are insignificant, a permit writer may simply choose to document

6.3.4 Extrapolation

As discussed in Section 6.3.1, one option for establishing risk-based feed rate limits from risk-based emissions limits involves the use of extrapolation (subject to approval). Extrapolation involves using test data collected at one metals feed rate to project an emissions level at a different metals feed rate. "Upward" extrapolation refers to projecting the emissions associated with a higher metals feed rate, whereas "downward" extrapolation refers to projecting the emissions associated with a lower metals feed rate. Extrapolation is of interest because: 1) it potentially eliminates the need to re-test at different metals feed rates to show compliance with more stringent risk-based emission limits; and 2) it can help to minimize the need for metals spiking.

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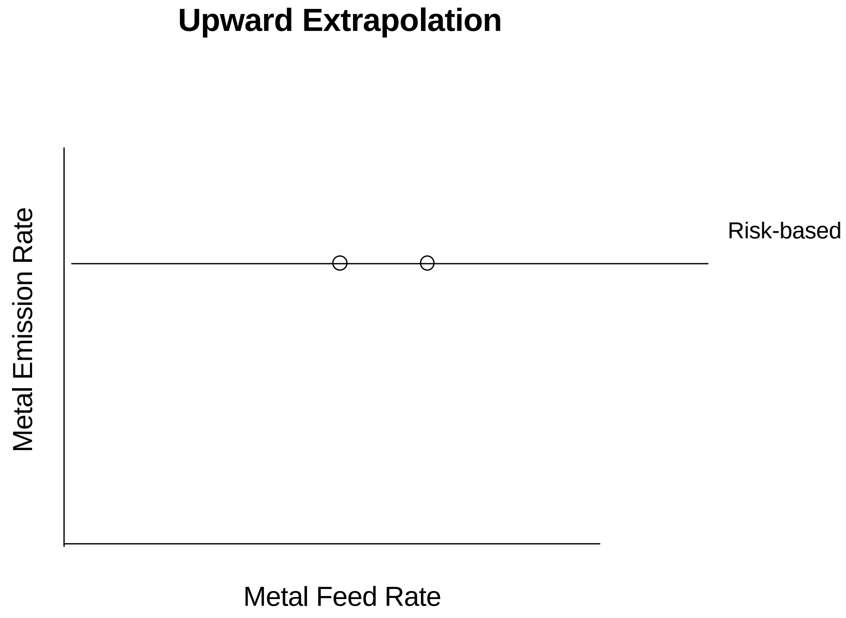
Upward Extrapolation
Risk-based
Metal Emission Rate
Metal Feed Rate

The permit writer should generally ensure that a proposed extrapolation procedure will be appropriately conservative, considering the extent and quality of the metals feed rate and emissions data. Depending on a review of the actual data, a conservative extrapolation procedure might include:

- Extrapolation from the lowest observed SRE that is not an outlier. The lowest SRE can either be determined for an individual metal, or it might be selected based on the collective data for metals within a given volatility group. Provided that the grouped data confirm that the metals behave similarly, a wider range of feed rates may be represented when the data for several metals are grouped together.

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Figure 6-2, these metals fall in the area of the circle that overlaps with the Group 2 semivolatile metal category, indicating that partitioning behavior may vary for different combustion systems with different operating conditions. Facility-specific data should generally be reviewed to determine whether any of these metals exhibit semivolatile metal behavior (as evidenced by more enrichment of these metals in air pollution control residues than in bottom ash or clinker residues). Or, in the absence of site-specific information, these metals could be treated conservatively as semivolatile metals.

Finally, Springsteen and others explain that three metals exhibit low-volatile behavior in cement kilns but may behave more like semivolatiles in incineration systems (Springsteen and others 1997). These metals include arsenic, antimony, and silver. Springsteen includes special recommendations for arsenic, antimony, and silver, since their behavior can be dependent on combustion system type (Springsteen and others 1997). In cement and lightweight aggregate kilns, these metals are included within the low-volatile grouping, and all low-volatile metals can be used interchangeably as surrogates for each other. In incinerators and boilers, arsenic, antimony, and silver can conservatively be used as surrogates for low-volatile metals, but low-volatile metals generally should not be used as surrogates for arsenic, antimony, and silver. In addition, arsenic, antimony, and silver generally should not be used as surrogates for each other for incinerators and boilers.

EPA OSW recommends that the general guidelines regarding specific metals and volatility groupings always be reviewed in conjunction with facility-specific data. Volatile metals will not be present in significant

- Use of the lowest observed SRE that is not an outlier. The lowest SRE can either be

(99 percent) of elemental mercury is diffused to the free atmosphere to become part of the global mercury

Available information suggests that substantial quantities of chromium are not likely to be emitted in the hexavalent form from combustion units. Laboratory work by Linak and others indicates that the fraction of hexavalent chromium emitted may be very small, typically ranging from less than one percent to approximately two percent of the total chromium measured (Linak and others 1996; Linak and Wendt 1998). The hexavalent fraction in the exhaust was found to be enhanced somewhat by high levels of chlorine, but was reduced to below analytical detection limits by the addition of small quantities of sulfur. Additional information indicating low percentages of hexavalent chromium from combustion units is provided by EPA (EPA 1990) and Bailiff and Kelly (Bailiff and Kelly 1990). However, in limited situations and under certain conditions, a high percentage of hexavalent chromium has been found in combustor emissions (EPA 1991).

The recommended chromium emissions speciation assumption provided in the EPA OSW risk assessment guidance (EPA 1998a) is a worst-case assumption (i.e., that 100 percent of the chromium emissions are in the hexavalent form). The basis for this assumption is that there is not sufficient evidence to reliably estimate the partitioning of chromium between the two valence states. The recommended assumption is very conservative. Therefore, a facility may wish to sample for hexavalent chromium during the risk burn to replace the recommended assumption with site-specific data. SW-846 (EPA 1996b) provides an in-stack emissions method (Method 0061) for differentiating between trivalent and hexavalent chromium.

6.4.3 Nickel

Nickel can achieve several oxidation states (up to four), with the most common being +2. The most prevalent forms of nickel are sulfides, oxides, chlorides, and silicates. Some forms of nickel (including nickel carbonyl, nickel subsulfide, and nickel refinery dust) are considered to be carcinogenic. Previously under the BIF regulations, EPA did not treat nickel as a carcinogen because of the presumption that nickel can only be emitted from combustion units as nickel oxide (which, by itself, is not considered to be a carcinogen).

The recommended assumption provided in the EPA OSW risk assessment guidance (EPA 1998a) is that nickel be evaluated as an inhalation carcinogen using the carcinogenic slope factor for nickel refinery dust. This recommendation represents a change from the regulatory approach under the BIF rule. The basis for the revised approach is that nickel oxide is a major component of nickel refinery dust, and the component in nickel refinery dust which causes it to be carcinogenic has not been established. For exposure pathways

CHAPTER 7

HYDROGEN CHLORIDE/ CHLORINE EMISSIONS AND PARTICLE-SIZE DISTRIBUTION

EPA OSW has recommended that hydrogen chloride and chlorine be evaluated for potential risks in site-specific risk assessments (EPA 1998a). Potential risks from HCl and Cl_2 are limited to the inhalation pathway. Since most facilities are either controlling or will control HCl and Cl_2 emissions under the hazardous waste combustor MACT rule, the primary consideration for the risk burn is whether additional control beyond applicable regulatory standards may be warranted at a particular site (see also Sections 1.3.2 and 1.3.3). This chapter (Section 7.1) identifies risk burn data needs and control parameters related to HCl and Cl_2. Since HCl and Cl_2 have been discussed at length in other documents (EPA 1992b, 1999d and 1999e), they are only mentioned briefly here.

This chapter (Section 7.2) also identifies risk burn data needs related to particle-size distribution. Information on particle-size distribution is needed for the air dispersion and deposition modeling that supports risk assessments (EPA 1998a and 1999b).

7.1 HYDROGEN CHLORIDE AND CHLORINE

The HCl and Cl_2 emissions standards which apply to hazardous waste combustors vary, depending on the type of combustion device and the time frame being considered. Technology-based limits for HCl have applied to hazardous waste incinerators since 1981 (40 CFR Part 264.343). The technology-based standards limit HCl emissions to the larger of 4 pounds per hour or 99% removal. The 40 CFR Part 264.343 provisions do not include an emission limit for Cl_2. For hazardous waste burning boilers and industrial furnaces, HCl and Cl_2 emissions have been regulated since 1991 under the BIF rule (40 CFR Part 266, Subpart H). The BIF standards are risk-based standards which consider exposure via the inhalation pathway based on RACs specified in the regulations. However, updated toxicological information (instead of the RACs specified in 40 CFR Subpart H) may be available and may need to be considered for site-specific risk assessments at BIF facilities. Similar provisions to those prescribed by 40 CFR Subpart H have been applied at some hazardous waste incineration facilities through individual permit decisions pursuant to the omnibus authority of Section 3005(c)(3) of RCRA and 40 CFR 270.32(b)(2). More recently, technology-based MACT emission limits have been promulgated for hazardous waste burning incinerators, cement kilns, and lightweight aggregate kilns (EPA 1999c). The MACT standards establish limits on parts per million volume (ppmv) of HCl and Cl_2 emissions, expressed as HCl equivalents (calculated as ppmv HCl + 2*ppmv Cl_2). Facilities have three years from the MACT rule promulgation date (September 30, 1999) to comply with the revised standards. Upon documentation of compliance with MACT, the RCRA incinerator and BIF emission standards are superseded (however, any RCRA permit requirements or conditions related to the combustor remain in effect until that permit is either modified to remove the conditions or the permit is terminated or expires). Technology-based standards for hazardous waste burning boilers are anticipated in a future MACT rulemaking.

The particular regulatory standards which apply at a given facility will inform decisions regarding the need for supplemental risk-based controls on HCl and Cl_2 emissions, as well as the type of supplemental risk-based permit conditions which may be appropriate. For example, it may be necessary to supplement the 40 CFR Part 264.343 incinerator standards to protect human health and the environment, because Cl_2 emissions are not limited at all by 40 CFR Part 264.343, and because the HCl removal efficiency standard does not equate to a specific emission limitationF3 11t-0.1103ous waste burning bonaan heehat permi7Howeveron volumeCFR Part 26 protective, additional site-specific risk-based limits should generally not be needed. However, if the regulatory limit is not sufficiently protective, a lower site-specific risk-based emissions limit for HCl or Cl_2 may need to be established in the RCRA permit to assure protection of human health and the environment.

When it is appropriate to establish a lower, site-specific risk-based emission limit for HCl or Cl_2 in the RCRA permit to supplement applicable regulatory standards, then EPA OSW recommends that stack emission measurements for both HCl and Cl_2

purpose of reviewing the MACT control parameters in this guidance is to identify the feed and operating conditions that influence HCl and Cl_2 emissions, as well as to highlight the controls which will be implemented at most hazardous waste combustors in accordance with the requirements of the MACT rule. To the extent that risks from HCl and Cl_2 emissions are already adequately controlled by regulatory limits on key control parameters, then fewer site-specific risk-based limits may be needed in the RCRA permit. However, if regulatory controls are not applicable or sufficiently comprehensive, then additional site-specific risk-based limits may be warranted to ensure protection of human health and the environment.

Risk-based limits for chlorine feed rates, scrubber parameters, and maximum HCl and Cl_2 emission rates may be established in the RCRA permit based on the risk burn and risk assessment as necessary for protection of human health and the environment. Alternatively, the permit writer may determine that limits imposed pursuant to MACT or other regulatory provisions are sufficient. Fewer permit limitations based on the risk burn may be necessary when the risk burn can be performed in conjunction with a RCRA trial burn or MACT performance test. A greater number of risk-based permit limitations may be necessary when the risk burn and RCRA or MACT performance tests reflect different operating modes.

TABLE 7-1

MACT CONTROL PARAMETERS ASSOCIATED WITH HYDROGEN CHLORIDE AND CHLORINE EMISSIONS (continued)

	Control Parameter	Limits From	Averaging Period	How Limit Is Established	Other Considerations

7.2 PARTICLE-SIZE DISTRIBUTION

Information on particle-size distribution and particle density are recommended for the air dispersion and deposition modeling that supports risk assessments (EPA 1998a and 1999b). Particle size and particle density directly affect particle terminal velocity. Large particles fall more rapidly than small particles and are more easily removed from the atmosphere by precipitation. Smaller particles have lower terminal velocities, and very small particles remain suspended in the air flow (EPA 1998a). For site-specific risk assessments, EPA OSW has recommended that most metals and a few organics with very low volatility be assumed to occur only in the particle phase (EPA 1998a). EPA OSW has recommended that mercury and more volatile organics be assumed to partition between the particle and vapor phases. Very volatile organics are modeled only in the vapor phase (EPA 1998a).

Because particle dispersion and deposition are directly related to particle size, predicted ambient impacts and associated risks are also highly dependent on particle-size distribution. A particle-size distribution that is more heavily weighted towards larger particles will result in higher deposition near the source, and reduced air concentration and deposition further away from the source. A particle-size distribution that is more heavily weighted towards smaller particles will decrease deposition near the source, and increase air concentrations and deposition away from the source. In general (but not necessarily in every case), higher deposition near the source is expected to result in higher risks. However, the relationship between deposition and risk will vary, depending on the size of the site and the location of potential receptors relative to maximum deposition. In an air model sensitivity analysis (The Air Group 1997), the particle-size distribution element was found to be a “moderately” sensitive parameter on a scale of “none” to “severe” sensitivity. Moderate sensitivity meant that site-specific data could result in variations in the model outputs of up to 50 percent from default assumptions.

In many cases, the APCD equipment is the primary determinant of particle size and total particle mass emitted from hazardous waste combustion facilities. Advances in air pollution control technology have led to improvements in particulate removal efficiency. Removal efficiencies typically decrease as particle size decreases (i.e., smaller particles are more difficult to remove). According to the proposed MACT rule (EPA 1996a), cyclone separators have typical removal efficiencies of less than 20 percent for particles less than 1 micron in diameter, and about 5 percent for particles less than 0.5 microns in diameter. Fabric filters are extremely efficient and have reported removal efficiencies of 99 to 99.99 percent for particles as low as 0.1 micron in diameter. ESPs are less efficient at capturing particles in the 0.1 to 1.0 micron range and have reported removal efficiencies of 90 to 95 percent (EPA 1999f). Based on these observations, a well-operated APCD greatly decreases the potential mass and mean particle size emitted from combustion facilities.

Some hazardous waste combustion facilities are not equipped with APCD devices. For these facilities, particle-size distribution is driven strictly by combustor design, feed composition, combustion quality, and flue gas cooling profile. In a comparison of particle-size distributions for two different types of combustion equipment, Linak found significantly different distributions (Linak and others 1999) . A laboratory scale refractory-lined combustor, which was shown to simulate the combustion conditions of a large utility residual oil fired boiler with respect to particulate emissions, produced very fine particulate with a mean diameter around 0.1 micron. Conversely, a pilot scale fire-tube package boiler produced a small fraction (approximately 0.2 percent) of mass with particle diameters less than 0.1 micron, and a very large fraction (approximately 99.8 percent) of the mass with particle diameters between 0.5 and 100 microns. The larger particles were shown to be porous, carbonaceous cenospheres resulting from poor carbon burnout.

7.2.1 Model Inputs

Particle-size inputs to the air dispersion and deposition model include: 1) particle density; 2) mass distribution by particle-size category; and 3) surface area distribution by particle-size category. A minimum of three particle-size categories (>10 microns, 2-10 microns, and <2 microns) are recommended (EPA the model to represent all particle mass (EPA 1998a). The use of a 1.0 micron particle-size results in the particles behaving similar to a vapor in the air model.

7.2.2 Test Conditions for Measuring Particle-Size Distribution

EPA OSW recommends that particle-size data generally be collected under normal operating conditions where ash spiking is not performed. Ash spiking will bias the particle-size distribution and is not likely to be representative of ongoing emissions in terms of particle size.

In lieu of sampling during normal operating conditions, a facility may prefer to measure particle-size distribution during the worst-case test conditions (when these tests do not involve ash spiking). In this case, EPA OSW recommends that the particle-size distribution measurement generally be performed during both the high temperature and low temperature operating extremes. Finer particles are likely to result from higher combustion temperatures, good combustion conditions, and rapid flue gas cooling profiles. Larger particles may be associated with poorer combustion situations or slower flue gas cooling profiles (such as through a heat exchanger or waste heat boiler). Testing during both the high temperature and low temperature operating extremes will allow potential variations in particle-size distribution to be determined and subsequently reflected in the air modeling.

Finally, soot blowing practices at a boiler may affect particle-size distribution. Normal soot blowing practices should generally be determined from the facility's operating record and reflected during one run of the particle-size determination. To the extent possible, EPA OSW recommends that the timing of the soot blowing and particle-size testing be coordinated so that soot blowing is not over-represented or under-represented in the sample, as compared to the number of hours per day that soot blowing normally occurs.

7.2.3 Alternatives When Site-Specific Measurements Are Not Available

In some cases, a site-specific particle-size distribution measurement will not be available. For example, a proposed new facility that needs to develop a particle-size distribution estimate may decide to use a representative distribution from a similar device as recommended by the EPA OSW risk assessment guidance

(EPA 1998a). Stack measurements from a similar unit equipped with similar APCD are preferred whenever possible. However, in the event that stack data from a similar unit are not available, a facility may explore several options. These include: 1) using literature estimates for similarly equipped facilities, 2) using APCD vendor estimates, or 3) performing multiple air and risk modeling runs to bound the range of potential impacts. Each of these options is discussed further below.

7.2.3.1 Literature Estimates

If a particle-size distribution stack measurement is not available for the actual facility (or for a similar facility), the use of a literature estimate may be considered. The literature estimate should generally match the actual facility as closely as possible with respect to the types of fuels and wastes burned and APCD equipment.

For sources equipped with ESPs or fabric filters, the EPA OSW risk assessment guidance (EPA 1998a)

always preferred.

7.2.3.2 APCD Vendor Estimates

In some cases, a facility may be able to obtain particle-size distribution data from the APCD vendor if site-specific data are not available. For example, vendor data for sources equipped with HEPA filters may be sufficient for estimating mass distributions within the three particle-size categories (>10 microns, 2-10 microns, and <2 microns) because 100% of the particle mass would be expected to be below 2 microns in diameter downstream of a HEPA filter.

7.2.3.3 Multiple Modeling Runs to Bound Potential Impacts

Another option when site-specific particle-size distribution data are not available is to perform multiple air and risk modeling runs, using a range of assumed size distributions, to bound the range of potential impacts. For this option, EPA OSW recommends that three different size distributions be modeled to determine the highest impacts for site-specific receptors considering all exposure pathways:

- 100% mass at 1 micron in diameter;
- 100% mass at 5 to 7.5 microns in diameter;
- 100% mass at 12 to 15 microns in diameter.

This approach may be very resource-intensive, but should assure that predicted impacts are conservatively bounded by the risk assessment in the absence of site-specific particle-size data.

CHAPTER 8

DATA ANALYSIS

Once the risk burn has been completed and emissions data are available, the data can be analyzed and the risk assessment can be performed. This chapter (Section 8.1) discusses consolidation of the emissions data from each risk burn test condition prior to evaluation in the risk assessment. This chapter (Section 8.2) also identifies various emissions scenarios that may be evaluated in the risk assessment. Since a risk burn can involve multiple test conditions, EPA OSW recommends that the permit writer and facility give early consideration to how the data from more than one test condition will be combined for subsequent evaluation. In addition, EPA OSW recommends that the permit writer and facility consider whether the risk burn data will be evaluated in conjunction with emissions estimates that may be based on information other than the risk burn (for example, emissions corresponding to an applicable regulatory standard).

8.1 DATA REDUCTION AND COPC SELECTION

A large amount of data will be generated during the risk burn, and these data will need to be reduced prior to evaluation in the risk assessment. Consolidation of data for each risk burn test condition, including treatment of non-detects, is discussed in Section 8.1.1. Section 8.1.2 explains how constituents which are not detected in any test run are addressed in the COPC selection process.

8.1.1 Data Reporting and Treatment of Non-Detects

Consolidation of risk burn emissions data prior to evaluation in a risk assessment is a multi-step process. First, analytical results for the various fractions of a stack gas sampling train are summed to determine a train total. A train total is reported for each constituent and each test run. Eventually, the reported results for three test runs are consolidated to arrive at a test condition total. At several points in the process, questions arise regarding how to treat non-detects. The EPA OSW risk assessment guidance (EPA 1998a)

found in the EPA OSW risk assessment guidance (EPA 1998a). A compound may be excluded from the COPC list if: 1) it is not present in the waste being burned, and 2) it does not have a high potential to be emitted as a PIC, and 3) it has no potential of being emitted and is not of concern due to other site-specific factors (such as background concentrations and community or regulatory concern) (EPA 1998a). Based on this COPC selection process, some constituents that are not detected during any of the test runs and which meet the specified criteria will be eliminated from further consideration in the risk assessment.

In the COPC selection process, EPA OSW recommends that care be taken not to eliminate non-detected constituents that may be limited quantitatively in the final permit, because compliance with an emission rate limit of zero cannot be determined. Quantitative emission limits for certain toxic and bioaccumulative constituents may be established in the final permit to ensure that emissions of those constituents do not exceed the levels which were evaluated in the risk assessment and found not to pose a significant risk to human health and the environment. Constituents which may be candidates for risk-based emission limits in the final permit include D/Fs, specific metals, HCl and Cl_2, and significant waste constituents (for example, chemical warfare agents). Although emission limits for individual organics other than D/Fs may not be routinely established, the permit writer may limit other organic contaminants that are found to be risk drivers, as appropriate.

At the conclusion of the COPC selection process, the constituents retained as COPCs will include: 1) constituents detected in at least one run of the risk burn, 2) constituents which are not detected during the risk burn, but which cannot be excluded as COPCs because they have the potential to be emitted or are otherwise of concern, and 3) constituents which may be limited by quantitative emission rates in the final RCRA permit. For constituents which are not detected but are retained as COPCs, EPA OSW has recommended that the full RDL or EDL generally be used in calculating an emission rate for each run and each test condition for subsequent evaluation in the risk assessment (EPA 1998a).

The final step in the risk burn data consolidation process is calculation of a test condition emission rate from the three test runs. For each test condition, EPA OSW has recommended that the emission rate for each constituent be calculated as the 95th percentile of the arithmetic test mean, or the maximum value from the three test runs, whichever is lower (EPA 1998a). The EPA OSW risk assessment guidance (EPA 1998a and

1999b) recommends that emissions data from the risk burn be evaluated in a site-specific risk assessment to provide reasonable maximum exposure (RME) estimates of potential risks to human and ecological receptors. Results from probabilistic risk assessments show that setting as few as two factors at RME levels or high end (e.g., near the 90th percentile) while the remaining variables are set at less conservative, typical or "central tendency" values (e.g., near the 50th percentile) results in a product of all input variables at an RME level (e.g., 99th percentile value) (EPA 1998a). The EPA OSW risk assessment guidance identifies risk burn emissions data as one of the variables that is recommended to be set at the RME level.

8.2 EMISSION SCENARIOS TO BE EVALUATED FOR RISK

Once the risk burn data have been consolidated for each test condition and COPCs have been selected as discussed in Section 8.1, the risk assessment can be performed When a risk burn involves multiple test conditions, the permit writer and facility will need to decide whether the data from each test condition should be evaluated separately, or whether the data will be combined in some manner. In addition, decisions will be needed regarding evaluation of emissions beyond those measured during the risk burn. For example, a facility may prefer to evaluate risks associated with emissions at a regulatory standard or with an emissions estimate (i.e., zero SRE) in the risk assessment. This section identifies various emissions combinations that may be evaluated for risk.

Consolidation of data from multiple test conditions can encompass a range of options, depending on how the test conditions are structured and how the data will be presented for the risk management decision. EPA OSW recommends that these options be considered carefully prior to establishing test conditions and subsequent data collection. As discussed in Chapter 3, EPA OSW recommends that the emissions scenarios to be evaluated in the risk assessment be clearly identified in the risk burn plan, and that the test plan also indicate whether the risk assessment will consider emissions estimates based on information other than the risk burn.

Possible emissions scenarios to be evaluated for risk include: 1) calculation of risk ranges corresponding to specific test conditions (e.g., DRE and SRE); 2) consolidation of the highest emissions data from multiple test conditions for calculation of a single high-end risk value; 3) combining test data with emission rate

by assuming zero SRE at a maximum mercury feed rate instead of spiking mercury during the SRE test. This maximum mercury emissions estimate could be combined with the measured emissions data for calculation of either a risk range or a single risk estimate.

Combining Test Data with Regulatory Standards

Finally, the facility described thus far may be planning for future compliance with the hazardous waste combustor MACT standards. The facility may have determined that physical modifications to the combustion system are not needed, but plans to reduce the feed rate of certain metals to meet the MACT standards. The facility may decide to evaluate an extra scenario in the site-specific risk assessment to reflect post-MACT operation. In this scenario, the MACT emission rate limits for D/Fs, metals, and HCl/Cl_2 might be evaluated in the risk assessment, together with emissions data for the non-MACT metals collected during the SRE test condition and the non-D/F organic emissions data from the DRE test condition of the risk burn.

Obviously, if a facility collects emissions data under additional test conditions, then the data management and analysis options become more complex. As explained in Chapter 3, EPA OSW recommends early communication and coordination between the permit writer and facility.

Finally, EPA OSW recommends that recent EPA direction in characterizing and communicating risk (EPA 1995c) to the public be considered. The *Guidance for Risk Characterization* (EPA 1995c) recommends that risk assessments include risks based on data reflecting both RME and central tendency (average) conditions. As appropriate, site-specific risk assessments may be completed based on both RME and average emissions data. This could assist in the risk communication process by allowing the facility and EPA to discuss a broader risk range with the public and to consider effects of variations in operating conditions on potential risks. However, RME conditions are generally expected to form the basis of permit conditions.

CHAPTER 9

RISK-BASED PERMIT CONDITIONS

After the site-specific risk assessment is performed and results are available, a final decision can be made regarding inclusion of risk-based conditions in the RCRA permit. The final RCRA permit represents an important and integral conclusion to the risk-based permitting process. The final permit identifies the operational conditions that are necessary to protect human health and the environment, and how that will be assured on an ongoing basis. This chapter concludes the ongoing dialogue provided throughout this document regarding potential risk-based permit terms.

Risk-based permit terms may be appropriate when emissions are projected to present a significant risk to human health and the environment. The EPA OSW risk assessment guidance (EPA 1998a) recommends several options when a risk assessment indicates potentially significant risks, and these options are repeated here for the convenience of the reader:

- Collecting additional site-specific information that is more representative of the exposure setting and performing additional iterations of the risk assessment based on the new information;
- Establishing permit terms (for example, waste feed limitations, process operating conditions, or environmental monitoring) to limit operations and performing additional iterations of the risk assessment to demonstrate that the resulting emissions are protective of human health and the environment;
- Denying the permit, if the initial risk assessment or subsequent iterations indicate potentially unacceptable risks.

However, even if the risk assessment indicates that projected risks will not be significant, risk-based permit terms may still be necessary to protect human health and the environment by ensuring that emissions remain below the levels which were measured during the risk burn and found to be protective. The risk burn and risk

consideration in determining appropriate permit terms. If the potential risks associated with all foreseeable operating modes and operating extremes are insignificant, it may be appropriate for the permit writer to conclude that risk-based permit conditions are not necessary to protect human health and the environment, and to simply document the basis for the risk assessment emissions assumptions in the administrative record. In some cases, it may be appropriate for the permit writer to incorporate general monitoring and reporting provisions into the final permit to protect human health and the environment by ensuring that significant changes that could affect emissions (including types of wastes treated or major changes to operating parameters) are reported to EPA or the appropriate state agency. When potential risks are more significant, a permit writer may conclude that specific permit limits are necessary to protect human health and the environment. As identified in Chapter 3, risk-based permit terms may take the form of emission limits and specifications for periodic stack testing, restrictions on feed or operating control parameters and associated monitoring provisions, or some combination.

In summary, the emission rates (and related feed and operating conditions) that are demonstrated during the risk burn and evaluated in the risk assessment should clearly correspond to potential permit terms and conditions. The permit terms can ensure protection of human health and the environment by prohibiting operations outside of the operating boundaries represented by a risk burn and risk assessment that demonstrates emissions will not pose a significant risk. When a permit decision involves the use of a site-specific risk assessment, final RCRA permit terms will ultimately depend on the operating practices, emission levels, and risk results specific to each facility, and the permit writer should work closely with the facility to determine appropriate conditions for the risk burn and a corresponding permit approach. Illustrations are provided in Appendix A.

REFERENCES

Acharya, P., DeCicco, S.G., Novak, R.G. 1991. “Factors that Can Influence and Control the Emission of Dioxins and Furans from Hazardous Waste Incinerators.” Journal Air and Waste Management Association. 41: 1605-1615. December.

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. "Toxicological Profile for Copper." December.

ATSDR. 1999. "Toxicological Profile for Aluminum." Availability Announced in Federal Register 64:51322. September 22.

The Air Group. 1997. “Model Parameter Sensitivity Analysis.” May 23.

Alcock, R.E., Gemmill, R., and Jones, K.C. 1999. “Improvements to the UK PCDD/F and PCB Atmospheric Emission Inventory Following an Emissions Measurement Programme.” Chemosphere. 38:759-770.

Altwicker, E.R., Konduri, R.K.N.V., Milligan, M.S. 1990a. “Role of Precursors in Formation of Polychloro-dibenzo-p-dioxins and Polychloro-dibenzofurans During Heterogeneous Combustion.” Chemosphere. 20:1935-1944.

Altwicker, E.R., Schonberg, J.S., Ravi, K., Konduri, N.V., and Milligan, M.S. 1990b. "Polychlorinated Dioxin/Furan Formation in Incinerators." Hazardous Waste and Hazardous Materials. 7(1): 73.

Bailiff, Megan D. and Kelly, Kathryn E. 1990. “Hexavalent Chromium in Hazardous Waste Incineration Facilities: From Stack Emissions to Health Risks.” Presented at the American Waste Management Association International Specialty Conference on Waste Combustion in Boilers and Industrial Furnaces. Kansas City, Missouri. April.

Berger, R., Baumbach, G., Vatter, J., and Hagenmaier. 1996. "Emissions of Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans of an Industrial Incineration Process at a Precious Metal Recovery Facility in Germany and their Reduction."   Presented at the 1996 International Conference on Incineration and Thermal Treatment Technologies. Savannah, Georgia. May.

Branter, Curtis, Conley, Dennis, Corrigan, Shannon, Moser, David. 1999. “Completion of the INEEL’s WERF Incinerator Trial Burn.” Presented at the 1999 International Conference on Incineration and Thermal Treatment Technologies. Orlando, Florida. May.

Bruce, Kevin R., Beach, Laura O., Gullett, Brian K. 1991. “Copper-Based Organic Catalysis in Formation of PCDD/PCDF in Municipal and Hazardous Waste Incineration.” Presented at the 1991 Incineration Conference. Knoxville, TN. May.

Bruce, K.R. 1993. "Effect of Sulfur on Formation of PCDD/PCDF During Incineration." Presented at the 1993 International Conference on Incineration and Thermal Treatment Technologies. Knoxville, Tennessee. May.

Buekens, A. and Huang, H. 1998. “Comparative Evaluation of Techniques for Controlling the Formation and Emission of Chlorinated Dioxins/Furans in Municipal Waste Incineration.” Journal of Jul224T522 74.88 TD TDiox0 -162:1-33D -0.0945 Tc 0.2145 Tw 5uekens, 17and HuaCesmebasi, E., Dempsey, Griffin, R.D. 1986. "A New Theory of Dioxin Formation in Municipal Solid Waste Combustion." Chemosphere. 15: 1987 - 1990.

Gullett, Brian K., Bruce, Kevin R., Beach, Laura O. 1990. “Formation of Chlorinated Organics During Solid Waste Combustion.” Waste Management & Research. 8:203-214.

Gullett, Brian K., Bruce, Kevin R., Beach, Laura O., Drago, Ann M. 1992. “Mechanistic Steps in the Production of PCDD and PCDF During Waste Combustion.” Chemosphere. 25:1387-1392.

Gullett, Brian K. and Lemieux, P.M. 1994. “Role of Combustion and Sorbent Parameters in Prevention of Polychlorinated Dibenzo-p-dioxin and Polychlorinated Dibenzofuran Formation during Waste Combustion.” Environmental Science and Technology. 28:107-118.

Gullett, Brian K. and Raghunathan, K. 1997. “Observations on the Effect of Process Parameters on Dioxin/Furan Yield in Municipal Waste and Coal Systems.” Chemosphere. 34: 1027-1032.

Gullett, Brian K. 1999. Personal communication between Brian Gullett, EPA ORD, and Beth Antley, EPA Region 4..

Gullett, B.K., Sarofim, A.F., Smith, K.A., Procaccini, C. 2000a. “The Role of Chlorine in Dioxin Formation.” Trans IChemE. Vol. 78, Part B. January.

Gullett, Brian K., Dunn, James E., Raghunathan, K. 2000b. “Effect of Cofiring Coal on Formation of Polychlorinated Dibenzo-*p*-Dioxins and Dibenzofurans during Waste Combustion.” Environmental Science & Technology. 34:282-290.

Gullett, Brian K., Touati, Abderrahmane, Lee, Chun Wai. In press. “Formation of Chlorinated Dioxins and Furans in a Hazardous-Waste-Firing Industrial Boiler.” Accepted for Publication in Environmental Science & Technology.

Handrich, Charles W. 1999. “Results of Risk Burn Data for Boilers and Industrial Furnaces in Louisiana.” Presented at the 1999 International Conference on Incineration and Thermal Treatment Technologies. Orlando, Florida. May.

Harris, R.E., Lanier, W.S., and Springsteen, B.R. 1994. "PCDD and PCDF Emission Characteristics from Hazardous Waste Burning Cement Kilns." Presented at the 1994 International Conference on Incineration and Thermal Treatment Technologies. Houston, Texas. May.

Hasselriis, Floyd. 1987. “Optimization of Combustion Conditions to Minimize Dioxin Emissions.” Waste Management & Research. 5: 311-326.

Karasek, F.W. and Dickson, L.C. 1987. “Model Studies of Polychlorinated Dibenzo-p-Dioxin Formation During Municipal Refuse Incineration.” Science. 237:754-756.

Kilgroe, James D., Nelson, Patrick L., Schindler, Peter J, Lanier, W. Steven. 1990. “Combustion Control of Organic Emissions from Municipal Waste Combustors.” Combustion, Science and Technology. 74:223-244.

Kilgroe, James D. 1996. “Control of Dioxin/Furan and Mercury Emissions from Municipal Waste Combustors.” Journal of Hazardous Materials. 47:163-194.

Lanier, W.S., Stevens, F.M., Springsteen, B.R., and Seeker, W.R. 1996. "Dioxin Compliance Strategies for the HWC MACT Standards." International Conference on Incinerator and Thermal Treatment Technologies. Savannah, Georgia. May.

Lemieux, P.M., Linak, W.P., McSorley, J.A., Wendt, J.O., and Dunn, J.E. 1990. "Minimization of Transient Emissions from Rotary Kiln Incinerators." Combustion Science and Technology. 74: 311-325.

Lemieux, P.M., Linak, William P., McSorley, Joseph, Wendt, Jost O.L. 1991. “Transient Suppression Packaging for Reduced Emissions from Rotary Kiln Incinerators.” Presented at the Second International Congress on Toxic Combustion By-Products: Formation and Control. Salt Lake City, Utah. March.

Lemieux, P.M. and Ryan, J.V. 1998a. "Enhanced Formation of Dioxins and Furans from Combustion Devices by Addition of Trace Quantities of Bromine." Presented at the 1998 International Conference on Incineration and Thermal Treatment Technologies. Salt Lake City, Utah. May.

Lemieux, P.M. and Ryan, J.V. 1998b. "Enhanced Formation of Chlorinated PICs by the Addition of Bromine." Combustion Science and Technology. 134:367-388.

Lemieux, P.M., Lee, C.W., Kilgroe, J.D., and Ryan, J.V. 1999. “Emissions of Polychlorinated Biphenyls as Products of Incomplete Combustion from Incinerators.” Presented at the 1999 International Conference on Incineration and Thermal Treatment Technologies. Orlando, Florida. May.

Linak, William P., McSorley, Joseph A., Wendt, Jost O. L., Dunn, James E. 1987. “Waste Characterization and the Generation of Transient Puffs in a Rotary Kiln Incinerator Simulator.” Presented at the Thirteenth Annual Research Symposium on Land Disposal, Remedial Action, Incineration, and Treatment of Hazardous Waste. Cincinnati, Ohio. May.

Linak, W.P., Ryan, J.V., and Wendt, J.O.L. 1996. "Formation and Destruction of Hexavalent Chromium in a Laboratory Swirl Flame Incinerator." Combustion Science and Technology. 116-117:479.

Linak, W.P. and Wendt, J.O.L. 1998. "Partitioning of the Refractory Metals, Nickel and Chromium, in Combustion Systems." Combustion Science and Technology. 134:291-314.

Linak, William P., Miller, Andrew C., Wendt, Jost O.L. 1999. “Fine Particle Emissions from Residual Fuel Oil Combustion: Characterization and Mechanisms of Formation.” Presented at the 5th International Conference on Technologies and Combustion for a Clean Environment. Lisboa, Portugal. July.

Rigo, H.G., Chandler, A.J., and Lanier, W.S. 1995. "The Relationship Between Chlorine in Waste Streams and Dioxin Emissions from Combustors." Draft. Prepared for the American Society of Mechanical Engineers. January 6.

Ryan, V.R., Lemieux, P.M., Lutes, C., and Tabor, D. 1996. "Development of PIC Target Analyte List for Hazardous Waste Incineration Processes." Presented at the International Conference on Incineration and Thermal Treatment Technologies. Savannah, Georgia. May.

Ryan, J.V., Lemieux, P.M., and Groff, P.W. 1997. "Evaluation of the Behavior of Flame Ionization Detection Total Hydrocarbon Continuous Emission Monitors at Low Concentrations." Presented at the International Conference on Incineration and Thermal Treatment Technologies. Oakland, California. May.

Santoleri, J.J. 1995. "Dioxin Emissions - Effect of Chlorine/Time/Temperature Relationship at 300 ^oC." Presented at the 1995 International Conference on Incineration and Thermal Treatment Technologies. Bellevue, Washington. May.

Santoleri, J.J. 1998. "The Impact of Thermal Oxidation Quench Systems on Dioxin Formation" Presented at the 1998 International Conference on Incineration and Thermal Treatment Technologies. Salt Lake City, Utah. May.

Schofield, B., Eicher, A.R., and Crouch, H.C. 1997. “Conducting the Maximum Waste Feed Rate, Minimum Combustion Temperature Test Condition for Boilers which Might Burn High Btu Waste - A Case Study.” Presented at the 1997 International Conference on Incineration and Thermal Treatment Technologies. Oakland, California. May.

Schreiber, Robert J., Jr. and Strubberg, Kathleen. 1994. “Hydrocarbon Emissions from Cement Kilns Burning Hazardous Waste.” Hazardous Waste & Hazardous Materials. Volume 11, Number 1, pp. 157-167.

Schreiber, R., Evers, Jeffrey J., and Winders, W.H. 1995. “Dioxin Emissions and Cement Kiln Operations.” Proceedings of the Waste Combustion in Boilers and Industrial Furnaces Conference, AWMA. Pittsburgh, Pennsylvania.

Schreiber, Robert J, Jr. 1995. “Dioxin Formation in Cement Kilns: A Case Study.” EI Digest. June.

Schreiber, Robert J., Jr. Undated. “EPA Future Dioxin Standards - Impact on Future Operations.”

Shaub, W.M. and Tsang, W. 1983. "Dioxin Formation in Incinerators." Environmental Science and Technology. 17:721. December.

Sidhu, L., Maqsud, L., Dellinger, B., and Mascolo, G. 1994. "The Homogeneous, Gas-Phase Formation of Chlorinated and Brominated Dibenzo-p-dioxins from 2,4,6-Trichloro and 2,4,6-Tribromophenols." Presented at the 25th Combustion Symposium, the Colloquium on Incineration and Wastes.

Sidhu, Sukh and Dellinger, Barry. 1997. “PCDD/F Formation in Cement Kiln Pre-Heat Zone from Reactions of Raw Meal Hydrocarbons.” Presented at the 1997 International Conference on Incineration and Thermal Treatment Technologies. Oakland, California. May.

Springsteen, B.R., Clark, W., Rizeq, R.G. 1997. “Use of Metals Extrapolation and Surrogates for Evaluating Metals Limits.” Presented at the International Conference on Incineration and Thermal Treatment Technologies. Oakland, California. May.

Stieglitz, L., Zwick, G., Beck, J., Bautz, H., Roth, W., Vogg, H. 1989a. “On the De-Novo Synthesis of PCDD/PCDF on Fly Ash of Municipal Waste Incinerators.” Chemosphere. 18:1219-1226.

Stieglitz, L., Zwick, G., Beck, J., Bautz, H., Roth, W. 1989b. “Carbonaceous Particles in Fly Ash - A Source for the De-Novo-Synthesis of Organochlorocompounds.” Chemosphere. 19:283-290.

Ullrich, R., Davidson, B., and Grater, L. 1996. "Practical Experience with Dioxin Synthesis and Control in a Variety of Full Scale Gas Cleaning Trains." Presented at the 1996 International Conference on Incineration and Thermal Treatment Technologies. Savannah, Georgia. May.

U.S. Environmental Protection Agency (EPA). 1976. “Environmental Assessment Sampling and Analytical Strategy Program.” EPA-600/2-76-093a. May.

EPA. 1983. "Guidance Manual for Hazardous Waste Incinerator Permits." Final. Prepared by the Mitre Corporation for the U.S. EPA Office of Solid Waste. SW-966. July.

EPA. 1989. "Guidance on Setting Permit Conditions and Reporting Trial Burn Results, Volume II of the Hazardous Waste Incineration Guidance Series." Office of Research and Development. EPA/625/6-89/019. January.

EPA. 1990. “Operations and Research at the U.S. EPA Incineration Research Facility. Annual Report for FY-89.” Risk Reduction Engineering Laboratory. ORD. Cincinnati, Ohio. EPA/600/9-90/012.

EPA. 1991. “Burning of Hazardous Waste in Boilers and Industrial Furnaces.” Final Rule. Federal Register 56:7134. February 21.

EPA. 1992a. "Implementation of Boiler and Industrial Furnace (BIF) Regulations - New Toxicological Data." Memorandum from Shiva Garg to EPA Regions 1 through 10. Office of Solid Waste and Emergency Response. February.

EPA. 1992b. "Technical Implementation Document for EPA's Boiler and Industrial Furnace Regulations." Office of Solid Waste and Emergency Response. EPA-530-R-92-001. March.

EPA. 1992c. “Guidance for Data Useability in Risk Assessment (Part A). Final. EPA 9285.7-09A. April.

EPA. 1993. "EPA Draft Strategy for Combustion of Hazardous Waste in Incinerators and Boilers." May 18.

EPA. 1994a. "Implementation Guidance for Conducting Indirect Exposure Analysis at RCRA Combustion Units. Attachment. Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities." Draft Revision. Office of Solid Waste and Emergency Response. EPA530-R-94-021. April 22.

EPA. 1994b. “Strategy for Hazardous Waste Minimization and Combustion.” EPA530-R-94-044. November.

EPA. 1994c. "Combustion Emissions Technical Resource Document." EPA530-R-94-014. May.

EPA. 1995a. "Dioxin Reassessment Review." Science Advisory Board Report. May.

EPA. 1995b. “Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources.” Fifth Edition. AP-42. Research Triangle Park, NC. January, as supplemented.

EPA. 1995c. "Guidance for Risk Characterization." Science Policy Council. February.

EPA. 1996a. "Revised Standards for Hazardous Waste Combustors." Proposed Rule. Title 40 of the Code of Federal Regulations Parts 60, 63, 260, 261, 264, 265, 266, 270, and 271. Federal Register 61: 17358. April 19.

EPA. 1996b. “SW-846, Test Methods for Evaluating Solid Waste.” Fourth Revision. December.

EPA. 1996c. “PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures.” EPA/600/P-96/001. National Center for Environmental Assessment, Office of Research and Development. September.

EPA. 1996d. “Guidance for Total Organics.” EPA/600/R-96/033. National Exposure Research Laboratory. Research Triangle Park, NC. March.

EPA. 1997a. “Mercury Study Report to Congress.” Volumes I through VIII. Final. Office of Air Quality Planning and Standards and Office of Research and Development. December.

EPA. 1997b. “Notice of Draft Source Category Listing for Section 112(d)(2) Rulemaking Pursuant to Section 112(c)(6) Requirements.” Federal Register 62:33625. June 20.

EPA. 1997c. “Health Effects Assessment Summary Tables, FY 1997 Update.” Office of Solid Waste and Emergency Response. EPA-450-R-97-036. PB97-921199. July.

EPA. 1997d. "Revised Technical Standards for Hazardous Waste Combustion Facilities." Proposed Rule. Title 40 of the Code of Federal Regulations Parts 60, 63, 260, 264, 265, 266, 270, and 271. Federal Register 62:24211. May 2.

EPA. 1997e. “Draft Technical Support Document for HWC MACT Standards (NODA), Volume III: Evaluation of Metal Emissions Database to Investigate Extrapolation and Interpolation Issues.” Office of Solid Waste and Emergency Response. RCRA Docket F-97-CS4A-FFFFF. April.

EPA. 1998a. "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities." Peer Review Draft. EPA530-D-98-001. Solid Waste and Emergency Response. July.

EPA. 1998b. “Region 6 Risk Management Addendum - Draft Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities.” EPA-R6-98-002. Region 6 Multimedia Planning and Permitting Division. July.

EPA. 1998c. “EPA QA/R-5: EPA Requirements for Quality Assurance Project Plans.” External Review Draft Final. Quality Assurance Division. October.

EPA. 1998d. “EPA QA/G-5: Guidance on Quality Assurance Project Plans.” EPA/600/R-98/018. Quality Assurance Division. February.

EPA. 1998e. "Development of a Hazardous Waste Incinerator Target Analyte List of Products of Incomplete Combustion." Final Report. Prepared by EPA National Risk Management Research Laboratory, Research Triangle Park, North Carolina, for the Office of Solid Waste. July.

EPA. 1999a. "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (Peer Review Draft) - *Errata*.” Solid Waste and Emergency Response. August 2.

EPA. 1999b. “Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities.” Peer Review Draft. EPA530-C-99-004. Solid Waste and Emergency Response. August.

EPA. 1999c. “NESHAPS: Final Standards for Hazardous Air Pollutants for Hazardous Waste Combustors.” Final Rule. Title 40 of the Code of Federal Regulations Parts 60, 63, 260, 261, 264, 265, 266, 270, and 271. Federal Register 64: 52828. September 30.

EPA. 1999d. "Final Technical Support Document for HWC MACT Standards." In Volume III, "Selection of MACT Standards and Technologies." July.

EPA. 1999e. "Final Technical Support Document for HWC MACT Standards." In Volume IV, "Compliance with the HWC MACT Standards." July.

EPA. 1999f. “Final Technical Support Document for HWC MACT Standards.” In Volume I, “Description of Source Categories.” July.

EPA. 1999g. “Final Technical Support Document for HWC MACT Standards.” In Volume V, “Emission Estimates and Engineering Costs.” July.

EPA. 2000. Integrated Risk Information System (IRIS). On-line Database (http://www.epa.gov/iris).

Van den Berg, M., Birnbaum, L., Bosveld, A., Brunström, B., Cook, P., Feeley, M., Giesy, J.P., Hanberg, A., Hasegawa, R., Kennedy, S., Kubiak, T., Larsen, J.C., van Leeuwen, F., Liem, A., Nolt, C., Peterson, R.E., Poellinger, L., Safe, S., Schrenk, D., Tillitt, D., Tysklind, M., Younes, M., Wærn, F., Zacharewski, T. 1998. “Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife.” Environmental Health Perspectives. 106:775-792. December.

Waterland, L.R. and Ghorishi, S.B. 1997. "Rapid High-Temperature Dioxin Formation: Pilot-Scale Test Results from the U.S. EPA Incineration Research Facility." Presented at the 1997 International Conference on Incineration and Thermal Treatment Technologies. Oakland, California. May.

Wendt, J.O.L., Linak, W.P., Lemieux, P.M. 1990. “Prediction of Transient Behavior During Batch Incineration of Liquid Wastes in Rotary Kilns.” Hazardous Waste & Hazardous Materials. Volume 7, Number 1.

Yonley, Carrie. 2000. Personal communication between Carrie Yonley, Schreiber, Yonley and Associates, and Beth Antley, EPA Region 4.

future MACT compliance (control parameters for minimum combustion temperatures, maximum waste feed rates, and maximum gas flow rates are required to be demonstrated during D/F testing pursuant to MACT). Therefore, Facility Z adds a D/F determination to the DRE test**.**

Non-D/F Organics

The feed and operating conditions that influence organic products of incomplete combustion (PICs) are already represented during the DRE test. Therefore, the facility plans to measure PICs and total organics in conjunction with the DRE performance demonstration. In addition, Facility Z arranges for the sampling contractor to operate a temporary total hydrocarbon continuous emissions monitor during the DRE/PIC testing.

Metals

The SRE tests already involve stack determinations for the five toxic metals identified in the MACT rule. However, Facility Z is concerned that the metals spiking during the SRE tests may result in emissions that exceed risk target values. Therefore, Facility Z proposes a separate test condition for the purpose of generating metals emissions data for the risk assessment. A normal test is proposed (as summarized in Table A.1-1) since Facility Z is capable of defining and maintaining normal operating conditions for metals.

The normal test for metals will be conducted at normal metal feed rates, at a combustion temperature of approximately 1,750 EF and a fabric filter inlet temperature of 450 EF. Emissions testing will be performed for eighteen metals.

Particle-Size Distribution

For Facility Z, the fabric filter will be the primary determinant of particle-size distribution. Therefore, significant variation in particle-size distribution between the different test conditions is not expected. A particle-size determination is added to the normal test, since this test does not include ash spiking**.**

HCl and Cl_2

Determinations for HCl and Cl_2 are already included in the SRE tests, and this data can also be used for the risk assessment.

TABLE A.1-1

FACILITY Z TEST CONDITIONS

	TEST CONDITIONS AND EMISSIONS DETERMINATIONS			
	DRE	**SRE 1**	**SRE 2**	**NORMAL**
	POHCs, PICs, D/Fs, TOE, Total Hydrocarbons, Carbon Monoxide	Metals, D/Fs, PM, HCl/Cl_2, Carbon Monoxide		Metals, Particle Size
Combustion temperature	1,600 EF	1,850 EF		1,750 EF
Fabric filter inlet temperature	350 EF	550 EF		450 EF
Organic liquid feed rate	Maximum	Maximum		Normal
Aqueous liquid feed rate	Maximum	Minimum		Normal
Combustion gas velocity	Maximum *	Maximum *		Normal
Ash feed rate	Above average	Maximum		Normal
Chlorine feed rate	Maximum	Maximum		Normal
Spiked metal feed rates	N/A	Maximum		Normal
Other metal feed rates	N/A	Normal		Normal
Fabric filter differential pressure	Within manufacturer's specifications	Within manufacturer's specifications		Normal
Venturi differential pressure	Minimum * (or as close as possible)	Minimum *		Normal
Venturi liquid-to-gas ratio	Minimum	Minimum		Normal
Venturi scrubber liquid exit pH	Minimum	Minimum		Normal
Scrubber blowdown rate	Minimum	Minimum		Normal
Carbon feed rate	Minimum	Minimum		Normal

Notes:

* = conflicting parameters

D/Fs = Dioxins/furans
DRE = Destruction and removal efficiency
N/A = Not applicable
PICs = Products of incomplete combustion
PM = Particulate matter
POHCs = Principal organic hazardous constituents
SRE = System removal efficiency
TOE = Total organic emissions

Site-Specific Risk Assessment

Facility Z performs the tests according to the approved test plan. As expected, D/F emissions are highest during the SRE test conditions. Emissions data are consolidated from all of the test conditions for evaluation in a single multi-pathway human health and ecological site-specific risk assessment as follows:

- D/F emissions from the SRE test conditions are evaluated, together with . . .
- Organic PIC emissions from the DRE test condition, and . . .
-

least one of the risk scenarios evaluated. However, since the projected risks came close to approaching target risk levels, the permit writer determines that closer monitoring and control for these metals is warranted. Therefore, quarterly average metals feed rate limits are established in the RCRA permit to ensure that these metals are not fed at higher rates than those demonstrated. With the exception of mercury, the metals feed rate limits are established in the RCRA permit based on feed rates demonstrated during the testing. For mercury, a risk-based feed rate limit is conservatively calculated from the risk-based emissions limit by assuming zero SRE (i.e., 100% of the mercury fed to the unit is emitted).

For the non-mercury metals, quarterly average feed rate limits are established based on two different test scenarios. For arsenic, beryllium, cadmium, chromium and lead, the quarterly average feed rate limits are established based on the SRE test (since the higher feed rates demonstrated during the SRE test were demonstrated to achieve compliance with the MACT standards, and since the MACT standards were shown to be sufficiently protective in the risk assessment). The RCRA permit is written with sunset provisions for the feed rate limits on these five metals. For nickel, quarterly average feed rate limits are established based on the normal test. The risk-based feed rate limits for nickel will remain in the RCRA permit after MACT. Since risks from the remaining eleven metals were very far from target levels, and since target risk levels could not possibly be exceeded based on the wastes burned at Facility Z, the permit writer decides to simply document the risk assessment feed and emissions assumptions for the remaining metals in the administrative record instead of imposing specific feed rate limits in the permit.

Short-term metal feed rate limits are not necessary for the RCRA permit, because acute risks were determined to be negligible (considering the range of inputs for metals at Facility Z). Although the SRE tests were performed for the purpose of establishing short-term metal feed rate limits for arsenic, beryllium, cadmium, chromium, and lead, these limits will apply in the future pursuant to MACT and are not a RCRA concern.

The RCRA permit is written with sunset provisions for all control parameters except for the quarterly average feed rate limits for mercury and nickel.

TABLE A.1-2

FINAL RCRA PERMIT LIMITS FOR FACILITY Z (continued)

		Basis		
Parameter	Value	Test	Established As:	Sunset
Minimum and maximum fabric filter pressure differential	inches water column, HRA	N/A	Manufacturer's specifications	Yes
Minimum venturi scrubber differential pressure	inches water column, HRA	SRE 2	Avg. of the test run averages	Yes
Minimum venturi liquid-to-gas ratio	gal/cfm, HRA	SRE	Avg. of the test run averages	Yes
Minimum venturi scrubber liquid exit pH	pH, HRA	SRE	Avg. of the test run averages	Yes
Minimum carbon injection feed rate	lbs/hr, HRA	DRE/ SRE	Avg. of the test run averages	Yes
Maximum stack carbon monoxide concentration	100 ppm at 7% oxygen, dry basis, HRA	N/A	Limit based on established guidance	Yes
Yes				

TABLE A.1-2

FINAL RCRA PERMIT LIMITS FOR FACILITY Z (continued)

		Basis		
Parameter	**Value**	**Test**	**Established As:**	**Sunset**
Maximum nickel feed rate	lbs/hr, quarterly average	Normal	Avg. of the test run averages	No
Maximum mercury feed rate	lbs/hr, quarterly average [4]	N/A	Feed rate calculated from the risk-based emission limit assuming zero SRE [4]	No
Minimum scrubber blowdown	gpm, HRA	SRE	Avg. of the test run averages	Yes
Carbon adsorption properties	Manufacturer's brand	N/A	Same as test	Yes
Group C Control Parameters				
Maximum heat input	million Btu/hr	N/A	Design basis	Yes
Burner/atomizer: - Maximum viscosity - Maximum turndown - Maximum solids - Minimum atomizing pressure differential	 - centipoise - gpm range - percent solids - psig (interlocked with AWFCO)	N/A	Manufacturer's recommendations	Yes
Minimum venturi scrubber nozzle pressure	psig (interlocked with AWFCO)	N/A	Manufacturer's recommendations	Yes
Minimum carbon carrier fluid nozzle pressure drop	psig (interlocked with AWFCO)	N/A	Manufacturer's recommendations	Yes

Notes:

AWFCO = Automatic waste feed cutoff system
Avg. = Average
Btu/hr = British thermal units per hour
cfm = Cubic feet per minute
D/F = Dioxin/furan
DRE = Destruction and removal efficiency
gal/cfm = Gallons per cubic feet per minute
gpm = Gallons per minute
gr/dscf = Grains per dry standard cubic foot
HRA = Hourly rolling average
lbs/hr = Pounds per hour
N/A = Not applicable
PM = Particulate matter
ppm = Parts per million
psig = Pounds per square inch, gauge
POHC = Principle organic hazardous constituent
SRE = System removal efficiency

TABLE A.1-2

FINAL RCRA PERMIT LIMITS FOR FACILITY Z (continued)

1 Under MACT, the limit will be based on the average of the maximum hourly rolling averages for each run.

2 Under MACT, the averaging period will be 12 hours.

3 Under MACT, the averaging period will be 12 hours and the limit will be based on the average of the maximum hourly rolling averages for each run.

4 Under MACT, the averaging period will be 12 hours and the limit will be based on the maximum theoretical emission concentration assuming that all mercury from all feed streams is emitted.

APPENDIX A.2

RISK BURN CONDITIONS AND PERMIT LIMITS FOR A ROTARY KILN INCINERATOR BURNING CONTAINERIZED WASTES

Note: This illustrative example does not represent the only approach to structuring a trial burn/risk burn/MACT performance test. Other regulatory and permitting options exist. Test plans and final permit conditions should always be developed on a site-specific basis after close interaction between the regulator and facility.

Appendix A.2 describes the risk burn and resulting permit limits for an example rotary kiln incineration facility (Facility Y). Facility Y burns a variety of waste streams including organic liquids, aqueous wastes, organic sludges, bulk solids, and containerized wastes in a rotary kiln combustion chamber. The rotary kiln is followed by a secondary combustion chamber, where organic liquids and aqueous wastes are fired. The downstream air pollution control system consists of a spray dryer and fabric filter. Facility Y is au Tc i389 is arntwNFhE0 e.

1,400 EF and 1,800 E

maximum total solids feed rate (for both the containerized and bulk feeds combined). Both feeds will consist of contaminated, moist soils with no heating value (this type of material is representative of the bulk solids which are normally burned, and is representative of materials which are sometimes burned in containers). These conditions represent a challenging DRE test because of the heavy loading of solid material forming a heat sink in the rotary kiln. The maximum containerized feed rate for the DRE 1 condition will be 9,000 lbs/hr, and the maximum container size will be 200 lb/hr, resulting in a feeding frequency of 45 drums per hour.

A separate test condition, DRE 2, is necessary to represent containerized feeds consisting of high-heating-value, highly volatile organics. For DRE 2, drums with a total heat content of 2 MM Btu each will be prepared by adding a glass jar of highly volatile, high-heating-value liquid organics to a wood chip/plastic pellet mixture. The drums will weigh 125 pounds each, and will be fed at the maximum rate allowed by the thermal design capacity of the kiln (40 MM Btu/hr). This results in a feeding frequency of 20 drums per hour. The DRE 2 test will be performed at a higher PCC temperature than the other DRE tests, because the higher kiln temperature ensures a maximum volatilization rate. The higher PCC temperature, in combination with the minimum SCC temperature, still represents a worst-case condition for organic destruction for containerized feeds. In addition, combustion gas velocity for the DRE 2 condition will be slightly lower than the other DRE conditions, since excess air to the PCC will be minimized in an attempt to minimize excess oxygen at the location where the containers are fed.

Several batch/containerized feed parameters will not be demonstrated during the testing. Maximum batch size (200 pounds) will be demonstrated during the DRE 1 condition, and maximum batch charge heat content (which is the more important indicator of a situation that could overwhelm the combustion system) will be demonstrated in the DRE 2 condition. However, maximum container feeding frequency will not be demonstrated in either test, because Facility Y cannot simultaneously demonstrate maximum size (or maximum batch charge heat content) and maximum feeding frequency. Larger batches fed less frequently are considered to be worse than smaller batches fed more frequently, within the total targeted feed rate limits for the containerized feeds of 9,000 lbs/hr and 40 MM Btu/hr for the DRE 1 and DRE 2 tests, respectively. In addition, demonstration of maximum kiln rotation speed is not necessary, since the method of introducing volatile liquids in glass jars will ensure a maximum rate of volatilization and puff intensity.

During the DRE 1 and DRE 4 test conditions, maximum total ash feed rate and maximum atomized ash feed rate will be demonstrated. Therefore, stack sampling for particulate matter will be performed during these test conditions.

System Removal Efficiency Test Condition

In anticipation of future MACT compliance, Facility Y adds a test condition to demonstrate system removal efficiencies (SREs) for semivolatile and low-volatile metals (arsenic, beryllium, cadmium, chromium, and lead). Stack determinations for hydrogen chloride (HCl) and chlorine (Cl_2) are also planned for the SRE test, since chlorine will be maximized during this test and worst-case operating conditions for the spray dryer will be demonstrated.

Maximum semivolatile and low-volatile metal feed rates will be achieved by spiking one metal from each of the two volatility groups to the SCC organic liquid feed. Facility Y will base their total metal feed rate limits

For mercury, Facility Y wishes to avoid spiking and will not demonstrate a maximum mercury feed rate during the SRE test. Facility Y plans to conservatively assume that 100% of the mercury fed to the unit is achieve the maximum 400 EF fabric filter inlet temperature at the lower SCC combustion temperatures planned for the DRE tests, the lime slurry feed rate will have to be lowered from the feed rate planned for the SRE test (which is supposed to represent the minimum). The permit writer and facility agree that this is acceptable, as long as the permit limit for minimum spray dryer slurry feed rate is based on the higher rate demonstrated during the SRE test.

Non-D/F Organics

The feed and operating conditions that influence organic products of incomplete combustion (PICs) are already represented during the DRE test conditions. Therefore, the facility adds PIC and total organic stack emissions determinations to the DRE test conditions. In addition, Facility Y arranges for the sampling contractor to provide a temporary total hydrocarbon continuous emissions monitor during the DRE/PIC testing.

Metals

The SRE test already involves stack determinations for the five toxic metals identified in the MACT rule, and Facility Y has performed a preliminary risk assessment which indicates that the MACT emission standards for semivolatile and low-volatile metals should be sufficiently protective.

be performed at the conclusion of the risk burn after the facility returns to normal operation.

HCl and Cl_2

Determinations for HCl and Cl_2 are already included in the SRE test, and this data can also be used for the risk assessment.

TABLE A.2-1

FACILITY Y TEST CONDITIONS

	TEST CONDITIONS AND EMISSIONS DETERMINATIONS				
	POHCs, PICs, D/Fs, TOE, Total Hydrocarbons, Carbon Monoxide PM (DRE 1 and 4 only)				Metals, HCl/Cl$_2$, Carbon Monoxide
	DRE 1	**DRE 2**	**DRE 3**	**DRE 4**	**SRE**
PCC combustion temperature	1,400 EF	1,800 EF	1,400 EF	1,400 EF	1,800 EF
SCC combustion temperature	1,800 EF	1,800 EF	1,800 EF	1,800 EF	2,200 EF *
Fabric filter inlet temperature	400 EF	400 EF	400 EF	400 EF	400 EF *
PCC organic liquid feed rate	**Maximum**	Minimal	Minimal	High	Maximum
PCC aqueous liquid feed rate	Minimal	Minimal	**Maximum**	Minimal	N/A
PCC organic sludge feed rate	Normal	Minimal	**Maximum**	Normal	N/A
PCC bulk solids feed rate	**Maximum**	Minimal	Minimal	Minimal	N/A
PCC container feed rate - total lb/hr - lbs/drum - drums/hr - MM Btu/drum - MM Btu/hr	**Maximum (mass input)** 9,000 200 45 0 0	**Maximum (thermal input)** 2,500 125 20 2 40	Minimal	Minimal	N/A
SCC organic liquid feed rate	**Maximum**	High	High	High	Maximum
SCC aqueous liquid feed rate	Minimal	Minimal	Minimal	**Maximum**	N/A
Thermal input, MM Btu/hr - PCC - SCC - Total	 42 41 83	 45 33 78	 45 35 80	 42 40 82	N/A
Combustion gas velocity	Maximum**	High **	Maximum**	Maximum**	Maximum**
Ash feed rate	Maximum total ash	N/A	N/A	Maximum atomized ash	N/A
Chlorine feed rate	Above average	Above average	Above average	Above average	Maximum

TABLE A.2-1

FACILITY Y TEST CONDITIONS (continued)

Site-Specific Risk Assessment

Facility Y performs the tests according to the approved test plan. Emissions data are consolidated from the test conditions for evaluation in four (4) separate multi-pathway human health and ecological site-specific risk assessment scenarios corresponding to each of the DRE 1, DRE 2, DRE 3 and DRE 4 test conditions as follows:

- D/F emissions and organic PIC emissions from each DRE test condition are evaluated, together with . . .
- Metals emissions (18 metals) from the SRE test condition, and . . .
- HCl and Cl_2 emissions from the SRE test condition.

Total chronic risks for all four risk scenarios are determined to be below target levels.

An acute risk evaluation is also performed to assess inhalation risks associated with maximum potential one-hour emissions.   Maximum one-hour emissions for the acute evaluation are estimated for D/Fs , other organics, and HCl/Cl_2 based on the test data listed above, with an upward adjustment to reflect upsets. However, for metals, the test data are not representative of maximum potential one-hour emissions. For the metals represented by the spiked metals (arsenic, beryllium, cadmium, chromium, and lead), the facility uses an approved extrapolation procedure to estimate maximum one-hour emission rates based on maximum

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tests, as well as the metals emissions for the non-MACT metals measured during the SRE test. Total chronic risks from these consolidated emissions are determined to be below target levels.

Final Permitted Emission Rates

As summarized in Table A.2-2, maximum emission rate limits are established in the RCRA permit for D/Fs, metals, and HCl/Cl_2 based on the levels needed to achieve target risk levels. The limits are established for the purpose of periodic verification testing to ensure that emissions remain below those evaluated in the risk assessment. If emissions increases occur above the permitted levels, then the permit calls for the risk assessment to be repeated. Since none of the non-D/F organics were found to be risk drivers, emission limits for individual non-D/F organic compounds are not established in the permit.

The "post-MACT scenario" risk evaluation showed that the MACT standards for D/Fs, metals, and HCl/Cl_2 will be sufficiently protective. Therefore, the RCRA permit includes "sunset" provisions on the emission limits for these pollutants in the RCRA permit. In this instance, the sunset provisions are structured so that the RCRA emission limits will no longer apply once the facility has documented compliance with MACT, and once the regulatory agency has completed a finding of compliance. Emission limits for the non-MACT metals (aluminum, antimony, barium, cobalt, copper, manganese, nickel, selenium, silver, thallium, vanadium, and zinc) will remain in the RCRA permit.

Final Permit Limits for Control Parameters

Table A.2-2 provides the final permit limits on relevant control parameters for Facility Y. During the DRE test conditions, carbon monoxide levels were greater than 100 ppm and total hydrocarbon levels were less than 10 ppm on an hourly rolling average basis. The permit writer establishes the RCRA permit limit for carbon monoxide as the average of the test run averages (i.e., a value greater than 100 ppm). Since carbon monoxide and total hydrocarbon spikes appeared to track pretty closely, the permit writer determines that there is no need to specify continued total hydrocarbon monitoring as a RCRA permit condition prior to MACT. However, after MACT, the facility will comply with a total hydrocarbon limit of 10 ppm instead of with the limit on carbon monoxide.

With the exception of mercury, quarterly average metals feed rate limits are established in the RCRA permit based on the feed rates demonstrated during the SRE test. For mercury, a risk-based feed rate limit is conservatively calculated from the risk-based emission limit by assuming zero SRE (i.e., 100% of the mercury fed to the unit is emitted).

Short-term metal feed rate limits are not necessary for the RCRA permit, because acute risks were determined to be negligible (considering the range of inputs for metals at Facility Y). Although the SRE tests were performed for the purpose of establishing short-term metal feed rate limits for arsenic, beryllium, cadmium, chromium, and lead, these limits will apply in the future pursuant to MACT and are not a RCRA concern.

The RCRA permit is written with sunset provisions for all control parameters except for the quarterly average feed rate limits on the non-MACT metals, and except for limits on containerized feeds which are not required to be established under the MACT rule. Although MACT will limit total mass feed rate for containers (as well as total hydrocarbons), the historical operating data for Facility Y suggests that preventive controls are needed to preclude overcharging of highly volatile, high-Btu containers. Therefore, the limits on “maximum Btu/drum” and “maximum total containerized thermal input” established based on the DRE 2 test will be retained in the RCRA permit. The RCRA permit may be modified to delete these provisions if similar limitations are placed in the Title V permit for this facility in the future.

TABLE A.2-2

FINAL RCRA PERMIT LIMITS FOR FACILITY Y

		Basis		
Parameter	**Value**	**Test**	**Established As:**	**Sunset**
Summary of Performance Standards and Emission Limits				

TABLE A.2-2

FINAL RCRA PERMIT LIMITS FOR FACILITY Y (continued)

Parameter	Value	Basis		Sunset
		Test		

TABLE A.2-2

FINAL RCRA PERMIT LIMITS FOR FACILITY Y (continued)

Parameter	Value	Basis		Sunset
		Test	Established As:	
Group B Control Parameters				
Limits on most difficult-to-burn POHCs	Allowable Appendix VIII constituents	DRE	Based on POHCs which achieved 99.99% DRE	Yes
Maximum chlorine feed rate	lbs/hr, HRA [4]	SRE	Avg. of the test run averages	Yes
Maximum ash feed rate - total - atomized	lbs/hr, HRA [5]	DRE 1 DRE 4	Avg. of the test run averages [5]	Yes
Maximum feed rates (arsenic, beryllium, cadmium, chromium, and lead)	lbs/hr, quarterly average [4]	SRE	Avg. of the test run averages	Yes
Maximum mercury feed rate	lbs/hr, quarterly average [6]	N/A	Feed rate calculated from the risk-based emission limit assuming zero SRE [6]	Yes
Maximum feed rates (aluminum, antimony, barium, cobalt, copper, manganese, nickel,				

TABLE A.2-2

FINAL RCRA PERMIT LIMITS FOR FACILITY Y (continued)

Parameter	Value	Basis		Sunset
		Test	Established As:	