CHAPTER 7

HAZARDOUS WASTE COMBUSTION

In this chapter…

Overview	III-99
What are the Regulated Units?	III-101
- Incinerators	III-101
- Boilers and Industrial Furnaces	III-101
Regulatory Requirements	III-103
- Combustion Standards under RCRA	III-103
- MACT Standards under the CAA	III-105
Additional Requirements	III-107
Summary	III-107
Additional Resources	III-108

OVERVIEW

A large number of TSDFs use **combustion**, the controlled burning of substances in an enclosed area, as a means of treating and disposing of hazardous waste. Approximately 11 percent of the hazardous nonwastewater generated in the United States in 1999 was treated using combustion. As a hazardous waste management practice, combustion has several unique attributes. First, if properly conducted, it permanently destroys toxic organic compounds contained in hazardous waste by breaking their chemical bonds and reverting them to their constituent elements, thereby reducing or removing their toxicity. Second, combustion reduces the volume of hazardous waste to be disposed of on land by converting solids and liquids to ash. Land disposal of ash, as opposed to disposal of untreated hazardous waste, is in many instances both safer and more efficient.

Combustion is an intricate treatment process. During burning, organic wastes are converted from solids and liquids into gases. These gases pass through the flame, are heated further, and eventually become so hot that their organic compounds break down into the constituent atoms. These atoms combine with oxygen and form stable gases that are released to the atmosphere after passing through air pollution control devices.

The stable gases produced by combustion of organics are primarily carbon dioxide and water vapor. Depending on waste composition, however, small quantities of carbon monoxide, nitrogen oxides, hydrogen chloride, and other gases may form. These gases have the potential to cause harm to human health and the environment. The regulation of these emissions is the primary focus of the RCRA combustion unit standards.

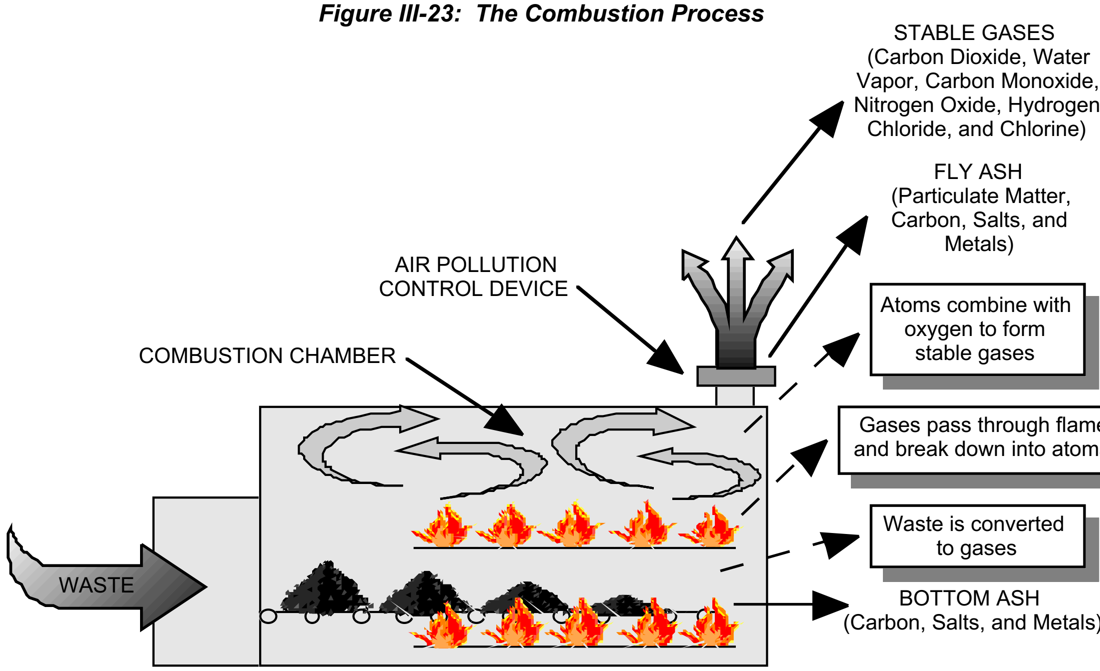
The management or disposal of metals and ash, other by-products of the combustion process, also causes concern. Ash is an inert solid material composed primarily of carbon, salts, and metals. During combustion, most ash collects at the bottom of the combustion chamber (**bottom ash**). When this ash is removed from the combustion chamber, it may be considered hazardous waste via the derived-from rule or because it exhibits a characteristic. Small particles of ash (particulate matter that may also have metals attached), however, may be carried up the stack with the gases (**fly ash**). These particles and associated metals are also regulated by the combustion regulations, as they may carry hazardous constituents out of the unit and into the atmosphere. Since combustion will not destroy inorganic compounds present in hazardous waste, such as metals, it is possible that such compounds may also end up in bottom ash and fly ash at harmful concentrations. Ash residue is subject to applicable RCRA standards and may need to be treated for metals or other inorganic constituents prior to land disposal (see Figure III-23).

In the early years of RCRA, EPA's idea was to combust as much hazardous waste as possible and landfill the resultant ash. This process destroyed the majority of the waste, thus reducing the volume requiring disposal. However, it was determined that incomplete or improperly conducted combustion had the potential to present a major public health risk, and therefore, became the topic of much public outcry. This public concern, coupled with EPA's advancements in assessing potential risks arising from combustion, caused a shift in EPA's strategy on combustion. This shift in thinking resulted in the increasing stringency of combustion requirements over time.

In September 1999, EPA issued a joint Clean Air Act (CAA)/RCRA rule that upgraded the emission standards for hazardous waste combustors, based on the **maximum achievable control technology (MACT)** approach commonly employed under the CAA. This process develops technology-based, emission limits for individual hazardous air pollutants. Much like the BDAT concept for LDR (as discussed in Section III, Chapter 6), the MACT emission standards are based on the performance of a technology. EPA researches available pollution control technologies to determine which available technology is the best at controlling each pollutant to determine allowable emission limits. The regulated community may then use any technology to meet the numeric emission standards set by EPA.

Consistent with EPA's trend of gradually increasing the stringency of standards over time, this joint rule promulgated more stringent emissions standards for dioxins, furans, mercury, cadmium, lead, particulate matter, hydrogen chloride, chlorine gas, hydrocarbons, carbon monoxide, and several low-volatile metals. After the promulgation of this rule, a number of parties representing the interests of both industrial sources and the environmental community, requested judicial review of this rule.

Figure III-23: The Combustion Process



In July 2001, the United States Court of Appeals for the District of Columbia Circuit vacated the challenged portions of the rule. When it made its decision, the Court invited any of the parties to request, either that the current standards remain intact, or that EPA be allowed time to publish interim standards. Acting on this initiative, EPA and the other parties jointly asked the Court for additional time to develop interim standards, and the Court granted this request. On February 13, 2002, EPA published these interim standards which temporarily replace the vacated standards. The interim standards will remain in place until EPA issues final "replacement" standards that comply with the Court's opinion. EPA has also completed other actions agreed to in the joint motion, such as extending the compliance date by one year to September 30, 2003, and finalizing several amendments to the complaince and implementation provisions by February 14, 2002. The MACT standards are discussed later in this chapter.

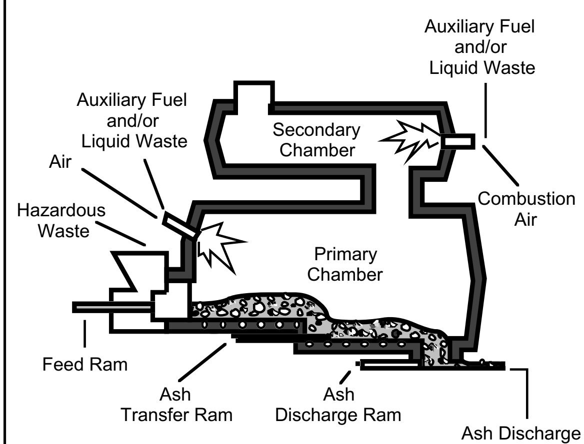
WHAT ARE THE REGULATED UNITS?

Hazardous wastes are combusted for various purposes. The purpose of combustion is directly related to the type of unit used. There are two classes of combustion units, those that burn waste for energy recovery and those that burn waste for destruction.

■ Incinerators

The first class of combustion units are hazardous waste incinerators. Incineration is the combustion of hazardous waste primarily for destruction (i.e., disposal). Incineration is a method of thermal destruction of primarily organic hazardous waste using controlled flame combustion (see Figure III-24). This process can reduce large volumes of waste materials to ash and lessen toxic gaseous emissions. An **incinerator** is an enclosed device that uses controlled flame combustion and does not meet the more specific criteria for classification as a boiler, industrial furnace, sludge dryer (a unit that dehydrates hazardous sludge), or carbon regeneration unit (a unit that regenerates spent activated carbon). Incinerators also include infrared incinerators (a unit that uses electric heat followed by a controlled flame afterburner) and plasma arc incinerators (a unit that uses electrical discharge followed by a controlled flame afterburner).

Figure III-24: Cross-Section of an Incinerator

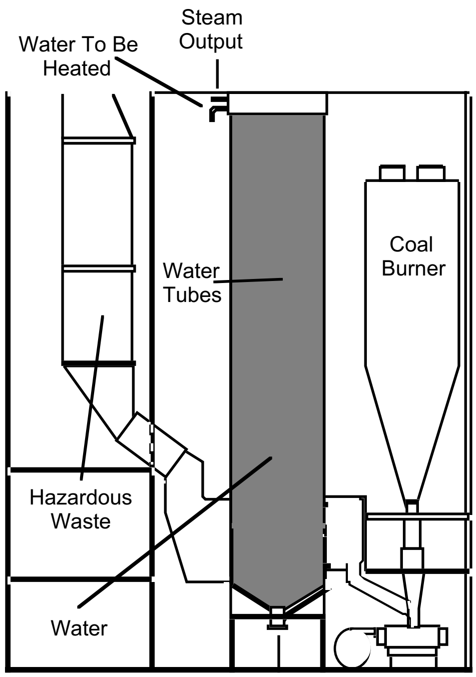


■ Boilers and Industrial Furnaces

The second class of combustion units are BIFs. Boilers are used to recover energy from hazardous waste, while industrial furnaces are used primarily to recover material values.

EPA defines **boilers** as enclosed devices that use controlled flame combustion to recover and export energy in the form of steam, heated fluid, or heated gases. A boiler is comprised of two main parts, the combustion chamber used to heat the hazardous waste and the tubes or pipes that hold the fluid used to produce energy (see Figure III-25). The regulatory definition of boiler requires that these two parts be in close proximity to one another to ensure the effectiveness of the unit's energy recovery system and to maintain a high thermal energy recovery efficiency. In addition, the unit must export or use the majority of the recovered energy for a beneficial purpose.

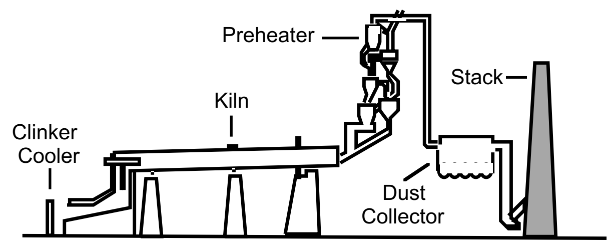
Figure III-25: Cross-Section of a Boiler



Industrial furnaces are enclosed units that are integral parts of a manufacturing process and use thermal treatment to recover materials or energy from hazardous waste (see Figure III-26). These units may use hazardous waste as a fuel to heat raw materials to make a commodity (e.g., a cement kiln making cement) or the unit may recover materials from the actual hazardous waste (e.g., a lead smelter recovering lead values). The following 12 devices meet the definition of an industrial furnace:

- Cement kiln
- Aggregate kiln
- Coke oven
- Smelting, melting, and refining furnace
- Methane reforming furnace
- Pulping liquor recovery furnace
- Lime kiln
- Phosphate kiln
- Blast furnace
- Titanium dioxide chloride process oxidation reactor
- Halogen acid furnace
- Combustion device used in the recovery of sulfur values from spent sulfuric acid.

Figure III-26: Cross-Section of an Industrial Furnace



After notice and comment, EPA may add other devices to this list of industrial furnaces upon consideration of factors related to the design and use of the unit.

Not all units that meet the definition of boiler or industrial furnace are subject to the 40 CFR Part 266, Subpart H, Boiler and Industrial Furnace (BIF) standards. Each individual unit must first be evaluated against a number of exemptions from the BIF requirements. For a variety of reasons (e.g., to avoid duplicative regulation), EPA exempted the following units from the BIF regulations:

- Units burning used oil for energy recovery
- Units burning gas recovered from hazardous or solid waste landfills for energy recovery
- Units burning hazardous wastes that are exempt from RCRA regulation, such as household hazardous wastes
- Units burning hazardous waste produced by CESQGs
- Coke ovens burning only K087 decanter tank tar sludge from coking operations
- Certain units engaged in precious metals recovery
- Certain smelting, melting, and refining furnaces processing hazardous waste solely for metals recovery
- Certain other industrial metal recovery furnaces.

REGULATORY REQUIREMENTS

Emissions from hazardous waste combustors are regulated under two statutory authorities—RCRA and the Clean Air Act (CAA). Applicable RCRA regulations include 40 CFR Part 264, Subpart O, and Part 265, Subpart O, for incinerators and 40 CFR Part 266, Subpart H, for BIFs. RCRA permitting requirements for these units are provided in 40 CFR Part 270. These units are also subject to the general TSDF facility standards under RCRA. Hazardous waste incinerators and hazardous waste burning cement kilns and lightweight aggregrate kilns (LWAKs) are also subject to the CAA MACT emission standards. The MACT standards set emission limitations for dioxins, furans, metals, particulate matter, total chlorine, hydrocarbons/ carbon monoxide, and destruction and removal efficiency (DRE) for organics. Once a facility has demonstrated complance with the MACT standards by conducting its comprehensive performance test and submitting its Notification of Compliance (NOC), it is no longer subject to the RCRA emission requirements with few exceptions. RCRA permitted facilities, however, must continue to comply with their permitted emissions requirements until they obtain modifications to remove any duplicative emissions conditions from their RCRA permits. The combustion standards under RCRA, as well as the MACT standards under the CAA, are discussed below.

■ Combustion Standards under RCRA

Emissions from combustion units may be comprised of a variety of hazardous pollutants. To minimize potential harmful effects of these pollutants, EPA developed performance standards to regulate four pollutant categories: organics, hydrogen chloride and chlorine gas, particulate matter, and metals. Boilers and most industrial furnaces have performance standards that they must meet. For each category or type of emission, the regulations establish compliance methods and alternatives.

Organics

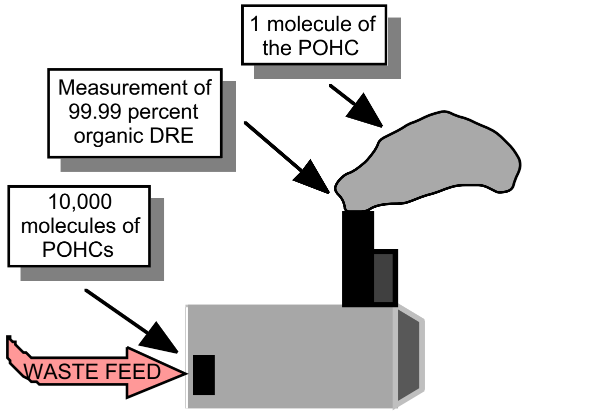
Because the primary purpose of a combustion unit is to destroy the organic components found in hazardous waste, it is essential to verify that the unit is efficiently destroying organics in the waste. This is determined based on the unit's organic **destruction and removal efficiency (DRE)** as demonstrated in a trial burn. Since it would be nearly impossible to determine the DRE results for every organic constituent in the waste, certain **principal organic hazardous constituents (POHCs)** are selected for this demonstration. These POHCs are selected for each facility based on their high concentration in the wastestream and their greater difficulty to burn. If the unit achieves the required DRE for the POHCs, then it is presumed that it will achieve the same (or better) DRE for all other easier-to-burn organics in the wastestream. At least one POHC will be selected from each wastestream that the facility manages. The facility designates the selected POHCs in their permit application (the permitting process for combustion units is fully discussed in Section III, Chapter 8).

The combustion unit must demonstrate a DRE of 99.99 percent for each POHC in the hazardous wastestream. This means that for every 10,000 molecules of the POHC entering the unit, only one molecule can be released to the atmosphere. In addition, due to an increased threat to human health and the environment posed by certain dioxin-containing wastes (F020, F021, F022, F023, F026, and F027), the required DRE for POHCs in these units has been established at 99.9999 percent, or one released molecule for every one million burned (see Figure III-27). These DRE standards must be met by both incinerators and BIFs.

Hydrogen Chloride and Chlorine Gas

Hydrogen chloride and chlorine gases form when chlorinated organic compounds in hazardous wastes are burned. If uncontrolled, this chlorine can become a human health risk and is a large component in the formation of acid rain. EPA has developed different requirements to control the emissions of chlorine from the different classes of combustion units.

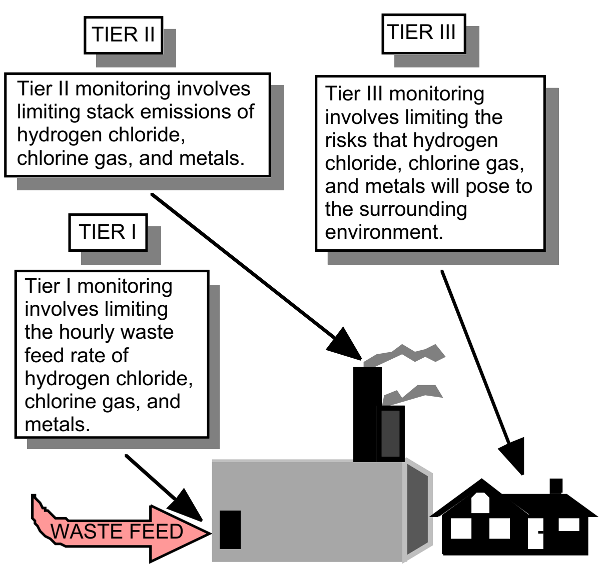
Figure III-27: Performance Standards for Organics



POHCs are chosen based on their high concentration in the wastestream and their greater difficulty to burn. If the unit demonstrates the required DRE for the POHCs, then it is presumed that it will be able to achieve the same (or better) DRE for all other easier-to-burn organics in the wastestream. For every 10,000 molecules of POHCs that enter a combustion process, the unit must destroy 9,999 of them.

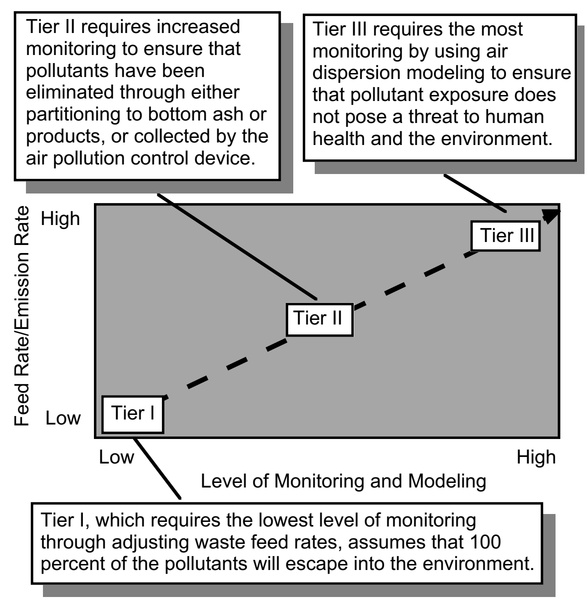
Boilers and most industrial furnaces must follow a tiered system for the regulation of both hydrogen chloride and chlorine gas. The owner and operator determines the allowable feed or emission rate of total chlorine by selecting one of three approaches, called tiers. Each tier differs in the amount of monitoring, and in some cases, air dispersion modeling (i.e., modeling the air pathways through which pollutants may travel), that the owner and operator is required to conduct (see Figure III-28).

Figure III-28: Performance Standards for Hydrogen Chloride, Chlorine Gas, and Metals



Each facility can select any of the three tiers. Factors that a facility may consider in selecting a tier include the physical characteristics of the facility and surrounding terrain, the anticipated waste compositions and feed rates, and the level of resources available for conducting the analysis. The main distinction between the tiers is the point of compliance. This is the point at which the owner and operator must ensure that chlorine concentrations will be below EPA's acceptable exposure levels. The owner and operator must determine if the cost of conducting monitoring and modeling is worth the benefit of possibly combusting waste with a higher concentration of chlorine (see Figure III-29).

Figure III-29: The Tiered System of Modeling and Monitoring



Owners and operators can choose any Tier for their hydrogen chloride, chlorine gas, and metals monitoring; however, the level of monitoring and modeling increase with each tier.

Particulate Matter

The third combustion unit performance standard is for **particulate matter**. Particulate matter consists of small dust-like particles emitted from combustion units. The particles themselves are not normally toxic, but may become caught in the lungs (causing respiratory damage) if inhaled, or may enter into the environment where they can cause either ecological damage or, via food chain intake, can reenter the human health exposure pathway. In addition, particulate matter may provide a point of attachment for toxic metals and organic compounds. To minimize these adverse conditions, RCRA combustion units may not emit more than 180 milligrams per dry standard cubic meter (dscm) of particulate matter.

Metals

The final performance standard is for toxic metals. For RCRA combustion units, both carcinogenic and noncarcinogenic metals are regulated under the same type of tiered system as chlorine. The facility determines an appropriate tier for each regulated metal and assures that the facility meets these feed rate and emission standards. A different tier may be selected for each metal pollutant (see Figure III-28).

Additional Performance Standards

EPA may require owners and operators of hazardous waste combustion units to comply with additional performance standards by virtue of the omnibus authority. This authority allows EPA to incorporate additional terms and conditions into a facility's permit as necessary to protect human health and the environment. (The omnibus authority is fully discussed in Section III, Chapter 8.)

EPA recommends that site-specific risk assessments, incorporating direct and indirect exposures, be considered during the combustion unit's permitting process. These risk assessments may be used to evaluate the unit's impact on the surrounding environment. If a site-specific risk assessment shows that additional protection should be afforded to the surrounding environment, EPA typically will use the omnibus authority to impose the necessary permit conditions (Omnibus permitting authority is fully discussed in Section III, Chapter 8).

Operating Requirements

The goal of setting operating requirements for hazardous waste combustion units is to ensure that the unit will operate in a way that meets the performance standards for organics, chlorine, particulate matter, and metal pollutants. The unit's permit will specify the operating conditions that have been shown to meet the performance standards for organics, chlorine gas, particulate matter, and metals (permit requirements for combustion units are fully discussed in Section III, Chapter 8).

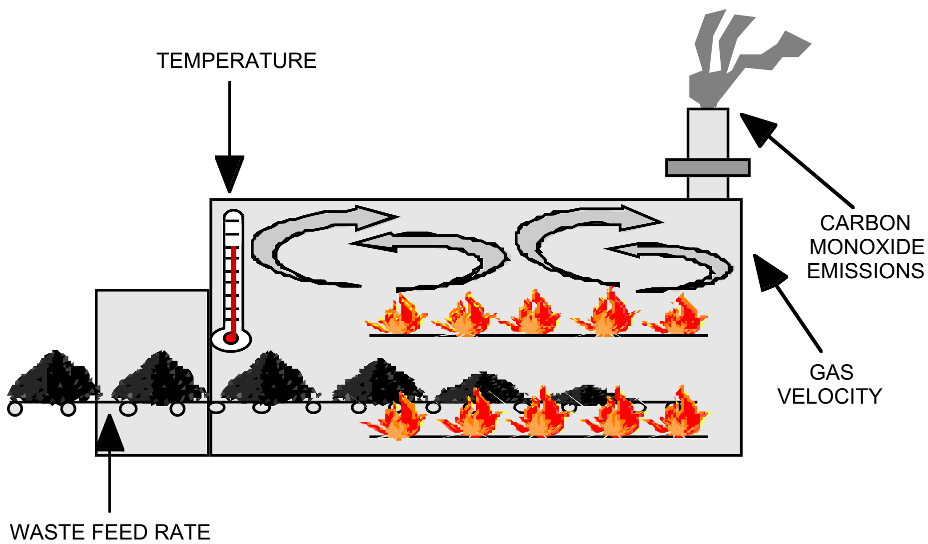
A RCRA permit for a hazardous waste combustion unit sets operating requirements that specify allowable ranges for, and requires continuous monitoring of, certain critical parameters that will ensure compliance with the performance standards. Operation within these parameters ensures that combustion is performed in the most protective manner and the performance standards are achieved (see Figure III-30). These parameters, or operating requirements, may include:

- Maximum waste feed rates
- Control of the firing system
- Allowable ranges for temperature
- Limits on variations of system design and operating procedures
- Gas flow rate.

■ MACT Standards under the CAA

Hazardous waste burning incinerators, cement kilns, and LWAKS, hereafter referred to as MACT combustion units, must also comply with emission limitations. The MACT emission standards are found under the CAA regulations, rather than the Subtitle C requirements. Instead of using operating requirements as a way of ensuring that the unit meets the performance standards, owners or operators of combustion units subject to MACT standards may use a pollution control technology to achieve the stringent numerical emission limits.

Figure III-30: Operating Requirements



Combustion facilities must operate in accordance with certain conditions that specify allowable ranges and limits for waste feed rates, temperature, gas velocity, and carbon monoxide emissions.

Organics

To control the emission of organics, these units must comply with similar DRE requirements to the other hazardous waste combustion units. Owners or operators of MACT combustion units must select POHCs and demonstrate a DRE of 99.99 percent for each POHC in the hazardous wastestream. Sources that burn hazardous waste F020-F023 or F026-F027 have a required DRE of 99.9999 percent for each POHC designated. Additionally, for dioxins and furans, EPA promulgated more stringent standards under MACT. For example, MACT incinerators and cement kilns that burn waste with dioxins and furans, must not exceed an emission limitation of either 0.2 nanograms of toxicity equivalence per dry standard cubic meter (TEQ/dscm) or 0.4 nanograms TEQ/dscm at the inlet to the dry particulate matter control device. This unit of measure is based on a method for assessing risks associated with exposures to dioxins and furans.

Hydrogen Chloride and Chlorine Gas

Rather than a tiered system to control hydrogen chloride and chlorine gas emissions, MACT combustion units must meet numerical emission limits for total chlorine. Owners and operators of these units must ensure that the total chlorine emission does not exceed specific limits, expressed in ppmv (parts per million by volume). For example, the allowable limit of total chlorine for a new incinerator is 21 ppmv. The owner or operator may choose to achieve this level by controlling the amount of chlorine entering the incinerator. By achieving the regulatory emission limit of chlorine, both hydrogen chloride and chlorine gas emissions will be reduced.

Particulate Matter

EPA developed more stringent standards for particulate matter in order to control certain metals. This surrogate is used because particulate matter may provide a point of attachment for toxic metals that can escape into the atmosphere from a combustion unit. For instance, a new LWAK cannot exceed an emission limit of 57 mg/dscm of particulate matter.

Metals

Hazardous waste burning incinerators, cement kilns, and LWAKs do not follow a tiered approach to regulate the release of toxic metals into the atmosphere. The MACT rule finalized numerical emission standards for three categories of metals:

mercury, low-volatile metals (arsenic, beryllium, and chromium), and semi-volatile metals (lead and cadmium). Units must meet emission standards for the amount of metals emitted. For example, a new cement kiln must meet an emission limit of 120 μg/dscm for mercury, 54 μg/dscm for the low-volatile metals, and 180 μg/dscm for the semi-volatile metals.

Operating Requirements

Owners or operators of MACT units must ensure that the MACT emission standards are not exceeded. To do this, the unit must operate under parameters that are demonstrated in a **comprehensive performance test (CPT)**. The unit's operating parameters, such as temperature, pressure, and waste feed are then set based on the result of the comprehensive performance test and documented in a notification of compliance. **Continuous monitoring systems** are used to monitor the operating parameters.

The facility may also choose to use an advanced type of monitoring known as **continuous emissions monitoring systems (CEMS)**. CEMS directly measure the pollutants that are exiting the combustion unit stack at all times. If a facility chooses to use a CEMS, they do not need to comply with the operating parameter that would otherwise apply.

ADDITIONAL REQUIREMENTS

Because hazardous waste combustion units are a type of TSDF, they are subject to the general TSDF standards (as discussed in Section III, Chapter 5) in addition to combustion unit performance standards and operating requirements. Combustion units are also subject to specific waste analysis, inspection and monitoring, and residue management requirements.

While combusting hazardous waste, the combustion process and equipment must be monitored and inspected to avoid potential accidents or incomplete combustion. The monitoring and inspection requirements for incinerators are detailed in the regulations, while the requirements for BIFs are determined on a site-specific basis. Possible inspection and monitoring requirements include:

- Monitoring the combustion temperature, and hazardous waste feed rate
- Sampling and analyzing the waste and exhaust emissions to verify that the operating requirements established in the permit achieve the performance standards
- Conducting visual inspections of the combustion unit and its associated equipment
- Testing the emergency waste feed cut-off system and associated alarms
- Placing monitoring and inspection data in the operating log.

Residues from the combustion of hazardous waste are also potentially subject to RCRA regulation. If a combustion unit burns a listed hazardous waste, the ash could also be considered a listed waste via the derived-from rule. The owner and operator must also determine whether this ash exhibits any hazardous waste characteristics. The same is true if a unit burns waste that only exhibits a characteristic. Ash that exhibits a characteristic must be managed as a hazardous waste.

SUMMARY

Combustion, the controlled burning of hazardous substances in an enclosed area, has the potential to adversely affect human health and the environment, and it is therefore subject to strict regulation. As a result, the burning of hazardous waste in incinerators and BIFs is regulated through stack emission limitations and unit operating requirements.

Combustion standards are comprised of two types of regulations: (1) standards under RCRA; and (2) MACT standards under the CAA.

RCRA combustion units must meet performance standards, including a demonstration of the unit's DRE for certain POHCs, and meet emission standards for hydrogen chloride, chlorine gas, metals, and particulate matter. Operating requirements are intended to ensure that the combustion unit will operate in a way that meets the performance standards for these pollutants. Operating conditions may include:

- Maximum waste feed rate
- Control of the firing system
- Allowable ranges for temperature
- Limits on variations of system design and operating procedures
- Gas flow rate.

The MACT standards under the CAA regulate incinerators and two types of industrial furnaces that burn hazardous waste: cement kilns and LWAKS. MACT combustion units must comply with strict emission limitations for dioxins, furans, metals, particulate matter, DRE, and total chlorine. To achieve the limits, the facility owner or operator may use a single or multiple pollution control technologies for the combustion unit. The facility also uses a CMS to monitor operating parameters such as temperature, pressure, waste feed, or CEMS to monitor the pollutants exiting the unit.

In addition to operating and performance requirements, all combustion units are subject to specific waste analysis, inspection and monitoring, and residue management requirements.

ADDITIONAL RESOURCES

A complete overview of the MACT standards and additional information about hazardous waste combustion can be found at www.epa.gov/epaoswer/hazwaste/combust.htm.