CHAPTER THIRTEEN

INCINERATION

13.1 INTRODUCTION

Environmental Protection Agency regulations require owners or operators of hazardous waste incinerators to perform specific testing prior to issuance of a final permit. These regulations are contained in 40 CFR Parts 264.340-264.347, 270.19, and 270.62.

The regulations require that incinerated hazardous wastes be destroyed with an efficiency of 99.99% or higher. In order to obtain a permit to incinerate hazardous wastes, owners or operators must demonstrate that their incinerator can operate at the required efficiency (usually referred to as destruction and removal efficiency, or DRE). This demonstration will most often involve a "trial" burn. Prior to the trial burn, the owner or operator must test the hazardous waste being evaluated for incineration and determine the presence and concentration of Appendix VIII constituents, along with other parameters. The analytical results obtained will allow the owner or operator to determine the principal organic hazardous constituents (POHCs) in the waste. These POHCs will usually be those compounds in the waste that are difficult to burn, toxic, and found at reasonably high concentrations in the waste. During the trial burn, the POHCs are monitored to determine whether the incinerator is meeting the required DRE.

The owner or operator will then prepare an incineration permit application, which is submitted to the appropriate state and EPA region. Contents of permits are listed in Sections 270.14, 270.19, and 270.62 of the RCRA regulations. As part of the permit application, the owner or operator will provide the waste analysis information, propose certain POHCs for the trial burn, and specify the sampling and analysis methods that will be used to obtain the trial burn data. This portion of the permit application is called the "trial burn plan." The regulatory agency(ies) will review the application and trial burn plan, make any necessary modifications, and authorize the owner to conduct the trial burn. After the trial burn, the results are submitted to the permit issuance authority and, assuming all requirements are met, a final incineration permit will be issued. The permit contains all the information pertaining to the licensed operation of the incinerator, and the owner or operator must comply with whatever conditions are specified in the permit. The rest of this chapter will explain the various sampling and analysis strategies that can be used during the trial burn and how analysis data can be used to obtain a final permit.

13.2 REGULATORY DEFINITION

As explained earlier, incinerator regulations are contained in 40 CFR Parts 264.340-.347, 270.19, and 270.62. Because Part 264 contains general requirements for hazardous waste incineration, it will not be discussed here.

Parts 270.19 and 270.62 describe actual sampling and analysis requirements and are summarized below. A summary of the major analytical requirements is given in this section and is followed by sections detailing acceptable sampling and analysis methods for meeting these requirements.

The trial burn plan must include the following items:

1. Heat value of the waste.

2. Viscosity or physical description.

3. A list of hazardous organic constituents that are listed in Appendix VIII and that are reasonably expected to be present in the waste.

4. Approximate concentration of those compounds.

5. A detailed description of sampling and analysis procedures that will be used.

During the trial burn (or as soon after as possible), the following determinations must be made:

1. The concentration of trial POHCs in the waste feed.

2. The concentration of trial POHCs, mass emissions, oxygen, and hydrogen chloride in the stack gases. (Determination of the oxygen and water concentration in the stack exhaust gas concentration is necessary for correction of measured particulate.)

3. The concentration of trial POHCs in any scrubber water, ash, or other residues that may be present as a result of the trial burn.

4. A computation of the DRE.

For routine operation, the only explicit sampling and analysis requirement is the determination of carbon monoxide in the stack gas. Although the permit writer or the state/local authorities may impose additional monitoring requirements in some instances, it is not anticipated that comprehensive sampling of the stack-gas effluent or specific analysis of POHCs will be required, except in trial burn situations.

13.3 WASTE CHARACTERIZATION STRATEGY

13.3.1 Sampling

Acquisition of a representative sample of hazardous waste for subsequent chemical analysis is accomplished by preparing a composite of several subsamples of the waste. Sampling equipment and tactics for collection of the subsamples are specified in Chapter Nine of this manual and generally involve grab sampling of liter- or kilogram-sized portions of waste materials. To ensure that the bulk of the waste is represented by the composite sample, the sampling strategy requires collection of a minimum of four subsamples that provide integration over both the depth and the surface area of the waste as contained in drums, tanks, holding ponds, etc. The composite sample prepared in the field must be mixed thoroughly and split into at least three replicate samples prior to shipment to the analytical laboratory. This step is primarily a precaution against breakage or loss of sample, but it also provides the potential for a check on the homogeneity of the composite sample. To ensure that sampling and analysis results will withstand legal scrutiny, chain-of-custody procedures are incorporated into sampling protocols. The sampling protocols also include explicit provisions for ensuring the safety of the personnel collecting the samples.

13.3.2 Analysis of Hazardous Wastes

The overall strategy for waste characterization includes test procedures (to determine the characteristics of the waste) and analysis procedures (to determine the composition of the waste). The analysis procedures can be divided into three sections:

1. Characteristics (useful for storage, etc.; not required).

2. Proximate analysis (useful data but not required, except for heat value).

3. Specific analysis (required for determination of POHCs).

Figure 13-1 provides an overview of this analytical approach. The discussion below provides a capsule description of each major element of this scheme and the use of the resulting information in the hazardous waste incineration permitting process.

13.3.2.1 Characteristics

The characteristics of the waste sample, defined in terms of ignitability, corrosivity, reactivity (including explosivity and toxic gas generation), and extraction procedure toxicity, are determined according to the procedures presented in Chapter Eight of this manual. These tests are performed on a sample from each waste stream, unless there is sufficient information from an engineering analysis to indicate the waste meets any of these criteria. This information is relevant to the Part 264, Subpart B, General Waste Analysis requirement in that it affects procedures for safely storing, handling, and disposing of the waste at the facility. The data are also relevant to possible exclusion from the trial burn requirements of Part 122. The data on the characteristics of each hazardous waste may be available from the waste generator and from manifest or shipping papers received by the facility owner/operator.

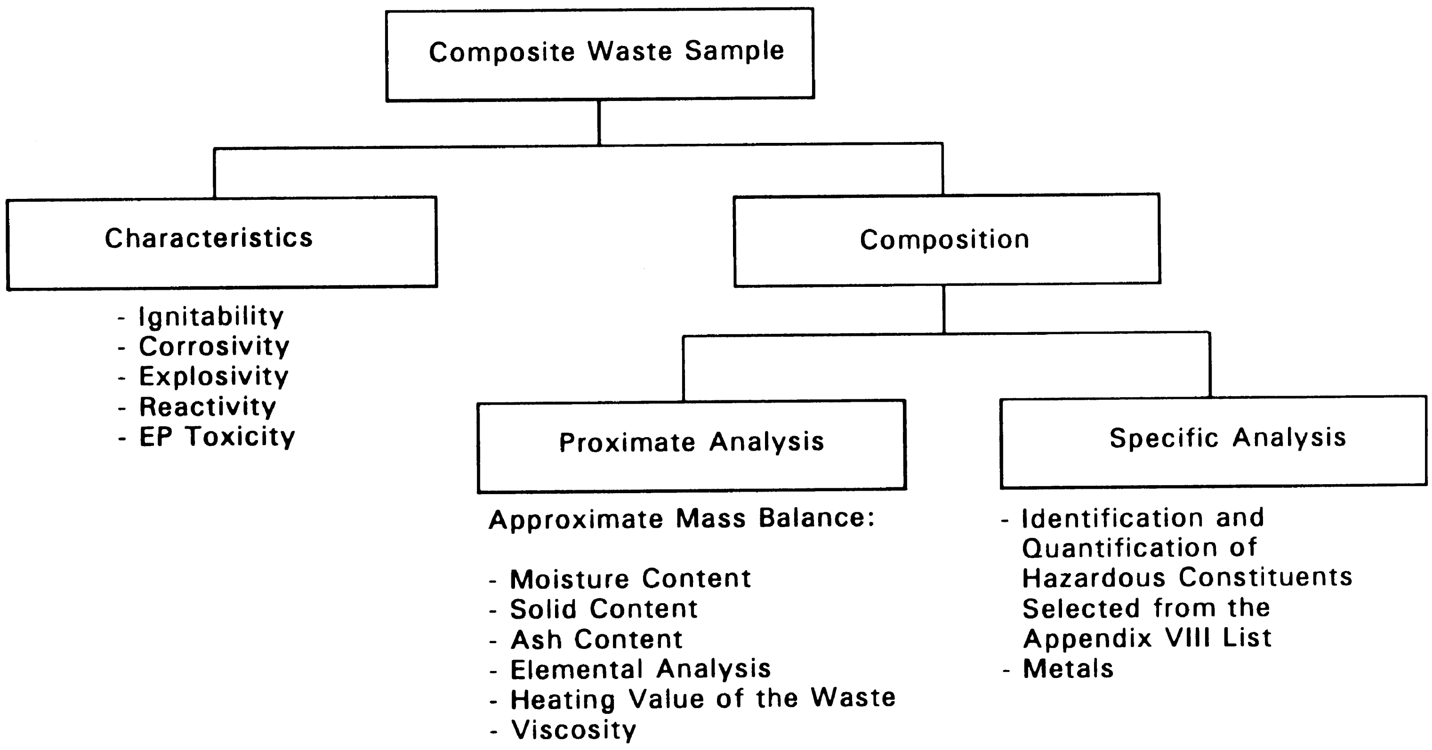


Figure 13-1. Overview of thhe analytical approach for waste characterization.

13.3.2.2 Proximate Analysis

The proximate analysis provides data relating to the physical form of the waste and an estimate of its total composition. This analysis includes determination of:

1. Moisture, solids, and ash content.
2. Elemental composition (carbon, nitrogen, sulfur, phosphorus, fluorine, chlorine, bromine, iodine to 0.1% level).
3. Heating value of the waste.
4. Viscosity.

Some or all of this information may satisfy the waste analysis requirements of the Part 264 regulations, as well as be responsive to the General Waste Analysis requirements of Subpart B. The elemental composition data allow one to predict if a high concentration of potentially significant combustion products (NO_x, SO_x, P_2O_5, hydrogen halides, and halogens) might be formed during incineration. These data also facilitate an informed selection of the Appendix VIII hazardous constituents that might be present in the waste by indicating whether the overall waste composition and hence the types of components present are consistent with expectations based on best professional judgment. For example, if bromine were not present in the waste, any organobromine compounds from Appendix VIII at levels of 1,000 mg/kg would be excluded from specific analysis.

13.3.2.3 Specific Analysis

The specific analysis portion of the waste characterization scheme provides qualitative confirmation of the presence and identity of the Appendix VIII constituents that might reasonably be expected to be present in the waste, based on professional judgment or on the results of proximate analysis. It is important to note that specific analysis does not involve screening every waste sample for all Appendix VIII hazardous components. A preliminary judgment is made as to the compounds or types of compounds that are actually present.

For the specific organic analyses, a high-resolution separation technique (fused-silica capillary gas chromatography) and a high-specificity detection technique (mass spectrometry) are used wherever possible. This approach ensures qualitative and quantitative analysis for a variety of waste types and process chemistries.

Specific analysis methods in this manual can be used for Appendix VIII constituents. Generally, the methods of choice for Appendix VIII components will be:

Method 6010	(Inductively Coupled Plasma Method)
Method 8270	(GC/MS Method for Semivolatile Organics: Capillary Column Technique)
Method 8240	(GC/MS Method for Volatile Organics)

Other more specific methods contained in this manual may be used; however, they cannot screen for a wide range of compounds. For example, Method 8010 can detect only those volatile compounds containing halogen.

13.3.3 Selection of POHCs

The criteria for selection of POHCs (typically one to six specific constituents per waste feed) include:

1. The expected difficulty of thermal degradation of the various hazardous organic constituents in the waste.

2. The concentration of those constituents in the waste.

It is anticipated that the designation of POHCs will be negotiated on a case-by-case basis for each permit application. It is important to note that it is not necessarily, or even generally, true that all Appendix VIII compounds present in the waste will be designated as POHCs. The intent is to select a few specific compounds as indicators of incinerator performance. The selected compounds should provide a sufficiently stringent test of the incinerator's performance to ensure that incineration of the waste can be carried out in an environmentally sound fashion. This criterion mandates selection of the more thermally stable constituents as POHCs.

At the same time, however, it is necessary that the designated POHCs be present in the waste in sufficiently high concentrations in order to be detected in the stack gas. This is a particularly important constraint for wastes that are to be incinerated with substantial quantities of auxiliary fuel, which effectively dilute the POHCs in the exhaust gas. Although the burning of auxiliary fuel might not affect the mass emission rate of POHCs, it would lead to an increased volumetric flow of stack gas and thus to a decreased concentration of POHCs at the stack. This lower concentration directly affects the detection limit achievable for a given stack-gas sample size (e.g., between 5 m^3 and 30 m^3).

It is recommended that, whenever possible, the permit writer select POHCs present in the waste at 1,000 mg/kg or higher. If it is considered desirable to designate as a POHC a thermally stable compound present at the hundreds-of-parts-per-million level, the trial burn permit application must include calculations and supporting data to indicate that 0.01% of the mass feed rate of that component in the waste could in fact be detected in the stack effluent. A waste concentration of 100 mg/kg probably represents a practical lower level below which determination of 99.99% DRE may require extraordinary sampling analysis and quality control procedures, which may significantly increase the sampling and analysis costs for that trial burn.

For a waste material that is a listed hazardous waste under RCRA regulations (40 CFR Part 261, Subpart D), the constituents that caused the Administrator to list the waste as toxic (tabulated in Appendix VII of 40 CFR Part 261) would be logical candidates for designation as POHCs, if these constituents are organic chemicals.

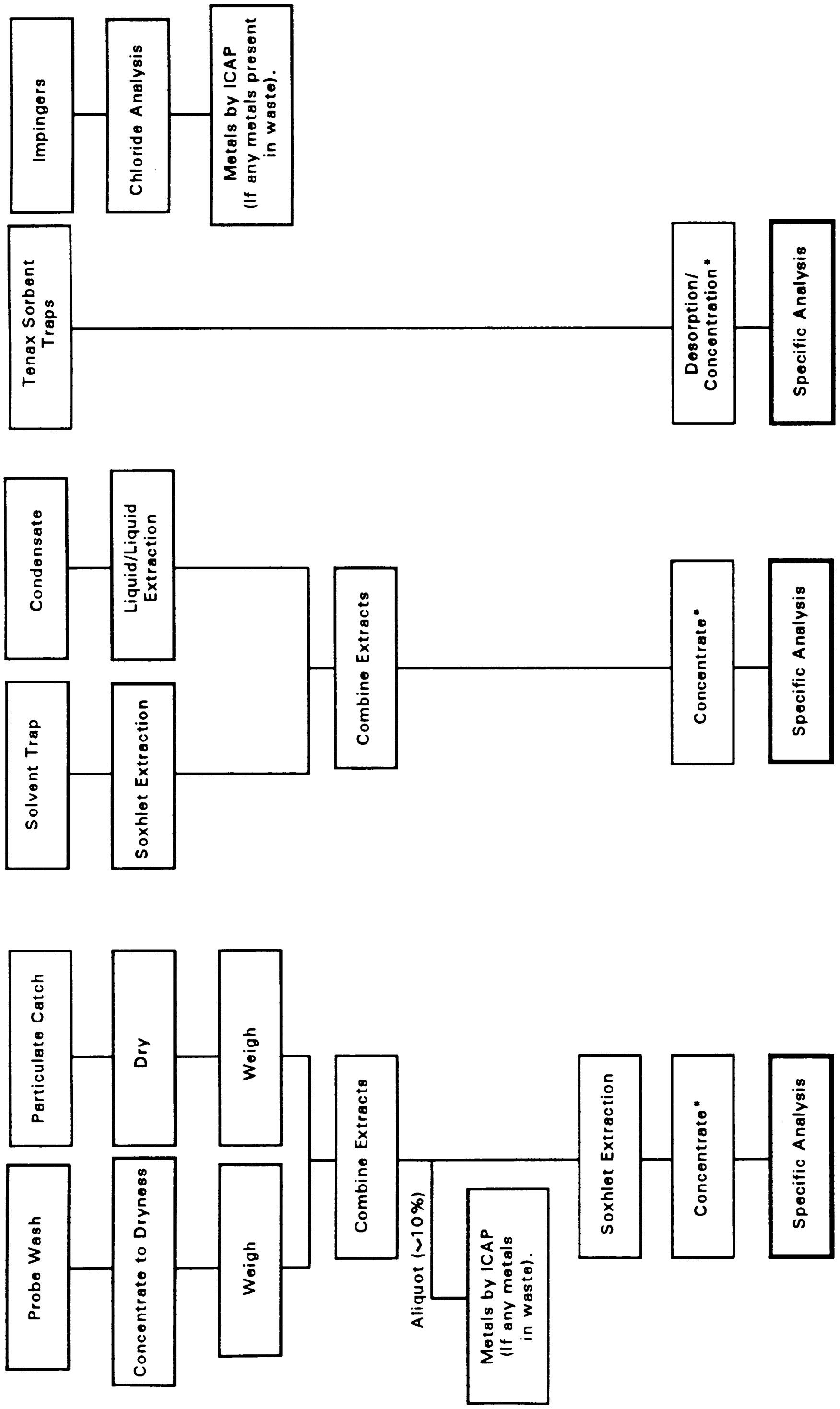
13.4 STACK-GAS EFFLUENT CHARACTERIZATION STRATEGY

The overall strategy for hazardous-waste-incinerator stack-gas effluent characterization to determine compliance with Part 264 performance standards is to collect replicate 3- to 6-hr, 5- to 30-m^3 samples of stack gas using a comprehensive sampling train, such as the EPA Modified Method 5 Sampling Train (MM5), the EPA/IERL-RTP Source Assessment Sampling System (SASS), or, for the volatile species, the Volatile Organic Sampling Train (VOST). These three strategies are described in detail in Chapter Ten (Methods 0010, 0020, and 0030). Any of the comprehensive sampling trains provides a sample sufficient for determination of particulate mass loading, concentrations of particulate and low-volatility vapor-phase organics, and concentrations of particulate and volatile metals. The VOST is used to collect the sample to be analyzed for volatile organic species. For burns of wastes that could also produce significant emissions of HCl, an MM5 type of train is used to collect and quantify HCl in the stack gas.

Figure 13-2 shows an overview of the analysis scheme for stack-gas samples. A separate sample (cyclone and particulate catch) will be used for determination of particulate mass loading and extraction of nonvolatile organic components. Heating during the particulate determination may drive off semivolatile organics. Volatile organic components of the stack gas will be collected using the VOST.

The directed analysis shown in Figure 13-2 is performed on triplicate samples. Although analysis of only two samples would allow an average level of a POHC to be determined, at least three samples should be analyzed so that an error bound for the measured values can be computed. The incremental cost of the replicate sampling and analysis is offset by increased confidence in the resulting data; quantitative results from a single sampling and analysis run should not generally be considered as an acceptable indicator of performance.

The survey analysis, which is a qualitative screen of the collected material to ensure that potentially hazardous but unexpected emissions do not go overlooked, need be performed on no more than one stack-gas sample. During a trial burn, the oxygen level in the stack gas must be measured using an Orsat or Fyrite analyzer, as detailed in 40 CFR Part 60, Appendix A, Method 3, so that the particulate loading may be corrected to a standard excess air level.



* As an alternative, the extracts from particulate and vapor portions of the train may be combined prior to analysis.

Figure 13-2. Overview of an analysis scheme for stack gas samples from a comprehensive sampling train.

For both trial and operating burns, on-line monitors (nondispersive infrared instruments) are used to provide continuous readings of carbon monoxide levels in the incinerator effluent.

13.5 ADDITIONAL EFFLUENT CHARACTERIZATION STRATEGY

The basic strategy for sampling scrubber water, ash, and other residue (if any) is to prepare composite samples from grab subsamples, collected using the same types of sampling devices and tactics as those used for waste characterization. This sampling is required only during trial burns, in accordance with 40 CFR Part 270.62. These additional effluent samples are analyzed for POHCs to determine appropriate disposal or subsequent treatment methods and to ensure that significant discharges of POHCs in other media do not go undetected.

13.6 SELECTION OF SPECIFIC SAMPLING AND ANALYSIS METHODS

The preceding discussion has briefly described the RCRA regulations that define sampling and analysis requirements for hazardous waste incineration and has presented an overview of the sampling and analysis procedures developed to meet these requirements.

This section will illustrate, by means of a hypothetical example, the transition from strategies, as described above, to methods, as described below. In the interest of clarity, the example is oversimplified, but should serve as a demonstration of how to develop and evaluate a hazardous waste incineration trial burn plan. The discussion will deal with sampling and analysis considerations only and will not address adequacy of design, operating conditions, or other engineering considerations.

13.6.1 Scenario

The owner/operator of an incineration facility seeks an RCRA permit to treat chlorinated organic waste material.

The facility is a liquid injection incinerator with a capacity of 10 x 10^6 Btu/hr and equipped with a wet scrubber for acid-gas removal. A waste oil (<0.1% chlorine) is burned as auxiliary fuel. The proposed operating conditions for hazardous waste incineration include a combustion zone temperature of 2000°F (1100°C) and a residence time of 2 sec with 150% excess air.

The waste is a still bottom from the production of perchloroethylene. Based on engineering analysis, it is expected to be a nonviscous organic liquid with a heating value >5,000 Btu/lb. The major components of the waste are expected to be highly chlorinated species such as hexachlorobenzene, hexachlorobutadiene, and other chlorinated aliphatic and aromatic compounds.

13.6.2 Strategy

There are insufficient data from other trial or operating burns to specify operating conditions under which this type of facility, when burning this type of waste, has been demonstrated to comply with the Part 264 performance criteria. Therefore, a trial burn will be required.

There are insufficient data to develop the trial burn plan available from the waste generator. Therefore, additional analyses of the waste will be necessary to support the trial burn permit application. The POHCs for which destruction and removal efficiencies are to be demonstrated in the trial burn must be designated, based on review of existing information and/or additional analysis of a representative sample of the waste.

Because the owner/operator plans to operate the facility under one set of temperature, residence time, and excess air conditions when treating hazardous waste, the trial burn will consist of three replicate tests under that set of operating conditions.

The trial burn sampling and analysis strategy must address:

1. The waste analysis requirements of 40 CFR Part 270.

2. The performance standards of 40 CFR Part 264, Subpart O.

3. The monitoring requirements of 40 CFR Part 264, Subpart O.

13.6.2.1 Sampling Strategy

During each of the three replicate tests, the following samples must be obtained:

1. One composite sample of the waste actually treated.

2. One time-averaged (3-4 hr) sample of stack gas.

3. One composite sample of spent scrubber water.

No bottom ash or fly ash streams (other than the stack particulate emissions) are expected to be generated as effluents from this facility.

13.6.2.2 Analysis Strategy

The <u>waste</u> must be analyzed to determine:

1. Quantity of designated trial burn POHCs.

2. Heating value of the waste.

3. Viscosity or physical form.

4. Quantity of organically bound chlorine. (This analysis is not mandatory; however, the data obtained may be helpful in determining a potential for HCl emissions.)

5. Identity and approximate quantity of known or suspected Appendix VIII constituents.

The stack gas must be analyzed to determine:

1. Quantity of designated trial burn POHCs.

2. Quantity of particulate matter emissions.

3. Quantity of hydrochloric acid emissions.

4. Carbon monoxide level.

5. Excess air level (oxygen/carbon dioxide level determination).

The scrubber water must be analyzed to determine quantities of designated trial burn POHCs.

13.6.3 Tactics and Methods

13.6.3.1 Selection of POHCs

The first step is to obtain a composite of the waste and to analyze it for Appendix VIII constituents. In this case the waste was sampled from a tank truck by taking a series of vertical cores at the available hatch location on the truck. The cores were obtained by using a Coliwasa (see Section 9.2.2.4 of Chapter Nine) and following the procedures. After the waste sample was collected, it was sent to the laboratory using chain-of-custody procedures (Section 9.2.2.7 of Chapter Nine) and was analyzed using Method 8270 (Chapter Four) (in this case the sample was directly injected with a split ratio of 100:1). The sample was also analyzed by Method 9020, Chapter Five. Table 13-1 summarizes the information that was obtained for the waste analysis. The major organic components that would appear to be candidates for selection as POHCs are listed in Table 13-2, along with relevant physical/chemical properties and recommended stack sampling and analysis methods.

The permit writer has designated hexachloro-butadiene, hexachlorobenzene, and hexachloroethane as POHCs. All three species are present in significant concentrations in the waste and will remain at >1,000 mg/kg concentration even if the waste were cut by as much as 1:10 with auxiliary fuel in order to limit the total chlorine feed rate and to maintain an adequate heating value in the total incinerator feed. Fully chlorinated species such as these are generally considered to be highly resistant to thermal degradation and thus provide an appropriate set of POHCs for DRE determination.

TABLE 13-1. INFORMATION ON COMPOSITION OF HYPOTHETICAL WASTE

Visual Inspection: The waste was a pitch-black, nonviscous liquid with obvious particulate loading. It had a pungent odor and fumed slightly when the cap was removed.

Loss on Ignition: Ignition at 900°C resulted in a 99.8% loss of mass.

Higher Heating Value: The waste would not burn in a bomb calorimeter; its higher heating value is estimated at approximately 2,000 Btu/lb.

TOX: 74.4% Cl.

GC/MS: This analysis indicates that hexachlorobutadiene is the major component (65%) and hexachlorobenzene is present at about 10% of the Total Organic Chlorine concentration. Other peaks in the chromatogram were identified as hexachloroethane (approx. 4%), tetrachloroethanes (approx. 3%), tetrachloroethylene (approx. 0.1%), plus four other chlorinated aliphatics at about 0.5% concentration of the CCl concentration.

Summary: All of the available evidence suggests that this waste contains essentially no perchloroethylene, that hexachlorobutadiene makes up about 65% of the waste, and that there are perhaps a dozen other components at 1-5% concentration. All of the minor components appear to be chlorinated, with hexachlorobenzene the most abundant.

TABLE 13-2

CANDIDATE POHCs FOR HYPOTHETICAL WASTE AND RECOMMENDED STACK SAMPLING AND ANALYSIS METHODS FOR HYPOTHETICAL TRIAL BURN

					Stack Sampling Method		Analysis Method	
Compound (POHC)	Approx. concentration in waste (%)	B.P. (°C)	ΔH^a (kcal/mole)	MW (g/mole)	Section number	Description	Method number	Description
Hexachlorobutadiene	65	215	N/A	260.76	1.2.1.8[b]	MM5 - Sorbent	8120, 8250, or 8270	GC/MS Extractables
Hexachlorobenzene	6	323	567.7	284.8	1.2.1.8[b]	MM5 - Particulate and Sorbents	8120, 8250, or 8270	GC/MS Extractables
Hexachloroethane	2	186.8	173.8	236.74	1.2.1.8[b]	MM5 - Sorbent	8120, 8250, or 8270	GC/MS Extractables
Tetrachloroethane[c]	1.5	130.5 (146.2)	230 (233)	167.84	1.2.1.13	VOST	8010 or 8240	GC/MS Volatiles
Tetrachloroethylene	0.1	121.0	197	165.85	1.2.1.13	VOST	8010 or 8240	GC/MS Volatiles

[a] The standard enthalpy of combustion.

[b] The SASS method (Chapter Nine, Method 0020) could also be selected. A specially fabricated glass-lined SASS train might be necessary to withstand the hydrochloric acid expected in the stack.

[c] Numbers given in parentheses refer only to 1,1,2,2-tetrachloroethane.

13.6.3.2 Selection of Sampling Methods

For sampling of wastes and liquid and solid effluents, the choice of method is based primarily on the nature of the medium. Review of available methods indicates that for dipper sampling (Chapter Nine) or sampling from the tap of the waste-feed pipe would be appropriate for collection of discrete subsamples of waste feed and of spent scrubber water at regular time intervals over the duration of each trial burn. These would then be combined to form the corresponding composite samples for each test.

For sampling of stack gas, both the nature of the medium and the nature (volatility, stability) of the POHC or other target species affect the choice of a sampling method. Table 13-2 summarizes these recommendations for the candidate POHCs in this example. Note that designation of tetrachloroethylene as a POHC in this instance would require use of VOST, although the MM5 or SASS approaches would collect all of the other candidate POHCs.

The MM5 train would also suffice to determine compliance with the two other performance standards of 40 CFR Part 264. The particulate matter emission rate can be determined from the mass of material collected in the probe wash, cyclone (if any), and filter of the MM5 train. The hydrochloric acid emission rate can be determined by using caustic scrubbing solution in the impinger portion of the MM5 train and determining the hydrochloric acid level as chloride.

In addition to the procedures chosen for the collection of POHCs, it would be necessary to specify procedures for the required monitoring for carbon monoxide and oxygen levels in the stack gas.

13.6.3.3 Selection of Analysis Methods

The analytical procedures used for qualitative identification and quantitative determination of POHCs and other target species are determined primarily by the nature (volatility, polarity) of the species sought.

This manual lists recommended analysis methods for each candidate POHC after the appropriate sample preparation steps in Methods 0010, 0020, and 0030 have been performed. Table 13-2 summarizes the recommendation for analysis of the candidate POHCs in this hypothetical example. Note that a single analytical method suffices to determine all of the hexachlorospecies of concern here although an additional method would be recommended if the analysis were to include the tetrachloroethanes and tetrachloroethylene.

13.6.4 Results and Calculations

This section illustrates the proper methods for calculating DRE, corrected particulate loading, and HCl emissions for the hypothetical example described above. Again, this example has been somewhat oversimplified for purposes of illustration.

According to 40 CFR Part 264, the DRE for each POHC is calculated as:

$$DRE = \frac{W_{in} - W_{out}}{W_{in}} \times 100\%$$

where:

W_{in} = mass feed rate of one POHC in the waste stream feeding the incinerator.

W_{out} = mass emission rate of the same POHC present in stack exhaust emissions.

13.6.4.1 Calculation of W_{in} (lb/hr):

$$W_{in} = \frac{C_w \times FR_w}{100}$$

where:

C_w = Concentration of one POHC in the waste, %.

FR_w = Mass feed rate of waste to the incinerator, lb/hr.

Assume that quantitative analysis of a representative aliquot drawn from the composite waste sample from test No. 1 gave the following concentrations:

hexachlorobutadiene	63 %
hexachlorobenzene	9.4%
hexachloroethane	1.1%

Further, assume that the thermal capacity of the facility (10×10^6 Btu/hr) was met by blending waste 1:10 with waste oil to give a feed mixture that was 8.2% chlorine and that had a heating value of 16,400 Btu/lb. The total mass feed rate to the incinerator was therefore 600 lb/hr, of which 540 lb/hr was auxiliary fuel (waste oil) and 60 lb/hr was chlorinated waste.

The W_{in} values for the three POHCs are therefore:

hexachlorobutadiene	(.63 x 60 lb/hr)	38 lb/hr
hexachlorobenzene	(.094 x 60 lb/hr)	5.6 lb/hr
hexachloroethane	(.011 x 60 lb/hr)	0.66 lb/hr

13.6.4.2 Calculation of W_{out} (lb/hr):

$$W_{out} = C_s \times ER_s \times 1.32 \times 10^{-4}$$

where:

C_s = Concentration of one POHC in the stack gas effluent, mg/dNm^3.

ER_s = Volumetric flow rate of stack gas, dNm^3/min.

1.32×10^{-4} = Conversion factor from mg/min to lb/hr.

Assume that quantitative analysis of the extract prepared from the time-integrated comprehensive sampling train sample from test No. 1 gave the following concentrations in the sampled gas:

hexachlorobutadiene	0.080 mg/m^3
hexachlorobenzene	0.020 mg/m^3
hexachloroethane	$\leq$0.004 mg/m^3

Further, assume that the average measured volumetric flow of stack gas during test No. 1 was 3,200 scfm or 90 dNm^3/min.

The W_{out} values for the three POHCs are therefore:

hexachlorobutadiene	$(.080 \times 90 \times 1.32 \times 10^{-4})$	9.5×10^{-4} lb/hr
hexachlorobenzene	$(.020 \times 90 \times 1.32 \times 10^{-4})$	2.4×10^{-4} lb/hr
hexachloroethane	$(\leq 0.004 \times 90 \times 1.32 \times 10^{-4})$	$<0.48 \times 10^{-4}$ lb/hr

13.6.4.3 Calculation of DRE:

$$\text{DRE} = \frac{W_{in} - W_{out}}{W_{in}} \times 100$$

The DRE values for the three POHCs are therefore:

hexachlorobutadiene	99.997
hexachlorobenzene	99.996
hexachloroethane	>99.993

Note that compliance with a "four-9's" performance standard could not have been demonstrated in this particular example for a component present at <1% in the waste itself (or <1,000 mg/kg in the 1:10 waste:fuel blend fed to the incinerator) unless the detection limit for that component in the stack gas were <4 ug/m^3.

In this example, compliance with the 99.99% DRE performance standard has been demonstrated, in one test, for each of the three POHCs. If these results were supported by data from the other two replicate trial burn tests, the "four-9's" DRE could be considered to have been established.

13.6.4.4 Calculation of HCl Emissions

An incinerator burning highly chlorinated hazardous waste capable of producing significant stack-gas emissions of hydrogen chloride (HCl) must monitor and/or control HCl emissions.

The hypothetical waste in this example contains approximately 75% chlorine by weight (Table 13-1). At the proposed 60-lb/hr feed rate of waste that is blended 1:10 with auxiliary fuel for a total feed of 600 lb/hr (9.8×10^6 Btu/hr), the maximum HCl emission rate would be 45 lb/hr of chlorine basis or 46 lb/hr as HCl. This rate exceeds the regulatory limit of 4 lb/hr; therefore, the scrubber efficiency must be determined.

The stack emission rate of HCl can be calculated from measured values in the following manner:

$$HCl_{out} = C_{in} \times ER_s \times 1.32 \times 10^{-4}$$

where:

C_{in} = Concentration of HCl in the stack-gas sample (mg/m^3).

ER_S = Volumetric flow rate of the stack gas, m^3/min.

1.32×10^{-4} = Conversion factor from mg/min to lb/hr.

Assume that quantitative analysis of the impinger/condensate solution from the time-integrated comprehensive sampling train from test No. 1 gave 34 mg/m^3 HCl in the stack effluent.

The stack emission rate of HCl is calculated by:

$$HCl_{out} = 34 \text{ mg/m}^3 \; (90 \text{ m}^3\text{/min}) \; (1.32 \times 10^{-4})$$

$$= 0.40 \text{ lb/hr HCl.}$$

This emission level is <1% of the 46 lb/hr of HCl potentially generated from the waste, an indication that the removal efficiency of the wet scrubber was >99%.

13.6.4.5 Calculation of Particulate Loading (mg/m^3)

An incinerator-burning hazardous waste must not emit particulate matter in excess of 180 mg/dscm when corrected to an oxygen concentration of 7% in the stack gas.

Assume that prior to chemical analysis, particulate samples from the stack effluent of the hypothetical waste (from probe washes and filter catches of the time-integrated comprehensive sample train) were dried and weighed. The hypothetical particulate loading from these measurements was calculated to be 80 mg/m^3 at the actual excess air level of the stack. The excess air level was determined to be 150%, based on hypothetical measured values of oxygen (12.8%) and carbon dioxide (6.7%). Correction to standard excess air level, as specified in the Part 264 regulations, leads to a particulate loading of 140 mg/m^3 (0.06 gr/scf). This total particulate emission is in compliance with the Part 264 performance standard that specifies $\leq$180 mg/m^3 ($\leq$0.08 gr/scf).

13.6.5 Summary

Incinerator performance in this example complies with the Part 264 Subpart O Incinerator Standards as they relate to:

1. Destruction and Removal Efficiency. All three POHCs showed compliance with the 99.99% DRE performance standard.

2. Limitation on HCl Emissions. The HCl emission rate of 0.40 lb/hr shows compliance with a 99% removal standard for HCl.

3. Limitation on Stack Emissions of Particulate Material. The corrected particulate loading of 140 mg/m^3 is less than the 180 mg/m^3 standard for particulate loading (corrected to a standard excess air level).

13.7 REFERENCES

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