

COMBUSTION OF HAZARDOUS WASTES

Sampling and Analysis Methods

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Foreword

Sampling and analysis methods for the measurement of hazardous constituents found in the influent and effluent streams at hazardous waste incineration facilities are described in this book. The need for such methods is based on promulgated EPA regulations which would ensure the combustion of hazardous wastes in an environmentally responsible manner.

The primary criterion upon which the operational specifications are based is the destruction and removal efficiency (DRE) of the incinerator. The DRE value, defined in terms of waste input and stack output levels of designated principal organic hazardous constituents (POHCs), must be equal to or greater than 99.99%. The book addresses the sampling and analysis methods to be used when measuring the levels of the POHC(s) in the various streams of an incinerator facility (inlet waste, stack gas, process water, fly ash, and bottom ash) for the purpose of calculating a DRE value for the incinerator.

Included in the book are concise summaries stating recommended methods, types of samples and specific analytes to which a method applies, a brief description of the method and instrumentation and operating conditions.

The information in the book is from *Sampling and Analysis Methods for Hazardous Waste Combustion (First Edition)*, prepared by Judith C. Harris, Deborah J. Larsen, Carl E. Rechsteiner, and Kathleen E. Thrun of Arthur D. Little, Inc. for the U.S. Environmental Protection Agency, December 1983.

The table of contents is organized in such a way as to serve as a subject index and provides easy access to the information contained in the book.

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NOTICE

This document has been reviewed by the technical staff within EPA's Office of Environmental Engineering and Technology and Office of Solid Waste and by external peer reviewers. The contents do not necessarily reflect the views and policies of the U.S. Environmental Protection Agency or the publisher, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Abbreviations and Glossary of Terms

AAS	Atomic Absorption Spectroscopy
Accuracy	The difference between a single value or the mean of a set of results and the value which is accepted as the correct (true) value for the quantity measured.
AFID	Alkali Flame Ionization Detector
amu	Atomic Mass Unit ($1 \text{ amu} = 9.314 \times 10^8 \text{ eV}$)
APCD	Air Pollution Control Device
Appendix VIII	Hazardous Constituent List (40 C.F.R. Part 261)
ASTM	American Society for Testing and Materials
atm	Atmosphere ($1 \text{ atm} = 1.013 \times 10^5 \text{ Pa} = 760 \text{ Torr}$)
Btu/lb	British Thermal Unit per Pound ($1 \text{ Btu/lb} = 2.3244 \times 10^3 \text{ J/Kg}$ $= 0.556 \times 10^{-3} \text{ kcal/g}$)
Btu/h	British Thermal Unit per Hour ($1 \text{ Btu/h} = 2.931 \times 10^{-1} \text{ W}$)
C	Corrosivity Test--RCRA Characteristic
C.F.R.	Code of Federal Regulations
CI	Chemical Ionization Mode (Mass Spectrometry)
cm	Centimeter (10^{-2} m)
CO	Carbon Monoxide
Coliwasa	Composite Liquid Waste Sampler
CV	Coefficient of Variation
2,4-D	2,4-Dichlorophenoxyacetic acid
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene

x **Abbreviations and Glossary of Terms**

DDT	Dichlorodiphenyltrichloroethane
D.E.S.	Diethylstilbestrol
DFTPP	Decafluorotriphenylphosphine
Directed Analysis	Qualitative confirmation of compound presence and identity. Also, quantitative data of known quality for a set of constituents that might reasonably be expected to be present in the waste based on professional judgment and/or the results of proximate and survey analyses.
DNPH	Dinitrophenylhydrazine
DRE	Destruction and Removal Efficiency--the measure of the mass emission rate of a principal organic hazardous constituent (POHC) in the output stack gas versus the mass feed rate of the same POHC in the influent waste.
dscf	Dry Standard Cubic Foot ($1 \text{ dscf} = 2.8317 \times 10^{-2} \text{ dscm}$)
dscm	Dry Standard Cubic Meter
E	Extraction Procedure Toxicity Test--RCRA Characteristic
ECD	Electron Capture Detector
EI	Electron Impact Ionization Mode (Mass Spectrometry)
EP	Extraction Procedure
EPA	U.S. Environmental Protection Agency
ESP	Electrostatic Precipitator
eV	Electron Volt ($1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$)
Excess Air	Air flow rate above that required to achieve theoretically complete combustion.
FID	Flame Photometric Detector
ft	Foot ($1 \text{ ft} = 3.0480 \times 10^{-1} \text{ m}$)
FT-IR	Fourier Transform-Infrared Spectroscopy
g	Gram (10^{-3} kg)

Abbreviations and Glossary of Terms

gal	Gallon (1 gal = $3.785 \times 10^{-3} \text{ m}^3$)
GC	Gas Chromatography
GC/AFID	Gas Chromatography/Alkali Flame Ionization Detector
GC/ECD	Gas Chromatography/Electron Capture Detector
GC/MS	Gas Chromatography/Mass Spectrometry
GC/MS/DS	Gas Chromatography/Mass Spectrometry/Data System
GC/NPD	Gas Chromatography/Nitrogen-Phosphorus Detector (Alkali Flame Ionization Detector)
GC/TD	Gas Chromatography/Thermionic Detector
gr	Grain (1 gr = $6.48 \times 10^{-5} \text{ kg}$)
GRAV	Gravimetric Analysis
h	Hour
HCl	Hydrochloric Acid
HPLC	High Performance Liquid Chromatography
HPLC/UV	High Performance Liquid Chromatography/Ultraviolet Spectroscopy
I	Ignitability Test--RCRA Characteristic
ICAP	Inductively Coupled Argon Plasma Atomic Emission Spectroscopy
I.D.	Internal Diameter
in	Inch (1 in = $2.54 \times 10^{-2} \text{ m}$)
IR	Infrared Spectroscopy
Isokinetic Sampling	Collection of stack gas samples under conditions such that the linear velocity of gas through the sampling nozzle is equal to that of the undisturbed gas stream at the sample point.
Isothermal	With or at equal temperatures.
J	Joule

xii Abbreviations and Glossary of Terms

kcal	Kilocalorie (1 kcal = 4.184×10^3 J)
K-D	Kuderna-Danish Evaporative Concentrator
kg	Kilogram (10^3 g)
L	Liter (1 L = 1.00×10^{-3} m ³)
LC	Liquid Chromatography
LC/EC	Liquid Chromatography/Electrochemical Detector
LOD	Loss on Drying
LOI	Loss on Ignition
LRMS	Low Resolution Mass Spectrometry
µg	Microgram (10^{-6} g)
µL	Microliter (10^{-6} L)
µm	Micrometer (10^{-6} m)
m	Meter
m ³	Cubic Meter
M5	Method 5 Sampling Train
mg	Milligram (10^{-3} g)
min	Minute (1 min = 60 sec)
mL	Milliliter (10^{-3} L)
mm	Millimeter (10^{-3} m)
MMS	Modified Method 5 Sampling Train
MS	Mass Spectrometry
mV	Millivolt (10^{-3} V)
MW	Molecular Weight
NDIR	Non-Dispersive Infrared Analyzer
NFPA	National Fire Protection Association

ng	Nanogram (10^{-9} g)
nm	Nanometer (10^{-9} m)
NO _x	Nitrogen Oxides (NO, NO ₂ , etc.)
N.O.S.	Not Otherwise Specified
O.D.	Outer Diameter
Opacity	Measurement of the optical density of stack gas emissions of an incinerator.
Pa	Pascal
PCB(s)	Polychlorinated Biphenyl(s)
POHC(s)	Principal Organic Hazardous Constituent(s)
P ₂ O ₅	Phosphorus Pentoxide
ppb	Part Per Billion

One part in 10^9 . For gaseous mixtures, a volume:volume basis is typically used and 1 ppb is on the order of $1 \mu\text{g}/\text{m}^3$:

$$\mu\text{g}/\text{m}^3 = \text{ppb} \times \frac{RT}{MW}$$

where $RT = 22.4 \text{ L/mole at } 0^\circ \text{ and } 1 \text{ atm}$
 $= 24.5 \text{ L/mole at } 25^\circ \text{ and } 1 \text{ atm}$

For liquid materials, a weight:volume basis is most commonly used and 1 ppb = $1 \mu\text{g}/\text{L}$ ($\approx 1 \mu\text{g}/\text{kg}$ for liquids with density ≈ 1). For solid materials, a weight:weight basis is most commonly used and 1 ppb = $1 \mu\text{g}/\text{kg}$.

ppm	Part Per Million
-----	------------------

One part in 10^6 (see ppb).
 $1 \text{ ppm} \approx 1 \text{ mg}/\text{m}^3$ gaseous streams
 $1 \text{ ppm} = 1 \text{ mg}/\text{L}$ liquid streams
 $1 \text{ ppm} = 1 \text{ mg}/\text{kg}$ solid streams

Precision	The reproducibility of measurements within a set of independent replicate determinations. The relative standard deviation expressed as a percentage of the mean is a common measure of precision.
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Abbreviations and Glossary of Terms

Proximate Analysis	Provides data relating to the physical form of the waste and provides an approximate mass balance as to the composition of the waste.
psi	Pounds Per Square Inch (1 psi = 6.8948×10^3 Pa)
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
R	Reactivity Test--RCRA Characteristic
RCRA	Resource Conservation and Recovery Act of 1976
RI	Refractive Index Detector
rpm	Revolutions Per Minute
RSD	Relative Standard Deviation
SASS	Source Assessment Sampling System
s	Second
SCFM	Standard Cubic Feet per Minute
SD	Standard Deviation
Segregation	Heterogeneity in a sample
Semivolatiles	Organic species with moderate vapor pressure sufficient to allow analysis by gas chromatography, generally have boiling points of 100°C or higher, molecular weights of 100-400, seven to twenty carbon atoms per molecule.
SO _x	Sulfur Oxides (SO ₂ , SO ₃)
Sparging	Removal of the volatile constituents of a sample by bubbling an inert gas stream through the sample.
Surrogate	A known compound added to a sample which is chemically similar to a POHC of interest so that an estimate of the accuracy of the analytical measurement and an assessment of the overall efficiency of the analytical procedures can be made.

Organic Analysis

Provides an overall description of the sample in terms of the major organic compounds and major inorganic compounds that are present in the sample. The analysis provides a qualitative description of the overall chemistry of the sample.

T	Transmittance
2,4,5-T	2,4,5-Trichlorophenoxyacetic acid
TCD	Thermal Conductivity Detector
TCDD(s)	Tetrachlorodibenzo-p-dioxin(s)
TCO	Total Chromatographicable Organics
TGA	Thermogravimetric Analysis
THEED	Tetrahydroxyethylenediamine
TLC	Thin Layer Chromatography
TOC	Total Organic Carbon Content
TOX	Total Organic Halogen Content
2,4,5-TP	2,4,5-Trichlorophenoxypropionic acid
TSDF	Hazardous Waste Treatment, Storage, and Disposal Facility
UV	Ultraviolet Spectroscopy
V	Volt
VOA	Volatile Organics Analysis
Volatiles	Organic species with appreciable vapor pressure at room temperature, generally have boiling points of 100°C or lower, molecular weights less than 200, one to seven carbon atoms per molecule.
W	Watt
W_{in}	Mass feed rate of one POHC in the waste stream feeding the incinerator.
W_{out}	Mass emission rate of the same POHC (see W_{in}) present in exhaust emissions prior to release to the atmosphere.

Contents and Subject Index

FOREWORD	v
ABBREVIATIONS AND GLOSSARY OF TERMS	ix
I. ABSTRACT	1
II. INTRODUCTION	2
Purpose	2
Scope	3
Use of Report	4
III. SAMPLING AND ANALYSIS STRATEGY TO MEET REGULATORY REQUIREMENTS	5
Introduction	5
General Facility Standards	5
Interim Status Standards for Incinerators	5
Permitting Standards for Incinerators	6
Hazardous Waste Permit Program	7
Waste Characterization Strategy	8
Sampling	8
Analysis	9
Characteristics	9
Composition-Proximate Analysis	11
Composition-Survey Analysis	11
Composition-Directed Analysis	12
Selection of POHC(s)	13
Stack Gas Effluent Characterization Strategy	14
Additional Effluent Characterization Strategy	16
Selection of Specific Sampling and Analysis Methods	16

Scenario	16
Strategy	17
Sampling Strategy	17
Analysis Strategy	18
Tactics and Methods	19
Selection of POHCs	19
Selection of Sampling Methods	19
Selection of Sample Preparation Methods	23
Selection of Analysis Methods	23
Results and Calculations	24
Calculation of W_{in}	24
Calculation of W_{out}	26
Calculation of DRE	27
Calculation of HCl Emissions	27
Calculation of Particulate Loading	28
Summary	29

IV. SAMPLING PROCEDURES

Overview	30
Sampling Methods for Influent Streams	30
Sampling Methods for Liquid Wastes	33
Coli-wasa (Method S001)	33
Dipper or Pond Sampler (Method S002)	33
Weighted Bottle Sampler (Method S003)	34
Tap Sampling (Method S004)	34
Sampling Methods for Solid Wastes	34
Thief or Grain Sampler (Method S005)	34
Trier or Sample Corer/Waste Pile Sampler (Method S006)	35
Trowel or Scoop (Method S007)	35
Sampling Methods for Slurry and Sludge Samples	35
Sampling Methods for Water Samples	35
Sampling Methods for Effluent Streams	36
Sampling Methods for Stack Gas	36
Modified Method 5 Train (Method S008)	36
Source Assessment Sampling System (SASS) (Method S009)	40
Gas Bulb and Gas Bag Sampling Systems (Methods S010, S011)	42
Volatile Organic Sampling Train (VOST) (Method S012)	44
Specific Sorbent/Reagent Methods	47
Monitoring of Gaseous Combustion Products	47
Sampling Methods for Solid and Liquid Effluents	50
Health and Safety Precautions	50
Collection of Representative Samples	51
Gases	51
Liquids	52
Solids	52
Slurries	52
Sample Handling	52

Identification of Samples	57
Sample Labels	58
Field Log Book	59
Field Observations	61
Sampling Method Summaries	62
V. SAMPLE PREPARATION PROCEDURES	67
Overview	67
Representative Aliquots from Field Samples (Methods P001-P003)	67
Recovery Measurements (Methods P011-P014)	68
Solvent Extraction of Organic Compounds (Methods P021-P024)	72
Aqueous Liquids (Method P021)	72
Semivolatiles (Method P021a)	72
Volatiles (Method P021b)	72
Sludges (Method P022)	72
Semivolatiles (Method P022a)	73
Volatiles (Method P022b)	73
Organic Liquids (Method P023)	73
Solids (Method P024)	74
Semivolatiles (Method P024a, b)	74
Volatiles (Method P024c)	75
Drying and Concentrating of Solvent Extracts (Method P031)	75
Digestion (Method P032)	75
Sample Cleanup Procedures (Methods P041-P045)	76
Sample Preparation Method Summaries	76
VI. ANALYSIS PROCEDURES	97
Overview	97
Waste Characteristics	97
Ignitability (Method C001)	97
Corrosivity (Method C002)	98
Reactivity (Method C003)	98
Extraction Procedure Toxicity (Method C004)	99
Proximate Analysis	99
Moisture, Solid and Ash Content (Methods A001-A002)	99
Macro-Scale Technique (Method A001)	99
Micro-Scale Technique (Method A002)	102
Elemental Composition (Method A003)	103
Total Organic Carbon and Total Organic Halogen (Method A004)	103
Viscosity (Method A005)	104
Heating Value of the Waste (Method A006)	104
Survey Analysis	104
Survey Analysis of Organic Content (Methods A011-A017)	105
Organic Content by TCO (Method A011)	105
Organic Content by GRAV (Method A012)	107
Organic Content-Volatiles (Method A013)	107

Compound Class Type by Infrared Analysis (Method A014)	108
Mass Spectrometric Analysis (Method A015)	109
Specific Major Components by GC/MS (Method A016)	112
Specific Major Components by HPLC/IR or HPLC/LRMS (Method A017)	112
Survey Analysis of Inorganics (Method A021)	116
Directed Analysis	116
Organic Constituents (Appendix VIII)	118
Volatiles (Method A101)	118
Extractable Species (Method A121)	118
Compounds by HPLC (Methods A122, A123)	119
Aldehydes and Acids (Methods A132, A133)	120
Alcohols (Method A134)	124
Inorganic-Containing POHCs	124
Others	124
Inorganic Constituents (Appendix VIII)	125
Metals (Methods A221-A235)	125
Anions (Methods A251, A252, A253)	126
Gases	128
Directed Organic Analysis Criteria	128
Instrumental Operating Parameters	129
Qualitative Identification	130
Quantitative Measurement	134
Analysis Method Summaries	135

VII. QUALITY ASSURANCE AND QUALITY CONTROL

PROCEDURES	215
Overview	215
Title Page and Table of Contents	216
Project Description	216
Project Organization and Responsibility	216
Quality Assurance Objectives	220
Accuracy	220
Precision	223
Completeness	223
Representativeness	223
Comparability	223
Sampling Procedures	224
Sample Custody	224
Data Maintenance and Chain-of-Custody	224
Calibration Procedures and Frequency	226
Sampling	226
Analysis	226
Analytical Procedures	226
Data Reduction, Validation, and Reporting	226
Data Reduction	226
Data Validation	234

Data Reporting	234
Internal Quality Control Checks	235
Blank Samples	235
Analytical Replicates	235
Spiked Samples	235
Performance and System Audit	236
Preventive Maintenance	236
Specific Routine Procedures Used to Assess Data Precision,	
Accuracy and Completeness	236
Calculation of Mean Values and Estimates of Precision	236
Assessment of Accuracy	237
Assessment of Causes of Variance	238
Corrective Action	238
Quality Assurance Reports	240
 VIII. REFERENCES	 242
 APPENDIX A: HAZARDOUS CONSTITUENTS—PHYSICAL/CHEMICAL DATA	 245
 APPENDIX B: HAZARDOUS CONSTITUENTS—STACK GAS SAMPLING METHODS	 320
 APPENDIX C: HAZARDOUS CONSTITUENTS—ANALYSIS METHODS	 344
 APPENDIX D: SUMMARY OF METHOD NUMBERS	 368
 APPENDIX E: MS—ANALYTICAL IONS	 375
 APPENDIX F: VOLATILE ORGANIC SAMPLING TRAIN	 392