FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

BACKGROUND DOCUMENT

FOR

CHLORINATED TOLUENE WASTES

K149, K150, AND K151

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July 1994

NRJ-071
0721-02.nrj

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EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA or the Agency) is establishing Best Demonstrated Available Technology (BDAT) treatment standards for the regulation of hazardous wastes listed in Title 40, Code of Federal Regulations, Section 261.32 (40 CFR 261.32) as K149, K150, and K151. These BDAT treatment standards are being established in accordance with the amendments to the Resource Conservation and Recovery Act (RCRA) of 1976, enacted by the Hazardous and Solid Waste Amendments (HSWA) of November 8, 1984. Compliance with the BDAT treatment standards is a prerequisite for land disposal of restricted wastes, as defined in 40 CFR Part 268. EPA may grant a variance from the applicable treatment standards under 40 CFR 268.44 and under 40 CFR 268.6. EPA may grant waste- and site-specific waivers from applicable treatment standards in 40 CFR 268.41-268.43.

K149, K150, and K151 wastes are generated in the production of chlorinated toluenes. These wastes are defined as follows:

- **K149** - Distillation bottoms from the production of alpha (methyl) chlorinated toluenes, ring-chlorinated toluenes, benzoyl chlorides, and compounds with mixtures of these functional groups. (The definition of this waste does not include K015 wastes, still bottoms from the distillation of benzyl chloride.)

- **K150** - Organic residuals, excluding spent carbon adsorbent, from the spent chlorine gas and hydrochloric acid recovery processes associated with the production of alpha (methyl) chlorinated toluenes, ring-chlorinated toluenes, benzoyl chlorides, and compounds with mixtures of these functional groups.

- **K151** - Wastewater treatment sludges, excluding neutralization and biological sludges, generated during the treatment of wastewaters from the production of alpha (methyl) chlorinated toluenes, ring-chlorinated toluenes, benzoyl chlorides and compounds with mixtures of these functional groups.

This background document provides the Agency's rationale and technical support for developing BDAT treatment standards for K149, K150, and K151 wastes under the Land Disposal Restrictions (LDR) program. This document also provides waste characterization data that may serve as a basis for determining whether a variance from the applicable treatment standards may be warranted for a particular type of chlorinated toluene waste that may be more difficult to treat than the wastes on which the BDAT treatment standards are based.

The Agency's legal authority and the petition process necessary for requesting a variance from the treatment standards are summarized in EPA's Final Best Demonstrated Available Technology (BDAT) Background Document for Quality Assurance/Quality Control Procedures and Methodologies (Methodology Background Document) (11). The methodologies used for establishing the nonwastewater and wastewater treatment standards for the constituents selected for regulation in K149, K150, and K151 wastes, are summarized in Appendices A and B of this document, respectively.

The Agency selected constituents for regulation in K149, K150, and K151 wastes based on an October 1992 final rule which listed these wastes as hazardous (14).

The Agency is regulating the land disposal of both nonwastewater and wastewater forms of K149, K150, and K151 wastes by establishing the BDAT treatment standards numerically equivalent to the universal standards (universal standards). A universal standard is a single concentration limit established for a specific constituent regardless of the waste matrix in which it is present, i.e., the same treatment standard applies to a particular constituent in each waste code in which it is regulated. The Agency is establishing two different sets of universal standards: one for nonwastewater forms of waste and one for wastewater forms of waste. These two sets differ in the population of regulated constituents and the individual universal standards. A more detailed discussion concerning the determination of these treatment standards is provided in EPA's Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards, Volume A: Universal Standards for Nonwastewater Forms of Wastes (12) and EPA's Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards, Volume B: Universal Standards for Wastewater Forms of Wastes (13).

The universal standards for the constituents selected for regulation in nonwastewater forms of K149, K150, and K151 wastes are based on incineration treatment performance data that were used to promulgate previous BDAT treatment standards. The universal standards for wastewater forms of these wastes are based on treatment performance data from several sources, including the BDAT database, the NPDES database, the WERL database, EPA-collected WAO/PACT® data, the EAD database, industry-submitted leachate treatment performance data, data submitted by the Chemical Manufacturers Association's Carbon Disulfide Task Force, data submitted by the California Toxic Substances Control Division, data in literature that were not already part of the WERL database, and data in literature submitted by industry on the WAO and PACT® treatment processes.

Table ES-1 lists the BDAT treatment standards for nonwastewater forms of K149, K150, and K151 wastes. Table ES-2 lists the BDAT treatment standards for wastewater forms of these wastes. The standards shown on Tables ES-1 and ES-2 are numerically equivalent to the universal standards for those constituents.

Table ES-1

BDAT Treatment Standards for Nonwastewater Forms of K149, K150, and K151 Wastes

BDAT List Constituent	Total Composition Concentration (mg/kg) Maximum for Any Single Grab Sample		
	K149	K150	K151
Benzene	NR	NR	10
Carbon tetrachloride	NR	6.0	6.0
Chlorobenzene	6.0	NR	NR
Chloroform	6.0	6.0	6.0
Chloromethane	30	30	NR
1,4-Dichlorobenzene	6.0	6.0	NR
Hexachlorobenzene	10	10	10
Pentachlorobenzene	10	10	10
1,2,4,5-Tetrachlorobenzene	14	14	14
1,1,2,2-Tetrachloroethane	NR	6.0	NR
Tetrachloroethylene	NR	6.0	6.0
Toluene	10	NR	10
1,2,4-Trichlorobenzene	NR	19	NR

NR = Not Regulated.

Table ES-2

BDAT Treatment Standards for Wastewater Forms of K149, K150, and K151 Wastes

BDAT List Constituent	Total Composition Concentration (mg/L) Maximum for Any 24-Hour Composite Sample		
	K149	K150	K151
Benzene	NR	NR	0.14
Carbon tetrachloride	NR	0.057	0.057
Chlorobenzene	0.057	NR	NR
Chloroform	0.046	0.046	0.046
Chloromethane	0.19	0.19	NR
1,4-Dichlorobenzene	0.090	0.090	NR
Hexachlorobenzene	0.055	0.055	0.055
Pentachlorobenzene	0.055	0.055	0.055
1,2,4,5-Tetrachlorobenzene	0.055	0.055	0.055
1,1,2,2-Tetrachloroethane	NR	0.057	NR
Tetrachloroethylene	NR	0.056	0.056
Toluene	0.080	NR	0.080
1,2,4-Trichlorobenzene	NR	0.055	NR

NR = Not Regulated.

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA or the Agency) is establishing Best Demonstrated Available Technology (BDAT) treatment standards for the regulation of hazardous wastes listed in Title 40, Code of Federal Regulations, Section 261.32 (40 CFR 261.32) as K149, K150, and K151 wastes. These BDAT treatment standards are being established in accordance with the amendments to the Resource Conservation and Recovery Act (RCRA) of 1976, enacted by the Hazardous and Solid Waste Amendments (HSWA) of November 8, 1984. Compliance with the BDAT treatment standards is a prerequisite for land disposal of restricted wastes, as defined in 40 CFR Part 268. EPA may grant a variance from the applicable treatment standards under 40 CFR 268.44 and under 40 CFR 268.6. EPA may grant waste- and site-specific waivers from applicable treatment standards in 40 CFR 268.41-268.43. The BDAT treatment standards for these wastes are presented in Tables 1-1 and 1-2 of this document.

K149, K150, and K151 wastes are generated in the production of chlorinated toluenes. These wastes are defined as follows:

- **K149** - Distillation bottoms from the production of alpha (methyl) chlorinated toluenes, ring-chlorinated toluenes, benzoyl chlorides, and compounds with mixtures of these functional groups. (The definition of this waste does not include K015 wastes, still bottoms from the distillation of benzyl chloride.)
- **K150** - Organic residuals, excluding spent carbon adsorbent, from the spent chlorine gas and hydrochloric acid recovery processes associated with the production of alpha (methyl) chlorinated toluenes, ring-chlorinated toluenes, benzoyl chlorides, and compounds with mixtures of these functional groups.
- **K151** - Wastewater treatment sludges, excluding neutralization and biological sludges, generated during the treatment of wastewaters from the production of alpha (methyl) chlorinated toluenes, ring-

chlorinated toluenes, benzoyl chlorides and compounds with mixtures of these functional groups.

This background document provides the Agency's rationale and technical support for developing BDAT treatment standards for K149, K150, and K151 wastes under the Land Disposal Restrictions (LDR) program. This document also provides waste characterization data that may serve as a basis for determining whether a variance from the applicable treatment standards may be warranted for a particular type of chlorinated toluene waste that may be more difficult to treat than the wastes on which the BDAT treatment standards are based.

The Agency's legal authority and the petition process necessary for requesting a variance from the treatment standards are summarized in EPA's Final Best Demonstrated Available Technology (BDAT) Background Document for Quality Assurance/Quality Control Procedures and Methodology (Methodology Background Document) (11). The methodologies used for establishing the nonwastewater and wastewater treatment standards for the constituents selected for regulation in K149, K150, and K151 wastes, are summarized in Appendices A and B of this document, respectively.

1.1 Regulatory Background

On October 15, 1992 (57 FR 47376), the Agency promulgated a hazardous waste listing rule for K149, K150, and K151 wastes generated during the production of chlorinated toluenes. The Agency listed thirteen constituents of concern in these wastes: benzene, carbon tetrachloride, chlorobenzene, chloroform, chloromethane, 1,4-dichlorobenzene, hexachlorobenzene, pentachlorobenzene, 1,2,4,5-tetrachlorobenzene, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, and 1,2,4-trichlorobenzene. One waste generated during the production of chlorinated toluenes (still bottoms from the distillation of benzyl chloride, K015) was already listed and regulated as a hazardous waste prior to the October, 1992 rulemaking.

The hazardous waste listing program and the LDR program both define "wastewater" quantitatively to mean forms of hazardous wastes with less than one percent total organic carbon (TOC) and less than one percent total suspended solids (TSS) (see 40 CFR 268.2 (f)). Although K149, K150, and K151 wastes meet the definition of nonwastewaters as generated, EPA establishes treatment standards for both wastewater and nonwastewater forms of these listed wastes to ensure that any waste streams that meet the definition of a wastewater are also treated to meet appropriate treatment standards prior to land disposal. The October 11, 1991 proposed rule and the October 15, 1992 final rule (57 FR 47376) stated that EPA did not list as hazardous those waste streams from the production, recovery, and refining of chlorinated toluenes meeting the definition of wastewaters. At that time, EPA chose not to list certain aqueous process streams from chlorinated toluene production as hazardous wastes. Streams generated from the treatment of K149, K150, and K151 wastes containing less than one percent TOC and less than one percent TSS, however, are defined as wastewater forms of these wastes to which the wastewater treatment standards promulgated in this rule apply.

Following the proposed listing of K149, K150, and K151 wastes as hazardous wastes, the Agency published an Advance Notice of Proposed Rulemaking (ANPRM) and request for comments in the October 24, 1991 Federal Register (56 FR 55160). In this advance notice, the Agency outlined its proposed approach for the regulation of newly listed wastes under the LDR Program and requested comments on the approach as well as treatment or recycling data on these wastes.

1.2 Summary

The Agency is regulating the land disposal of both nonwastewater and wastewater forms of K149, K150, and K151 wastes by establishing BDAT treatment standards numerically equivalent to the universal standards (universal standards). A universal standard is a single concentration limit established for a specific constituent regardless of the waste matrix in which it is present, i.e., the same treatment standard applies to a particular constituent in each waste code in which it is regulated. The Agency is establishing two different sets of universal standards: one for nonwastewater forms of waste and one for wastewater forms of waste. These two sets differ in the population of regulated constituents and the individual universal standards. A more detailed discussion concerning the determination of these treatment standards is provided in EPA's Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards, Volume A: Universal Standards for Nonwastewater Forms of Listed Hazardous Wastes (12) and EPA's Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards, Volume B: Universal Standards for Wastewater Forms of Listed Hazardous Wastes (13).

The universal standards for the constituents selected for regulation in nonwastewater forms of K149, K150, and K151 wastes are based on incineration treatment performance data that were used to promulgate previous BDAT treatment standards. The universal standards for wastewater forms of these wastes are based on treatment performance data from several sources, including the BDAT database, the NPDES database, the WERL database, EPA-collected WAO/PACT® data, the EAD database, industry-submitted leachate treatment performance data, data submitted by the Chemical Manufacturers Association's Carbon Disulfide Task Force, data submitted by the California Toxic Substances Control Division, data in literature that were not already part of the WERL database, and data in literature submitted by industry on the WAO and PACT® treatment processes.

Table 1-1 presents the BDAT treatment standards for nonwastewater forms of K149, K150, and K151 wastes. Table 1-2 presents the BDAT treatment standards for wastewater forms of these wastes. The standards shown on Tables 1-1 and 1-2 are numerically equivalent to the universal standards for those constituents.

1.3 Contents of This Document

Section 2.0 of this document summarizes the BDAT standards, the basis for listing chlorinated toluene wastes as hazardous, and how the BDAT standards reflect the goals of the LDR program. Section 3.0 describes the chlorinated toluenes industry and processes generating K149, K150, and K151 wastes and presents data characterizing these wastes. Existing waste management practices for these wastes are also described in Section 3.0. Section 4.0 explains the methodology and rationale for selecting the regulated constituents, discusses the treatment technologies the Agency has designated as "applicable" and "demonstrated" for these wastes, identifies BDAT for wastewater and nonwastewater forms of these wastes, and presents the determination of the BDAT treatment standards for these wastes. In addition, potential reuse and recycling, source reduction, pollution prevention, and waste minimization alternatives for K149, K150, and K151 wastes are discussed in Section 4.0. Section 5.0 details the regulatory history and status of these waste streams under the LDR and other Agency programs. References are listed in Section 6.0 and are cited numerically within this document in parentheses, e.g., (1). Acknowledgements are provided in Section 7.0. Tables are located at the end of each section.

Table 1-1

BDAT Treatment Standards for Nonwastewater Forms of K149, K150, and K151 Wastes

BDAT List Constituent	Total Composition Concentration (mg/kg) Maximum for Any Single Grab Sample		
	K149	K150	K151
Benzene	NR	NR	10
Carbon tetrachloride	NR	6.0	6.0
Chlorobenzene	6.0	NR	NR
Chloroform	6.0	6.0	6.0
Chloromethane	30	30	NR
1,4-Dichlorobenzene	6.0	6.0	NR
Hexachlorobenzene	10	10	10
Pentachlorobenzene	10	10	10
1,2,4,5-Tetrachlorobenzene	14	14	14
1,1,2,2-Tetrachloroethane	NR	6.0	NR
Tetrachloroethylene	NR	6.0	6.0
Toluene	10	NR	10
1,2,4-Trichlorobenzene	NR	19	NR

NR = Not Regulated.

Table 1-2

BDAT Treatment Standards for Wastewater Forms of K149, K150, and K151 Wastes

BDAT List Constituent	Total Composition Concentration (mg/L) Maximum for Any 24-Hour Composite Sample		
	K149	K150	K151
Benzene	NR	NR	0.14
Carbon tetrachloride	NR	0.057	0.057
Chlorobenzene	0.057	NR	NR
Chloroform	0.046	0.046	0.046
Chloromethane	0.19	0.19	NR
1,4-Dichlorobenzene	0.090	0.090	NR
Hexachlorobenzene	0.055	0.055	0.055
Pentachlorobenzene	0.055	0.055	0.055
1,2,4,5-Tetrachlorobenzene	0.055	0.055	0.055
1,1,2,2-Tetrachloroethane	NR	0.057	NR
Tetrachloroethylene	NR	0.056	0.056
Toluene	0.080	NR	0.080
1,2,4-Trichlorobenzene	NR	0.055	NR

NR = Not Regulated.

2.0 LAND DISPOSAL RESTRICTIONS FOR K149, K150, AND K151 WASTES

2.1 Summary of Basis for Listing of Chlorinated Toluene Wastes

The Agency found that certain residuals from the production, recovery, and refining of chlorinated toluenes (K149, K150, and K151 wastes) typically contain constituents that, when mismanaged, pose a substantial present or potential threat to human health and the environment due to their corrosive properties. In addition, the Agency compiled evidence that these wastes contain hazardous constituents that are mobile and/or persistent in the environment and are therefore capable of reaching receptors in harmful concentrations.

2.2 Key Points of Chlorinated Toluene Waste Standards and How They Reflect LDR Goals

The LDR program is designed to protect human health and the environment by prohibiting the land disposal of RCRA hazardous wastes unless specific treatment standards are met.

In RCRA Section 3004(m), Congress directed the Agency to:

> ". . . promulgate . . . levels or methods of treatment . . . which substantially diminish the toxicity of the waste or . . . the likelihood of migration of hazardous constituents . . . so that short-term and long-term threats to human health and the environment are minimized."

Key provisions of the LDR program require that: (1) treatment standards are met prior to land disposal, (2) treatment is not evaded by long-term storage, (3) actual treatment occurs rather than dilution, (4) recordkeeping and tracking follow a waste from "cradle to grave" (i.e., generation to disposal), and (5) certification verifies that the specified treatment standards have been met.

The Agency is establishing treatment standards for both nonwastewater and wastewater forms of K149, K150, and K151 wastes as concentrations numerically equivalent to the universal standards for the constituents selected for regulation in these wastes. The Agency believes that establishing treatment standards for the regulated constituents in chlorinated toluene wastes as equivalent to the corresponding universal standards meets its goal of minimizing threats to human health and the environment from land disposal since these standards are based on treatment performance data representing the treatment technology identified as "best" for chlorinated toluene wastes. The universal standards for nonwastewater and wastewater forms of wastes were developed based on treatment performance data used to promulgate previous BDAT treatment standards, and, therefore, have already been determined to meet the Agency's requirements of BDAT.

3.0 DETAILED DESCRIPTION OF CHLORINATED TOLUENE WASTE STREAMS

3.1 Chlorinated Toluene Industry

The Agency is aware of four facilities in the United States that generate chlorinated toluene wastes K149, K150, and K151. These facilities manufacture and sell chlorinated toluenes as intermediates and raw materials for the production of pesticides, dyes and dye carriers, pharmaceuticals, solvents, and polymer initiators and plasticizers. Three types of chlorinated toluene products are manufactured by this industry: methyl-chlorinated toluenes, ring-chlorinated toluenes, and aromatic acid chlorides.

3.1.1 Chlorinated Toluene Production Processes

The chlorinated toluene production process is divided into three operations: the chlorination reaction, HCl recovery, and product distillation and purification. Figure 3-1 depicts the process and the three operations as Groups A, B, and C, respectively (1). These three operations are discussed in detail in the following sections.

Chlorination Reactions

Different chlorination reactions are used for producing methyl-chlorinated toluenes, ring-chlorinated toluenes, and aromatic acid chlorides; each of which is described below.

Methyl-Chlorinated Toluenes. Methyl-chlorinated toluenes are most often produced through ultraviolet (UV) light-catalyzed chlorination, although thermal chlorination can also be used. Both of these processes involve free-radical chain reactions and chlorinate the toluene methyl group and not the aromatic ring. The raw

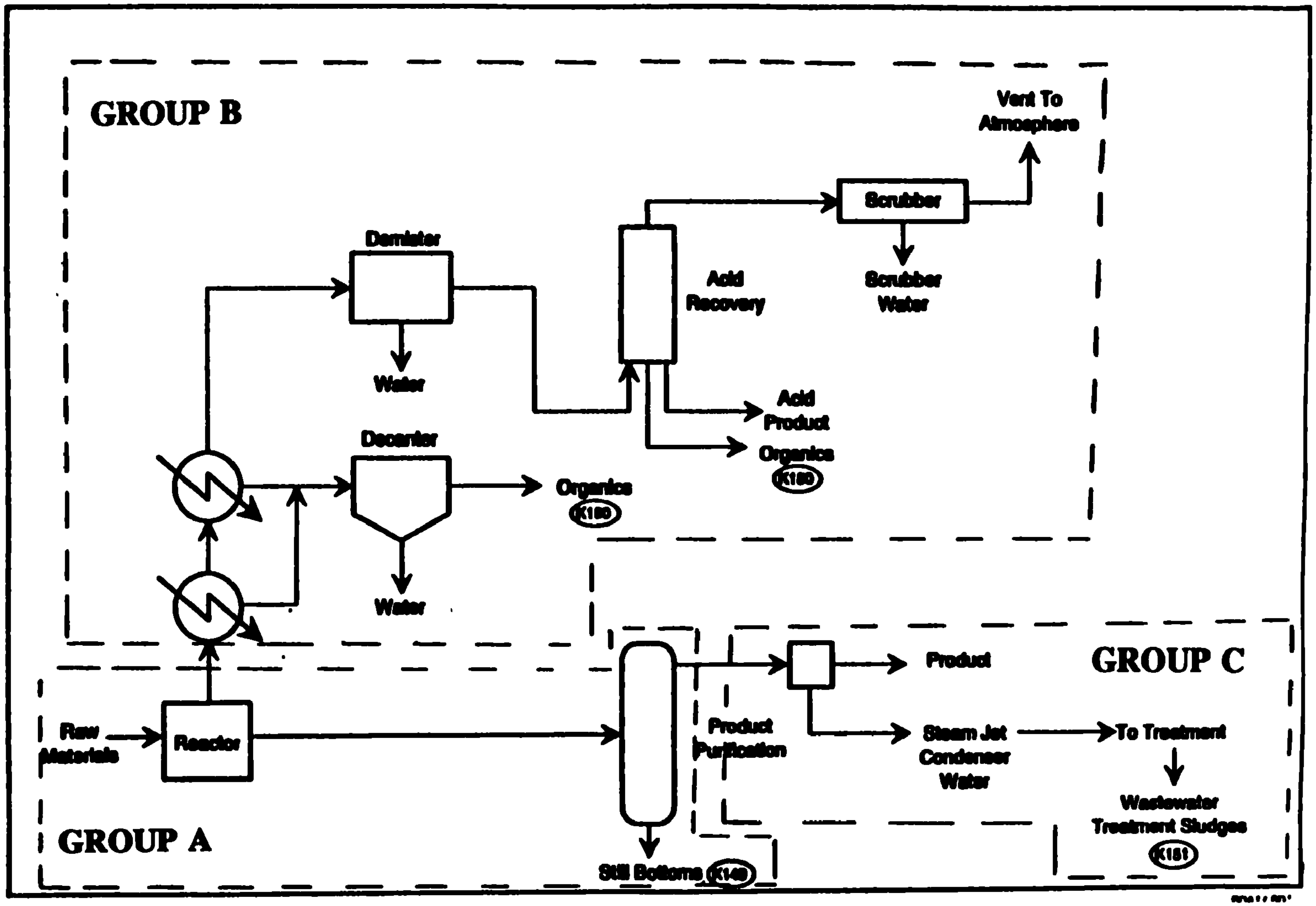

Figure 3-1

Chlorinated Toluene Process Diagram
Reference: Based on (1).

materials consumed by each process include chlorine and toluene. Simple chlorinated toluenes are often further chlorinated to obtain higher chlorinated products. Each chlorination step results in the generation of approximately one mole of HCl by-product per mole of product formed. The acidic off-gas generated from the reaction is routed to an HCl recovery system (1).

Smaller amounts of by-products and impurities are also generated during the manufacture of methyl-chlorinated toluenes, including: over-chlorinated substances, under-chlorinated or unreacted feedstock material, chlorinated and non-chlorinated impurities from the feedstock materials, and chlorinated decomposition products. The majority of the lighter components (such as chloromethane, benzene, mono- and dichlorobenzenes, and toluene) are removed with the acid vapor stream and collected for HCl recovery. The heavier chlorinated aromatics generally remain with the product stream and are pumped from the reactor to the distillation train (1).

Ring-Chlorinated Toluenes. Ring-chlorinated toluenes are produced by direct chlorination via the Lewis acid-catalyzed process. In this process, toluene or chlorinated toluene is charged to the reactor with chlorine and a small amount of catalyst, such as ferric chloride. Higher chlorinated products are obtained by recycling monochlorinated toluenes to the reactor (1).

As with the production of the methyl-chlorinated toluenes, each subsequent Lewis acid-catalyzed chlorination generates approximately one mole of HCl per mole of product formed. The HCl by-product is usually recovered. Other by-products, impurities, and exit streams generated by Lewis acid-catalyzed chlorination include over-chlorinated substances, under-chlorinated or unreacted feedstock material, and are analogous to those previously discussed for methyl-chlorinated reactions (1).

Aromatic Acid Chlorides. Catalytic steam hydrolysis is used to produce aromatic acid chlorides through dechlorination of the side chain of benzotrichloride and substitution of a double bonded oxygen atom for the chlorine atoms. Benzotrichloride, the primary feedstock in this process, is first partially hydrolyzed to benzoic acid by steam. A Lewis acid catalyst is then added to promote the chloride transfer from the unconverted benzotrichloride to the benzoic acid, while the hydroxy group is transferred from the benzoic acid to benzotrichloride (1).

Two moles of HCl by-product are generated for every mole of product formed. By-products, impurities, and exit streams generated from aromatic acid chloride manufacture include over-chlorinated substances, under-chlorinated or unreacted feedstock materials, and are analogous to those previously discussed for methyl-chlorinated reactions (1).

HCl Recovery

The processes used to manufacture chlorinated toluenes generate large quantities of HCl by-product. All facilities reported the use of HCl recovery systems (1). The three waste streams of concern generated from HCl recovery are organic liquids, solids, and aqueous liquids.

The chlorinated toluene reactor overhead stream from all three reaction processes passes through condensers and is decanted, generating condensed organic and aqueous liquids. The organic condensate contains products, product isomers, and under- and over-chlorinated by-products. These organic liquids are either disposed of or recycled to the process; when disposed, these organic liquids comprise the listed waste K150. The condensed aqueous stream is discharged into the wastewater treatment system. After demisting, the uncondensed HCl and highly volatile organics are then routed to the acid recovery units (1).

The acid recovery units generally consist of a multi-stage HCl absorber followed by a water scrubber. The HCl absorber collects gaseous HCl and converts it into approximately 30 percent crude HCl product. As that crude HCl is collected, purified, and stored, additional organic constituents are likely to separate into a distinct organic phase. These organic materials are drained periodically and also comprise the listed waste K150. The scrubber uses water to absorb any residual chlorine in the gas. The overhead gases from the acid recovery units are then scrubbed, such as with caustic solution, to remove any residual chlorine in the stream prior to discharge into the atmosphere (1).

The crude HCl product from the recovery units contains a variety of contaminants, including organics, metals, and color. To meet HCl product specifications, these contaminants are removed via filtration or adsorption with activated carbon. Once saturated, the activated carbon or filter media are regenerated in place, returned and regenerated by the carbon supplier, or disposed (1).

__Product Distillation and Purification__

The crude chlorinated product is routed to a series of continuous vacuum distillation columns or vacuum batch stills to separate the product from unreacted feed, by-products, catalysts, and organic contaminants. If continuous columns are used, the first fractionation column typically separates unreacted feedstock and incompletely reacted compounds in the overhead stream for recycle to the reactor from the bottoms stream which is routed to the next unit for further purification. A second or third column is often used to separate the product from the crude mixture. With the bottoms stream from the previous column as feed, each column produces a product in the overhead stream, with higher boiling products collected from the overhead stream from each successive column (1).

A batch vacuum still sometimes follows an initial continuous column. The column still bottoms or crude reactor product is fed to the batch still, where three cuts are typically taken from the top. The first (or low-boiling) cut usually consists of unreacted feed and is recycled to the reactor; the second (or intermediate) cut is routed to the still; and the third (or product) cut is stored for sale or later use (1).

Constituents with high boiling points (e.g., over-chlorinated toluenes and polymeric compounds) are removed from the distillation train in the heavy ends or still bottoms stream. Product and undesired by-products are also present in this highly concentrated organic waste. This stream comprises the listed waste K149 (1).

The distillation units are typically operated under a vacuum, using steam jet ejectors. These ejectors generate a condensate stream containing small amounts of entrained organics released from the distillation column's overhead condenser vent. The condensate is typically routed to wastewater treatment prior to discharge. Wastewater treatment sludges, excluding neutralization and biological sludges, comprise the listed waste K151 (1).

3.1.2 Chlorinated Toluene End Product Uses

Chlorinated toluenes are used as intermediates and raw materials in the production of pesticides, dyes and dye carriers, pharmaceuticals, solvents, and polymer initiators and plasticizers (1). Table 3-1 lists end uses for chlorinated toluene compounds (4). Table 3-2 lists products manufactured at specific chlorinated toluene facilities (2).

3.2 Processes Generating K149, K150, and K151 Wastes

This section presents a summary of the available information on the listed wastes, defined as K149, K150, and K151, generated by the chlorinated toluene manufacturing process. Figure 3-1 is a flow diagram of a typical chlorinated toluene manufacturing process (1). This flow diagram identifies the processes generating K149, K150, and K151 wastes. These listed wastes are typically generated in nonwastewater form. Therefore, the following sections focus on the processes which generate the nonwastewater forms of K149, K150, and K151 wastes.

3.2.1 K149 Wastes

K149 wastes consist of distillation bottoms from the production of alpha (methyl) chlorinated toluenes, ring-chlorinated toluenes, benzoyl chlorides, and compounds with mixtures of these functional groups. The definition of this waste does not include K015 wastes, still bottoms from the distillation of benzyl chloride (5).

3.2.1.1 Overview of Process Generating K149 Wastes

K149 wastes are generated from the distillation column used to separate chlorinated toluene products from heavier chlorinated by-products and impurities as shown in Group A of Figure 3-1. The distillation column feed consists of numerous compounds which make up the reactor products. The composition of the reactor products varies depending on the raw materials fed to the reactor (eg, chlorine, toluene, benzotrichloride) and the production process used at the facility (1). The still bottoms from the distillation column comprise K149 wastes (5).

Several thermodynamic and kinetic parameters are critical to the various chlorinated toluene manufacturing processes. The use of excess chlorine is necessary in the UV light catalyzed chlorination process to ensure successive replacement of the alpha hydrogen (6). In the Lewis acid-catalyzed chlorination process, use of a particular catalyst, such as ferric chloride, aids in targeting the aromatic ring for chlorine substitution. The catalytic steam hydrolysis chlorination process requires heated water (steam) to ensure oxidation of the alkyl chain. Further, a specific catalyst, such as a Lewis acid catalyst, is used to promote chloride transfer from unconverted benzotrichloride to benzoic acid, while the hydroxy group is transferred from the benzoic acid to the benzotrichloride (1).

Other quantifiable process parameters which may affect the generation of K149 include the operational temperatures and pressures of the distillation column used for product purification and feed flowrates to the column.

3.2.2 K150 Wastes

K150 wastes consist of organic residuals, excluding spent carbon adsorbent, from the spent chlorine gas and hydrochloric acid recovery processes associated with the production of alpha (methyl) chlorinated toluenes, ring-chlorinated toluenes, benzoyl chlorides, and compounds with mixtures of these functional groups (5).

3.2.2.1 Overview of Process Generating K150 Wastes

K150 wastes are generated from reactor off-gas separation processes and from the hydrochloric (HCl) acid recovery process, as shown in Group B on Figure 3-1. The feed streams from the off-gas separation and HCl recovery processes contain a large quantity of HCl and various volatile organic and aqueous compounds (1). The organic residuals from the separation and acid recovery processes comprise K150 wastes (5).

Process parameters which may affect the generation of K150 wastes include flowrates for the product reactor overhead stream, water used in the scrubber to absorb any residual chlorine, and the caustic used to remove residual chlorine prior to atmospheric discharge (9).

3.2.3 K151 Wastes

K151 wastes consist of wastewater treatment sludges, excluding neutralization and biological sludges, generated during the treatment of wastewaters from the production of alpha (methyl) chlorinated toluenes, ring-chlorinated toluenes, benzoyl chlorides and compounds with mixtures of these functional groups (5).

3.2.3.1 Overview of Process Generating K151 Wastes

K151 wastes are generated from the treatment of product purification wastewater as shown in Group C on Figure 3-1. The product purification distillation units are typically operated under a vacuum, using steam jet ejectors. These ejectors generate a condensate stream containing small amounts of entrained organics released from the distillation column's overhead condenser vent. This condensate is typically sent to wastewater treatment prior to discharge (1). The wastewater treatment sludges generated from the treatment of these wastewaters comprise K151 wastes (5).

3.3 <u>Waste Stream Characteristics</u>

3.3.1 Waste Stream Status Under Other Regulations

Under the Clean Water Act (CWA), the discharge of pollutants to United States surface waters and Publicly-Owned Treatment Works (POTWs) from certain chlorinated toluene facilities is regulated under the Organic Chemicals, Plastics, and Synthetic Fibers (OCPSF) Point Source Category (40 CFR Part 414). This regulation establishes effluent limitations and standards for benzene, carbon tetrachloride, chlorobenzene, chloroform, 1,4-dichlorobenzene, hexachlorobenzene, tetrachloroethylene, toluene, 1,2,4-trichlorobenzene, oil and grease, pH, biological oxygen demand, and total suspended solids for wastewaters discharged from chlorinated toluene manufacturers.

Eleven of the thirteen constituents selected for regulation in chlorinated toluene wastes are also regulated under the Emergency Planning and Community Right-to-Know Act (EPCRA) Section 313: benzene, carbon tetrachloride, chloroform, chloromethane, chlorobenzene, 1,4-dichlorobenzene, hexachlorobenzene, 1,1,2,2-tetrachloroethane, tetrachloroethylene, 1,2,4-trichlorobenzene, and toluene. In addition, several chlorinated toluene products are also regulated under EPCRA Section 313, including: benzal chloride, benzoic trichloride, and benzoyl chloride. Under Section

313, facilities that manufacture, process, or otherwise use these chemicals, and that meet certain other criteria, must report the releases and transfers of these chemicals.

Under the Clean Air Act (CAA), Section 112, National Emission Standards for Hazardous Air Pollutants (NESHAP) program, chlorinated toluene facilities are included in the Hazardous Organic NESHAP (HON) source category (40 CFR Part 63) promulgated on February 28, 1994. Process vents, transfer racks, storage tanks, and wastewater treatment emissions at facilities that meet certain criteria are regulated under the HON.

3.3.2 Waste Stream Descriptions

Waste characterization data for K149, K150, and K151 wastes are listed in Tables 3-3, 3-4, and 3-5, respectively (5). These tables show the BDAT and non-BDAT list constituents and the corresponding median concentrations for K149, K150, and K151 wastes. Several BDAT list constituents were present in K149, K150, and K151 wastes including: benzene, carbon tetrachloride, chlorobenzene, chloroform, chloromethane, 1,4-dichlorobenzene, hexachlorobenzene, pentachlorobenzene, 1,2,4,5-tetrachlorobenzene, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, and 1,2,4-trichlorobenzene. Two non-BDAT list constituents were present in K149 wastes: benzotrichloride and benzyl chloride.

3.3.3 Amenability of Chlorinated Toluenes to Chemical Analysis

3.3.3.1 SW-846 Method Applicability

EPA-approved methods for the analysis of BDAT List constituents in nonwastewater and wastewater forms of waste are presented in the Agency's Test Methods for Evaluating Solid Wastes, Volume IB, Laboratory Manual Physical/Chemical Methods (SW-846) (10). Each BDAT list constituent selected for regulation in chlorinated toluene wastes is listed as a target analyte by at least one SW-846 method. Table 3-6 lists the SW-846 methods applicable to the analysis of each constituent selected for regulation in chlorinated toluene waste. SW-846 Method 8240 is used to quantify benzene, carbon tetrachloride, chlorobenzene, chloroform, chloromethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, and toluene in waste matrices. SW-846 Method 8270 is used to quantify 1,4-dichlorobenzene, hexachlorobenzene, pentachlorobenzene, 1,2,4,5-tetrachlorobenzene, and 1,2,4-trichlorobenzene in waste matrices. Both methods use gas chromatography/mass spectrometry to analyze samples (10).

3.3.3.2 Sample Preparation Issues

Common interferences inherent with gas chromatographic analyses include crossover contamination, which may occur when low concentration samples are analyzed immediately after high concentration samples, contamination from glassware, contamination from the diffusion of volatile organics through sample containers during shipment and storage, and degradation of analytes due to soap residue on glassware (10).

3.3.3.3 Actual and Potential Commercial Use of Chlorinated Toluene Wastes

Based on an EPA report concerning waste minimization, the demand for exchange of wastes containing halogenated organics, such as K149, K150, and K151 wastes, was very low (8).

3.4 Chlorinated Toluene Industry Waste Management Practices

This section provides a description of waste management practices used by the chlorinated toluene industry. The majority of the facility-specific information for this industry has been claimed RCRA Confidential Business Information by the manufacturers and therefore could not be incorporated in this document. The available, non-confidential information indicates that the predominant waste management practices used by the chlorinated toluene industry included: incineration, pretreatment, and hazardous and nonhazardous landfilling (1).

3.4.1 Description of K149 Waste Management Practices

K149 wastes are defined as distillation bottoms from the production of alpha (methyl) chlorinated toluenes, ring-chlorinated toluenes, benzoyl chlorides, and compounds with mixtures of these functional groups (5).

Information obtained from EPA site visits and the 1988 RCRA 3007 Questionnaires indicate the total generation rate for K149 in 1987 was approximately 2,200 MT/yr (excluding benzyl chloride still bottoms already designated as K015 wastes) (5). Information obtained by EPA indicated that Velsicol Chemical Corporation collected and transported K149 wastes off site to Texas for incineration at $0.20 to $0.25 per pound in 1982 (7). According to information obtained by EPA from MONTCO Research Products, this firm collected and shipped K149 wastes off site to a landfill in Alabama at a cost of $60 per drum in 1983 (3).

3.4.2 Description of K150 Waste Management Practices

K150 wastes are defined as organic residuals, excluding spent carbon adsorbent, from the spent chlorine gas and hydrochloric acid recovery processes associated with the production of alpha (methyl) chlorinated toluenes, ring-chlorinated toluenes, benzoyl chlorides, and compounds with mixtures of these functional groups (5).

Information obtained from EPA site visits and the 1988 RCRA 3007 Questionnaires indicate that the total generation rate for K150 wastes in 1987 was approximately 400 MT/yr (5). Velsicol Chemical Corporation collected transported K150 wastes off site to Texas for incineration at a price of $0.15 to $0.20 per pound in

1982 (7). MONTCO Research Products collected and shipped K150 wastes off site to a landfill in Alabama at a cost of $60 per drum in 1983 (3).

3.4.3 Description of K151 Waste Management Practices

K151 wastes are defined as wastewater treatment sludges, excluding neutralization and biological sludges, generated during the treatment of wastewaters from the production of alpha (methyl) chlorinated toluenes, ring-chlorinated toluenes, benzoyl chlorides and compounds with mixtures of these functional groups (5).

Information obtained from EPA site visits and the 1988 RCRA 3007 Questionnaires indicate the total generation rate for K151 waste in 1987 was approximately 600 MT/yr (5).

3.4.4 Other Chlorinated Toluene Waste Minimization, Pollution Prevention, Recycling, and Reuse Techniques

Commercial applications have successfully demonstrated the use of halogenated organic wastes in cement kilns (8). Destruction of the waste provides energy value and a low alkali cement. One potentially limiting factor in the reuse of halogenated organics is the formation of salts due to high halogen loadings (e.g., greater than 10 percent). These salts form a molten ring which interferes with proper kiln operation. Cement kilns normally limit the chlorine content of waste fuels to 5 to 10%, although wastes with higher chlorine contents are burned when the waste is blended with other fuel (8).

Table 3-1

Chlorinated Toluene End Uses

Category/Products	End Uses
I. Methyl-Chlorination (Ultraviolet light-catalyzed and thermal processes)	
• Benzyl chloride	plasticizers
• Benzal chloride	benzotrichloride, benzaldehyde, cinnamic acid production
• Benzotrichloride	benzoyl chloride and benzotrifluoride production, dye stuff intermediate, UV stabilizers
• Dichlorobenzyl chloride	pharmaceutical dye intermediate, insecticide
• p-Chlorobenzotrichloride	dinitroaniline herbicide intermediate, p-benzoylchloride production
II. Aromatic Ring Chlorination (Lewis Acid-Catalyzed Process)	
• o-Chlorotoluene	paint and rubber solvents, reaction solvents, dye carriers, o-chlorobenzaldehyde, o-chlorobenzoic acid, and dichlorotoluene production
• p-Chlorotoluene	herbicides, dinitroaniline, diphenyl ether, p-chlorobenzaldehyde, p-chlorobenzoic acid, p-chlorobenzylchloride, and dichlorotoluene production
• Dichlorotoluene	dichlorobenzyl chloride production, herbicide, dyestuff and herbicide intermediates
• Trichlorotoluene	intermediate for organic chemicals and herbicides
• Dichlorobenzoyl chloride	pharmaceutical and dye intermediate
III. Acid Chloride Synthesis (Catalytic Steam Hydrolysis)	
• Benzoyl chloride	dye intermediate, benzoyl peroxide and dichlorobenzoyl chloride production, analytical reagent
• p-Chlorobenzoyl chloride	pharmaceutical and dye intermediate

Reference: (4).

Table 3-2

List of Products Manufactured at Chlorinated Toluene Facilities in the U.S.

Facility	City	State	Products

Chesebrough-Pond's Inc.	Edison	NJ	2-Aminoethyl hydrogen sulfate
			Benzal chloride
			Benzoin
			Benzyl chloride
			2,5-Dimethyl hexadiene-2,4
			Dodecylbenzyl chloride
			Ethylaminoacetate hydrochloride
			Ethylbenzyl chloride
			Ethyl chrysanthemate
			Flavor and Fragrance Chemicals
			  Benzyl alcohol
			Hydrochloric acid
			Isobutyl benzoin ether
			Isopropyl benzoin ether
			Medicinal (Pharmaceutical) Chemicals
			  Chlorobutanol
			o-Methylbenzyl chloride
			p-Methylbenzyl chloride
			Methylene bisthiocyanate
			Methyl phenylglyoxalate
			Pesticides
			  Hexachloro dimethyl sulfone
			Phenylacetic acid, potassium salt
			2-Thiopheneactic acid
			2-Thiopheneacetyl chloride
			General and Compounded Products
			  Dichlorobenzyl chlorides (mixed isomers)
			  Photosensitizers

Monsanto Company (Delaware River Plant)	Bridgeport	NJ	Benzyl chloride
			2-Ethylhexyl diphenyl phosphate
			Hydrochloric acid
			Isodecyl diphenyl phosphate
			Plasticizers
			  n-Butyl benzyl phthalate
			  iso-octyl diphenyl phthalate
			Tetrachlorophthalic anhydride
			General and Compounded Products
			  Alkyl aryl phosphate
			  Benzylate aromatics
			  Blends of mixed phthalates/adipates
			  Santicizer® 141
			  Santicizer® 148

Table 3-2

(Continued)

Facility	City	State	Products
Occidental Corporation	Niagara Falls	NY	Benzotrichloride Benzoyl chloride Chlorine p-Chlorobenzotrifluoride o-Chlorotoluene p-Chlorotoluene 3,4-Dichlorobenzotrifluoride 3,5-Dichlorobenzoyl trichloride o,α-Dichlorotoluene Hydrochloric acid Hypophosphorous acid Manganese hypophosphite Phosphorous oxychloride Phosphorous pentoxide Phosphorous trichloride Sodium hydroxide Sodium hypochlorite Sodium hypophosphite Sulfur dichloride Sulfur monochloride Sulfuryl chloride Thionyl chloride *General and Compounded Products* Alkyl acid phosphates Dechlorane Plus® Fluorolubes® Halso 99®
Velsicol Corporation	Chattanooga	TN	Benzoic acid, technical grade Benzoyl chloride Hydrochloric acid Pentaerythritol tetrabenzoate Plasticizers Diethylene glycol dibenzoate Glyceryl tribenzoate Neopentyl glycol dibenzoate Polyethylene glycol dibenzoate Propylene glycol dibenzoate Sucrose benzoate *General and Compounded Products* Benzoic acid, USP/FCC "low odor" Benzoic acid, USP/FCC "regular"

Reference: (2).

Table 3-3

Waste Characterization Data for K149 Wastes

BDAT List Constituent	Median Constituent Concentration (mg/kg)
Chlorobenzene	>350[a]
Chloroform	50
Chloromethane	7,000
1,4-Dichlorobenzene	>700[a]
Hexachlorobenzene	3,500
Pentachlorobenzene	1,500
1,2,4,5-Tetrachlorobenzene	250
Toluene	3,000
Non-BDAT List Constituent	**Median Constituent Concentration (mg/kg)**
Benzotrichloride	70,000
Benzyl Chloride	>750[a]

[a]Agency-collected data indicate concentrations in excess of the presented values. However, specific concentrations are not presented to preserve confidentiality.

Reference: (5).

Table 3-4

Waste Characterization Data for K150 Wastes

BDAT List Constituent	Median Constituent Concentration (mg/kg)
Carbon tetrachloride	550
Chloroform	45
Chloromethane	13,500
1,4-Dichlorobenzene	3,200
Hexachlorobenzene	2,000
Pentachlorobenzene	2,100
1,2,4,5-Tetrachlorobenzene	7,000
1,1,2,2-Tetrachloroethane	>125[a]
Tetrachloroethylene	150
1,2,4-Trichlorobenzene	12,000

[a]Agency-collected data indicate concentrations in excess of the presented values. However, specific concentrations are not presented to preserve confidentiality.

Reference: (5).

Table 3-5

Waste Characterization Data for K151 Wastes

BDAT List Constituent	Median Constituent Concentration (mg/kg)
Benzene	>100[a]
Carbon tetrachloride	75
Chloroform	190
Hexachlorobenzene	>500[a]
Pentachlorobenzene	>200[a]
1,2,4,5-Tetrachlorobenzene	>150[a]
Tetrachloroethylene	>250[a]
Toluene	34,000

[a]Agency-collected data indicate concentrations in excess of the presented values. However, specific concentrations are not presented to preserve confidentiality.

Reference: (5).

Table 3-6

SW-846 Method Applicability for Constituents Regulated in K149, K150, and K151 Wastes

Constituent	EPA Approved Analytical Method
Benzene	8240
Carbon tetrachloride	8240
Chlorobenzene	8240
Chloroform	8240
Chloromethane	8240
1,4-Dichlorobenzene	8270
Hexachlorobenzene	8270
Pentachlorobenzene	8270
1,2,4,5-Tetrachlorobenzene	8270
1,1,2,2-Tetrachloroethane	8240
Tetrachloroethylene	8240
Toluene	8240
1,2,4-Trichlorobenzene	8270

Reference: Based on (10).

4.0 BDAT TREATMENT STANDARDS FOR CHLORINATED TOLUENE WASTES K149, K150, AND K151

4.1 Determination of BDAT Treatment Standards for K149, K150, and K151 Wastes

4.1.1 Selection of Regulated Constituents

This section presents the methodology and rationale for selecting constituents for regulation in nonwastewater and wastewater forms of chlorinated toluene wastes. Generally, constituents selected for regulation must satisfy the following criteria:

(1) They must be on the BDAT List of constituents. Presence on the BDAT list means that EPA-approved methods exist for analysis of the constituent in treated waste matrices.

(2) They must be present in, or be suspected of being present in, the untreated waste. For example, analytical difficulties may prevent a constituent from being reliably identified in the untreated waste, but its identification in a treatment residual may lead the Agency to conclude that it is present in the untreated waste.

4.1.1.1 BDAT List Constituents Present in K149, K150, and K151 Wastes

BDAT List constituents believed to be present in K149, K150, and K151 wastes are presented in Tables 3-3, 3-4, and 3-5, respectively.

K149, K150, and K151 wastes were analyzed for the following BDAT List constituents: benzene, carbon tetrachloride, chlorobenzene, chloroform, chloromethane, 1,4-dichlorobenzene, hexachlorobenzene, pentachlorobenzene, 1,2,4,5-tetrachlorobenzene, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, and 1,2,4-trichlorobenzene.

The Agency evaluated the available waste characterization data to determine which constituents are present in K149, K150, and K151 wastes. Constituents believed to be present were identified as those constituents which were detected in the untreated waste. Table 4-1 presents the constituents detected, and therefore believed to be present, in K149, K150, and K151 wastes. All of the constituents presented in Table 4-1 characterized as being present in K149, K150, and K151 wastes are BDAT List constituents.

4.1.1.2 Other Constituents Present in K149, K150, and K151 Wastes

Two constituents that are not on the BDAT List were believed to be present in K149 wastes based on the available waste characterization data: benzyl chloride and benzotrichloride. All of the constituents believed to be present in K150 and K151 wastes were BDAT List constituents.

4.1.1.3 Constituents Selected for Regulation in K149, K150, and K151 Wastes

The Agency selected all of the BDAT List constituents detected in K149, K150, and K151 wastes for regulation in the respective waste. A list of these constituents for each waste code is shown in Table 4-1.

4.1.2 Identification of Best Demonstrated Available Technologies (BDAT)

The Agency's determination of applicable and demonstrated technologies and BDAT for treatment of nonwastewater and wastewater forms of chlorinated toluene wastes is presented below. The Agency notes, however, that any treatment technology which reduces the concentration of regulated constituents to the level of the treatment standards or below and is not considered impermissible dilution is also acceptable.

In order to establish BDAT, the Agency first identifies which technologies are "applicable" for treatment of the constituents of interest. An applicable technology is one which, in theory, can treat the waste in question or a waste similar to the waste in question in terms of parameters that affect treatment selection. Detailed descriptions of the technologies identified as applicable for the treatment of listed hazardous wastes are provided in EPA's Treatment Technology Background Document (9). The identification of treatment technologies as applicable for treating BDAT List constituents is based on an evaluation of current waste management practices, current literature sources, field testing, data submitted by equipment manufacturers and industrial concerns, and the engineering judgement of EPA technical staff personnel.

The Agency next determines which of the applicable technologies are "demonstrated" for treatment of the wastes. To be designated as demonstrated, a technology must be used in a full-scale operation for treatment of the waste of interest or a similar waste. Technologies that are available only at pilot- or bench-scale operations are not considered demonstrated technologies.

The Agency determines which of the demonstrated technologies is "best" based on a thorough review of all the performance data available on treatment of the waste of concern or wastes judged to be similar, and determines whether this "best" demonstrated technology is also commercially "available." If the "best" demonstrated technology is "available," then the technology is determined to represent BDAT.

4.1.2.1 Nonwastewaters

This section presents the Agency's determination of applicable and demonstrated technologies, and BDAT for treatment of nonwastewater forms of K149, K150, and K151 wastes.

4.1.2.1.1 Applicable Treatment Technologies

Since nonwastewater forms of K149, K150, and K151 wastes contain organic constituents at treatable concentrations, applicable treatment technologies include those that destroy or reduce the total amount of organic constituents in the waste. The Agency has identified the following technologies as applicable for the treatment of organic constituents in nonwastewater forms of these chlorinated toluene wastes:

- Critical fluid extraction;
- Fuel substitution;
- High-temperature thermal distillation;
- Incineration;
- Pressure filtration;
- Solvent extraction;
- Thermal desorption; and
- Total recycle or reuse.

The concentration and type(s) of constituents present in the waste generally determine which technology is most applicable. A brief discussion of each of the technologies identified as applicable for treatment of the constituents in nonwastewater forms of chlorinated toluene wastes is given below.

Critical Fluid Extraction

Critical fluid extraction is a separation and recovery technology in which a solvent is brought to its critical state (a thermodynamically unique equilibrium state between liquid and gas at high pressure and temperature) to extract organic constituents from a waste. The solvents used are usually gaseous when at ambient conditions. In the extraction procedure, the solvent is pressurized, thus converting it from a gas to a liquid. As a liquid, it dissolves the organic constituents and removes them from the waste matrix. After the extraction, the solvent is returned to its gaseous state; a small volume of extract remains that contains a high concentration of organic constituents. This technology generates two residuals: a treated waste residual and an extract. The extract may either be recycled or treated by incineration (9).

Fuel Substitution

Fuel substitution is a destruction technology in which heat is transferred to a waste to destabilize chemical bonds and destroy organic constituents. Fuel substitution involves using hazardous waste as fuel in industrial furnaces and boilers. The hazardous waste that is substituted for fuel may be blended with other nonhazardous wastes (e.g., municipal sludge) and/or fossil fuels. Fuel substitution has been used in the treatment of industrial waste solvents, refinery wastes, synthetic fibers/petrochemical wastes, waste oils, and wastes produced during the manufacture of pharmaceuticals, pulp and paper, and pesticides. Fuel substitution generates two residuals: ash and scrubber water (9).

High-Temperature Thermal Distillation

High-temperature thermal distillation is a separation and recovery technology that subjects hydrocarbon-bearing wastes to indirect, electrically generated heat in an inert atmosphere. The process removes volatile hydrocarbon constituents from a waste; these constituents can be subsequently recovered in a reusable form by cooling the hydrocarbon-bearing inert gases at high pressure. This process generates two residuals: a treated waste residual and an extract (9).

Incineration

Incineration is a high-temperature thermal destruction technology in which heat is transferred to a waste to destabilize chemical bonds and destroy hazardous organic constituents. Three incineration technologies are applicable for the treatment of organic constituents in nonwastewater forms of chlorinated toluene wastes: liquid injection, rotary kiln, and fluidized bed.

In a liquid injection incinerator, liquid wastes are atomized and injected into the incinerator, where additional heat is supplied to destabilize chemical bonds in the presence of air or oxygen. Once the chemical bonds are broken, these constituents react with oxygen to form carbon dioxide and water vapor. Liquid injection is applicable to wastes with low viscosity values, small particle size, and low suspended solids content.

In a rotary kiln incinerator, solid and/or semi-solid wastes are fed into the higher end of a sloping kiln. The rotation of the kiln mixes the waste with hot gases. Eventually, the waste reaches its ignition temperature, and is converted to gas and ash through volatilization and combustion reactions. Ash is removed from the lower slope-end of the kiln. Combustion gases from the kiln, containing volatilized and partially combusted waste constituents, enter an afterburner for further combustion to complete the destruction of the organic waste constituents. Other wastes may also be injected into the afterburner.

In a fluidized-bed incinerator, solid and/or semi-solid wastes are injected into a fluidized material (generally sand and/or incinerator ash), where they are heated to their ignition temperature. In the incinerator, the waste is converted to gas and ash through volatilization and combustion reactions. Heat energy from the combustion reaction is then transferred back to the fluidized bed. The velocity of the combustion gases is reduced in a wider space above the bed, known as the freeboard, allowing larger ash and waste particles which were not combusted to fall back into the bed. Ash is removed periodically during both operation and bed change-outs.

Combustion gases from incineration are fed into a scrubber system for cooling and removal of any entrained particles and acid gases. In general, with the exception of liquid injection incineration, two residuals are generated by incineration processes: ash and scrubber water. Since only wastes with low or negligible solids content are amenable to liquid injection incineration, this technology does not normally generate an ash residual, but does generate a scrubber water residual (9).

Pressure Filtration

Pressure filtration, also known as sludge filtration, sludge dewatering, or cake-formation filtration, is a separation and recovery technology used for wastes that contain high concentrations (>1%) of suspended solids. Filtration separates particles from a fluid/particle mixture by passing the fluid through a medium that permits the flow of the fluid but retains the particles. Sludge filtration is commonly applied to waste sludges such as those from a clarifier; typically, these sludges can be dewatered to 20 to 50% solids using this technology. Pressure filtration generates two residuals: dewatered sludge and water (9).

Solvent Extraction

Solvent extraction is a separation and recovery technology that removes organic constituents from a waste by mixing the waste with a solvent that preferentially dissolves and removes the constituents of concern from the waste. Wastes commonly treated by this technology have a broad range of total organic content. Selection of an appropriate solvent is dependent on the relative solubilities of the constituents to be removed and the other organic compounds in the waste. Organics are removed from the waste due to greater constituent solubility in the solvent phase than in the waste phase. Solvent extraction generates two residuals: a treated waste residual and an extract. The extract may either be recycled or treated by incineration (9).

Thermal Desorption

Thermal desorption is a separation and recovery technology in which heat is used to volatilize organic constituents from wastes. Thermal desorption has been defined as a thermal treatment that uses direct or indirect heat exchange to elevate the temperature of a waste, thereby volatilizing the organic constituents. Thermal desorption differs from thermal destruction (incineration) in the way in which the organic constituents are treated. The objective of thermal desorption is to sufficiently elevate the temperature of the organic constituents to effect a phase separation to a gaseous state without combustion; the objective of incineration is to combust the organic constituents. Thermal desorption units function by creating steam from the volatilization of the moisture in the waste from heating. The steam tends to strip organic compounds from the waste and aids in the volatilization of organic compounds. Generally, this technology generates two residuals: a treated waste residual and an extract.

Total Recycle or Reuse

Total recycle or reuse of a waste material within the same process or an external process eliminates the generation of a waste for treatment and disposal and subsequently generates no treatment residuals.

4.1.2.1.2 Demonstrated Treatment Technologies

Demonstrated treatment technologies are those which have been demonstrated to be effective in full-scale operation for treatment of the waste of interest or a similar waste. The Agency has no data indicating that any of the applicable technologies are being used to treat K149, K150, and K151 wastes. The Agency, however, has identified incineration as a demonstrated technology for treatment of a similar waste, K015.

K015 wastes are generated by the organic chemicals industry and are listed as still bottoms from the distillation of benzyl chloride. Because K015 and K149, K150, and K151 wastes are generated by similar industries and in similar processes, the Agency believes that treatment technologies which are demonstrated for K015 wastes may also be considered demonstrated for K149, K150, and K151 wastes.

The Agency has no evidence that fuel substitution is being used on wastes having similar concentration levels of chlorinated organic compounds. When chlorinated hydrocarbons are combusted, hydrogen chloride gas or chlorine gas is produced. These gases may not be compatible with normal fuel uses in industrial furnaces or boilers (i.e., they may not be compatible with the furnace materials of construction or the furnace product quality). Thus, EPA believes that fuel substitution cannot be considered a demonstrated technology for nonwastewater forms of K149, K150, and K151 wastes.

Since the Agency has no indication that any of the other applicable technologies are demonstrated in full-scale operation for treatment of the waste in question or a similar waste, incineration is identified as the only demonstrated technology for nonwastewater forms of K149, K150, and K151 wastes.

4.1.2.1.3 Identification of BDAT

The Agency determines best demonstrated and available technology (BDAT) based on a thorough review of all data on the treatment of the waste of concern or wastes judged to be similar. The "best" demonstrated technology is evaluated to determine whether this treatment technology is available. To be "available," a technology: (1) must provide substantial treatment; and (2) must be commercially available. If the "best" demonstrated technology is "available," then the technology is demonstrated to represent BDAT.

The Agency has determined that incineration, the only demonstrated technology, provides substantial treatment of a similar waste, K015, based on the reduction of all BDAT List organic constituents to nondetectable concentrations. In addition to achieving substantial treatment, incineration is commercially available, meeting the second criterion of "availability." Therefore, incineration represents BDAT for nonwastewater forms of K149, K150, and K151 wastes; as presented in Table 4-2.

The Agency notes, however, that when it establishes concentration-based treatment standards, the regulated community may use any non-prohibited technology to treat the waste to meet the treatment standards. Compliance with a concentration-based treatment standard requires only that the effluent concentration be achieved; once achieved, the waste may be land disposed. The waste need not be treated by the technology identified as BDAT; in fact, concentration-based treatment standards provide flexibility in the choice of a treatment technology. Any treatment, including recycling or any combination of treatment technologies, unless prohibited (e.g., impermissible dilution) or unless defined as land disposal (e.g., land treatment), can be used to achieve these standards.

4.1.2.2 Wastewaters

This section presents the Agency's determination of applicable and demonstrated technologies, and BDAT for treatment of wastewater forms of K149, K150, and K151 wastes.

4.1.2.2.1 Applicable Treatment Technologies

Applicable treatment technologies for organics in wastewater forms of chlorinated toluene wastes include those that destroy or reduce the total amount of organic constituents in the waste. The technologies listed below are applicable for treatment of organic constituents in wastewater forms of chlorinated toluene wastes:

- Biological treatment (including aerobic fixed film, aerobic lagoon, activated sludge, filtration, anaerobic fixed film, rotating biological contactor, sequential batch reactor, and trickling filter technologies);
- Carbon adsorption (including activated carbon and granular activated carbon technologies);
- Chemical oxidation;
- Chemically assisted clarification (including chemical precipitation technology);
- PACT® treatment (including powdered activated carbon addition to activated sludge and biological granular activated carbon technologies);
- Reverse osmosis;
- Solvent extraction (including liquid-liquid extraction technology);
- Stripping treatment (including steam stripping and air stripping technologies); and
- Wet air oxidation (including supercritical oxidation technology).

The concentration and type(s) of waste constituents present in the waste generally determine which technology is most applicable. A brief discussion of each of the technologies identified as applicable for the treatment of constituents in wastewater forms of chlorinated toluene wastes is given below.

Biological Treatment

Biological treatment includes aerobic fixed film, aerobic lagoons, activated sludge, anaerobic fixed film, rotating biological contactor, sequential batch reactor, and trickling filter technologies. Biological treatment is a destruction technology in which organic constituents in wastewaters are biodegraded. This technology generates two treatment residuals: a treated effluent and a waste biosludge. Waste biosludge may be land disposed without further treatment if the concentrations of its regulated constituents fall at or below their BDAT treatment standards (9).

Carbon Adsorption

Carbon adsorption is a separation technology in which hazardous organic constituents in wastewaters are selectively adsorbed onto activated carbon. This technology generates two treatment residuals: a treated effluent and spent activated carbon. The spent activated carbon can be reactivated, recycled, or incinerated (9).

Chemical Oxidation

Chemical oxidation is a destruction technology in which inorganic cyanide, some dissolved organic compounds, and sulfides are chemically oxidized to yield carbon dioxide, water, salts, simple organic acids, and, in the case of sulfides, sulfur. This technology generates one treatment residual: treated effluent (9).

Chemically Assisted Clarification

Chemically assisted clarification, including chemical precipitation, is a separation technology in which coagulating and flocculating chemicals are added to form insoluble solid precipitates with the organics or inorganics in the wastewater. The solids formed are then separated from the wastewater by settling, clarification, and/or polishing filtration. This technology generates two treatment residuals: treated wastewater effluent and separated solid precipitate. The solid precipitate then requires additional treatment to meet the nonwastewater BDAT treatment standards (9).

PACT® Treatment

PACT® treatment is a combination of carbon adsorption and biological treatment in which hazardous organic constituents are biodegraded or selectively adsorbed onto powdered-activated carbon. This technology generates two treatment residuals: a treated effluent and spent carbon/biosludge. The spent carbon may be regenerated and recycled to the process or may be incinerated (9).

Reverse Osmosis

Reverse osmosis is a separation technology in which dissolved organics (usually salts) are removed from a wastewater by filtering the wastewater through a semipermeable membrane at a pressure greater than the osmotic pressure caused by the dissolved organics in the wastewater. This technology generates two treatment residuals: the treated effluent wastewater and the concentrated organic salt materials which do not pass through the membrane (9).

Solvent Extraction

Solvent extraction is a separation technology in which organics are removed from a waste due to greater constituent solubility in the solvent phase than in the waste phase. This technology generates two residuals: a treated waste residual and an extract. The extract may be recycled or treated by incineration (9).

Stripping Treatment

Stripping treatment is a separation technology. Steam stripping is a technology in which wastewaters containing volatile organics have the organics removed by application of heat using steam as the heat source. Air stripping is a technology in which wastewaters containing volatile organics have the organics removed by volatilization. This technology generates one treatment residual: treated effluent. Emissions from stripping treatment may require further treatment (9).

Wet Air Oxidation

Wet air oxidation is a destruction technology in which organic constituents in wastes are oxidized and destroyed under pressure at elevated temperatures in the presence of dissolved oxygen. This technology is applicable for wastes comprised primarily of water and up to 10% total organic constituents. Wet air oxidation generates one treatment residual: treated effluent. The treated effluent may require further treatment for organic constituents by carbon adsorption or PACT® treatment. Emissions from wet air oxidation may also require further treatment (9).

4.1.2.2.2 Demonstrated Treatment Technologies

Demonstrated treatment technologies are those which have been demonstrated in full-scale operation for treatment of the wastes of interest or a similar waste. The Agency has identified all of the applicable treatment technologies for wastewater forms of chlorinated toluene wastes listed in Section 4.2.2.1, except chemical oxidation, to be demonstrated technologies from an evaluation of the available treatment performance data in Appendix B. Treatment performance data for the regulated constituents in wastewater forms of K149, K150, and K151 wastes, presented in Appendix B, include data from bench-, pilot-, and full-scale treatment using these technologies.

4.1.2.2.3 Identification of BDAT

The procedure used to identify BDAT for wastewater forms of K149, K150, and K151 wastes follows the methodology described in EPA's Methodology Background Document (11). All applicable and demonstrated treatment technologies are identified for the wastes of interest, and treatment performance data are examined to identify the technologies that perform "best." The treatment performance data are evaluated to determine:

- Whether the data represent operation of a well-designed and well-operated treatment system;
- Whether sufficient analytical quality assurance/quality control measures were used to ensure the accuracy of the data; and
- Whether the appropriate measure of performance was used to assess the performance of the particular treatment technology.

The Agency then determines whether the best demonstrated technology is "available." To be "available," a technology (1) must provide substantial treatment and (2) must be commercially available.

The Agency determined the best demonstrated technology for each regulated constituent in K149, K150, and K151 wastes by thoroughly reviewing all of the treatment performance data available for each constituent, presented in Appendix B of this document.

The demonstrated technologies identified and determined to be "best" for each constituent are all commercially available. In addition, treatment performance data included in Appendix B show substantial treatment of each constituent by the corresponding technology identified as best. Therefore, the technologies selected as best and demonstrated for each constituent are also considered to be available, and therefore, BDAT for that constituent. The BDAT for each constituent selected for regulation in the wastewater forms of K149, K150, and K151 wastes is shown in Table 4-3.

4.1.3 Identification of Treatment Standards

The Agency is transferring universal standards to the constituents selected for regulation in nonwastewater and wastewater forms of K149, K150, and K151 wastes. A universal standard is a single concentration limit established for a specific constituent regardless of the waste matrix in which it is present. Universal standards may be used to replace treatment standards in previously promulgated waste codes and as the treatment standards for listed hazardous waste codes in the future.

This section presents the universal standards that were transferred to the regulated constituents in nonwastewater and wastewater forms of K149, K150, and K151 wastes and the specific data used to determine the treatment standards.

4.1.3.1 Nonwastewaters

The Agency is transferring universal standards to the constituents selected for regulation in nonwastewater forms of K149, K150, and K151 wastes. Table 4-4 presents the specific treatment performance data used to determine the universal standards for the regulated constituents in these chlorinated toluene wastes.

Universal standards for the constituents selected for regulation in K149, K150, and K151 wastes were based upon incineration treatment performance data. These data represent BDAT for wastes included in previous rulemakings, and, therefore, have been judged to meet the Agency's requirements of BDAT. Thus, incineration was determined to be BDAT for the constituents of interest in universal standards. Because incineration has been identified as BDAT for nonwastewater forms of chlorinated toluene wastes, the Agency feels it is appropriate to transfer the universal standards for nonwastewater forms of waste to the constituents selected for regulation in nonwastewater forms of K149, K150, and K151 wastes.

Table 4-5 presents the BDAT treatment standards for nonwastewater forms of chlorinated toluene wastes by waste code. The treatment standards database and the methodology for identifying universal standards for constituents in nonwastewater forms of K149, K150, and K151 wastes are presented in Appendix A of this document. A more detailed discussion concerning the determination of universal standards for nonwastewater forms of listed hazardous wastes is provided in EPA's Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards, Volume A: Universal Standards for Nonwastewater Forms of Listed Hazardous Wastes (12).

4.1.3.2 Wastewaters

The Agency is transferring universal standards to the constituents selected for regulation in wastewater forms of K149, K150, and K151 wastes. Table 4-6 presents the specific treatment performance data used as the basis of the universal standards for the regulated constituents in these chlorinated toluene wastes.

Universal standards for wastewater forms of wastes are based on treatment performance data from several sources including the BDAT database, the NPDES database, the WERL database, EPA-collected WAO/PACT® data, the EAD database, industry-submitted leachate treatment performance data, data submitted by the Chemical Manufacturers Association's Carbon Disulfide Task Force, data submitted by the California Toxic Substances Control Division, data in literature that were not already part of the WERL database, and data in literature submitted by industry on the WAO and PACT® treatment processes. Since these standards reflect the performance of numerous industrial wastewater treatment systems, the Agency believes it is appropriate to transfer the universal standards for wastewater forms of waste to the constituents selected for regulation in wastewater forms of K149, K150, and K151 wastes.

Table 4-7 presents the BDAT treatment standards for wastewater forms of chlorinated toluene wastes by waste code. The treatment performance database and the methodology for identifying universal standards for constituents in wastewater forms of K149, K150, and K151 wastes are presented in Appendix B of this document. A more detailed discussion concerning the determination of the universal standards for wastewater forms of listed hazardous wastes is provided in EPA's Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards, Volume B: Universal Standards for Wastewater Forms of Listed Hazardous Wastes (13).

4.2 Detailed Descriptions of Technologies Identified as BDAT

The detailed descriptions of technologies that are presented in the following subsections were summarized from information provided in EPA's Treatment Technology Background Document (9).

4.2.1 Nonwastewaters

4.2.1.1 Incineration

4.2.1.1.1 Treatment Applicability

Incineration is used to treat wastes containing a wide variety of organic constituents. Incineration is applicable to wastes that contain low concentrations of water, metals, and other inorganics. The types of incineration applicable for the treatment of organics in nonwastewater forms of chlorinated toluene wastes are: liquid injection, rotary kiln, and fluidized bed. Liquid injection is applicable to wastes with viscosity values less than 750 Saybolt Seconds Universal (SSU). Rotary kiln and fluidized bed incineration are used to treat wastes with a wide range of viscosity, particle size, and suspended solids concentration (9).

4.2.1.1.2 Treatment Process Parameters

Incineration treats wastes through thermal decomposition of organic compounds. The thermal decomposition is performed via cracking and oxidation reactions at temperatures in the range of 760° to 1,650°C. These reactions convert organic constituents into carbon dioxide and water vapor. Depending upon the physical form of the waste, the waste is fed to the incineration system by pumping through nozzles or atomizing burners, positive displacement pumps and water cooled injection ports, rams, gravity feeds, air lock feeders, vibratory, screw, or belt feeders (9).

The waste heat content can be as low as 2,230 kcal/kg to maintain combustion; however, wastes are typically blended to a net heat content of 4,450 kcal/kg.

A liquid injection incineration system consists of a single combustion chamber. A burner or nozzle is used to atomize the waste and inject it into the combustion chamber, where it is incinerated in the presence of air. Air is introduced into the combustion chamber via a forced draft system. The forced draft system also provides turbulence for mixing. The combustion chamber is a cylinder typically lined with refractory brick. The incinerator is fired horizontally or vertically.

Rotary kiln incineration systems consist of a slowly rotating, refractory-lined cylinder mounted at a slight incline. Rotary kilns typically include a secondary combustion chamber (afterburner) for further combustion of volatilized waste constituents. Solid wastes are introduced to the high end of the kiln, while liquid wastes generally enter through atomizing nozzles in the afterburner. As with the liquid injection system, air is supplied to the rotary kiln through a forced draft system. Additionally, the rotation of the kiln enhances the exposure of solids to heat, provides mixing, and causes ash to move to the lower end of the kiln for removal (9).

A fluidized bed incineration system consists of a column containing an inert material such as sand. The area above the sand in the column is referred to as the "freeboard." A blower forces air up through the end, fluidizing it. This air provides oxygen for combustion and promotes rapid mixing of the injected waste. The fluidized sand has a high heat capacity which causes the injected waste incineration temperature quickly. The freeboard provides additional time for combustion of volatile constituents. Fluidized bed incinerators can operate at lower temperatures more effectively than other incinerators due to the excellent mixing properties associated with fluidized bed incinerators (9).

4.2.1.2.3 Process Constraints

Waste characteristics affecting the performance of incineration include the thermal conductivity of the waste, the constituent boiling points, the constituent bond dissociation energies, the heating value of the waste, the concentration of explosive constituents, and the concentration of noncombustible constituents (9).

Incineration systems transfer heat through the waste by radiation, convection, and conduction. Heat flow by conduction is proportional to the temperature gradient across the waste. The proportionality constant is referred to as thermal conductivity. Thermal conductivity is a property of the waste being incinerated. If the thermal conductivity of the waste is low, heat transfer across the material is not effective, and the effectiveness of the incineration process is decreased (9).

The volatility of waste constituents is inversely proportional to the boiling points of the waste constituents. If the boiling points of the waste constituents are high, higher temperatures may be required to volatilize less volatile constituents (9).

Activation energy is the amount of heat energy needed to destabilize molecular bonds so that exothermic combustion reactions can occur. Bond dissociation energy is the energy needed to break individual bonds in a molecule. Activation energy and bond dissociation energy are theoretically equal; however, interactions between different molecular bonds may influence activation energy, making activation energy difficult to quantify. Bond dissociation energies are quantifiable. If the bond dissociation energies of waste constituents are high, higher temperatures may be necessary for combustion to proceed (9).

The heating value of a waste is the amount of heat released from the exothermic combustion reactions of the waste. The heating value of the waste must be sufficient to heat incoming waste to the temperature required for incineration and to maintain combustion. Wastes with low heating values generally contain high concentrations of water or halogenated compounds. Auxiliary fuel may be required when incinerating these wastes to provide the necessary heat to maintain combustion (9).

Water, metals, and other inorganics are noncombustible constituents. Wastes containing high concentrations of these constituents generally have low heating values and require auxiliary fuel. Additionally, volatile metals may fuse to the walls of the combustion chamber inhibiting effective operation of the incinerators (9).

4.2.2 Wastewaters

Five of the eight technologies identified as applicable and demonstrated for treatment of chlorinated toluene wastewaters were identified as BDAT for the regulated constituents in K149, K150, and K151 wastes. These technologies are as follows, each of which is described below:

- Biological Treatment;
- Steam Stripping;
- Filtration;

- PACT®;
- Granular Activated Carbon (GAC) Adsorption.

The criteria for selection of BDAT were discussed in Section 4.1.2.2.3.

4.2.2.1 Biological Treatment

The four most common biological treatment technologies are activated sludge, aerated lagoon, trickling filter, and rotating biological contactor (RBC) (9). These technologies are discussed below.

4.2.2.1.1 Treatment Applicability

Biological treatment technologies are applicable to wastewaters that contain biodegradable organics (9).

4.2.2.1.2 Treatment Process Parameters

A typical activated sludge system includes an equalization basin, a settling tank, an aeration basin, a clarifier, and a sludge recycle line. Wastewater enters the system in the equalization basin, where it is homogenized to prevent process upsets. The wastewater then enters a settling tank where settleable solids are removed. From the settling tank, the wastewater is discharged to an aeration basin, where aerobic bacteria are maintained in suspension. Mechanical or diffused aeration is used to supply oxygen to the aeration basin. The wastewater containing the aerobic bacteria is continuously discharged from the aeration basin into a clarifier. In the clarifier, the biomass is separated from the treated wastewater. The treated wastewater and a portion of the biomass is discharged. This portion may be dewatered by sludge filtration or on sludge drying beds prior to discharge. The remainder of the biomass is returned to the aeration basin to maintain the bacterial population (9).

An aerated lagoon system is similar to an activated sludge system in that suspended aerobic bacteria are used to degrade organic compounds in wastewater. However, an aerated lagoon initially contains a smaller population of microorganisms since there is no sludge recycle. As a result, water must remain in the aerated lagoon system longer to achieve similar effluent quality. Process upsets due to feed variations are less likely in aerated lagoon than in activated sludge systems due to the larger tank volumes and longer residence time used in aerated lagoon treatment. The longer residence time also provides time for additional degradation of complex organic chemicals. The effluent from the aerated lagoon system can be discharged to a settling tank for solids removal or the mechanical aerators used in the aerated lagoon may be shut down to allow settling of solids in the treatment tank or pond. The settled solids are often dewatered prior to disposal (9).

A trickling filter system consists of an equalization basin, a settling tank, a filter, medium, an influent wastewater distribution system, an under drain system, a clarifier, and a recirculation line. The wastewater enters the equalization basin where it is homogenized. The equalization basin effluent is discharged to the settling tank where solids are removed. From the settling tank, the wastewater is distributed over the filter medium with a rotating distribution arm or a fixed distribution system. The filter medium consists of rocks or plastic rings with microorganisms attached to their surfaces. The wastewater forms on this layer as it flows down through the filter medium. Oxygen reaches the microorganisms through spaces in the media promoting aerobic biological decomposition. A biomass is produced which is separated from the wastewater in a clarifier (9).

A rotating biological contactor is a series of closely spaced, parallel disks made of polystyrene, polyvinyl chloride, or similar materials. The disks are partly submerged in a tank containing wastewater and rotated at an average rate of 2 to 5 revolutions per minute. The disks are covered with a biological slime that degrades dissolved organics. As the disk rotates out of the water, oxygen is available, promoting biological decomposition. A biomass is produced which sloughs off the disk. The biomass is separated from the treated effluent in a clarifier (9).

4.2.2.1.3 Process Constraints

Several waste characteristics affect the performance of aerobic biological treatments including the ratio of biological oxygen demand (BOD) to total organic carbon content (TOC), concentration of surfactants, and concentration of toxic constituents in the wastes. The ratio of BOD to TOC content in the waste provides an estimation of the percentage of biodegradable organics in the waste. If the percentage of biodegradable organics is low, aerobic biological treatment systems may not effectively treat the waste. Surfactants can affect biological treatment performance by forming a film on organic constituents, thereby establishing a barrier to oxygen transfer and effective biodegradation (9).

A number of constituents and waste characteristics have been identified as potentially toxic to the microorganisms used in aerobic biological treatments. These include metals, oil and grease, and high concentrations of total dissolved solids, ammonia, and phenols (9). Presence of these toxic constituents in a waste, therefore, may reduce the effectiveness of aerobic biological treatment.

4.2.2.2 Steam Stripping

4.2.2.2.1 Treatment Applicability

Steam stripping is applicable to the treatment of wastes containing volatile organics. Steam stripping is typically applicable when the waste contains less than one percent volatile organics (9).

4.2.2.2.2 Treatment Process Parameters

The apparatus required for steam stripping includes a boiler, a stripping column, a condenser, and a collection tank. The stripping column consists of vertical columns filled with trays or packing. Liquid waste enters the top of the column. The boiler is located at the bottom of the column. The boiler produces vapor which rises through the column and meets the falling liquid. As the vapor and liquid come into contact at each equilibrium stage, volatile constituents are removed from the liquid phase into the vapor phase. Equilibrium stages are produced by the trays or packing in the column. The steam containing volatile compounds exits the top of the column and is condensed. The condensate is discharged to the collection tank and the non-condensed vapors are vented to an air pollution control system or to the atmosphere. The remaining liquid in the column is discharged to the boiler and recycled to the stripper (9).

4.2.2.2.3 Process Constraints

Waste characteristics affecting the performance of steam stripping include the constituent boiling points, the concentration of suspended solids, the surface tension, and the concentration of oil and grease.

If the boiling points of the lower volatile and higher volatile constituents in the waste are similar, then the system may not treat the waste effectively. If the waste contains high concentrations of suspended solids or oil and grease, the solids and/or oil and grease may clog the column or coat heat transfer surfaces, inhibiting transfer of constituents from the liquid phase to the vapor phase. These wastes may require filtration prior to steam stripping treatment. If a waste has a high surface tension, it is more likely to foam. Defoaming compounds can be added to the waste to prevent foaming. Packed columns also reduce foaming (9).

4.2.2.3 Filtration

4.2.2.3.1 Treatment Applicability

Filtration is applicable to the treatment of wastes that contain high concentrations of suspended solids, generally higher than 1 percent (9).

4.2.2.3.2 Treatment Process Parameters

The waste stream is pumped through a cloth filter, drawn by a vacuum through a cloth filter, or gravity-drained and pressed between two belts. A particle "cake" then forms on the filter, acting as a filter for subsequent solid removal. The "cake" is then removed from the filter with a scraping knife. The "cake" is further treated by incineration, solvent extraction, stabilization, or disposal (9).

4.2.2.3.3 Process Constraints

Waste characteristics affecting the performance of filtration include solid waste particle size and the type of solid waste particles. The effectiveness of the filter for removing particles is related to pore size. Particles that are larger than the pore size of the filter are removed more easily. Pretreatment of the waste stream with coagulants and flocculants will increase particle sizes and, therefore, enhance the treatment performance. Gelatinous solids formed during metal precipitation will not form a cake during filtration. Pretreatment of these types of waste stream particles with coagulants and filter aids or precoating the filter may be necessary for filtration to perform properly (9).

4.2.2.4 Powdered Activated Carbon Treatment (PACT)®

4.2.2.4.1 Treatment Applicability

PACT® is a variation of the aerobic biological treatment, activated sludge process and is applicable to wastewaters that contain biodegradable organics (9).

4.2.2.4.2 Treatment Process Parameters

PACT® is a variation of the activated sludge process. Powdered activated carbon is added to the aeration basin during wastewater treatment. The carbon absorbs compounds that are not readily biodegradable or toxic constituents that might be harmful to the microorganisms in the aeration basin. The carbon is removed with the biological sludge and recovered, regenerated, and recycled. For more discussion on the activated sludge process, see Section 4.2.2.1 (9).

4.2.2.4.3 Process Constraints

Several waste characteristics affect the performance of aerobic biological treatments including the ratio of biological oxygen demand (BOD) to total organic carbon content (TOC), concentration of surfactants, and concentration of toxic constituents. The ratio of BOD to TOC content in the waste provides an estimation of the percentage of biodegradable organics in the waste. If the percentage of biodegradable organics is low, aerobic biological treatment systems may not effectively treat the waste. Surfactants can affect biological treatment performance by forming a film on organic constituents, thereby establishing a barrier to oxygen transfer and effective biodegradation (9).

A number of constituents and waste characteristics have been identified as potentially toxic to the microorganisms used in aerobic biological treatments. These include metals, oil and grease, and high concentrations of total dissolved solids, ammonia, and phenols (9).

4.2.2.5 Granular Activated Carbon (GAC) Adsorption

4.2.2.5.1 Treatment Applicability

GAC adsorption technology is applicable to wastewaters containing dissolved organics at concentrations less than 1,000 mg/L (9).

4.2.2.5.2 Treatment Process Parameters

In GAC systems, a column is packed with granular activated carbon and wastewater is passed through the carbon bed. Initially, the contaminants are adsorbed in the upper layers of the carbon bed. As these layers become saturated, the adsorption zone moves down the carbon bed. Eventually, the carbon bed becomes completely saturated and the influent concentration of the constituents in the waste equals the effluent concentration. The system is then taken off line and the activated carbon is regenerated or disposed of. The organic residual adsorbed by the carbon is either incinerated or disposed (9).

4.2.2.5.3 Process Constraints

Waste characteristics affecting the performance of GAC adsorption include the type and concentration of adsorbable constituents and the concentration of suspended solids and oil and grease. Activated carbon has a greater ability to adsorb aromatic and nonpolar compounds than aliphatic and polar compounds. The concentration of adsorbable constituents affects the required frequency of change-out of the carbon. In general, wastewaters containing concentrations of organics greater than 1,000 mg/L, require frequent change-out of the carbon (9). Suspended solids, oil and grease reduce the effectiveness of the carbon. These compounds cause clogging and coating of the activated carbon pores, as well as competing for adsorption sites (9).

4.3 Waste Minimization, Pollution Prevention, and Reuse and Recycling Potential

EPA's progress over the years in improving environmental quality through its media-specific pollution control programs has been substantial. Over the past two decades, standard industrial practice for pollution control concentrated to a large extent on "end of pipe" treatment and disposal of hazardous and non-hazardous wastes. However, EPA realizes that there are limits to the degree of environmental improvement that can be achieved under these programs which emphasize management after pollutants have been generated. EPA believes that eliminating or reducing discharges and/or emissions to the environment through the implementation of cost effective source reduction and environmentally sound recycling practices can provide additional environmental improvements.

Companies which manufacture chlorinated toluene products have implemented corporate recycle and reuse programs (1). In addition, halogenated organic wastes are sometimes used as fuel. However, due to the release of hydrogen chloride and chlorine gas during combustion, as well as other concerns, their use as fuel is limited (8).

Table 4-1

Constituents Selected for Regulation in K149, K150, and K151 Wastes

BDAT List Constituent	K149	K150	K151
Benzene	--	--	X
Carbon tetrachloride	--	X	X
Chlorobenzene	X	--	--
Chloroform	X	X	X
Chloromethane	X	X	--
1,4-Dichlorobenzene	X	X	--
Hexachlorobenzene	X	X	X
Pentachlorobenzene	X	X	X
1,2,4,5-Tetrachlorobenzene	X	X	X
1,1,2,2-Tetrachloroethane	--	X	--
Tetrachloroethylene	--	X	X
Toluene	X	--	X
1,2,4-Trichlorobenzene	--	X	--

Note: X indicates that the constituent is selected for regulation in the individual waste stream.

Reference: (5).

Table 4-2

Best Demonstrated Available Technology (BDAT) for Constituents Selected for Regulation in Nonwastewater Forms of K149, K150, and K151 Wastes

Regulated Constituent	BDAT
Benzene	Incineration
Carbon tetrachloride	Incineration
Chlorobenzene	Incineration
Chloroform	Incineration
Chloromethane	Incineration
1,4-Dichlorobenzene	Incineration
Hexachlorobenzene	Incineration
Pentachlorobenzene	Incineration
1,2,4,5-Tetrachlorobenzene	Incineration
1,1,2,2-Tetrachloroethane	Incineration
Tetrachloroethylene	Incineration
Toluene	Incineration
1,2,4-Trichlorobenzene	Incineration

Reference: (12).

Table 4-3

Best Demonstrated Available Technology (BDAT) for Constituents Selected for Regulation in Wastewater Forms of K149, K150, and K151 Wastes

Regulated Constituent	BDAT
Benzene	Steam Stripping (SS)
Carbon tetrachloride	Biological Treatment (BT)
Chlorobenzene	Biological Treatment (BT)
Chloroform	Steam Stripping (SS)
Chloromethane	Steam Stripping (SS)
1,4-Dichlorobenzene	Activated Sludge Biological Treatment (AS)
Hexachlorobenzene	Activated Sludge and Filtration (AS+Fil)
Pentachlorobenzene	Activated Sludge and Filtration (AS+Fil)
1,2,4,5-Tetrachlorobenzene	Activated Sludge and Filtration (AS+Fil)
1,1,2,2-Tetrachloroethane	Granular Activated Carbon (GAC)
Tetrachloroethylene	Steam Stripping (SS)
Toluene	Steam Stripping (SS)
1,2,4-Trichlorobenzene	Powdered Activated Carbon Addition to Activated Sludge (PACT®)

Reference: (13).

Table 4-4

Determination of BDAT Treatment Standards for Constituents in Nonwastewater Forms of K149, K150, and K151 Wastes

Regulated Constituent	Treatment Test from Which the Performance Data[a] Were Transferred	Constituent from Which the Concentration in Treated Waste Was Transferred	Concentration in Treated Waste (mg/kg)	Constituent from Which the Accuracy Correction Data Were Transferred	Accuracy Correction Factor (Matrix Spike % Recovery)	Variability Factor	BDAT Treatment Standard (Conc. x ACF x VF) (mg/kg)
Benzene	K019	Benzene	<2.0	Benzene	1.18 (85)[b]	2.8	10
Carbon tetrachloride	K019	Carbon tetrachloride	<2.0	Carbon tetrachloride	1.06 (94)	2.8	6.0
Chlorobenzene	K019	Chlorobenzene	<2.0	Chlorobenzene	1.01 (99)[b]	2.8	6.0
Chloroform	K019	Chloroform	<2.0	Chloroform	1.06 (94)	2.8	6.0
Chloromethane	K001-C	Chloromethane	<10.0	1,1,-Dichloroethylene	1.16 (86)[b]	2.8	30
1,4-Dichlorobenzene	K019	1,4-Dichlorobenzene	<2.0	1,4-Dichlorobenzene	1.11 (90)[b]	2.8	6.0
Hexachlorobenzene	John Zink[c] (Test 2)	Hexachlorobenzene	<0.33	Hexachlorobenzene	4.76 (21)[b]	2.8	10
Pentachlorobenzene	John Zink[c] (Test 2)	Hexachlorobenzene	<0.33	Hexachlorobenzene	4.76 (21)[b]	2.8	10
1,2,4,5-Tetrachloro-benzene	K019	1,2,4,5-Tetrachlorobenzene	<5.0	1,2,4,5-Tetrachlorobenzene	1 (103)	2.8	14
1,1,2,2-Tetrachloroethane	K019	bis(2-Chloroethyl)ether	<2.0	bis(2-Chloroethyl)ether	1 (103)	2.8	6.0
Tetrachloroethylene	K019	Tetrachloroethylene	<2.0	Tetrachloroethylene	1.06 (94)	2.8	6.0

< - Indicates a detection limit value.
[a]Performance data consist of the concentration in treated waste, accuracy correction factor, and variability factor.
[b]This number represents a constituent-specific matrix spike.
[c]This test represented the incineration of waste code U127.

·ference (12).

(Continued)

Regulated Constituent	Treatment Test from Which the Performance Data[a] Were Transferred	Constituent from Which the Concentration in Treated Waste Was Transferred	Concentration in Treated Waste (mg/kg)	Constituent from Which the Accuracy Correction Data Were Transferred	Accuracy Correction Factor (Matrix Spike % Recovery)	Variability Factor	BDAT Treatment Standard (Conc. x ACF x VF) (mg/kg)
Toluene	K019	Toluene	<2.0	Toluene	1.06 (94)	2.8	10
1,2,4-Trichlorobenzene	K019	1,2,4-Trichlorobenzene	<5.0	1,2,4-Trichlorobenzene	1.33 (75)[b]	2.8	19

< - Indicates a detection limit value.
[a]Performance data consist of the concentration in treated waste, accuracy correction factor, and variability factor.
[b]This number represents a constituent-specific matrix spike.
[c]This test represented the incineration of waste code U127.

Reference (12).

Table 4-5

BDAT Treatment Standards for Nonwastewater Forms of K149, K150, and K151 Wastes

Waste Code	Regulated Constituent	BDAT Treatment Standard (mg/kg)
K149	Chlorobenzene	6.0
	Chloroform	6.0
	Chloromethane	30
	1,4-Dichlorobenzene	6.0
	Hexachlorobenzene	10
	Pentachlorobenzene	10
	1,2,4,5-Tetrachlorobenzene	14
	Toluene	10
K150	Carbon tetrachloride	6.0
	Chloroform	6.0
	Chloromethane	30
	1,4-Dichlorobenzene	6.0
	Hexachlorobenzene	10
	Pentachlorobenzene	10
	1,2,4,5-Tetrachlorobenzene	14
	1,1,2,2-Tetrachloroethane	6.0
	Tetrachloroethene	6.0
	1,2,4-Trichlorobenzene	19
K151	Benzene	10
	Carbon tetrachloride	6.0
	Chloroform	6.0
	Hexachlorobenzene	10
	Pentachlorobenzene	10
	1,2,4,5-Tetrachlorobenzene	14
	Tetrachloroethene	6.0
	Toluene	10

Reference: (12).

Table 4-6

Determination of BDAT Treatment Standards for Constituents in Wastewater Forms of K149, K150, and K151 Wastes

Regulated Constituent	Treatment Technology	Database Reference	Average Concentration in Treated Waste (mg/L)	Variability Factor	BDAT Treatment Standard (mg/L)
Benzene	SS	EAD	0.010	14	0.14
Carbon tetrachloride	BT	EAD	0.010	5.7	0.057
Chlorobenzene	BT	EAD	0.010	5.7	0.057
Chloroform	SS	EAD	0.0122	3.7	0.046
Chloromethane	SS	EAD	0.050	3.8	0.19
1,4-Dichlorobenzene	AS	WERL	0.01633	5.5	0.090
Hexachlorobenzene	AS+Fil	WERL	0.010	5.5	0.055
Pentachlorobenzene	AS+Fil	WERL	0.010	5.5	0.055
1,2,4,5-Tetrachlorobenzene	AS+Fil	WERL	0.010	5.5	0.055
1,1,2,2-Tetrachloroethane	GAC	WERL	0.010	5.7	0.057
Tetrachloroethylene	SS	EAD	0.0104	5.3	0.056
Toluene	SS	EAD	0.010	8.0	0.080
1,2,4-Trichlorobenzene	PACT®	WERL	0.010	5.5	0.055

AS = Activated Sludge Biological Treatment
AS + Fil = Activated Sludge Biological Treatment and Filtration
BT = Biological Treatment
EAD = Engineering and Analysis Division
GAC = Granular Activated Carbon
PACT® = Powdered Activated Carbon Addition to Activated Sludge
SS = Steam Stripping
WERL = Water Engineering Research Lab

Reference: (13).

Table 4-7

BDAT Treatment Standards for Wastewater Forms of K149, K150, and K151 Wastes

Waste Code	Regulated Constituent	BDAT Treatment Standard (mg/L)
K149	Chlorobenzene	0.057
	Chloroform	0.046
	Chloromethane	0.19
	1,4-Dichlorobenzene	0.090
	Hexachlorobenzene	0.055
	Pentachlorobenzene	0.055
	1,2,4,5-Tetrachlorobenzene	0.055
	Toluene	0.080
K150	Carbon tetrachloride	0.057
	Chloroform	0.046
	Chloromethane	0.19
	1,4-Dichlorobenzene	0.090
	Hexachlorobenzene	0.055
	Pentachlorobenzene	0.055
	1,2,4,5-Tetrachlorobenzene	0.055
	1,1,2,2-Tetrachloroethane	0.057
	Tetrachloroethene	0.056
	1,2,4-Trichlorobenzene	0.055
K151	Benzene	0.14
	Carbon tetrachloride	0.057
	Chloroform	0.046
	Hexachlorobenzene	0.055
	Pentachlorobenzene	0.055
	1,2,4,5-Tetrachlorobenzene	0.055
	Tetrachloroethene	0.056
	Toluene	0.080

Reference: (13).

5.0 REGULATORY HISTORY AND STATUS OF THESE WASTES

5.1 Other Land Disposal Restrictions for These Wastes

There are no other land disposal restrictions for chlorinated toluene wastes K149, K150, and K151.

5.2 Land Disposal Restrictions for Similar Wastes

K015 wastes are the only other waste currently regulated under Subtitle C of RCRA that is generated by chlorinated toluene facilities. K015 wastes are defined as still bottoms from the distillation of benzyl chloride.

Treatment standards have been promulgated for the following hazardous constituents in K015 wastes: toluene, anthracene, benzal chloride, benzo(b and k) fluoranthene, phenanthrene, chromium, and nickel.

5.3 Effluent Guidelines

Effluent guidelines, limitations and standards applicable to chlorinated toluene facilities are discussed in Section 3.3.1 of this Background Document.

5.4 Clean Air Act Regulations and Other Process Controls

Clean Air Act regulations applicable to chlorinated toluene facilities are discussed in Section 3.3.1 of this Background Document.

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7.0 ACKNOWLEDGEMENTS

Radian Corporation provided technical support for the development of this document for the U.S. Environmental Protection Agency, Office of Solid Waste under Contract Numbers 68-W9-0072, 68-W0-0025, and 68-W3-0001. This document was prepared under the direction of Richard Kinch, Chief, Waste Treatment Branch; Larry Rosengrant, Section Chief, Treatment Technology Section; and Angela Wilkes and Dave Levy, Project Officers for the Radian contract. Lisa Jones served as the Project Manager. Steve Silverman served as EPA legal advisor.

The following personnel from Radian Corporation supported the development of this document: Tom Ferguson and Gayle Kline, Program Managers; Richard Weisman and Mary Willett, Project Directors; and the Radian engineering team, Tania Ashman-Allam, Julian Bentley, Jennifer Dann, Chrisanti Haretos, Nancy Johnson, Kirsten Mahsman, Timothy Meeks, Tim McLaughlin, Robert Shark, and Grace Shields, as well as Charles Peck of Versar Inc.

Appendix A

Treatment Performance Database and Methodology for Identifying Universal Standards for Constituents in Nonwastewater Forms of K149, K150, and K151 Wastes

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This appendix presents the development of the universal treatment standards (i.e., universal standards) for the constituents selected for regulation in nonwastewater forms of K149, K150, and K151 wastes. Section A.1 presents the methodology for determining nonwastewater universal standards and introduces the universal standards database. Section A.2 presents a constituent-by-constituent discussion of the determination of the universal standards for each regulated constituent.

A.1 Methodology for Determining Nonwastewater Universal Standards

The performance data presented in Table A-1 represent the universal standards database for the constituents selected for regulation in K149, K150, and K151 wastes. These data consist of the treatment performance data used to develop nonwastewater treatment standards in the First, Second, Third Third, and Phase I Land Disposal Restrictions Program rulemaking efforts. In order to determine the universal standards, the Agency examined the treatment performance data used in calculating each treatment standard applicable to a specific constituent.

The Agency chose which treatment performance data to transfer as the universal standard on a constituent-by-constituent basis. Six factors were considered in selecting the "best" performance data and standard from the available treatment standard performance data:

(1) Where possible, the Agency preferred performance data (i.e., the matrix spike recovery data, detection limit, and variability factor (according to Table A-1)) for the same constituent.

(2) The matrix spike recovery data were evaluated to determine whether acceptable recoveries were obtained according to EPA's quality assurance/quality control guidelines.

(3) When performance data from the same constituent were unavailable, the Agency used performance data from a constituent with similar composition and functional groups.

(4) When evaluating the matrix spike recovery data, the Agency preferred to use a matrix spike recovery for a specific constituent instead of a value averaged over a group of constituents (e.g., volatile organics).

(5) The method detection limit was examined to determine if it could be met routinely by industry.

(6) The treatment performance data and standard corresponding to the "best" data was compared to the detection limits used to calculate other treatment standards to determine if the constituent could be treated to similar levels in similar waste codes.

A.2 Determination of Universal Standards for Constituents in Nonwastewater Forms of K149, K150, and K151 Wastes

Treatment standard data for the constituents selected for regulation in nonwastewater forms of K149, K150, and K151 wastes are presented in Table A-1. A constituent-by-constituent discussion of the determination of the universal standard for each of these constituents is given below. The universal standards and corresponding performance data for each constituent selected for regulation in K149, K150, and K151 wastes are also presented in Table 4-4. A more detailed discussion of the determination of the universal standards is provided in EPA's Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards, Volume A: Universal Standards for Nonwastewater Forms of Listed Hazardous Wastes (12).

Benzene

The universal standard for benzene was determined to be 10 mg/kg, based upon the K083 treatment standard. The Agency chose to use the K083 treatment performance data since these data represent the use of an accuracy correction factor and detection limit from the same constituent as the constituent of concern. Treatment data were not transferred from F039 and U019 wastes because the detection limit was considered to be an outlier compared to the magnitude of the detection limits from other incineration tests. The treatment standard was established at 10 mg/kg in order that the treatment standard could be routinely met by industry, considering the detection limits reported for benzene in other waste codes.

Carbon Tetrachloride

The universal standard for carbon tetrachloride was determined to be 6.0 mg/kg, based upon the K021 and K073 treatment standards. The Agency chose to use the K021 and K073 treatment performance data since these data represent the use of an accuracy correction factor and detection limit from the same constituent as the constituent of concern. The treatment standard was established at 6.0 mg/kg to remain consistent with other similar constituents in the same treatability group. The Agency believes that a treatment standard of 6.0 mg/kg may be reasonably achieved based on detection limits reported for carbon tetrachloride in other waste codes.

Chlorobenzene

The universal standard for chlorobenzene was determined to be 6.0 mg/kg, based upon the K019 treatment standard. The Agency chose to use the K019 treatment performance data since these data represent the use of an accuracy correction factor and detection limit from the same constituent as the constituent of concern. The treatment standard was established at 6.0 mg/kg to remain consistent with other similar constituents in the same treatability group. The Agency believes that a treatment standard of 6.0 mg/kg may be reasonably achieved based on detection limits reported for chlorobenzene in other waste codes.

Chloroform

The universal standard for chloroform was determined to be 6.0 mg/kg, based upon the K009, K010, K019, and K029 treatment standards. The Agency chose to use the K009, K010, K019, and K029 treatment performance data since these data represent the use of an accuracy correction factor and detection limit from the same constituent as the constituent of concern. The Agency believes that a treatment standard of 6.0 mg/kg may be reasonably achieved based on detection limits reported for chloroform in other waste codes.

Chloromethane

The universal standard for chloromethane was determined to be 30 mg/kg, based upon the F039 and U045 data, which represent the only concentration-based standards the Agency has promulgated in the First, Second, or Third Thirds for this constituent. The treatment standard was established at 30 mg/kg to remain consistent with other similar constituents in the same treatability group.

1,4-Dichlorobenzene

The universal standard for 1,4-dichlorobenzene was determined to be 6.0 mg/kg, based upon the F039 and U072 treatment standards. The Agency chose to use the F039 and U072 treatment performance data since these data represent the use of an accuracy correction factor and detection limit from the same constituent as the constituent of concern. The treatment standard was established at 6.0 mg/kg to remain consistent with other similar constituents in the same treatability group. The Agency believes that a treatment standard of 6.0 mg/kg may be reasonably achieved based on the detection limits reported for 1,4-dichlorobenzene in other waste codes.

Hexachlorobenzene

The universal standard for hexachlorobenzene was determined to be 10 mg/kg, based upon the K085 treatment standard. The Agency chose to use the K085 treatment performance data since these data represent the use of an accuracy correction factor

factor and detection limit from the same constituent as the constituent of concern. Treatment data for hexachlorobenzene were not transferred from K016, K018, F025, F039, and U127 because the detection limit was considered to be an outlier compared to the magnitude of the detection limits from other incineration tests. The treatment standard was established at 10 mg/kg in order that the treatment standard could be routinely met by industry, considering the detection limits reported for hexachlorobenzene in other waste codes.

Pentachlorobenzene

The universal standard for pentachlorobenzene was determined to be 10 mg/kg, based upon the K042 and K085 treatment standards. The Agency chose to use the K042 and K085 treatment performance data since these data represent the transfer of an actual matrix spike recovery as opposed to an averaged value. Treatment data for pentachlorobenzene were not transferred from K030, F039, and U183 because the detection limit was considered to be an outlier compared to the magnitude of the detection limits from other incineration tests. The treatment standard was established at 10 mg/kg in order that the treatment standard could be routinely met by industry, considering the detection limits reported for pentachlorobenzene in other waste codes.

1,2,4,5-Tetrachlorobenzene

The universal standard for 1,2,4,5-tetrachlorobenzene was determined to be 14 mg/kg, based upon the K030 treatment standard. The Agency chose to use the K030 treatment performance data since these data represent the use of an accuracy correction factor and detection limit from the same constituent as the constituent of concern. The Agency believes that a treatment standard of 14 mg/kg may be reasonably achieved based on detection limits reported for 1,2,4,5-tetrachlorobenzene in other waste codes.

1,1,2,2-Tetrachloroethane

The universal standard for 1,1,2,2-tetrachloroethane was determined to be 6.0 mg/kg, based upon the K020, K028, K095, and K096 treatment standards. The Agency chose to use the K020, K028, K095, and K096 treatment performance data rather than transferring other treatment performance data. Treatment data for 1,1,2,2-tetrachloroethane were not transferred from F001, F002, F003, F004, F005, F039, and U209 because the detection limit was considered to be an outlier compared to the magnitude of the detection limits from other incineration tests. The treatment standard was established at 6.0 mg/kg to remain consistent with other similar constituents in the same treatability group. The Agency believes that a treatment standard of 6.0 mg/kg may be reasonably achieved based on the detection limits reported for 1,1,2,2-tetrachloroethane in other waste codes.

Tetrachloroethylene

The universal standard for tetrachloroethylene was determined to be 6.0 mg/kg, based upon the K016, K019, K020, K028, K030, K095, and K096 treatment standards. The Agency chose to use the K016, K019, K020, K028, K030, K095, and K096 treatment performance data since these data represent the use of an accuracy correction factor and detection limit from the same constituent as the constituent of concern. The Agency believes that a treatment standard of 6.0 mg/kg may be reasonably achieved based on the detection limits reported for tetrachloroethylene in other waste codes.

1,2,4-Trichlorobenzene

The universal standard for 1,2,4-trichlorobenzene was determined to be 19 mg/kg, based upon the F039, K019, K030, and K096 treatment standards. The Agency chose to use the K019 treatment performance data since these data represent the use of an accuracy correction factor and detection limit from the same constituent as the constituent of concern.

Toluene

The universal standard for toluene was determined to be 10 mg/kg, based upon the K015 treatment standard. The Agency chose to use the K015 treatment performance data since these data represent the use of an accuracy correction factor and detection limit from the same constituent as the constituent of concern. Treatment data were not transferred from F001, F002, F003, F004, F005, F039, K001, K037, K086, U051, and U220 because the detection limit was considered to be an outlier compared to the magnitude of the detection limits from other incineration tests. Likewise, the Agency believes that the K087 standard of 0.65 mg/kg and the K022 standard of 0.034 mg/kg may not be reasonably achieved based on the detection limits reported for toluene in other waste codes. The treatment standard was established at 10 mg/kg in order that the treatment standard could be routinely met by industry, considering the detection limits reported for toluene in other waste codes.

Table A-1

Treatment Standard Data for Constituents Selected for Regulation in Nonwastewater Forms of K149, K150, and K151 Wastes

Regulated Constituent	Treatment Standard (Conc. x ACF x VF) (mg/kg)	Waste Code(s)	Concentration in Treated Waste (mg/kg)	Treatment Test from Which the Performance Data[a] Was Transferred	Constituent from Which the Concentration in Treated Waste Was Transferred	Constituent from Which the Accuracy Correction Data Was Transferred	Accuracy Correction Factor (Matrix Spike % Recovery)	Variability Factor
Benzene	0.071	K060, K087	<0.025	K087	Benzene	Benzene	1.02 (98)[b]	2.8
	4.4	K085, K105	<0.33	3rd 3rd Test Burn (Test 2)[d]	Hexachlorobenzene	Hexachlorobenzene	4.76 (21)[b]	2.8
	6.0	K103, K104	<2.0	K019	1,2-Dichloroethane	1,2-Dichloroethane	1.06 (94)	2.8
	6.6	K083	<2.0	K019	Benzene	Benzene	1.18 (85)[b]	2.8
	36	F039, U019	<10.0	K001-C	Benzene	Benzene	1.28 (78)[b]	2.8
Carbon tetrachloride	5.6	F001-F005, F039, U211	<2.0	K019	Carbon tetrachloride	Trichloroethylene	1 (107)[b]	2.8
	6.2[c]	F025	<2.0	K019	1,1,1-Trichloroethane	1,1,1-Trichloroethane	1.1 (91)	2.8
	6.2[c]	K021, K073	<2.0	K019	Carbon tetrachloride	Carbon tetrachloride	1.1 (91)	2.8
Chlorobenzene	4.4	K085, K105	<0.33	3rd 3rd Test Burn (Test 2)[d]	Hexachlorobenzene	Hexachlorobenzene	4.76 (21)[b]	2.8
	5.7	F001-F005, F039, U037	<2.0	K019	Chlorobenzene	Chlorobenzene	1.01 (99)[b]	2.8
	6.0[c]	K019	<2.0	K019	Chlorobenzene	Chlorobenzene	1.01 (99)[b]	2.8

< - Indicates a detection limit value.
[a]Performance data consist of the concentration in treated waste, accuracy correction factor, and variability factor.
[b]This number represents a constituent-specific matrix spike.
[c]See notes.
[d]This test represented the incineration of waste code U127.

Reference: (12).

Regulated Constituent	Treatment Standard (Conc. x ACF x VF) (mg/kg)	Waste Code(s)	Concentration in Treated Waste (mg/kg)	Treatment Test from Which the Performance Data[a] Was Transferred	Constituent from Which the Concentration in Treated Waste Was Transferred	Constituent from Which the Accuracy Correction Data Was Transferred	Accuracy Correction Factor (Matrix Spike % Recovery)	Variability Factor
Chloroform	5.6	F039, U044, K117, K118, K136	<2.0	K019	Chloroform	Trichloroethylene	1 (107)[b]	2.8
	6.0	K009, K010, K019, K029	<2.0	K019	Chloroform	Chloroform	1.06 (94)	2.8
	6.2[c]	F025, K021, K073	<2.0	K019	Chloroform	Chloroform	1.1 (91)	2.8
Chloromethane	33	F039, U045	<10.0	K001-C	Chloromethane	1,1,-Dichloroethylene	1.16 (86)[b]	2.8
1,4-Dichlorobenzene	4.4	K042, K085, K105	<0.33	3rd 3rd Test Burn (Test 2)[d]	Hexachlorobenzene	Hexachlorobenzene	4.76 (21)[b]	2.8
	6.2	F039, U072	<2.0	K019	1,4-Dichlorobenzene	1,4-Dichlorobenzene	1.11 (90)[b]	2.8
Hexachlorobenzene	4.4	K085	<0.33	3rd 3rd Test Burn (Test 2)[d]	Hexachlorobenzene	Hexachlorobenzene	4.76 (21)[b]	2.8
	28	K016, K018	<10.0	K019	Hexachlorobenzene	Hexachlorobenzene	1 (103)	2.8
	37	F025, F039, U127	<10.0	K019	Hexachlorobenzene	1,2,4-Trichlorobenzene	1.33 (75)[b]	2.8

< - Indicates a detection limit value.
[a]Performance data consist of the concentration in treated waste, accuracy correction factor, and variability factor.
[b]This number represents a constituent-specific matrix spike.
[c]See notes.
[d]This test represented the incineration of waste code U127.

Reference: (12).

Table A-1

(Continued)

Regulated Constituent	Treatment Standard (Conc. x ACF x VF) (mg/kg)	Waste Code(s)	Concentration in Treated Waste (mg/kg)	Treatment Test from Which the Performance Data[a] Was Transferred	Constituent from Which the Concentration in Treated Waste Was Transferred	Constituent from Which the Accuracy Correction Data Was Transferred	Accuracy Correction Factor (Matrix Spike % Recovery)	Variability Factor
Pentachlorobenzene	4.4	K042, K085	<0.33	3rd 3rd Test Burn (Test 2)[d]	Hexachlorobenzene	Hexachlorobenzene	4.76 (21)[b]	2.8
	28	K030	<10.0	K019	Pentachlorobenzene	Pentachlorobenzene	1 (103)	2.8
	37	F039, U183	<10.0	K019	Pentachlorobenzene	1,2,4-Trichlorobenzene	1.33 (75)[b]	2.8
1,2,4,5-Tetrachloro-benzene	4.4	K042, K085	<0.33	3rd 3rd Test Burn (Test 2)[d]	Hexachlorobenzene	Hexachlorobenzene	4.76 (21)[b]	2.8
	19	F039, U207	<5.0	K019	1,2,4,5-Tetrachlorobenzene	1,2,4-Trichlorobenzene	1.33 (75)[b]	2.8
	14	K030	<5.0	K019	1,2,4,5-Tetrachlorobenzene	1,2,4,5-Tetrachlorobenzene	1 (103)	2.8
1,1,2,2-Tetrachloroethane	5.6	K020, K028, K095, K096	<2.0	K019	bis(2-Chloroethyl)ether	bis(2-Chloroethyl)ether	1 (103)	2.8
	42[c]	F039, U209	<10.0	K001-C	1,1,2,2-Tetrachloroethane	Trichloroethylene	1.49 (67)[b]	2.8

< - Indicates a detection limit value.
[a]Performance data consist of the concentration in treated waste, accuracy correction factor, and variability factor.
[b]This number represents a constituent-specific matrix spike.
[c]See notes.
[d]This test represented the incineration of waste code U127.

Referen[illegible] [illegible]12).

e A-1

(Continued)

Regulated Constituent	Treatment Standard (Conc. x ACF x VF) (mg/kg)	Waste Code(s)	Concentration in Treated Waste (mg/kg)	Treatment Test from Which the Performance Data[a] Was Transferred	Constituent from Which the Concentration in Treated Waste Was Transferred	Constituent from Which the Accuracy Correction Data Was Transferred	Accuracy Correction Factor (Matrix Spike % Recovery)	Variability Factor
Tetrachloroethylene	5.6	F001-F005, F039, U210	<2.0	K019	Tetrachloroethylene	Trichloroethylene	1 (107)[b]	2.8
	6.0	K016, K019, K020, K028, K030, K095, K096	<2.0	K019	Tetrachloroethylene	Tetrachloroethylene	1.06 (94)	2.8
	6.2[c]	K073	<2.0	K019	Tetrachloroethylene	Tetrachloroethylene	1.1 (91)	2.8
Toluene	0.034	K022	<0.012	K022	Toluene	Toluene	1 (106)[b]	2.8
	0.65	K087	0.095	K087	Toluene	Toluene	1 (104)[b]	6.85
	6.0	K015	<2.0	K019	Toluene	Toluene	1.06 (94)	2.8
	28	U051, U220, F001-F005, F039, K001, K086	<10.0	K001-C	Toluene	Toluene	1.01 (99)[b]	2.8
	28	K037	<10.0	K037	Toluene	Toluene	1 (165)[b]	2.8

< - Indicates a detection limit value.
[a]Performance data consist of the concentration in treated waste, accuracy correction factor, and variability factor.
[b]This number represents a constituent-specific matrix spike.
[c]See notes.
[d]This test represented the incineration of waste code U127.

Reference: (12).

Table A-1

(Continued)

Regulated Constituent	Treatment Standard (Conc. x ACF x VF) (mg/kg)	Waste Code(s)	Concentration in Treated Waste (mg/kg)	Treatment Test from Which the Performance Data[a] Was Transferred	Constituent from Which the Concentration in Treated Waste Was Transferred	Constituent from Which the Accuracy Correction Data Was Transferred	Accuracy Correction Factor (Matrix Spike % Recovery)	Variability Factor
1,2,4-Trichlorobenzene	4.4	K042, K085	<0.33	3rd 3rd Test Burn (Test 2)[d]	Hexachlorobenzene	Hexachlorobenzene	4.76 (21)[b]	2.8
	19	F039, K019, K030, K096	<5.0	K019	1,2,4-Trichlorobenzene	1,2,4-Trichlorobenzene	1.33 (75)[b]	2.8

Notes:

Carbon tetrachloride — The accuracy correction factors used in the F025, K021, and K073 treatment standards were transferred from the K019 treatment test. The accuracy correction factor for the average of the semivolatile constituents was transferred as 1.1 instead of 1.06. The treatment standard should have been 6.0 mg/kg.

Chloroform — The accuracy correction factors used in the F025, K021, and K073 treatment standards were transferred from the K019 treatment test. The accuracy correction factor for the average of the semivolatile constituents was transferred as 1.1 instead of 1.06. The treatment standard should have been 6.0 mg/kg.

Tetrachloroethylene — The accuracy correction factor used in the K073 treatment standard was transferred from the K019 treatment test. The accuracy correction factor for the average of the semivolatile constituents was transferred as 1.1 instead of 1.06. The treatment standard should have been 6.0 mg/kg.

< - Indicates a detection limit value.
[a]Performance data consist of the concentration in treated waste, accuracy correction factor, and variability factor.
[b]This number represents a constituent-specific matrix spike.
[c]See notes.
[d]This test represented the incineration of waste code U127.

Reference

Appendix B

Treatment Performance Database and Methodology for Identifying Universal Standards for Constituents in Wastewater Forms of K149, K150, and K151 Wastes

B.1 Methodology for Determining Wastewater Treatment Standards

The universal standards for regulated constituents in wastewater forms of K149, K150, and K151 wastes are based on treatment performance data from several sources, including the BDAT treatment performance database, the NPDES database, the WERL database, WAO/PACT® data, the EAD database, industry-submitted leachate treatment performance data, data submitted by the Chemical Manufacturers Association's Carbon Disulfide Task Force, data submitted by the California Toxic Substances Control Division, data in literature that were not already part of the WERL database, and data in literature submitted by industry on the WAO and PACT® treatment process. This appendix presents the wastewater treatment performance database and discusses use of the data to determine BDAT and to calculate the universal standards for the constituents selected for regulation in wastewater forms of K149, K150, and K151 wastes.

Table B-1 and Table B-2 are database and treatment technology keys, respectively, for the data tables presented in this appendix. Tables B-3 through B-14 in this appendix present the available wastewater treatment performance data for each constituent selected for regulation in K149, K150, and K151 wastes. The data used to determine the universal standards are indicated with a footnote. A discussion of the determination of the universal standards for each of the constituents selected for regulation in K149, K150, and K151 wastes is presented in Section B.2.

The calculation of the universal standards involved three steps: (1) identification of best demonstrated technologies and treatment performance data; (2) determination of a variability factor specific to each constituent in a treatment performance data set to correct for normal variation in the performance of a particular technology over time; and (3) calculation of the treatment standard, which is equal to the average effluent concentration multiplied by the variability factor. The universal standards and specific treatment performance data used to determine the treatment standards for the constituents selected for regulation in wastewater forms of K149, K150, and K151 are presented in Table 4-6.

Identification of Best Demonstrated Technologies and Treatment Performance Data

To determine the best demonstrated technology for each BDAT List organic constituent, the Agency examined the universal wastewater treatment performance database. To determine "best," a hierarchy was established to evaluate the wastewater treatment performance data. The following outlines the methodology used to determine "best" for wastewater constituents that are included in this document:

(1) For any organics with EAD performance data and a promulgated EAD effluent limitation, the EAD data were used to calculate the BDAT treatment standard for that constituent. The data representing EAD Option 1 (see Reference 13 for a description of Option 1) were used in all cases.

(2) For any constituent for which promulgated EAD standards (based on actual treatment performance data) do not exist, data from an Agency-sponsored BDAT wastewater treatment test were used to determine the BDAT treatment standard.

(3) For any constituent with industry-submitted leachate treatment performance data, where the data showed substantial treatment and the data were considered better or more representative of treatment performance than Agency data, the Agency used the industry-submitted leachate data to calculate the BDAT concentration-based standard.

(4) For any constituent without EAD data, BDAT wastewater treatment test data, or industry-submitted leachate treatment performance data showing substantial treatment, other available treatment performance data were evaluated to determine BDAT and were used to calculate the BDAT concentration-based standard. Considered in this evaluation were the treatment technology for which data were available, whether the data represented a full-, pilot-, or bench-scale technology, the concentration of the constituent of interest in the influent to treatment, the average

concentration of the constituent of interest in the effluent from treatment, and the removal efficiency of the treatment technology. Full-scale treatment data with an influent concentration range greater than 100 micrograms per liter (μg/L) were preferred over pilot- or bench-scale data and preferred over data with a low (i.e., 0-100 μg/L) influent concentration range. If several sets of data met these criteria (i.e., full-scale available technologies with high influent concentrations), they were compared by examination of their average effluent values and percent removals to determine the data set(s) which had the lowest effluent values and the technology with the highest percent removal.

(5) For any constituent where treatment performance data were not available from any of the examined sources, data were transferred for calculation of a BDAT treatment standard from a similar constituent in a waste judged to be similar.

Details regarding the identification of BDAT for the constituents selected for regulation in wastewater forms of K149, K150, and K151 wastes are presented in Section B.2 and in EPA's Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards, Volume B: Universal Standards for Wastewater Forms of Listed Hazardous Wastes (13).

For most constituents selected for regulation in K149, K150, and K151 wastes, the Agency had treatment performance data from the Engineering and Analysis Division (formerly Industrial Technology Division (ITD)) database. The Agency believes that these data represent the best demonstrated treatment performance for the following reasons:

- The EAD database consists of treatment performance data from Organic Chemical Plastics and Synthetic Fiber (OCPSF) sampling episodes. These episodes included long-term sampling of several industries and the data are therefore a good reflection of the treatment of organics in industrial wastewaters.
- The EAD data were carefully screened prior to inclusion in the OCPSF database and were used in determining an EAD promulgated limit.

- A promulgated EAD limit represents data that have undergone both EPA and industry review and acceptance.

Variability Factors

A variability factor accounts for the variability inherent in the treatment system performance, treatment residual collection, and analysis of the treated waste samples. Variability factors are calculated as described in EPA's Methodology Background Document (11).

Due to the nature of the data gathered from various sources presented in this appendix, variability factors for all of the constituents selected for regulation in K149, K150, and K151 wastes are not calculated as described in Reference 11, since in many cases, original effluent points were not available.

The variability factor calculated during the EAD regulation effort was used for those constituents for which a treatment standard was based on an EAD effluent limitation (i.e., selected volatile and semivolatile organic constituents).

For constituents where a variability factor was unknown or could not be calculated, an average variability factor was used. The average variability factors were generated from the EAD variability factors and are specific to the type of constituent under consideration (i.e., volatile organic or semivolatile organic). The average variability factor for volatile organics is the average of the variability factors from EAD data, as shown in Table B-15. The average variability factor for semivolatile organics is the average of the variability factors shown in Table B-16. Determination of these average variability factors is similar to the procedure used by EPA in previous BDAT rulemakings to determine average accuracy correction factors.

For all constituents selected for regulation in K149, K150, and K151 wastes, an EAD variability factor was used in the determination of the treatment standard. In these cases, an accuracy correction factor was not used because it would lead to over-correcting the data.

Treatment Standard Calculation

A constituent-by-constituent discussion of the determination of the universal standards for wastewaters is presented in Section B.2.

B.2 Determination of Universal Standards for Constituents in Wastewater Forms of K149, K150, and K151 Wastes

Wastewater treatment performance data for the constituents selected for regulation in K149, K150, and K151 wastes are presented in Tables B-3 through B-14. A constituent-by-constituent discussion of the data used to calculate the universal standards for the constituents selected for regulation in wastewater forms of K149, K150, and K151 wastes is given below.

Benzene

BDAT for benzene was identified as steam stripping (SS). Steam stripping was selected as BDAT because it represents treatment performance data from the EAD database. The universal standard was calculated using the EAD median long-term average of 10 μg/L and the EAD variability factor for benzene. The determination of the resulting universal standard for benzene (0.14 mg/L) is shown in Table 4-6.

Carbon Tetrachloride

BDAT for carbon tetrachloride was identified as biological treatment (BT). Biological treatment was selected as BDAT because it represents treatment performance data from the EAD database and was used as part of the BDAT Solvents Rule. The universal standard was calculated using the effluent concentration of 10 μg/L and the average of the EAD variability factors for volatile constituents. The determination of the resulting universal standard for carbon tetrachloride (0.057 mg/L) is shown in Table 4-6.

Chlorobenzene

BDAT for chlorobenzene was identified as biological treatment (BT). Biological treatment was selected as BDAT because it represents treatment performance data from the EAD database and was used as part of the BDAT Solvents Rule. The universal standard was calculated using the effluent concentration of 10 μg/L and the average of the EAD variability factors for volatile constituents. The determination of the resulting universal standard for chlorobenzene (0.057 mg/L) is shown in Table 4-6.

Chloroform

BDAT for chloroform was identified as steam stripping (SS). Steam stripping was selected as BDAT because it represents treatment performance data from the EAD database. The universal standard for chloroform was calculated using the EAD median long-term average of 12.2 μg/L and the EAD variability factor for chloroform. The determination of the resulting universal standard for chloroform (0.046 mg/L) is shown in Table 4-6.

Chlorometbane

BDAT for chloromethane was identified as steam stripping (SS). Steam stripping was selected as BDAT because it represents treatment performance data from the EAD database. The universal standard for chloromethane was calculated using the EAD median long-term average of 50 μg/L and the EAD variability factor for chloromethane. The determination of the resulting universal standard for chloromethane (0.19 mg/L) is shown in Table 4-6.

1,4-Dichlorobenzene

BDAT for 1,4-dichlorobenzene was identified as activated sludge biological treatment (AS). Activated sludge was selected as BDAT because it represents full-scale data with high influent concentrations and a high removal efficiency. The universal standard was calculated using an effluent concentration of 16.33 μg/L (which represents an average of the data presented for the activated sludge technology in the high effluent concentration ranges) and the average of the EAD variability factors for semivolatile constituents. The determination of the resulting universal standard for 1,4-dichlorobenzene (0.090 mg/L) is shown in Table 4-6.

Hexachlorobenzene

BDAT for hexachlorobenzene was identified as activated sludge followed by filtration (AS+Fil). Activated sludge followed by filtration was selected as BDAT because it represents full-scale data with high influent concentrations and a high removal efficiency. The universal standard for hexachlorobenzene was calculated using an effluent concentration of 10 μg/L and the EAD variability factors for hexachlorobenzene. The determination of the resulting universal standard for hexachlorobenzene (0.055 mg/L) is shown in Table 4-6.

Pentachlorobenzene

No wastewater treatment performance data were available for pentachlorobenzene from any of the examined sources. Treatment performance data were therefore transferred from a constituent judged to be similar in elemental composition and functional groups within the structure of the chemical, hexachlorobenzene. Using a transfer from this constituent results in a BDAT for pentachlorobenzene of activated sludge followed by filtration. The determination of the resulting universal standard for pentachlorobenzene (0.055 mg/L) is shown in Table 4-6.

1,2,4,5-Tetrachlorobenzene

The data available for 1,2,4,5-tetrachlorobenzene were compiled from the NPDES database. Since influent values were not available for the NPDES data and since the NPDES average effluent value was below the compound detection limit of 1.5 μg/L, it cannot be determined that these data represent treatment. Treatment performance data were therefore transferred to this constituent from a constituent judged to be similar in elemental composition and functional groups within the structure of the chemical, hexachlorobenzene. Using a transfer from this constituent results in a BDAT for 1,2,4,5-tetrachlorobenzene of activated sludge followed by filtration. The determination of the resulting universal standard for 1,2,4,5-tetrachlorobenzene (0.055 mg/L) is shown in Table 4-6.

1,1,2,2-Tetrachloroethane

BDAT for 1,1,2,2-tetrachloroethane was identified as granular carbon adsorption (GAC). Granular activated carbon was selected as BDAT because it represents full-scale data with a high influent concentration and a high removal efficiency. The universal standard was calculated using the effluent concentration of 10.0 μg/L and the average of the EAD variability factors for volatile constituents. The determination of the resulting universal standard for 1,1,2,2-tetrachloroethane (0.057 mg/L) is shown in Table 4-6.

Tetrachloroethylene

BDAT for tetrachloroethylene was identified as steam stripping (SS). Steam stripping was selected as BDAT because it represents treatment performance data from the EAD database. The universal standard for tetrachloroethylene was calculated using the EAD median long-term average of 10.4 μg/L and the EAD variability factor for tetrachloroethylene. The determination of the resulting universal standard for tetrachloroethylene (0.056 mg/L) is shown in Table 4-6.

Toluene

BDAT for toluene was identified as steam stripping (SS). Steam stripping was selected as BDAT because it represents treatment performance data from the EAD database. The universal standard for toluene was calculated using the EAD median long-term average of 10 μg/L and the EAD variability factor for toluene. The determination of the resulting universal standard for toluene (0.056 mg/L) is shown in Table 4-6.

1,2,4-Trichlorobenzene

BDAT for 1,2,4-trichlorobenzene was identified as PACT®. PACT® was selected as BDAT since this technology represents full-scale treatment with high influent concentrations and a high removal efficiency. The universal standard for 1,2,4-trichlorobenzene was calculated using the effluent concentration of 10 μg/L and the average of the EAD variability factors for semivolatile constituents. The determination of the resulting universal standard for 1,2,4-trichlorobenzene (0.055 mg/L) is shown in Table 4-6.

Table B-1

Key to Data Sources for Wastewaters

Code	Database
BDAT	Best Demonstrated Available Technology
EAD	Engineering Analysis Division
NPDES	National Pollutant Discharge Elimination System
WAO	Wet Air Oxidation
WERL	Water Engineering Research Laboratory
OCPSF	Organic Chemicals, Plastics, and Synthetic Fibers
LEACHATE	Leachate Treatment Performance Data Submitted by Industry

Table B-2

Key to Treatment Technologies

Code	Technology
AC	Activated Carbon
AFF	Aerobic Fixed Film
AL	Aerobic Lagoons
API	API Oil/Water Separator
AS	Activated Sludge
AirS	Air Stripping
AnFF	Anaerobic Fixed Film
BGAC	Biological Granular Activated Carbon
BT	Biological Treatment
CAC	Chemically Assisted Clarification
ChOx	Chemical Oxidation
Chred	Chemical Reduction
DAF	Dissolved Air Flotation
Fil	Filtration
GAC	Activated Carbon (Granular)
KPEG	Dechlorination Using Alkoxide
LL	Liquid-Liquid Extraction
PACT®	Powdered Activated Carbon Addition to Activated Sludge
RBC	Rotating Biological Contactor
RO	Reverse Osmosis
SCOx	Super Critical Oxidation
SExt	Solvent Extraction
SS	Steam Stripping

Table B-2

(Continued)

Code	Technology
TF	Trickling Filter
UF	Ultrafiltration
UV	Ultraviolet Radiation
WOx	Wet Air Oxidation

Addition codes included in Tables B-3 through B-14:

"__ + __" - Indicates that the first process unit is followed in the process train by the second (e.g., AS + Fil - Activated Sludge followed by Filtration).

"__w + __" - Indicates that the two units are used together (e.g., UFwPAC - Ultrafiltration using Powdered Activated Carbon).

"__[B]" - Indicates batch instead of continuous flow.

Table B-3

Treatment Performance Data for Benzene in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
AL	Bench	371D	NR	1000-10000	NR	60.000	NR	98	WERL
AL	Full	6B	NR	100-1000	2	10.000	NR	98.9	WERL
AL	Full	1B	NR	100-1000	6	10.000	NR	94.4	WERL
AL	Full	6B	NR	100-1000	2	10.000	NR	92.3	WERL
AL+AS	Full	233D	NR	10000-100000	21	13.000	NR	99.9	WERL
API+DAF+AS	Full	1482D	NR	1000-10000	4	3.700	NR	99.96	WERL
AS	Full	6B	NR	100-1000	7	10.000	NR	98.8	WERL
AS	Bench	200B	NR	100-1000	16	0.800	NR	99.3	WERL
AS	Bench	200B	NR	100-1000	8	1.000	NR	99.83	WERL
AS	Full	1B	NR	100-1000	6	2.000	NR	99	WERL
AS	Full	6B	NR	100-1000	22	30.000	NR	91.7	WERL
AS	Full	1B	NR	100-1000	6	1.000	NR	99.55	WERL
AS	Full	6B	NR	100-1000	14	10.000	NR	95.7	WERL
AS	Full	6B	NR	100-1000	3	10.000	NR	95.6	WERL
AS	Full	1B	NR	100-1000	6	2.000	NR	98.9	WERL
AS	Bench	202D	NR	100000-1000000	NR	40.000	NR	99.97	WERL
AS	Full	6B	NR	1000-10000	3	10.000	NR	99.09	WERL
AS	Full	6B	NR	1000-10000	27	11.000	NR	99.8	WERL
AS	Full	6B	NR	1000-10000	3	10.000	NR	99.71	WERL
AS	Full	6B	NR	0-100	28	10.000	NR	89.6	WERL
AS	Bench	200B	NR	0-100	16	0.500	NR	97.8	WERL
AS	Full	6B	NR	10000-100000	15	10.000	NR	99.97	WERL
AS	Full	234A	NR	100-1000	NR	0.600	NR	99.83	WERL
AS	Full	201B	NR	0-100	10	6.000	NR	81	WERL
AS	Full	1B	NR	0-100	6	16.000	NR	84	WERL
AS	Pilot	206B	NR	0-100	20	0.200	NR	99.73	WERL
AS	Full	234A	NR	0-100	NR	0.700	NR	97.4	WERL
AS+Fil	Full	6B	NR	100000-1000000	3	20.000	NR	99.99	WERL

Table B-3

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
AirS	Bench	1328E	NR	10000-100000	5	9300.000	NR	90	WERL
AirS	Full	322B	NR	100-1000	22	0.440	NR	99.74	WERL
AirS	Pilot	224B	NR	100-1000	1	0.500	NR	99.67	WERL
AirS	Full	322B	NR	1000-10000	19	52.000	NR	98.7	WERL
AirS	Pilot	1362E	NR	100-1000	3	1.000	NR	99.09	WERL
AirS+GAC	Full	229A	NR	0-100	19	1.000	NR	90.9	WERL
GAC	Full	245B	NR	1000-10000	1	10.000	NR	99.28	WERL
LL	Full	K104	5	4500-320000	5	35600.000	76.0	NR	BDAT
LL	Full	K103	5	32000-81000	5	3560.000	76.0	NR	BDAT
LL+SS	Full	K103/ K104	5	4500-320000	5	5.600	76.0	NR	BDAT
LL+SS+AC	Full	K103/ K104	5	4500-320000	4	19.000	76.0	NR	BDAT
PACT®	Bench	242E	NR	0-100	NR	5.000	NR	83	WERL
PACT®	Bench	200B	NR	100-1000	12	0.700	NR	99.34	WERL
PACT®	Bench	Zimpro	NR	290	1	1.000	NR	99.7	WAO
PACT®	Bench	Zimpro	NR	29	1	5.000	NR	83	WAO
RO	Full	250B	NR	1000-10000	NR	140.000	NR	92.2	WERL
RO	Full	250B	NR	0-100	NR	3.800	NR	95.1	WERL
RO	Pilot	323B	NR	0-100	1	32.000	NR	19	WERL
RO	Pilot	250B	NR	100-1000	NR	50.000	NR	78	WERL
RO	Full	250B	NR	100-1000	NR	67.000	NR	92.7	WERL
SS[a]	Full	0415	10	22300-48100	4	38.800	NR	NR	EAD[a]
SS[a]	Full	2680	10	34693-147212	10	10.000	NR	NR	EAD[a]
SS[a]	Full	1494	10	239-2008310	13	44.8000	NR	NR	EAD[a]
SS[a]	Full	0415	10	274000-412000	3	200.300	NR	NR	EAD[a]
SS	Full	6B	NR	100000-1000000	3	200.000	NR	99.94	WERL
SS	Full	6B	NR	100000-1000000	12	48.000	NR	99.99	WERL
SS	Full	6B	NR	10000-100000	2	10.000	NR	99.97	WERL

Table B-3

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
SS	Full	6B	NR	10000-100000	10	10.000	NR	99.99	WERL
SS	Full	251B	NR	100-1000	10	10.000	NR	96.3	WERL
TF	Full	1B	NR	0-100	5	1.000	NR	97.5	WERL
TF+AS	Full	6B	NR	10000-100000	3	10.000	NR	99.97	WERL
UF	Pilot	250B	NR	1000-10000	NR	230.000	NR	78	WERL
WOx	Full	242E	NR	1000-10000	NR	29.000	NR	99.64	WERL
WOx [B]	Bench	1054E	NR	1000-10000	NR	500.000	NR	53	WERL
WOx [B]	Bench	1054E	NR	100000-1000000	NR	180000.000	NR	82	WERL

*Data used in developing treatment standard

= Not Reported.

ence: (13).

Table B-4

Treatment Performance Data for Carbon Tetrachloride in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
AL	Pilot	203A	NR	0-100	14	11.000	NR	84	WERL
AL	Pilot	203A	NR	0-100	14	15.000	NR	78	WERL
AS	Pilot	203A	NR	0-100	14	13.000	NR	81	WERL
AS	Full	1B	NR	100-1000	6	16.000	NR	88	WERL
AS	Pilot	206B	NR	0-100	20	0.200	NR	99.67	WERL
AS	Full	975B	NR	0-100	NR	3.000	NR	94.8	WERL
AS	Bench	202D	NR	10000-100000	NR	130.000	NR	99.32	WERL
AS	Full	6B	NR	100-1000	3	10.000	NR	96.7	WERL
AS	Pilot	241B	NR	100-1000	5	5.000	NR	98.3	WERL
AS	Pilot	240A	NR	0-100	12	4.000	NR	90.7	WERL
AS+Fil	Full	6B	NR	1000-10000	14	10.000	NR	99.09	WERL
AS+Fil	Full	6B	NR	10000-100000	2	10.000	NR	99.96	WERL
AirS	Bench	1328E	NR	10000-100000	5	7600.000	NR	89	WERL
BT[a]	Full	P225	NR	51-44000	17	10.000	NR	NR	EAD[a,b]
BT	Full	REF4	NR	95	1	5.500	NR	NR	EAD[b]
CAC	Pilot	203A	NR	100-1000	14	101.000	NR	0	WERL
GAC	Full	1264B	NR	0-100	NR	1.000	NR	87	WERL
GAC	Full	237A	NR	0-100	1	10.000	NR	89	WERL
PACT	Bench	242E	NR	1000-10000	NR	30.000	NR	98.5	WERL
PACT	Bench	Zimpro	NR	860	1	1.000	NR	99.9	WAO
PACT	Bench	Zimpro	NR	2000	1	30.000	NR	98.5	WAO
RO	Pilot	323B	NR	100-1000	1	2.000	NR	98	WERL
SCOx	Pilot	65D	NR	100-1000	NR	20.000	NR	96.5	WERL
SS	Full	251B	NR	10000-100000	10	5.000	NR	99.99	WERL
SS	Full	251B	NR	1000-10000	10	10.000	NR	99.41	WERL
TF	Pilot	203A	NR	0-100	14	26.000	NR	62	WERL
TF	Pilot	240A	NR	0-100	12	4.000	NR	90.7	WERL

Table B-4

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
WOx	Bench	Zimpro	NR	4330000	1	12000.000	NR	99.7	WAO
WOx	Full	242E	NR	1000000	NR	2000.000	NR	99.92	WERL

[a]Data used in developing treatment standard
[b]EAD data presented in the BDAT Solvents Rule F001-F005 Background Document

NR = Not Reported.

Reference: (13).

Table B-5

Treatment Performance Data for Chlorobenzene in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
AFF	Bench	501A	NR	0-100	9	1.000	NR	90.7	WERL
AL	Bench	371D	NR	1000-10000	NR	160.000	NR	94.7	WERL
AS	Bench	200B	NR	100-1000	12	1.100	NR	99.17	WERL
AS	Bench	200B	NR	100-1000	6	1.300	NR	99.81	WERL
AS	Full	975B	NR	100-1000	NR	6.000	NR	94.6	WERL
AS	Full	6B	NR	100-1000	4	10.000	NR	98.9	WERL
AS	Bench	200B	NR	0-100	8	0.200	NR	99.23	WERL
AS	Full	975B	NR	100-1000	NR	10.000	NR	94.6	WERL
AS	Full	975B	NR	0-100	NR	6.000	NR	84	WERL
AS	Full	1B	NR	100-1000	6	3.000	NR	98.9	WERL
AS	Pilot	206B	NR	100-1000	20	1.300	NR	99.34	WERL
AS	Pilot	241B	NR	100-1000	5	4.000	NR	98.6	WERL
AS	Full	975B	NR	100-1000	NR	12.000	NR	97.8	WERL
AirS	Bench	1328E	NR	1000-10000	5	1800.000	NR	77	WERL
AirS	Bench	1328E	NR	10000-100000	5	3300.000	NR	89	WERL
BGAC	Bench	501A	NR	0-100	23	0.290	NR	97.6	WERL
BT	Full	P206	NR	929-49775	8	841.000	NR	NR	EAD[b]
BT	Full	P246	NR	10-3040	13	101.000	NR	NR	EAD[b]
BT	Full	P263	NR	443-832	3	504.000	NR	NR	EAD[b]
BT	Full	REF4	NR	1900	1	12.000	NR	NR	EAD[b]
BT[a]	Full	P202	NR	79-429	20	10.000	NR	NR	EAD[a,b]
BT+AC	Full	P246	NR	10-7200	16	30.000	NR	NR	EAD[b]
GAC	Full	245B	NR	100-1000	1	10.000	NR	96.6	WERL
GAC	Full	245B	NR	1000-10000	1	10.000	NR	99.7	WERL
GAC	Full	237A	NR	1000-10000	1	10.000	NR	99.17	WERL
GAC	Full	1421D	NR	0-100	NR	0.250	NR	56	WERL
PACT®	Full	6B	NR	1000-10000	4	10.000	NR	99.38	WERL
PACT®	Bench	200B	NR	100-1000	11	0.800	NR	99.37	WERL

Table B-5

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
PACT®	Bench	242E	NR	0-100	NR	5.000	NR	84	WERL
PACT®	Bench	Zimpro	NR	31	1	5.000	NR	84	WAO
RO	Pilot	323B	NR	0-100	1	12.000	NR	50	WERL
RO	Full	250B	NR	0-100	NR	4.000	NR	53	WERL
RO	Full	250B	NR	1000-10000	NR	120.000	NR	91.6	WERL
SS	Full	251B	NR	100-1000	10	10.000	NR	97.4	WERL
WOx	Bench	Zimpro	NR	5535000	1	1550000.000	NR	72	WAO
WOx	Bench	Zimpro	NR	792000	1	61000.000	NR	92.3	WAO

[a]Data used in developing treatment standard
[b]EAD data presented in the BDAT Solvents Rule F001-F005 Background Document

Not Reported.

ence: (13).

Table B-6

Treatment Performance Data for Chloroform in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
AL	Full	1607B	NR	0-100	3	9.000	NR	90.1	WERL
AL	Full	1B	NR	100-1000	6	26.000	NR	96.8	WERL
AL	Pilot	203A	NR	100-1000	14	53.000	NR	61	WERL
AL	Full	141A	NR	100-1000	NR	16.000	NR	92.3	WERL
AL	Full	1607B	NR	100-1000	2	10.000	NR	97.4	WERL
AL	Full	1607B	NR	100-1000	3	130.000	NR	86	WERL
AL	Pilot	203A	NR	100-1000	14	31.000	NR	77	WERL
AS	Full	1B	NR	0-100	3	20.000	NR	80	WERL
AS	Full	6B	NR	100-1000	7	30.000	NR	77	WERL
AS	Full	1B	NR	0-100	5	6.000	NR	86	WERL
AS	Full	6B	NR	100-1000	3	10.000	NR	97.7	WERL
AS	Bench	202D	NR	10000-100000	NR	200.000	NR	99.43	WERL
AS	Full	234A	NR	0-100	NR	1.200	NR	61	WERL
AS	Full	1B	NR	0-100	6	21.000	NR	62	WERL
AS	Full	375E	NR	0-100	7	1.000	NR	75	WERL
AS	Full	1B	NR	100-1000	6	59.000	NR	51	WERL
AS	Full	975B	NR	0-100	NR	2.000	NR	93.8	WERL
AS	Full	234A	NR	0-100	NR	2.300	NR	72	WERL
AS	Full	234A	NR	0-100	NR	0.500	NR	98.4	WERL
AS	Full	6B	NR	100-1000	3	10.000	NR	98.2	WERL
AS	Full	238A	NR	0-100	3	2.400	NR	46	WERL
AS	Full	1607B	NR	100-1000	3	50.000	NR	86	WERL
AS	Full	1607B	NR	1000-10000	2	40.000	NR	96.9	WERL
AS	Pilot	206B	NR	100-1000	20	3.600	NR	97.4	WERL
AS	Full	375E	NR	0-100	7	20.000	NR	78	WERL
AS	Full	1587E	NR	0-100	NR	1.600	NR	65	WERL
AS	Pilot	241B	NR	100-1000	5	44.000	NR	85	WERL
AS	Full	234A	NR	0-100	NR	1.300	NR	84	WERL

Table B-6

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
AS	Pilot	203A	NR	100-1000	14	18.000	NR	87	WERL
AS	Full	6B	NR	1000-10000	27	19.000	NR	98.7	WERL
AS	Full	201B	NR	0-100	29	38.000	NR	53	WERL
AS	Full	234A	NR	0-100	NR	1.300	NR	65	WERL
AS	Pilot	240A	NR	0-100	14	2.000	NR	98	WERL
AS+Fil	Full	6B	NR	1000-10000	3	10.000	NR	99.41	WERL
AS+Fil	Full	6B	NR	100-1000	14	10.000	NR	95.8	WERL
AirS	Bench	1328E	NR	100000-1000000	5	16000.000	NR	93.1	WERL
AirS	Pilot	369A	NR	0-100	NR	1.400	NR	98.2	WERL
AirS	Pilot	213B	NR	0-100	1	13.000	NR	77	WERL
AirS	Bench	1328E	NR	10000-100000	5	4400.000	NR	83	WERL
AirS	Pilot	225B	NR	0-100	1	0.130	NR	98.9	WERL
AirS	Bench	17A	NR	0-100	NR	2.600	NR	96.9	WERL
AirS	Bench	17A	NR	1000-10000	NR	110.000	NR	91.7	WERL
AirS	Bench	17A	NR	0-100	NR	3.900	NR	88	WERL
AirS	Bench	17A	NR	100-1000	NR	4.200	NR	98.6	WERL
AirS	Pilot	210B	NR	100-1000	1	1.000	NR	99.2	WERL
AirS	Bench	17A	NR	100-1000	NR	3.700	NR	98.6	WERL
AirS	Bench	1328E	NR	100-1000	5	34.000	NR	84	WERL
AirS	Pilot	434B	NR	1000-10000	4	41.000	NR	98	WERL
CAC	Pilot	203A	NR	100-1000	14	106.000	NR	22	WERL
CAC+AirS	Full	1833D	NR	0-100	25	0.200	NR	89	WERL
ChOx	Bench	640E	NR	100-1000	2	7.000	NR	96	WERL
ChOx	Bench	640E	NR	100-1000	1	3.000	NR	99	WERL
ChOx (ozone)	Pilot	331D	NR	0-100	NR	46.000	NR	37	WERL
ChOx (ozone)	Pilot	331D	NR	0-100	NR	2.800	NR	35	WERL
GAC	Full	1264B	NR	0-100	NR	1.000	NR	87	WERL

Table B-6

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
GAC	Pilot	331D	NR	0-100	NR	1.000	NR	98.6	WERL
GAC	Full	245B	NR	100-1000	1	10.000	NR	97.6	WERL
GAC	Full	237A	NR	100-1000	1	10.000	NR	98.1	WERL
GAC	Full	245B	NR	100-1000	1	10.000	NR	96.2	WERL
PACT®	Bench	242E	NR	0-100	NR	20.000	NR	47	WERL
PACT®	Bench	Zimpro	NR	1470	1	1.000	NR	99.9	WAO
PACT®	Bench	Zimpro	NR	38	1	20.000	NR	47	WAO
RO	Pilot	180A	NR	0-100	NR	0.890	NR	71	WERL
RO	Full	250B	NR	1000-10000	NR	110.000	NR	94.5	WERL
RO	Full	250B	NR	100-1000	NR	53.000	NR	87	WERL
SCOx	Pilot	65D	NR	100-1000	NR	1.700	NR	99.83	WERL
SS[a]	Full	415T	10	7330-1088000	15	10.500	NR	NR	EAD[a]
SS[a]	Full	913	10	28700-200000	14	129.200	NR	NR	EAD[a]
SS	Full	6B	NR	100000-1000000	15	10.000	NR	99.99	WERL
SS	Full	6B	NR	10000-100000	2	120.000	NR	99.88	WERL
SS	Full	251B	NR	1000000	10	6000.000	NR	99.99	WERL
SS	Full	251B	NR	100000-1000000	10	9600.000	NR	96.4	WERL
TF	Pilot	240A	NR	0-100	14	11.000	NR	89	WERL
TF	Full	1B	NR	0-100	4	14.000	NR	86	WERL
TF	Pilot	203A	NR	100-1000	14	102.000	NR	24	WERL
WOx	Bench	Zimpro	NR	4450000	1	3000.000	NR	99.9	WAO
WOx	Bench	Zimpro	NR	270000	1	1000.000	NR	99	WAO

[a]Data used in developing treatment standard

NR = Not Reported.

Reference: (13)

Table B-7

Treatment Performance Data for Chloromethane in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
NR	NR	CT0000434	NR	NR	5	22.600	NR	NR	NPDES
NR	NR	KY0003514	NR	NR	1	6.000	NR	NR	NPDES
NR	NR	PA0011371	NR	NR	9	1.000	NR	NR	NPDES
NR	NR	LA0004057	NR	NR	22	12.300	NR	NR	NPDES
NR	NR	MA0005304	NR	NR	21	10.048	NR	NR	NPDES
NR	NR	IL0001627	NR	NR	9	9.333	NR	NR	NPDES
NR	NR	NY0202061	NR	NR	29	1.000	NR	NR	NPDES
NR	NR	NY0075957	NR	NR	13	20.769	NR	NR	NPDES
NR	NR	NY0008605	NR	NR	15	6.400	NR	NR	NPDES
NR	NR	NJ0028291	NR	NR	2	1.000	NR	NR	NPDES
R	NR	MD0000345	NR	NR	1	10.000	NR	NR	NPDES
NR	NR	KY0003603	NR	NR	1	10.000	NR	NR	NPDES
NR	NR	WV0004740	NR	NR	1	10.000	NR	NR	NPDES
NR	NR	OH0025461	NR	NR	2	21.700	NR	NR	NPDES
NR	NR	SC0001180	NR	NR	40	8.974	NR	NR	NPDES
NR	NR	LA0066214	NR	NR	15	11.786	NR	NR	NPDES
NR	NR	LA0066435	NR	NR	12	6.500	NR	NR	NPDES
NR	NR	LA0065501	NR	NR	6	10.000	NR	NR	NPDES
NR	NR	TX0007439	NR	NR	42	3.500	NR	NR	NPDES
AS	Full	1B	NR	100-1000	6	110.000	NR	66	WERL
AS	Full	1B	NR	100-1000	5	11.000	NR	96.3	WERL
AS	Full	1B	NR	100-1000	5	91.000	NR	75	WERL
AS+Fil	Full	6B	NR	0-100	7	50.000	NR	39	WERL
BT	Full	KY0002119	NR	NR	1	10.000	NR	NR	WERL
BT	Full	LA0038245	NR	NR	38	10.263	NR	NR	WERL
BT	Full	PA0026689	NR	NR	2	12.100	NR	NR	WERL
BT	Full	WV0023116	NR	NR	18	16.111	NR	NR	WERL
D+Fil	Full	PA0010502	NR	NR	26	1.308	NR	NR	WERL

Table B-7

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
SS[a]	Full	725	50	9440-1290000	13	923.100	NR	NR	EAD[a]
SS	Full	6B	NR	100000-1000000	11	50.000	NR	99.96	WERL
SS	Full	251B	NR	10000-100000	10	5.000	NR	99.99	WERL

[a]Data used in developing treatment standard

NR = Not Reported.

Reference: (13).

Table B-8

Treatment Performance Data
for 1,4-Dichlorobenzene in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
AFF	Bench	501A	NR	0-100	27	0.200	NR	98.1	WERL
AL	Pilot	192D	NR	0-100	NR	10.000	NR	88	WERL
AL	Pilot	203A	NR	0-100	11	31.000	NR	67	WERL
AL	Pilot	203A	NR	0-100	11	12.000	NR	87	WERL
AL	Pilot	192D	NR	100-1000	NR	10.000	NR	90.5	WERL
AS	Full	1B	NR	0-100	2	10.000	NR	76	WERL
AS	Full	234A	NR	0-100	NR	0.500	NR	81	WERL
AS	Pilot	241B	NR	100-1000	4	10.000	NR	90.7	WERL
AS[a]	Full	975B	NR	1000-10000	NR	12.000	NR	99.63	WERL[a]
AS	Pilot	192D	NR	100-1000	NR	10.000	NR	90.5	WERL
AS	Pilot	631D	NR	0-100	NR	0.004	NR	99	WERL
S	Pilot	631D	NR	0-100	NR	0.004	NR	99	WERL
AS	Pilot	240A	NR	100-1000	12	8.000	NR	93.8	WERL
AS	Pilot	192D	NR	0-100	NR	10.000	NR	88	WERL
AS	Full	234A	NR	0-100	NR	0.500	NR	90	WERL
AS	Pilot	241B	NR	100-1000	11	19.000	NR	95.1	WERL
AS	Full	201B	NR	0-100	2	6.000	NR	79	WERL
AS	Full	1B	NR	0-100	1	5.000	NR	93.1	WERL
AS	Full	1B	NR	0-100	1	8.000	NR	83	WERL
AS	Pilot	203A	NR	0-100	11	5.000	NR	94.6	WERL
AS	Full	234A	NR	0-100	NR	0.500	NR	91.7	WERL
AS[a]	Full	6B	NR	100-1000	4	10.000	NR	97	WERL[a]
AS	Full	975B	NR	0-100	NR	4.900	NR	92.8	WERL
AS[a]	Full	975B	NR	100-1000	NR	27.000	NR	96.6	WERL[a]
AirS	Bench	1328E	NR	10000-100000	5	3600.000	NR	90	WERL
BGAC	Bench	501A	NR	0-100	34	0.270	NR	97.5	WERL
CAC	Pilot	203A	NR	0-100	11	66.000	NR	29	WERL
ChOx	Bench	975B	NR	0-100	NR	5.000	NR	91.1	WERL

Table B-8

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
GAC	Full	245B	NR	100-1000	1	10.000	NR	96	WERL
GAC	Full	1421D	NR	0-100	NR	0.200	NR	92	WERL
PACT®	Bench	975B	NR	0-100	NR	5.000	NR	93.5	WERL
PACT®	Bench	975B	NR	0-100	NR	5.000	NR	92.3	WERL
PACT®	Bench	Zimpro	NR	36.6	1	0.015	NR	99.96	WAO
RBC	Pilot	192D	NR	0-100	NR	10.000	NR	88	WERL
RO	Pilot	180A	NR	0-100	NR	0.670	NR	61	WERL
TF	Pilot	240A	NR	100-1000	11	16.000	NR	88	WERL
TF	Pilot	203A	NR	0-100	11	58.000	NR	38	WERL

[a]Data used in developing treatment standard

NR = Not Reported.

Reference: (13).

Table B-9

Treatment Performance Data for Hexachlorobenzene in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (μg/L)	Range of Influent Concentrations (μg/L)	No. of Data Points	Average Effluent Concentration (μg/L)	Recovery (%)	Removal (%)	Reference
AS	Full	375E	NR	0-100	7	0.010	NR	83	WERL
AS	Full	375E	NR	0-100	7	0.010	NR	94.4	WERL
AS+Fil[a]	Full	6B	NR	100-1000	14	10.000	NR	96.7	WERL[a]
GAC	Full	237A	NR	0-100	1	20.000	NR	38	WERL

[a]Data used in developing treatment standard

NR = Not Reported.

Reference: (13).

Table B-10

Treatment Performance Data for 1,2,4,5-Tetrachlorobenzene in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (μg/L)	Range of Influent Concentrations (μg/L)	No. of Data Points	Average Effluent Concentration (μg/L)	Recovery (%)	Removal (%)	Reference
NR	NR	MI0000868	NR	NR	9	1.111			NPDES

NR = Not Reported.

Reference: (13).

Table B-11

Treatment Performance Data for 1,1,2,2-Tetrachloroethane in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
NR	NR	NY0007048	NR	NR	9	1.560	NR	NR	NPDES
NR	NR	NJ0028291	NR	NR	2	1.000	NR	NR	NPDES
NR	NR	LA0066435	NR	NR	13	7.570	NR	NR	NPDES
NR	NR	LA0066214	NR	NR	15	5.000	NR	NR	NPDES
NR	NR	LA0065501	NR	NR	6	5.000	NR	NR	NPDES
NR	NR	NJ0030392	NR	NR	4	0.005	NR	NR	NPDES
AS	NR	202D	NR	100000-1000000	NR	11000.000	NR	94.5	WERL
AS	NR	1B	NR	0-100	2	3.000	NR	93.5	WERL
AirS	NR	1363E	NR	100-1000	NR	4.600	NR	99	WERL
AirS	NR	71D	NR	100-1000	1	41.000	NR	95.5	WERL
BT	NR	LA0038245	NR	NR	38	5.313	NR	NR	NPDE
GAC*	NR	245B	NR	1000-10000	1	10.000	NR	99.1	WERL

*Data used in developing treatment standard

NR = Not Reported.

Reference: (13).

Table B-12

Treatment Performance Data for Tetrachloroethylene in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
AL	Full	1B	NR	0-100	6	10.000	NR	80	WERL
AS	Full	1B	NR	0-100	3	10.000	NR	83	WERL
AS	Full	1B	NR	0-100	5	2.000	NR	97.5	WERL
AS	Full	1B	NR	0-100	4	8.000	NR	85	WERL
AS	Full	238A	NR	0-100	3	2.100	NR	87	WERL
AS	Full	1587E	NR	0-100	NR	0.870	NR	97.8	WERL
AS	Full	234A	NR	0-100	NR	22.000	NR	49	WERL
AS	Full	238A	NR	0-100	3	1.600	NR	87	WERL
AS	Full	1B	NR	0-100	4	1.000	NR	96	WERL
AS	Full	234A	NR	100-1000	NR	3.900	NR	96.7	WERL
S	Full	1B	NR	0-100	5	9.000	NR	75	WERL
AS	Full	1B	NR	100-1000	5	5.000	NR	96.7	WERL
AS	Full	1B	NR	0-100	3	22.000	NR	45	WERL
AS	Full	1B	NR	0-100	6	28.000	NR	71	WERL
AS	Pilot	241B	NR	100-1000	5	11.000	NR	95.3	WERL
AS	Full	1B	NR	1000-10000	6	440.000	NR	85	WERL
AS	Full	201B	NR	0-100	22	8.000	NR	89.5	WERL
AS	Full	1B	NR	0-100	4	6.000	NR	93	WERL
AS	Full	1B	NR	100-1000	6	48.000	NR	79	WERL
AS	Full	1B	NR	100-1000	6	26.000	NR	78	WERL
AS	Full	234A	NR	0-100	NR	0.600	NR	95.9	WERL
AS	Full	1B	NR	0-100	6	8.000	NR	85	WERL
AS	Full	1B	NR	0-100	5	14.000	NR	74	WERL
AS	Full	1B	NR	100-1000	4	100.000	NR	83	WERL
AS+Fil	Full	6B	NR	10000-100000	3	230.000	NR	99.04	WERL
AS+Fil	Full	6B	NR	100-1000	15	11.000	NR	97.7	WERL
AirS	Pilot	221B	NR	0-100	1	0.500	NR	95.8	WERL
S	Pilot	71D	NR	0-100	1	0.200	NR	98.7	WERL

Table B-12

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
AirS	Full	223B	NR	100-1000	1	0.800	NR	99.43	WERL
AirS	Pilot	222B	NR	0-100	1	0.200	NR	94.3	WERL
AirS	Pilot	217B	NR	100-1000	1	0.300	NR	99.73	WERL
AirS	Pilot	207B	NR	0-100	1	0.500	NR	98.3	WERL
AirS	Full	69A	NR	0-100	NR	0.960	NR	98.4	WERL
AirS	Pilot	220B	NR	0-100	1	0.200	NR	99.76	WERL
AirS	Pilot	208B	NR	0-100	1	0.200	NR	99.17	WERL
AirS	Pilot	1363E	NR	0-100	NR	0.200	NR	97.1	WERL
AirS	Pilot	214B	NR	100-1000	1	0.900	NR	99.31	WERL
AirS	Full	1042E	NR	100-1000	NR	0.500	NR	99.71	WERL
AirS	Full	322B	NR	100-1000	9	1.200	NR	99.75	WERL
AirS	Pilot	1362E	NR	1000-10000	3	5.000	NR	99.74	WERL
ANFF	Bench	724D	NR	10000-100000	NR	4.400	NR	99.99	WERL
BT	Full	P225	NR	95-31500	18	47.000	NR	NR	EAD[b]
BT	Full	P280	NR	110-1748	12	10.000	NR	NR	EAD[b]
BT	Full	REF4	NR	62	1	7.300	NR	NR	EAD[b]
CAC+AirS	Full	1833D	NR	0-100	7	0.100	NR	89	WERL
ChOx	Pilot	2026A	NR	0-100	4	2.000	NR	86	WERL
ChOx	Pilot	2026A	NR	0-100	4	1.700	NR	84	WERL
Chred	Bench	NR	NR	250	1	5.000	NR	NR	ART
GAC	Full	1264B	NR	0-100	NR	1.000	NR	95.2	WERL
GAC	Full	245B	NR	1000-10000	1	10.000	NR	99.13	WERL
GAC	Full	237A	NR	100-1000	1	10.000	NR	96.3	WERL
PACT®	Bench	242E	NR	100-1000	NR	10.000	NR	92.6	WERL
PACT®	Bench	Zimpro	NR	304	NR	1.000	NR	99.7	WAO
PACT®	Bench	Zimpro	NR	136	1	10.000	NR	93	WAO
RO	Pilot	323B	NR	0-100	1	30.000	NR	68	WERL
RO	Pilot	180A	NR	0-100	NR	0.250	NR	81	WERL

Table B-12

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
SS[a]	Full	913	10	1080-241000	14	18.400	NR	NR	EAD[a]
SS	Full	251B	NR	1000-10000	10	10.000	NR	99.29	WERL
SS	Full	6B	NR	1000-10000	2	10.000	NR	99.95	WERL
TF	Full	1B	NR	0-100	5	12.000	NR	81	WERL
TF	Full	1B	NR	100-100000	5	26.000	NR	83	WERL
TF	Full	1B	NR	0-100	3	18.000	NR	54	WERL
TF	Full	1B	NR	0-100	4	1.000	NR	96.9	WERL
TF	Full	1B	NR	0-100	6	6.000	NR	92.7	WERL
TF	Full	1B	NR	0-100	5	3.000	NR	94.3	WERL
UV(B)	Bench	1138E	NR	0-100	1	7.500	NR	85	WERL
WOx		REF10	NR	41000	1	1000.000	NR	NR	EAD[b]
VOx	Pilot	78D	NR	1000000	NR	900.000	NR	99.98	WERL

[a]Data used in developing treatment standard
[b]EAD data presented in the BDAT Solvents Rule F001-F005 Background Document

NR = Not Reported.

Reference: (13).

Table B-13

Treatment Performance Data for 1,2,4-Trichlorobenzene in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Recovery (%)	Removal (%)	Reference
AFF	Bench	501A	NR	0-100	23	0.870	NR	90.5	WERL
AS	Full	6B	NR	100-1000	330	71.000	NR	88	WERL
AS	Pilot	241B	NR	100-1000	9	89.000	NR	86	WERL
AS	Full	1B	NR	0-100	6	8.000	NR	92	WERL
AS	Full	201B	NR	0-100	13	14.000	NR	80	WERL
AS	Full	1B	NR	1000-10000	4	89.000	NR	91.9	WERL
AS	Full	975B	NR	100-1000	NR	36.000	NR	84	WERL
AS	Bench	200B	NR	100-1000	14	12.000	NR	90	WERL
BGAC	Bench	501A	NR	0-100	34	0.280	NR	96.9	WERL
GAC	Full	245B	NR	1000-10000	1	10.000	NR	99.74	WERL
GAC	Full	1421D	NR	0-100	NR	0.830	NR	90	WERL
PACT®	Bench	200B	NR	100-1000	12	2.100	NR	98	WERL
PACT®*	Full	6B	NR	100-1000	10	10.000	NR	96	WERL*
RO	Pilot	180A	NR	0-100	NR	0.020	NR	95.7	WERL
TF	Full	1B	NR	0-100	3	5.000	NR	91.7	WERL

*Data used in developing treatment standard

NR = Not Reported.

Reference: (13).

Table B-14

Wastewater Treatment Performance Data for Toluene in Wastewaters

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Removal (%)	Reference
AL	Full	6B	NR	100-1000	3	10.000	98.2	WERL
AL	Bench	371D	NR	1000-10000	NR	90.000	97	WERL
AL	Full	1B	NR	100-1000	6	32.000	96.1	WERL
AL+AS	Full	233D	NR	1000-10000	21	4.000	99.85	WERL
API+DAF+AS	Full	1482D	NR	10000-100000	4	11.000	99.93	WERL
AS	Bench	202D	NR	10000-100000	NR	10.000	99.98	WERL
AS	Full	6B	NR	10000-100000	3	73.000	99.84	WERL
AS	Full	6B	NR	1000-10000	3	10.000	99.57	WERL
AS	Full	975B	NR	1000-10000	NR	12.000	99.68	WERL
AS	Full	6B	NR	10000-100000	3	76.000	99.90	WERL
	Bench	200B	NR	100-1000	10	0.800	99.3	WERL
AS	Full	6B	NR	1000-10000	24	10.000	99.73	WERL
AS	Full	1B	NR	1000-10000	6	9.000	99.81	WERL
AS	Full	6B	NR	1000-10000	15	10.000	99.88	WERL
AS	Full	6B	NR	1000-10000	3	24.000	99.76	WERL
AS	Full	975B	NR	1000-10000	NR	280.000	96.3	WERL
AS	Full	6B	NR	1000-10000	7	10.000	99.5	WERL
AS	Full	975B	NR	100-1000	NR	23.000	86	WERL
AS	Full	6B	NR	1000-10000	33	20.000	99.8	WERL
AS	Pilot	226B	NR	100000-1000000	7	300.000	99.85	WERL
AS	Full	6B	NR	100-1000	14	10.000	97.8	WERL
AS	Full	6B	NR	100-1000	4	10.000	97.6	WERL
AS	Full	1B	NR	0-100	5	4.000	88	WERL
AS	Full	975B	NR	100-1000	NR	7.600	99.04	WERL
AS	Full	1B	NR	100-1000	6	4.000	99.48	WERL
AS	Full	234A	NR	0-100	NR	0.700	97.1	WERL
AS	Full	1B	NR	0-100	4	3.000	90.6	WERL
	Full	1587E	NR	0-100	NR	0.100	99	WERL

Table B-14

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Removal (%)	Reference
AS	Full	201B	NR	100-1000	32	57.000	87	WERL
AS	Full	1B	NR	100-1000	5	12.000	96.8	WERL
AS	Full	1B	NR	0-100	4	1.000	98	WERL
AS	Full	234A	NR	0-100	NR	0.200	96.2	WERL
AS	Full	1B	NR	100-1000	4	4.000	96.4	WERL
AS	Full	1B	NR	0-100	5	2.000	97.6	WERL
AS	Full	238A	NR	0-100	3	6.200	92.7	WERL
AS	Full	6B	NR	100-1000	3	10.000	94.4	WERL
AS	Full	1B	NR	0-100	5	2.000	97.1	WERL
AS	Full	1B	NR	0-100	4	4.000	86	WERL
AS	Pilot	241B	NR	100-1000	5	4.000	98.6	WERL
AS	Full	234A	NR	0-100	NR	0.200	96.9	WERL
AS	Full	1B	NR	0-100	5	3.000	94	WERL
AS	Full	1B	NR	100-1000	6	20.000	89	WERL
AS	Full	1B	NR	0-100	6	1.000	97.3	WERL
AS	Full	1B	NR	0-100	5	1.000	97.4	WERL
AS	Full	234A	NR	0-100	NR	0.200	97.7	WERL
AS	Full	1B	NR	0-100	6	2.000	96.3	WERL
AS	Full	1B	NR	100-1000	5	56.000	93.8	WERL
AS	Pilot	206B	NR	100-1000	20	0.600	99.76	WERL
AS	Full	1B	NR	100-1000	6	10.000	96.4	WERL
AS	Full	234A	NR	100-1000	NR	0.200	99.9	WERL
AS	Full	1B	NR	100-1000	6	31.000	95.4	WERL
AS	Pilot	REF2	NR	92000	6	23467.000	NR	BDAT*
AS+Fil	Full	6B	NR	10000-100000	3	10.000	99.98	WERL
AirS	Full	322B	NR	100-1000	24	0.660	99.77	WERL
AirS	Pilot	1362E	NR	0-100	3	1.700	95.3	WERL
AirS	Bench	1328E	NR	10000-100000	5	2800.000	92.4	WERL

Table B-14

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Removal (%)	Reference
AirS	Full	69A	NR	0-100	NR	0.940	97	WERL
AirS	Full	322B	NR	0-100	5	2.000	97.4	WERL
AirS	Pilot	224B	NR	0-100	1	0.500	98.9	WERL
AirS	Full	322B	NR	1000-10000	6	34.000	99.18	WERL
AirS	Full	322B	NR	10000-100000	3	114.000	99.33	WERL
AirS + GAC	Full	229A	NR	0-100	19	1.000	90	WERL
BT	Full	P206	NR	834-57475	10	1491.000	NR	BDAT[b]
BT	Full	P211	NR	1154-4000	7	10.000	NR	BDAT[b]
BT	Full	P202	NR	60-155	20	10.000	NR	BDAT[b]
BT	Full	P244	NR	1109	1	10.000	NR	BDAT[b]
BT	Full	P210	NR	135-5805	2	10.000	NR	BDAT[b]
	Full	P223	NR	99-265	3	10.000	NR	BDAT[b]
BT	Full	P217	NR	34400-60000	3	73.000	NR	BDAT[b]
BT	Full	P234	NR	2350-35000	32	21.000	NR	BDAT[b]
BT	Full	P242	NR	1200-1533	2	10.000	NR	BDAT[b]
BT	Full	P221	NR	10-323	3	10.000	NR	BDAT[b]
BT	Full	P208	NR	140-640	14	10.000	NR	BDAT[b]
BT	Full	P240	NR	22700	1	10.000	NR	BDAT[b]
BT	Full	P246	NR	77-12938	9	630.000	NR	BDAT[b]
BT	Full	P251	NR	15840-26060	3	10.000	NR	BDAT[b]
BT	Full	P253	NR	66-230	3	103.000	NR	BDAT[b]
BT	Full	P257	NR	1730-12900	27	12.000	NR	BDAT[b]
BT	Full	P265	NR	37750-50000	3	10.000	NR	BDAT[b]
BT	Full	P286	NR	24000-160000	3	76.000	NR	BDAT[b]
BT	Full	P215	NR	3300-4550	3	10.000	NR	BDAT[b]
BT	Full	P230	NR	3503-30347	15	10.000	NR	BDAT[b]
BT	Full	REF4	NR	680	1	4.000	NR	BDAT[b]
BT + AC	Full	P246	NR	77-12938	10	113.000	NR	BDAT[b]

Table B-14

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Removal (%)	Reference
GAC	Pilot	435B	NR	10000-100000	NR	10.000	99.96	WERL
GAC	Full	245B	NR	10000-100000	1	10.000	99.94	WERL
GAC	Pilot	REF7	NR	120	1	0.300	NR	BDAT[b]
PACT®	Bench	200B	NR	100-1000	13	0.300	99.75	WERL
PACT®	Bench	242E	NR	0-100	NR	5.000	91.2	WERL
PACT®	Bench	Zimpro	NR	2730	1	1.000	99.9	WAO
PACT®	Bench	Zimpro	NR	57	1	5.000	91	WAO
RO	Full	250B	NR	100-1000	NR	20.000	92.5	WERL
RO	Pilot	250B	NR	0-100	NR	12.000	86	WERL
RO	Full	250B	NR	1000-10000	NR	420.000	94.7	WERL
SS[a]	NR	0415	10	19300-29000	3	12.000	NR	EAD[a]
SS	Full	6B	NR	1000-10000	2	10.000	99.71	WERL
SS	Full	6B	NR	10000-100000	3	12.000	99.95	WERL
SS[a]	NR	0415[a]	10	2570-4230	4	22.300	NR	EAD[a]
SS	Pilot	REF4	NR	92000	5	42.000	NR	BDAT[b]
SS	Full	P246	NR	57-98	4	10.000	NR	BDAT[b]
SS+AC	Full	P297	NR	640-8650	3	11.000	NR	BDAT[b]
TF	Full	6B	NR	100-1000	3	10.000	96.3	WERL
TF	Full	1B	NR	0-100	5	10.000	88	WERL
TF	Full	1B	NR	0-100	6	7.000	86	WERL
TF	Full	1B	NR	0-100	5	2.000	97.2	WERL
TF	Full	1B	NR	0-100	6	1.000	98.2	WERL
TF	Full	1B	NR	100-1000	4	7.000	97.8	WERL
UF	Pilot	250B	NR	100-1000	NR	84.000	35	WERL
WOx	NR	REF10	NR	8500000	1	200000.000	NR	BDAT[b]
WOx	Bench	Zimpro	NR	4330000	1	12000.000	99.7	WAO
WOx	Bench	Zimpro	NR	5000	1	500.000	90	WAO
WOx	Pilot	Zimpro	NR	30000	1	500.000	98.3	WAO

Table B-14

(Continued)

Technology	Technology Scale	Facility	Detection Limit (µg/L)	Range of Influent Concentrations (µg/L)	No. of Data Points	Average Effluent Concentration (µg/L)	Removal (%)	Reference
WOx	Full	Zimpro	50	62000-82000	2	10950.000	NR	WAO
WOx	Full	242E	NR	100-1000	NR	57.000	72	WERL
WOx	Pilot	78D	NR	10000-100000	NR	500.000	98.3	WERL
WOx+PACT®	Pilot	Zimpro	5	130000-180000	3	5.000	99.9	WAO
WOx [b]	Bench	78D	NR	1000-10000	NR	500.000	90	WERL
WOx [b]	Bench	78D	NR	10000-100000	NR	1000.000	98.8	WERL
WOx [b]	Bench	1054E	NR	10000-100000	NR	500 000	98.9	WERL
WOx [b]	Bench	1054E	NR	1000000	NR	220000.000	95.7	WERL

[a]Data used in developing treatment standard
[b]EAD data presented in the BDAT Solvents Rule F001-F005 Background Document

NR = Not Reported.

ence: (13).

Table B-15

Volatile Variability Factor Calculation

Volatiles	EAD Variability Factor
Acrylonitrile	4.83045
Benzene	13.5252
Chloroethane	5.34808
Chloroform	3.71334
Chloromethane	3.79125
1,1-Dichloroethane	5.88383
1,2-Dichloroethane	8.22387
1,1-Dichloroethene	2.4723
trans-1,2-Dichloroethene	5.34808
Methylene chloride	3.86915
Tetrachloroethylene	5.34808
Toluene	7.9506
1,1,1-Trichloroethane	5.34808
1,1,2-Trichloroethane	5.34808
Trichloroethylene	5.34808
Vinyl chloride	5.34808
AVERAGE =	5.7310
Volatiles VF = 5.7310	

Reference: (13).

Table B-16

Semivolatile Variability Factor Calculation

Semivolatiles	EAD Variability Factor
Acenaphthalene	5.89125
Acenaphthene	5.89125
Anthracene	5.89125
Benzo(a)anthracene	5.89125
Benzo(a)pyrene	5.89125
Benzo(k)fluoranthene	5.89125
bis(2-Ethylhexyl)phthalate	5.91768
Chrysene	5.89125
Diethyl phthalate	4.75961
Dimethyl phthalate	4.63833
Di-n-butyl phthalate	3.23768
Fluoranthene	5.89125
Fluorene	5.89125
Naphthalene	5.89125
Nitrobenzene	4.83045
Phenanthrene	5.89125
Pyrene	5.89125
AVERAGE =	5.5340
Semivolatiles VF = 5.5340	

Reference: (13).