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FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) BACKGROUND DOCUMENT FOR CHLORINATED ALIPHATICS PRODUCTION WASTES - K174 and K175

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This background document provides EPA's rationale and technical support for developing Land Disposal Restriction (LDR) treatment standards for K174 and K175. EPA proposed to list these wastes and proposed treatment standards for these wastes on August 25, 1999 (64 FR 46476). EPA defines K174 and K175 as follows:

- K174 – Wastewater treatment sludges from the production of ethylene dichloride or vinyl chloride monomer (including sludges that result from commingled ethylene dichloride or vinyl chloride monomer wastewater and other wastewater), unless the sludges meet the following conditions: (i) they are disposed of in a Subtitle C or non-hazardous landfill licensed or permitted by the state or federal government; (ii) they are not otherwise placed on the land prior to final disposal; and (iii) the generator maintains documentation demonstrating that the waste was either disposed of in an on-site landfill or consigned to a transporter or disposal facility that provided a written commitment to dispose of the waste in an off-site landfill. Respondents in any action brought to enforce the requirements of Subtitle C must, upon a showing by the government that the respondent managed wastewater treatment sludges from the production of vinyl chloride monomer or ethylene dichloride, demonstrate that they meet the terms of the exclusion set forth above. In doing so, they must provide appropriate documentation (e.g., contracts between the generator and the landfill owner/operator, invoices documenting delivery of waste to landfill, etc.) that the terms of the exclusion were met.

- K175 – Wastewater treatment sludges from the production of vinyl chloride monomer using mercuric chloride catalyst in an acetylene-based process.

EPA is prohibiting the land disposal of both nonwastewater and wastewater forms of Hazardous Wastes K174 and K175, unless these wastes are in compliance with the LDR treatment standards being promulgated today. Specifically, EPA is promulgating numerical treatment standards for arsenic and for certain dioxin and furan constituents equivalent to existing Universal Treatment Standards (UTS) found at 40 CFR §268.48. Where universal treatment standards did not exist for certain constituents of concern, EPA is requiring waste-specific standards for these constituents, and is adding these constituents to the universal treatment standards list and the treatment standard for F039 which lists constituents of concern in multi-source leachate from landfills. EPA is also promulgating an alternative treatment standard of CMBT (combustion) for treatment of the dioxin and furan components of the K174 waste.

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For nonwastewater forms of K175, EPA is promulgating a treatment standard consisting of the following requirements. The waste must meet a numerical standard of 0.025 mg/L mercury as measured by the Toxicity Characteristic Leaching Procedure (TCLP) mercury. The waste must also exhibit a pH #6.0. Finally, this waste must also be macroencapsulated in accordance with 40 CFR 268.45 Table 1 unless the waste is placed in: (1) a Subtitle C monofill containing only K175 wastes that meet all applicable 40 CFR 268.40 treatment standards; or (2) a dedicated Subtitle C landfill cell in which all other wastes being co-disposed are at pH#6.0. For wastewater forms of K175, EPA is promulgating a numerical treatment standard equivalent to the UTS for mercury (0.15 mg/L).

Characterization of Wastes

Information for this BDAT analysis was derived from responses to a questionnaire sent by EPA under the authority of RCRA §3007, direct contact (via telephone or letters) with selected facilities, and a series of engineering site visits. After collecting this information, EPA studied the specific characteristics of the waste and how these wastes will be categorized in LDR treatment standards. EPA also used relevant information from public comments received on the proposed rule.

EPA found that K174 and K175 are both wastewater treatment sludges that, as generated, meet the definition of nonwastewaters (40 CFR §268.2), due to significant solids and total organic carbon (TOC) content. It will be rare that generators or treatment facilities will handle these wastes in a wastewater form. However, EPA established treatment standards for both wastewater and nonwastewater forms of K174 and K175 to ensure that any waste streams that meet the definition of wastewater are also treated prior to land disposal to minimize short- and long-term effects on human health and the environment.

Both K174 and K175 have characteristics that could affect the efficiency of some treatment and disposal systems. EPA found that the low BTU values of K174 and K175 and the high oil and grease content in K175 may affect certain treatment systems. Additionally, EPA found K175 to have elevated concentrations of mercury in the sulfide form, which makes mercury recovery more difficult in

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roasting and retorting treatment. In this form, mercury leaches more easily under alkaline conditions when disposed in a landfill with free sulfide.

Development of BDAT Treatment Standards

In developing the LDR treatment standards, EPA must promulgate regulations specifying those levels or methods of treatment which substantially diminish the toxicity of the waste [RCRA §3004(m)]. These treatment standards were developed by first identifying the constituents that form the bases for listing these wastes. EPA then identified any additional constituents that would require treatment; for many of these constituents, EPA compared waste concentration data identified through surveys, engineering site visits, and record sampling to previously investigated performance data obtained through development of UTS at 40 CFR §268.48 and development of treatment standards for "U and P" listed wastes at 40 CFR §268.40.

As a result, EPA is finalizing numerical treatment standards for arsenic, and for several dioxin/furan congeners, in K174. EPA is also promulgating an alternative treatment standard of combustion (CMBST) for K174. The technology is sufficient to ensure adequate treatment of the dioxin/furan congeners without requiring the testing of constituent levels following treatment (monitoring of arsenic still would be required prior to disposal).

EPA identified dioxins and furans as the basis for listing K174, and is therefore promulgating treatment standards to ensure adequate treatment of these constituents prior to land disposal. EPA also identified that several of these congeners are present in the waste at levels above their existing UTS. Five of the dioxin and furan congeners were not on the UTS list, but EPA determined that treatment of these constituents is critical to proper treatment of the wastes. The five constituents, which form part of the basis for listing K174 wastes, are 1,2,3,4,6,7,8-heptachlorodibenzo-*p*-dioxin; 1,2,3,4,6,7,8-heptachlorodibenzofuran; 1,2,3,4,7,8,9-heptachlorodibenzofuran; 1,2,3,4,6,7,8,9-octachlorodibenzo-*p*-dioxin; and 1,2,3,4,6,7,8,9-octachlorodibenzofuran. EPA evaluated potential BDAT based on the

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properties of these individual compounds and existing treatment data as available. EPA is adding the five constituents to the UTS table and the F039 listing.

EPA is also promulgating a treatment standard for arsenic in K174 wastes. Although EPA identified arsenic in K174 wastes at levels below its UTS, EPA is promulgating treatment standards for this constituent to ensure adequate treatment because it was identified during the risk assessment of K174 as presenting potential risks (although it is not being promulgated as a basis for listing). Within the record sampling data for K174, EPA found no additional constituents identified in the list of UTS or "U and P" listed wastes requiring treatment.

EPA proposed several options for K175 nonwastewater treatment standards; one option included a technology-specific treatment standard of mercury recovery (RMERC), which is the current treatment standard for characteristically hazardous (D009) mercury wastes in the 'high mercury' subcategory (>260 mg/kg). Public comments that questioned the ability of mercury recovery to be a demonstrated and available option for K175, as well as EPA's own re-evaluation of the mercury treatment standard in all hazardous wastes (proposed rule May 28, 1999), led EPA to finalize a different treatment standard.

EPA is finalizing a numerical treatment standard for mercury (as measured by TCLP) in nonwastewater forms of K175. The mercury constituent forms the basis for listing K175 wastes and is also present in the waste at levels above UTS. EPA is also promulgating a requirement that the disposed waste have a pH #6.0. Finally, EPA is promulgating the requirement that nonwastewater forms of K175 be macroencapsulated in accordance with 40 CFR 268.45 Table 1 unless the waste is placed in: (1) a Subtitle C monofill containing only K175 wastes that meet all applicable 40 CFR 268.40 treatment standards; or (2) a dedicated Subtitle C landfill cell in which all other wastes being co-disposed are at pH#6.0. EPA is promulgating these restrictions on the disposal environment to ensure that threats from mercury are indeed minimized.[1]

[1] The pH and macroencapculation/ landfill requirement does not apply to wastewater forms of K175.

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EPA is not promulgating treatment standards for any other constituents in K175. Zinc was the only additional constituent identified in the list of UTS or "U and P" listed wastes in K175 that was present above UTS. EPA decided not to propose a treatment standard for zinc, because zinc is not an underlying hazardous constituent as currently defined in 40 CFR §268.2.

For all remaining constituents, with and without existing UTS, EPA is not promulgating treatment standards. Table ES-1 gives a full listing of the constituents of concern and their corresponding final treatment standard in K174 and K175.

The treatment standards finalized for wastewater and nonwastewater forms of K175 and for all but five of the chemicals in the K174 wastes are consistent with the UTS limits published in the Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Treatment Standards Volume A: Universal Treatment Standards for Wastewater Forms of Listed Hazardous Wastes (July 1994) and Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Treatment Standards Volume B: Universal Treatment Standards for Wastewater Forms of Listed Hazardous Wastes (July 1994), and as currently presented in 40 CFR 268.48. The treatment standards for the remaining five dioxin and furan congeners were developed consistent with existing EPA procedures detailed in Best Demonstrated Available Technology (BDAT) Background Document for Quality Assurance/Quality Control Procedures and Methodology (October, 1991). Development of treatment standards for these five compounds are discussed in Appendix A.

Table ES-1. Summary of Treatment Standards for Constituents in Listed Chlorinated Aliphatic Wastes

Constituent of Concern	Numerical Standard (40 CFR §268)	
	WW (mg/L)	NWW (mg/kg)
K174		
1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin (1,2,3,4,6,7,8-HpCDD)	0.000035 or CMBST [A]	0.0025 or CMBST [A]
1,2,3,4,6,7,8-Heptachlorodibenzofuran (1,2,3,4,6,7,8-HpCDF)	0.000035 or CMBST [A]	0.0025 or CMBST [A]
1,2,3,4,7,8,9- Heptachlorodibenzofuran (1,2,3,4,7,8,9-HpCDF)	0.000035 or CMBST [A]	0.0025 or CMBST [A]
HxCDDs (All Hexachlorodibenzo-*p*-dioxins)	0.000063 or CMBST [A]	0.001 or CMBST [A]
HxCDFs (All Hexachlorodibenzofurans)	0.000063 or CMBST [A]	0.001 or CMBST [A]

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Table ES-1. Summary of Treatment Standards for Constituents in Listed Chlorinated Aliphatic Wastes		
Constituent of Concern	**Numerical Standard (40 CFR §268)**	
	WW (mg/L)	**NWW (mg/kg)**
1,2,3,4,6,7,8,9-Octachlorodibenzo-*p*-dioxin (OCDD)	0.000063 or CMBST [A]	0.005 or CMBST [A]
1,2,3,4,6,7,8,9- Octachlorodibenzofuran (OCDF)	0.000063 or CMBST [A]	0.005 or CMBST [A]
PeCDDs (All Pentachlorodibenzo-*p*-dioxins)	0.000063 or CMBST [A]	0.001 or CMBST [A]
PeCDFs (All Pentachlorodibenzofurans)	0.000035 or CMBST [A]	0.001 or CMBST [A]
TCDDs (All tetrachlorodi-benzo-*p*-dioxins)	0.000063 or CMBST [A]	0.001 or CMBST [A]
TCDFs (All tetrachlorodibenzofurans)	0.000063 or CMBST [A]	0.001 or CMBST [A]
Arsenic	1.4	5.0 mg/L TCLP
K175		
Mercury [B]	NA	0.025 mg/L TCLP
pH [B]	NA	pH #6.0
All K175 wastewaters	0.15	NA

A. For these wastes, the definition of CMBST is limited to: (1) combustion units operating under 40 CFR Part 266, (2) combustion units permitted under 40 CFR Part 264, Subpart O, or (3) combustion units operating under 40 CFR Part 265, Subpart O, which have obtained a determination of equivalent treatment under 40 CFR §268.42(b).
B. Disposal of K175 wastes that have complied with all applicable 40 CFR 268.40 treatment standards must also be macroencapsulated in accordance with 40 CFR 268.45 Table 1 unless the waste is placed in: a Subtitle C monofill containing only K175 wastes that meet all applicable 40 CFR 268.40 treatment standards; or a dedicated Subtitle C landfill cell in which all other wastes being co-disposed are at pH#6.0.

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1.0 INTRODUCTION

RCRA Section 3004(m) specifies that treatment standards must minimize long- and short-term threats to human health and the environment arising from land disposal of hazardous wastes. EPA's general approach for complying with this requirement was promulgated as part of the November 7, 1986 Solvents and Dioxins Rule. More recently, EPA has presented its guidance in establishing treatment standards in the Final Best Demonstrated Available Technology (BDAT) Background Document for Quality Assurance/Quality Control Procedures and Methodology, October 1991.

EPA's treatment standards for individual wastes are presented at 40 CFR §268.40. For a given waste, a treatment standard specifies (1) the concentration of each constituent in total or TCLP analysis, or (2) a technology which must be used for treating the waste. EPA establishes treatment standards for wastewaters and nonwastewaters, as well as any subgroups which may be appropriate (e.g., "high mercury" or "low mercury" categories for D009 wastes). EPA has also established universal treatment standards for underlying hazardous constituents; these are listed at 40 CFR §268.48.

The U.S. Environmental Protection Agency (EPA) is finalizing Land Disposal Restriction (LDR) treatment standards based on the BDAT for the regulation of listed hazardous wastes identified in Title 40, Code of Federal Regulations, Section 261.32 (40 CFR §261.32) as K174 and K175. These BDAT treatment standards are being promulgated 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. HSWA amended RCRA to require EPA to promulgate treatment standards for a waste within 6 months after determining it is hazardous [Section 3004(g)(4)].

Compliance with the treatment standards is a prerequisite for land disposal, as defined in 40 CFR Part 268. In 40 CFR §268.44, EPA supplies provisions, that, if met, may justify granting a variance from the applicable treatment standards. In 40 CFR §268.6, EPA supplies provisions, that, if

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met, may justify granting waste- and site-specific waivers from the applicable treatment standards in 268.40.

The hazardous wastes numbered K174 and K175 are generated during production of chlorinated aliphatic hydrocarbons and during the production of ethylene dichloride or vinyl chloride monomer. These hazardous wastes are defined as follows:

- K174 – Wastewater treatment sludges from the production of ethylene dichloride or vinyl chloride monomer (including sludges that result from commingled ethylene dichloride or vinyl chloride monomer wastewater and other wastewater), unless the sludges meet the following conditions: they are disposed of in a Subtitle C or D landfill licensed or permitted by the state or federal government; they are not otherwise placed on the land prior to final disposal; and the generator maintains documentation demonstrating that the waste was either disposed of in an on-site landfill or consigned to a transporter or disposal facility that provided a written commitment to dispose of the waste in an off-site landfill. Respondents in any action brought to enforce the requirements of Subtitle C must, upon a showing by the government that the respondent managed wastewater treatment sludges from the production of vinyl chloride monomer or ethylene dichloride, demonstrate that they meet the terms of the exclusion set forth above. In doing so, they must provide appropriate documentation (e.g., contracts between the generator and the landfill owner/operator, invoices documenting delivery of waste to landfill, etc.) that the terms of the exclusion were met.

- K175 – Wastewater treatment sludges from the production of vinyl chloride monomer using mercuric chloride catalyst in an acetylene-based process.

This background document provides EPA's rationale and technical support for developing LDR treatment standards for K174 and K175.

1.1 Regulatory Background

Section 3001(e)(2) of RCRA requires EPA to determine whether to list as hazardous, wastes from the production of chlorinated aliphatics. In June of 1991, EPA entered into a proposed consent decree in a lawsuit filed by the Environmental Defense Fund, et al. (EDF v. Reilly, Civ. No. 89-0598 (D.D.C.), hereafter referred to as the consent decree). The consent decree sets out a series of deadlines for promulgating RCRA listing decisions, including a requirement to propose a hazardous

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waste listing determination for wastewaters and wastewater treatment sludges generated from the production of specified chlorinated aliphatic chemicals. The wastewater and wastewater treatment sludges subject to the consent decree are those from the production of chlorinated aliphatics for which other process wastes already have been designated as hazardous waste F024 in 40 CFR §261.31. According to the consent decree, EPA was required to propose listing determinations by July 30, 1999 and promulgate final listing determinations on or before September 30, 2000. EPA proposed to list as hazardous and to simultaneously propose land disposal restrictions for three chlorinated aliphatics wastes (K173, K174, K175) on August 25, 1999 (64 FR 46476). EPA is finalizing its decision to list two of these wastes, K174 and K175.

In separate regulatory actions, EPA has promulgated 11 different listed wastes from the production of chlorinated aliphatics. In addition, LDR treatment standards have been promulgated for these wastestreams. This background document does not affect the scope of the chlorinated aliphatics process wastes that already have been listed as hazardous in prior EPA rulemakings, and for which treatment standards have previously been promulgated.

EPA's investigation of the wastes generated by the chlorinated aliphatics industry has been underway since 1992 and can be characterized in terms of two major information collection efforts: field investigations and survey evaluation. EPA's field investigations included engineering site visits, "familiarization sampling" (sample collection and analysis to gain a preliminary understanding of the nature and concentration of potential constituents of concern), and "record sampling" (sample collection and analysis to provide data to use in assessing the potential risks posed by the wastes). The survey effort included the development, distribution, and assessment of an extensive industry-wide RCRA Section 3007 survey.

1.2 Summary

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

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Section 3004(m), Congress directed EPA 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) record keeping 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.

In developing these LDR treatment standards for K174 and K175 wastes, EPA identified the constituents that form the bases for listing these wastes and also identified the presence of those other constituents near or in excess of current numerical UTS. Once the constituents of concern were identified, EPA used the Best Demonstrated Available Technology (BDAT) methodology to develop treatment standards for each of the constituents. EPA has previously investigated performance data for many of these constituents through its development of UTS at 40 CFR §268.48 as well as its development of treatment standards for "U and P" listed wastes at 40 CFR §268.40. EPA also considered specific characteristics of K174 and K175 wastes that would affect treatment.

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). Universal treatment standards represent a significant improvement in the LDR program. In the past, different listed hazardous wastes may have had different concentration standards for the same constituent, which raised significant compliance problems when wastes with different standards for the same chemical were comanaged. With the universal treatment standards, the variability in constituent concentrations across listed hazardous waste treatment standards was eliminated. Now, when a mixture of listed hazardous wastes is treated, the constituents must be treated to the same constituent concentration standard regardless of the waste codes contained in the mixture.

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EPA found that all but five of the regulated constituents are already included in the list of UTS at 40 CFR §268.48. The remaining constituents of concern were dioxin and furan congeners, 1,2,3,4,6,7,8-heptachlorodibenzo-*p*-dioxin; 1,2,3,4,6,7,8-heptachlorodibenzofuran; 1,2,3,4,7,8,9-heptachlorodibenzofuran; 1,2,3,4,6,7,8,9-octachlorodibenzo-*p*-dioxin; and 1,2,3,4,6,7,8,9-octachlorodibenzofuran. EPA calculated treatment standards based on the properties of these individual compounds and existing treatment data as available, and EPA is adding these constituents to the UTS table.

EPA has established two different sets of universal treatment 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 treatment standards. A more detailed discussion concerning the determination of these treatment standards is provided in EPA's Proposed Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards, Volume A: Universal Standards for Nonwastewater Forms of Listed Hazardous Wastes and EPA's Proposed Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards, Volume B: Universal Standards for Wastewater Forms of Listed Hazardous Wastes.

1.3 Contents of This Document

Section 2.0 of this document describes the industry and processes generating Hazardous Waste Numbers K174 and K175, the basis for listing chlorinated aliphatic wastes as hazardous, and waste stream characteristics. Section 3.0 presents the constituents selected for development of treatment standards for these wastes. Sections 4.0 and 5.0 discuss the treatment technologies EPA has designated as "applicable" and "demonstrated" for K174 and K175, respectively, identifies BDAT for wastewater and nonwastewater forms of these wastes, and presents the proposed treatment standards. References are listed in Section 6.0. Additional technical discussion and calculations for the development of numerical treatment standards for certain dioxin and furan compounds in K174 wastes is presented in Appendix A.

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2.0 DESCRIPTION OF CHLORINATED ALIPHATICS WASTES LISTED

2.1 Industry Overview

2.1.1 Introduction

EPA defines a chlorinated aliphatic as any organic compound characterized by a straight-chain, branched-chain, or cyclic hydrocarbons containing one to five carbons, with varying amounts and locations of chlorine substitution. Hydrocarbons are organic compounds composed solely of the atoms hydrogen and carbon. Aliphatics occur where chemical bonding between carbon atoms are single, double, or triple covalent bonds (not aromatic bonds). Cyclic aliphatic hydrocarbons included in this class consist of alkanes, alkenes or alkadienes, or alkynes. For an aliphatic to be chlorinated, the hydrogen atoms in the "aliphatic hydrocarbon" have been chemically replaced with chlorine atoms, at different positions and also in multiple positions.

Chlorinated aliphatics manufacturing is most often conducted at fully integrated petrochemical processing facilities. Ethylene dichloride and vinyl chloride monomer production overwhelmingly comprises the largest market, in terms of production volume and number of facilities involved, in the chlorinated aliphatics industry. Ethylene dichloride is an intermediate for vinyl chloride, which in turn is a raw material to polyvinyl chloride (PVC). EPA's investigation of the industry, as well as investigation of publically available data sources such as www.chemexpo.com, show that other products can include chlorinated methanes, chlorinated ethanes and ethylenes, and higher chlorinated compounds (up to five carbon lengths).

2.1.2 Industry Study Profile

EPA's principal data sources in collecting information regarding the industry, their products and wastes, waste characteristics, and waste generation and management were as follows:

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- A questionnaire developed under the authority of RCRA §3007 for distribution to the chlorinated aliphatics production industry. EPA distributed the survey in November of 1992 to collect data characterizing operations in 1991. In June of 1997 EPA sent requests for updated data (for calendar year 1996) regarding consent decree wastes generated by each facility.

- EPA conducted engineering site visits at 16 facilities to obtain more detailed information regarding waste generation and management. EPA also collected a total of 15 familiarization samples at these facilities to assess the effectiveness of the laboratory analytical methods for the analysis for analysis of the consent decree wastes, wastewaters and wastewater sludges. EPA used the familiarization data for preliminary waste characterization only and not to quantitatively identify constituent concentrations in the waste.

- EPA conducted record sampling activity at twelve facilities. Nine facilities were located in Louisiana and Texas, and three were located in Tennessee and Kentucky. These facilities were selected in order to obtain the most representative sampling of all chlorinated aliphatics processes. EPA collected 52 samples (41 wastewaters and 11 wastewater treatment sludges). The use of record sampling data in this report is discussed in Section 2.3.2.

2.2 Processes Generating Hazardous Wastes

EPA is finalizing a decision to list as hazardous two wastes. The regulatory definitions of these wastes are presented in Section 1. In summary, these wastes are as follows:

- K174 are wastewater treatment sludges from the production of ethylene dichloride or vinyl chloride monomer from the balanced process.

- K175 are wastewater treatment sludges from the production of vinyl chloride monomer using mercuric chloride catalyst in an acetylene-based process (i.e., the VCM-A process).

Two production processes are discussed in this section; the production of ethylene dichloride and vinyl chloride monomer (EDC/VCM) using the balanced process and production of VCM using the acetylene process (i.e., VCM-A process). These processes generate wastes K174 and K175, respectively. EPA studied these processes in detail to determine which constituents in these wastes should be treated prior to land disposal.

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An additional consideration regarding constituents potentially present in these wastes is that chlorinated aliphatics production facilities are primarily located in and around the petroleum industry along the Gulf Coast. The majority of these facilities are fully integrated petrochemical processing facilities in which chlorinated aliphatic wastewaters are co-managed with non-chlorinated aliphatic wastewaters creating a non-dedicated wastewater treatment sludge.

2.2.1 Ethylene Dichloride/ Vinyl Chloride Production Using the Balanced Process

Fifteen facilities generate wastewater treatment sludge from the manufacture of EDC and/or VCM via the "balanced process." The balanced process consists of the following three primary reactions steps:

1) direct chlorination of ethylene to produce EDC:

$$CH_2{=}CH_2 + Cl_2 \;\; ! \;\; ClCH_2CH_2Cl$$

2) thermal cracking of EDC (following purification from previous step) to produce VCM and hydrogen chloride

$$ClCH_2CH_2Cl \;\; ! \;\; CH_2{=}CHCl + HCl$$

3) oxychlorination of ethylene and HCl from thermal cracking to produce EDC:

$$CH_2{=}CH_2 + 2HCl + \tfrac{1}{2}\, O_2 \;\; ! \;\; ClCH_2\, CH_2Cl + H_2O$$

This process results in the production of water as a reaction product. This water is removed in product purification. The overall reaction from these three steps is the production of vinyl chloride as follows:

$$2\, CH_2{=}CH_2 + Cl_2 + \tfrac{1}{2}\, O_2 \;\; ! \;\; 2\, CH_2{=}CHCl + H_2O$$

As shown in the overall reaction, ethylene dichloride is consumed as an intermediate in the reaction to vinyl chloride, and this is the typical case at many facilities. However, in some cases EDC is manufactured at one facility and sent off-site as a product, where subsequently it is used as the intermediate to manufacture VCM.

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Following the manufacture of VCM, many facilities consume VCM on-site as an intermediate in the manufacture of polyvinyl chloride (PVC), however, this polymerization reaction was not investigated in the course of the Industry Study because it does not involve the manufacturing of 'chlorinated aliphatic' chemicals identified in the consent decree.

Distillation and purification processes, scrubbers used during start-up/shut-down, washings, phase separation, rainwater, and equipment washdowns contribute to generation of wastewaters during the EDC/VCM production process. Treatment of EDC/VCM wastewaters generates wastewater treatment sludges. These sludges are classified as K174. Sludges are generally dewatered using either plate-and-frame filter presses or belt filter presses and dewatered sludge is temporarily stored in roll-off containers prior to on-site or off-site transportation and management.

2.2.2 VCM Production Using the Acetylene Process (VCM-A)

Production of VCM based on acetylene is less common than the aforementioned EDC/VCM balanced process using ethylene as feedstock. In fact, EPA identified only one facility that produces VCM using the VCM-A process. The VCM-A process produces only a small fraction of total vinyl chloride monomer in comparison to the balanced process. In this process, VCM is manufactured via the hydrochlorination of acetylene using a mercuric chloride catalyst. The basic process chemistry is as follows:

$$CH/CH + HCl \;\; ! \;\; CH_2{=}CHCl$$

In this process, acetylene from the on-site acetylene plant is first purified to remove water. Following drying, the acetylene is mixed with anhydrous hydrogen chloride (HCl) and flows through tubular catalytic reactors containing mercuric chloride supported on activated carbon. Once in the reactors, the acetylene and HCl combine to form VCM. The reactor products are sent to a phase separator. The liquid phases, consisting primarily of VCM, are forwarded to purification.

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VCM purification consists of a series of distillation columns. Through this series of columns, the following compounds are recovered:

- unreacted HCl and acetylene, which are recycled back to the reactors
- purified VCM, which is sold as a product
- "heavy ends" from the process, which are combusted onsite.

Water is not a reaction byproduct. The only wastewater generated from this process is rainwater and other padwater collected from the process area. Due to the presence of residual mercuric chloride catalyst from catalyst change-outs on the process pad, the padwater (containing mercury) is forwarded to a separate sodium sulfide treatment system prior to being discharged under an NPDES permit. The padwater is not listed. Mercury sulfide wastewater treatment sludge is generated from the treatment of the process area padwater. This sludge is dewatered prior to temporary storage on-site in a container. This sludge is regulated as K175.

EPA collected a single sample of wastewater treatment sludge during its record sampling activities. Analysis determined that the sludge had very high levels of mercury (9,200 ppm of total mercury; 0.26 ppm of mercury by the TCLP). The TCLP concentration exceeds the maximum concentration for the Toxicity Characteristic (0.2 ppm -- D009). The sludge from the single generator of K175 is currently managed at a hazardous waste landfill in Carlyes, Louisiana.[2]

[2] In 1988 the Louisiana DEQ determined the waste was not hazardous, and therefore not subject to many RCRA regulations (including land disposal restrictions for D009). Despite the nonhazardous designation, it is sent to a hazardous waste landfill for disposal.

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2.3 Waste Stream Characteristics

2.3.1 Sampling and Analysis Methodology

For the characterization of K174 and K175 wastes, EPA primarily used information gathered from the record sampling activities discussed in Section 2.1.2. The target compounds were grouped into the following categories for analysis:

- Volatiles, SW-846 Method 8260A (44 analytes)
- Semi-volatiles, SW-846 Method 8270B (68 analytes)
- Metals, Methods Sw-846 Methods 6010, 7470/7471, 7770, 7841 (24 analytes)
- Dioxins and furans, Office of Water Method 1613[3] (25 analytes)

In addition, the TCLP, Method 1311, was used in the analysis of all wastewater treatment sludge samples, with the same analytes as listed above. Additional characterization procedures were also performed on the wastewater and sludge samples: Total Organic Carbon (TOC), total dissolved solids (TDS), total suspended solids (TSS), and oil and grease were determined for some of the wastewater samples; and TOC, percent solids, oil and grease, and heat content (BTU) analyses were determined for some of the wastewater treatment sludge samples.

2.3.2 Waste Stream Characterization

General waste chemistry data are summarized in Table 2-1 for K174 and K175. Data regarding the general chemical and physical nature of the waste are useful in assessing the applicability of treatment techniques, anticipate any potential difficulties with treatment, and assessing if the wastes would likely be wastewaters or nonwastewaters when initially generated by the facilities. Additional data characterizing hazardous constituents in K174 and K175 are presented in Section 3.

[3] In its analyses, EPA used a method which was a compilation of Office of Water Method 1613 and SW-846 Method 8290.

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Evaluation of Table 2-1 demonstrates that K174 and K175 sludges are nonwastewaters when generated, therefore facilities that generate K174 and K175 are subject to treatment standards for nonwastewater forms of waste. Other significant information from examination of Table 2-1 is that K175 has a significantly greater oil and grease content than K174. The heat content of K175 (1,100 BTU/lb) is lower than 5,000 BTU/lb, which is one of the criteria for burning hazardous waste for metals recovery in a conditionally exempt manner (40 CFR §266.100(c)(2)(ii)).

Of the seven EDC/VCM sludge streams that were sampled during the Industry Study, four are considered "dedicated." Waste streams are considered dedicated when the only processes contributing to the waste streams are from the desired process (i.e., the four sludges are generated *only* from the treatment of wastewaters generated from the manufacture of EDC/VCM; no other processes contribute to the wastewater treatment sludge). The characterization data for these four sludge samples were used in performing the risk assessment for the listing determination. These same data are used to characterize the EDC/VCM sludge waste streams for treatment standard development and constituent selection for this report. This is conducted to maintain consistency with the information used for various EPA analyses.

As identified earlier, EPA collected a single sample of K175 during its record sampling activities (from the single facility generating K175). Data from this sample were used in treatment standard development.

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Table 2-1. General Chemistry Data for K174 and K175

Parameter	Result	Comments
K174		
TOC	0.37 to 6.8 percent	Results from 2 samples
Oil and Grease	0.07 to 0.1 percent	Results from 2 samples
Percent solids	26 to 60 percent	Results from 4 samples
K175		
TOC	2.3 percent	Results from 1 sample
Oil and Grease	4.2 percent	Results from 1 sample
BTU/lb	1,100	Results from 1 sample
Percent Solids	44 percent	Results from 1 sample

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3.0 SELECTION OF CONSTITUENTS FOR REGULATION

This section presents the methodology and rationale for selecting constituents for regulation in nonwastewater forms of K174 and K175. Constituents were selected for regulation because they are present in the wastes at high levels, relative to either of the following: (1) concentrations which would cause the waste to exhibit risks below EPA risk criteria (i.e., their presence is the basis for listing), or (2) concentrations known to be achievable by available, well-operated technologies for reducing the toxicity of the waste (i.e., they are present in the wastes above UTS). While many other constituents may be present in the wastes, EPA generally elected not to develop treatment standards due to the following reasons:

- They are expected to be present in the wastes at levels below those anticipated to be achievable in a well-designed and applicable waste treatment unit. Development of proposed numerical treatment standards for such constituents would not result in reduced toxicity of the waste, because the waste would likely meet the proposed treatment standards even without waste treatment.

- They are expected to be treated concurrently with other constituents. It is common for a single treatment technology to reduce the toxicity or mobility of many constituents. Therefore, treatment standards proposed for a small number of constituents would necessarily result in the waste being effectively treated for other constituents not proposed for regulation. To assist in such determinations, EPA uses treatability groups to identify similarities in compounds.

This section identifies those constituents in K174 and K175 wastes for which treatment standards were developed. Subsequent sections of this report describe applicable and demonstrated technologies for effectively treating wastes for such constituents, and development of appropriate numerical treatment standards (or alternative technology-specific standards) for each of the wastes.

3.1 Constituents Identified as the Bases for Listing

In its risk assessment, EPA found that certain constituents present in K174 and K175 pose unacceptable risks to human health and the environment. The following constituents were identified as the basis for listing these wastes (i.e., to be included in 40 CFR Appendix VII):

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- K174 –

  1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin (1,2,3,4,6,7,8-HpCDD)
  2,3,4,6,7,8-Heptachlorodibenzofuran (1,2,3,4,6,7,8,-HpCDF)
  1,2,3,4,7,8,9-Heptachlorodibenzofuran (1,2,3,6,7,8,9-HpCDF)
  HxCDDs (All Hexachlorodibenzo-*p*-dioxins)
  HxCDFs (All Hexachlorodibenzofurans)
  1,2,3,4,6,7,8,9-Octachlorodibenzo-*p*-dioxin (OCDD)
  1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)
  PeCDDs (All Pentachlorodibenzo-*p*-dioxins)
  PeCDFs (All Pentachlorodibenzofurans)
  TCDDs (All tetrachlorodibenzo-*p*-dioxins)
  TCDFs (All tetrachlorodibenzofurans).

- K175 –

  Mercury.

For K174, EPA found risks for arsenic that were within its discretionary range for using the constituent as a basis for listing. Though treatment standards are being applied to arsenic in K174 wastes, EPA is not including arsenic as a basis for listing K174 wastes.

3.2 Other Constituents Present in Wastes

EPA identified additional constituents in the wastes that were present at levels higher than (or comparable to) UTS. As discussed in Section 1, UTS were developed from waste treatment data representing BDAT. Therefore, wastes with high concentrations (relative to UTS) of hazardous constituents should be capable of being treated to lower contaminant levels.

Tables 3-1 and 3-2 were developed to assist in this comparison. Each of these tables characterizes a different waste (i.e., K174 and K175, respectively). These tables present the maximum wet weight concentrations and maximum dry weight concentrations of each constituent detected in K174 and K175 wastes consistent with the discussion presented in Section 2.3.2 (i.e., based on record sampling results for a portion of the samples collected and analyzed). These concentrations were compared to the constituent's UTS value. If the maximum concentration of the constituent in any sample exceeded the respective UTS, it was identified for additional consideration (these constituents

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are marked in bold on the table). Any constituents not marked in bold were found at levels below their respective UTS values. K174 and K175 are evaluated against nonwastewater UTS because they are sludges.

Depending on the water content of a given sample, sludges may show high variability in the concentration of constituents. For example, the four samples of K174 identified in Section 2 for use in treatment standards development ranged from 26 to 60 percent solids. The nonwastewater treatment standards for organics were developed largely from testing of dry incinerator ash (i.e., close to 100 percent solids). To standardize the comparison between the constituent concentrations in K174 and K175, and the UTS limits derived from the testing of dry incinerator ash (in some cases), Tables 3-1 and 3-2 presents maximum dry and wet weight concentrations in the wastes. The dry weight concentrations are always higher than the wet weight concentrations.

Maximum concentrations in Table 3-1 (K174 waste) were based on four different sludge samples. Wet weight concentrations were determined first, then dry weight concentrations were calculated by dividing the wet weight contaminant concentration by the solids percentage. Maximum concentrations in Table 3-2 (K175 waste) were calculated similarly based on one K175 waste sample. In both cases, TCLP concentrations were unchanged because leachate concentrations cannot be 'adjusted' for percent solids.

In some cases, organic constituents were not found during analysis of the total waste but were detected in TCLP leachate. This is also designated where appropriate. For organics in nonwastewaters, UTS are typically expressed as total concentrations (for metals, leachate concentrations are used). Detailed review of some of these organic constituents shows that the detection limits used were well below their UTS levels, indicating that constituents found only in TCLP leachate are not expected to be present above UTS during total analysis.

Additionally, each of the constituents identified in Tables 3-1 and 3-2 were organized into one of eleven treatability groups. These groupings are consistent with those used in developing UTS (EPA,

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1994a and 1994b). This division is useful in assessing the difficulty of treating certain constituents such as those without UTS. The treatability groups relevant for compounds found in these wastes are as follows:

- Aromatic Hydrocarbons
- Carbon Disulfide
- Chlorobenzenes
- Chloroethers
- Halogenated Volatiles
- Metals
- Organo-Bromines
- Oxygenated Hydrocarbons
- PCBs and Dioxins/Furans
- Phthalates
- Polynuclear Aromatic Hydrocarbons.

Comparison of the maximum waste concentrations to the UTS values in Tables 3-1 and 3-2 demonstrate the following:

- For K174 there were 12 dioxins and furans in excess of the nonwastewater UTS (noted using boldface in Table 3-1) as measured using dry weight. In many instances, wet weight concentrations were also above UTS. No other constituents exceeded UTS using wet or dry weight.

- For K175, di-n-butyl phthalate exceeded its nonwastewater UTS only when measured by dry weight. Mercury and zinc exceeded their nonwastewater UTS as measured using the TCLP. (Boldface in Table 3-2 shows constituents that exceeded UTS.)

3.3 Constituents Selected for Regulation

In identifying the constituents in K174 and K175 selected for regulation in 40 CFR §268.40, EPA considered the following:

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- Establishing treatment standards for each of the constituents that form the basis for listing K174 and K175. This includes dioxin and furan congeners for K174, and mercury for K175. Not all of these constituents had existing UTS (i.e., hepta and octa dioxin and furan congeners did not). EPA developed treatment standards for each of the constituents because not all of the congeners are expected to be present in each facility's waste above UTS on a consistent basis. This approach will best ensure that risks from these wastes are minimized, as required by RCRA Section 3004(m).

- Not including zinc, although present in K175 above its respective UTS, as a constituent in 40 CFR §268.40 for these wastes. This is because zinc does not meet the EPA definition of hazardous constituent or "underlying hazardous constituent." EPA defines an underlying hazardous constituent as "any constituent listed in 40 CFR §268.48, Table UTS-Universal Treatment Standards, except fluoride, selenium, sulfides, vanadium, and zinc, which can reasonably be expected to be present at the point of generation of the hazardous waste at a concentration above the constituent-specific UTS treatment standards" [40 CFR §268.2(i)].

- For K174, arsenic is present at levels below its corresponding UTS value (0.053 mg/L versus a UTS of 5 mg/L). Potential health risks due to arsenic through the ground water pathway were identified in EPA's risk assessment, although the constituent is not a basis for listing. Nevertheless, due to the well-documented health risks from arsenic, including risks evaluated for K174, EPA is promulgating a treatment standard for arsenic to ensure that risks from this constituent are minimized.

- Not promulgating a treatment standard in K175 wastes for di-n-butyl phthalate. This constituent exceeds UTS when evaluated using dry weight, but not wet weight. EPA does not anticipate that incineration will be used to treat K175 wastes; instead, stabilization is expected to be used to treat the mercury. Consequently, EPA finds that the UTS of 28 mg/kg is not appropriate in this instance and have not added di-n-butyl phthalate to the list of constituents for which treatment of K175 will be required.

Several remaining constituents identified in the wastes were not further evaluated, in part because UTS do not exist for these compounds. Additionally, other chlorinated aliphatic compounds manufactured as products (and therefore potentially present in the wastes) were not evaluated. However, for many of these compounds the concentrations in the waste were comparable to levels found for other constituents of similar structure. Further, treatment techniques which reduce the concentration or mobility of other constituents included in 40 CFR §268.40 for K174 and K175 would also likely reduce the concentrations of these other products or constituents without UTS. For

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example, treatment techniques which destroy dioxins and furans are also likely to decrease concentrations of other organic constituents.

In summary, EPA is finalizing numerical treatment standards for constituents in K174 and K175 in 40 CFR §268.40 that were proposed in 64 FR 46476 (August 25, 1999). These constituents were principally selected by examining the constituents proposed as the basis for listing, examining concentrations of the constituents in the waste, and considering whether the contaminant is an "underlying hazardous constituent" that is above its respective UTS. The specific numerical or technology-specific standards promulgated for each constituent in each waste are presented in the following sections, following discussion of treatment technologies appropriate for minimizing the presence or mobility of the constituent in the wastes.[4] The constituents selected for treatment standards are as follows:

- K174 –
  - 1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin (1,2,3,4,6,7,8-HpCDD)
  - 1,2,3,4,6,7,8-Heptachlorodibenzofuran (1,2,3,4,6,7,8-HpCDF)
  - 1,2,3,4,7,8,9- Heptachlorodibenzofuran (1,2,3,4,7,8,9-HpCDF)
  - HxCDDs (All Hexachlorodibenzo-*p*-dioxins)
  - HxCDFs (All Hexachlorodibenzofurans)
  - 1,2,3,4,6,7,8,9-Octachlorodibenzo-*p*-dioxin (OCDD)
  - 1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)
  - PeCDDs (All Pentachlorodibenzo-*p*-dioxins)
  - PeCDFs (All Pentachlorodibenzofurans)
  - TCDDs (All tetrachlorodibenzo-*p*-dioxins)
  - TCDFs (All tetrachlorodibenzofurans)
  - Arsenic.

- K175 –
  - Mercury.

[4]As explained in subsequent sections, EPA is promulgating an alternative treatment standard of combustion for K174 and is including pH limitations for K175.

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Table 3-1. Constituents Detected in K174

Constituent	Treatability Group	UTS WW (mg/L)	UTS NWW (mg/kg)	Maximum Concentration (mg/kg unless otherwise noted)	
				wet weight	dry weight
Constituents with UTS					
Acetone	Oxygenated Hydrocarbon	0.28	160	2	3.3
Allyl chloride (3-Chloropropylene)	Halogenated Volatile	0.036	30	0.008	0.013
2-Butanone (Methyl ethyl ketone)	Oxygenated Hydrocarbon	0.28	36	0.12	0.2
Carbon disulfide	Carbon Disulfide	3.8	4.8 mg/L TCLP	0.0072 mg/L TCLP	
Chloroform	Halogenated Volatile	0.046	6.0	0.56	2.2
1,2-Dichloroethane	Halogenated Volatile	0.21	6.0	0.53	2.1
Methylene chloride	Halogenated Volatile	0.089	30	0.043	0.17
Tetrachloroethylene	Halogenated Volatile	0.056	6.0	0.018 J	0.07 J
Trichloroethylene	Halogenated Volatile	0.054	6.0	0.0028 J	0.0047 J
Vinyl chloride	Halogenated Volatile	0.27	6.0	0.015 J	0.058 J
Bis(2-chloroethyl)ether	Chloroether	0.033	6.0	0.800	2.1
Bis(2-ethylhexyl) phthalate	Phthalate	0.28	28	5.9 J	23 J
Hexachlorobenzene	Chlorobenzene	0.055	10	0.11 J	0.18 J
Arsenic	Metal	1.4	5.0 mg/L TCLP	0.053 mg/L TCLP	
Nickel	Metal	3.98	5.0 mg/L TCLP	1.3 mg/L TCLP	
Zinc	Metal	2.61	5.3 mg/L TCLP	4.0 mg/L TCLP	
1,2,3,4,7,8-HxCDD	Dioxins/Furans	0.000063	0.001	0.008 µg/kg [A]	0.014 µg/kg
1,2,3,6,7,8-HxCDD	Dioxins/Furans	0.000063	0.001	0.083 µg/kg	0.32 µg/kg
1,2,3,7,8,9-HxCDD	Dioxins/Furans	0.000063	0.001	0.062 µg/kg	0.24 µg/kg
1,2,3,4,7,8-HxCDF	**Dioxins/Furans**	0.000063	**0.001**	**1.425 µg/kg**	**5.5 mg/kg**

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Constituent	Treatability Group	UTS WW (mg/L)	UTS NWW (mg/kg)	Maximum Concentration (mg/kg unless otherwise noted)	
				wet weight	dry weight
1,2,3,6,7,8-HxCDF	Dioxins/Furans	0.000063	0.001	0.084 µg/kg [A]	0.14 µg/kg
1,2,3,7,8,9-HxCDF	Dioxins/Furans	0.000063	0.001	0.039 µg/kg [A]	0.065 µg/kg
2,3,4,6,7,8-HxCDF	**Dioxins/Furans**	0.000063	**0.001**	0.648 µg/kg	**2.5 mg/kg**
1,2,3,7,8-PeCDF	Dioxins/Furans	0.000035	0.001	0.028 µg/kg	0.080 µg/kg
2,3,4,7,8-PeCDF	Dioxins/Furans	0.000035	0.001	0.127 µg/kg	0.49 µg/kg
1,2,3,7,8-PeCDD	Dioxins/Furans	0.000063	0.001	not detected [A]	not detected
2,3,7,8-TCDD	Dioxins/Furans	0.000063	0.001	0.039 µg/kg	0.15 µg/kg
2,3,7,8-TCDF	Dioxins/Furans	0.000063	0.001	0.145 µg/kg	0.56 µg/kg
Total TCDD	**Dioxins/Furans**	0.000063	**0.001**	B	**1.6 mg/kg**
Total TCDF	**Dioxins/Furans**	0.000063	**0.001**	B	**10 mg/kg**
Total PeCDD	Dioxins/Furans	0.000063	0.001	B	0.18 µg/kg
Total PeCDF	**Dioxins/Furans**	0.000035	**0.001**	B	**1.4 mg/kg**
Total HxCDD	**Dioxins/Furans**	0.000063	**0.001**	B	**1.2 mg/kg**
Total HxCDF	**Dioxins/Furans**	0.000063	**0.001**	B	**32 mg/kg**
Constituents without UTS					
2-Hexanone	Oxygenated Hydrocarbon	—	—	0.0025	0.004
Vinyl acetate	Oxygenated Hydrocarbon	—	—	0.007	0.019
Benzoic acid	Oxygenated Hydrocarbon	—	—	0.19 J	0.32 J
Calcium	Metal	—	—	848 mg/L TCLP	
Cobalt	Metal	—	—	0.07 mg/L TCLP	
Copper	Metal	—	—	22.3 mg/L TCLP	
Magnesium	Metal	—	—	154 mg/L TCLP	
Manganese	Metal	—	—	12.9 mg/L TCLP	
Molybdenum	Metal	—	—	0.022 mg/L TCLP	
Potassium	Metal	—	—	9.3 mg/L TCLP	
1,2,3,4,6,7,8-HpCDD	**Dioxins/Furans**	0.000035[(P)]	**0.0025[(P)]**	0.777 µg/kg	**3 mg/kg**

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Constituent	Treatability Group	UTS WW (mg/L)	UTS NWW (mg/kg)	Maximum Concentration (mg/kg unless otherwise noted)	
				wet weight	dry weight
1,2,3,4,6,7,8-HpCDF	**Dioxins/Furans**	0.000035(P)	**0.0025(P)**	**20.7 µg/kg**	**80 mg/kg**
1,2,3,4,7,8,9-HpCDF	**Dioxins/Furans**	0.000035(P)	**0.0025(P)**	**13.5 µg/kg**	**52 mg/kg**
OCDD	**Dioxins/Furans**	0.000063(P)	**0.005(P)**	**6.48 µg/kg**	**25 mg/kg**
OCDF	**Dioxins/Furans**	0.000063(P)	**0.005(P)**	**212 µg/kg**	**820 mg/kg**
Total HpCDD	Dioxins/Furans	—	—	B	4.4 µg/kg
Total HpCDF	Dioxins/Furans	—	—	B	150 µg/kg

J – Compound's concentration is estimated.
Data are from four samples, OG-4, OG-6, GI-01, and OC-02 with solids contents of 59.9%, 38.1%, 25.9%, and 34.4% respectively. Dry weight concentrations are calculated by dividing the wet weight contaminant concentration by the percentage appropriate to the sample, and presenting the highest calculated dry weight concentration in this table.
Bolded constituents exceed their respective UTS for nonwastewater forms of waste.
UTS for dioxins and furans refer to the class (e.g., all TCDDs) rather than to specific constituents, except for the hepta and octa isomers where UTS is for the specific contaminant. Conversion: 1 µg/kg = 0.001 mg/kg.
A. The BDAT Background Document for the proposed rule listed maximum (wet weight) concentrations for these four contaminants different than what is here. These values were actually detection limits. Both the dry weight and wet weight concentrations in the table refer to maximum detected concentrations.
(P) Proposed treatment standard (64 FR 46476, August 25, 1999). Treatment standards are being finalized in this rule.
B. Wet weight data for total tetra, penta, hexa, and hepta dioxins and furans were not presented in the BDAT Background Document for the proposed rule.

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Table 3-2. Constituents Detected in K175

Constituent	Treatability Group	UTS WW (mg/L)	UTS NWW (mg/kg)	Maximum Concentration (mg/kg unless otherwise noted)	
				wet weight	dry weight
Constituents with UTS					
Carbon disulfide	Carbon Disulfide	3.8	4.8 mg/L TCLP	0.014 mg/L TCLP	
1,2-Dichlorobenzene	Chlorobenzene	0.088	6.0	2.01	4.6
1,3-Dichlorobenzene	Chlorobenzene	0.036	6.0	0.7	1.6
1,4-Dichlorobenzene	Chlorobenzene	0.09	6.0	0.96	2.2
Bis(2-ethylhexyl)benzene	Aromatic Hydrocarbon	0.28	28	3.4	7.8
Fluoranthene	Polynuclear Aromatic Hydrocarbon	0.068	3.4	0.67	1.5
Pyrene	Polynuclear Aromatic Hydrocarbon	0.067	8.2	2.32	5.3
1,2,4-Trichlorobenzene	Aromatic Hydrocarbon	0.055	19	2.34	5.4
Di-n-butyl phthalate	**Phthalate**	0.057	**28**	20	**46**
Chromium	Metal	2.77	0.86 mg/L TCLP	0.10 mg/L TCLP	
Mercury	**Metal**	0.15	**0.025 mg/L TCLP**	**0.26mg/L TCLP**	
Nickel	Metal	3.98	5.0mg/L TCLP	1.0 mg/L TCLP	
Zinc	**Metal**	2.61	**5.3 mg/L TCLP**	**9.5 mg/L TCLP**	
1,2,3,4,7,8-HxCDF	Dioxins/Furans	0.000063	0.001	0.083 µg/kg	0.19 µg/kg
1,2,3,6,7,8-HxCDF	Dioxins/Furans	0.000063	0.001	0.0481 µg/kg	0.11 µg/kg
1,2,3,7,8,9-HxCDF	Dioxins/Furans	0.000063	0.001	0.0192 µg/kg	0.044 µg/kg
2,3,4,6,7,8-HxCDF	Dioxins/Furans	0.000063	0.001	0.0319 µg/kg	0.073 µg/kg
1,2,3,7,8-PeCDF	Dioxins/Furans	0.000063	0.001	0.0288 µg/kg	0.066 µg/kg
2,3,4,7,8-PeCDF	Dioxins/Furans	0.000035	0.001	0.0197 µg/kg	0.045 µg/kg

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Constituent	Treatability Group	UTS WW (mg/L)	UTS NWW (mg/kg)	Maximum Concentration (mg/kg unless otherwise noted)	
				wet weight	dry weight
2,3,7,8-TCDF	Dioxins/Furans	0.000063	0.001	0.0101 µg/kg	0.023 µg/kg
Total HxCDD	Dioxins/Furans	0.000063	0.001	0.0656 µg/kg	0.15 µg/kg
Total HxCDF	Dioxins/Furans	0.000063	0.001	0.3758 µg/kg	0.86 µg/kg
Total PeCDF	Dioxins/Furans	0.000063	0.001	0.1704 µg/kg	0.39 µg/kg
Total TCDD	Dioxins/Furans	0.000063	0.001	0.0038 µg/kg	0.009 µg/kg
Total TCDF	Dioxins/Furans	0.000063	0.001	0.0481 µg/kg	0.11 µg/kg
Constituents without UTS					
Calcium	Metal	—	—	417 mg/L TCLP	
Copper	Metal	—	—	0.64 mg/L TCLP	
Magnesium	Metal	—	—	2.7 mg/L TCLP	
Manganese	Metal	—	—	0.3 mg/L TCLP	
Potassium	Metal	—	—	1.6 mg/L TCLP	
1,2,3,4,6,7,8-HpCDD	Dioxins/Furans	0.000035(P)	0.0025(P)	0.1748 µg/kg	0.40 µg/kg
1,2,3,4,6,7,8-HpCDF	Dioxins/Furans	0.000035(P)	0.0025(P)	0.1093 µg/kg	0.25 µg/kg
1,2,3,4,7,8,9-HpCDF	Dioxins/Furans	0.000035(P)	0.0025(P)	0.0297 µg/kg	0.068 µg/kg
Total HpCDD	Dioxins/Furans	–	–	0.3496 µg/kg	0.80 µg/kg
Total HpCDF	Dioxins/Furans	–	–	0.1398 µg/kg	0.32 µg/kg
OCDD	Dioxins/Furans	0.000063(P)	0.005(P)	1.44 µg/kg	3.3 µg/kg
OCDF	Dioxins/Furans	0.000063(P)	0.005(P)	0.1005 µg/kg	0.25 µg/kg

Bolded constituents exceed their respective UTS for nonwastewater forms of waste.
UTS for dioxins and furans refer to the class (e.g., all TCDDs) rather than to specific constituents, except for the hepta and octa isomers where UTS is for the specific contaminant. Conversion: 1 µg/kg = 0.001 mg/kg.
Organic constituents that are detected only in TCLP leachate are not presented here, if their NWW UTS is based on total analyses.
Data are from one sample, BG-06 with a solids content of 43.7%. Dry weight concentrations are calculated by dividing the wet weight contaminant concentration by this percentage (i.e., 0.437).
(P) Proposed treatment standard (64 FR 46476, August 25, 1999). Treatment standards are being finalized in this rule.

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4.0 TREATMENT STANDARD DEVELOPMENT FOR K174

This section describes the treatment standards that EPA is promulgating to best meet the requirements of RCRA Section 3004(m) for wastewater and nonwastewater forms of K174. Section 5.0 describes similar information for K175.

4.1 Summary of Constituents Selected for Regulation

As presented in Section 3, treatment standards were developed for the following constituents in wastewater and nonwastewater forms of K174:

- 1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin (1,2,3,4,6,7,8-HpCDD)
- 1,2,3,4,6,7,8-Heptachlorodibenzofuran (1,2,3,4,6,7,8-HpCDF)
- 1,2,3,4,7,8,9- Heptachlorodibenzofuran (1,2,3,4,7,8,9-HpCDF)
- HxCDDs (All Hexachlorodibenzo-*p*-dioxins)
- HxCDFs (All Hexachlorodibenzofurans)
- 1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)
- 1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)
- PeCDDs (All Pentachlorodibenzo-*p*-dioxins)
- PeCDFs (All Pentachlorodibenzofurans)
- TCDDs (All tetrachlorodi-benzo-*p*-dioxins)
- TCDFs (All tetrachlorodibenzofurans)
- Arsenic.

These constituents represent two treatability groups: dioxin/furans and metals. Different treatment technologies are applicable for each category. Treatment technologies applicable to dioxins/furans in wastewater and nonwastewater forms of the wastes are discussed in Sections 4.2.1 and 4.3.1, respectively. Treatment technologies applicable to arsenic in wastewater and nonwastewater forms of wastes are discussed in Sections 4.2.2 and 4.3.2, respectively. Identification of BDAT for wastewater and nonwastewater forms of K174 are presented in Sections 4.2.3 and 4.3.3, respectively.

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Identification of treatment standards for wastewater and nonwastewater forms of K174 are presented in Sections 4.2.4 and 4.3.4, respectively.

4.2 Wastewater Forms of K174

4.2.1 Applicable and Demonstrated Technologies for Treating Dioxins/Furans

To be applicable, a technology must theoretically be usable to treat the waste in question or a waste that is similar, in terms of parameters that affect treatment selection (EPA, 1994b). In general, technologies applicable to the treatment of organic compounds are applicable to dioxin/furan compounds. EPA (1994b) presents a thorough discussion of the following technologies which are applicable and have been demonstrated to treat dioxins/furans in wastewater forms of other hazardous wastes:

- biological treatment (including aerobic fixed film, aerobic lagoon, activated sludge, anaerobic fixed film, rotating biological contractor, sequential batch reactor, and trickling filter technologies)
- carbon adsorption treatment (including activated carbon and granular activated carbon technologies)
- chemically assisted clarification treatment (including chemical precipitation technology)
- chemical oxidation
- PACT® treatment (including powdered activated carbon addition to activated sludge and biological granular activated carbon technologies)
- reverse osmosis treatment
- solvent extraction treatment (including liquid/liquid extraction)
- stripping treatment (including steam stripping and air stripping technologies)
- wet air oxidation treatment (including supercritical oxidation technology)
- glycolate dechlorination

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- total recycle or reuse.

The concentrations and type(s) of constituents present in the waste generally determine which technology is most applicable. Carbon adsorption, for example, is often used as a polishing step following primary treatment by biological treatment, solvent extraction, or wet air oxidation. Typically, carbon adsorption is applicable for treatment of wastewaters containing less than 0.1% total organic constituents. Wet air oxidation, PACT® treatment, biological treatment, and solvent extraction are generally applicable for treatment of wastewaters containing up to 1% total organic constituents. EPA does not have information on the total organic content of wastewater forms of K174 because such wastes are typically generated as wastewaters. Therefore, each of these treatment technologies can potentially be used for K174 wastewaters.

Brief descriptions of the above treatment technologies are presented below.

Biological Treatment

Biological treatment is a destruction technology that biodegrades hazardous organic constituents in wastewaters. This technology generates two treatment residuals: a treated effluent and a waste biosludge.

Carbon Adsorption

Carbon adsorption is a separation technology that selectively adsorbs organic constituents in wastewaters onto activated carbon. This technology generates two treatment residuals: a treated effluent and spent activated carbon. The spent activated carbon may be reactivated, recycled, incinerated, or land disposed (in accordance with land disposal restrictions).

Chemically Assisted Clarification Treatment

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Chemically assisted clarification, including chemical precipitation, is a separation technology that removes organic and inorganic constituents from wastewater by the addition of chemicals that cause the formation of precipitates. The solids formed are then separated from the waste water by settling, clarification, and/or polishing filtration. This technology generates two treatment residuals: treated wastewater effluent and separated solid precipitate.

Chemical Oxidation

Chemical oxidation is a destruction technology that oxidizes inorganic cyanide, some dissolved organic compounds, and sulfides to yield carbon dioxide, water, salts, simple organic acids, and sulfates. This technology generates one treatment residual: treated effluent.

PACT® Treatment

PACT® treatment combines carbon adsorption and biological treatment to biodegrade hazardous organic constituents and selectively adsorb them onto powdered activated carbon. This technology generates two treatment residuals: a treated effluent and spent carbon/biosludge. The spent carbon is often regenerated and recycled to the process or incinerated.

Reverse Osmosis

Reverse osmosis is a separation technology that removes dissolved organics (usually salts) from a wastewater by filtering the waste water 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 and the concentrated organic salt materials which do not pass through the membrane.

Solvent Extraction

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Solvent extraction is a separation technology that removes organic compounds from a waste due to greater constituent solubility in a solvent phase than in the waste phase. This technology generates two residuals: a treated waste residual and an extract.

Stripping Treatment

Stripping treatment is a separation technology in which volatile organic constituents in a liquid waste are physically transferred to a flowing gas or vapor. In steam stripping, steam contacts the waste, strips the volatile organics, and carries them to a condenser where the mixture of organic vapors and steam is condensed and collected in an accumulator tank. In air stripping, air contacts the waste and strips the volatile organic constituents. Stripping generates one treatment residual: treated effluent.

Wet Air Oxidation

Wet air oxidation is a destruction technology that oxidizes hazardous organic constituents in wastes under pressure at elevated temperatures in the presence of dissolved oxygen. This technology is applicable for wastes comprised primarily of water and with up to 10 percent total organic constituents. Wet air oxidation generates one treatment residual: treated effluent. The treated effluent may require further treatment for hazardous organic constituents by carbon adsorption or PACT® treatment. Trapped air emissions from wet air oxidation may also require further treatment.

Glycolate Dechlorination

EPA (1994b) describes a bench-scale process involving dechlorination of toxics (e.g., dioxins) using an alkoxide formed by the reaction of potassium hydroxide with polyethylene glycol (KPEG). The U.S. Navy's Environmental Restoration Division also provides another description of this process[5]. The KPEG technology is an example of the use of an alkaline polyethylene glycol reagent (APEG), and

[5] http://erb.nfesc.navy.mil/restoration/technologies/remed/phys_chem/phc-12.asp. The date of the report was not provided, but appears to be from 1998.

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is considered as an innovative remediation technology applicable to small volume of soils (i.e., nonwastewaters) due to cost constraints. The process involves the mixing and heating of contaminated soils and the reagent in a batch treatment vessel. The reaction between the chlorinated organics and the KPEG causes replacement of a chlorine molecule with polyethylene glycol. The reagent then dehalogenates the pollutant to form a glycol ether and/or a hydroxylated compound and an alkali metal salt, which are water-soluble byproducts.

Total Recycle or Reuse

Total recycle or reuse within the same process or an external process eliminates waste generation. As a result of recycling, however, impurities may require removal from the system on a periodic or continuous basis.

4.2.2 Applicable and Demonstrated Technologies for Treating Arsenic

Applicable technologies for treating metals are those that remove, or transfer, metals from the wastewater to a nonwastewater media, such as a sludge. Several technologies for organics apply to treatment of arsenic in wastewater because the metal species flocculate with the organic compounds and are removed in a sludge stream. The concentration of metals (e.g., arsenic) is expected to be low, so the metals could be treated in conjunction with organics, without contributing to toxicity or causing other interferences.

The technologies listed in this section are applicable and have been demonstrated to treat metal constituents in wastewater forms of other hazardous wastes. EPA (1994b) presents a thorough discussion of these technologies which include the following:

- biological treatment (including activated sludge, aerobic lagoon, rotating biological contractor, and trickling filter technologies)
- chemically assisted clarification treatment (including chemical precipitation technology)

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- chemical oxidation
- PACT® treatment
- chemical reduction treatment (including chemical reduction or precipitation followed by sedimentation and filtration technologies)
- electrochemical treatment
- lime, sedimentation, and filtration treatment.

Descriptions of biological treatment, chemically assisted clarification treatment, chemical oxidation and PACT® treatment may be found above in Section 4.2.1. The remaining applicable technologies are described below.

Chemical Reduction Treatment

Chemical reduction treatment reduces metal constituents from a higher oxidation state to a lower oxidation state, and subsequently removes the contaminants from the wastewater using chemical precipitation and subsequent sedimentation and/or filtration. This technology generates two treatment residuals: a treated effluent and a settled or filtered solid containing the precipitated metal.

Electrochemical Treatment

Electrochemical treatment is a technology in which direct current is applied to iron electrodes submerged in the wastewater, generating ferrous ions. Metal constituents are removed by adsorbing and coprecipitating within insoluble ferrous ion matrices. These matrices settle out of solution using chemically assisted clarification (described in Section 4.2.1). This technology produces two treatment residuals: a treated effluent and a settled solid containing the precipitated metal.

Lime, Sedimentation and Filtration Treatment

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As a separation technology, this treatment mixes wastewaters with lime (primarily calcium oxide) which produced an insoluble metal oxide which settles out of solution. The wastewater is filtered to remove the precipitated material. This treatment technology produces two residuals: a treated effluent and a filter cake containing lime and metals oxides.

4.2.3 Identification of BDAT for Wastewater Forms of K174

EPA determines BDAT for individual constituents and wastes, upon review of all available performance data on treatment of the waste of concern or of similar wastes (EPA, 1994a). Once the applicable and demonstrated treatment technologies are identified for the particular waste, performance data are examined to identify the "best" performing technologies. This criteria includes:

- whether the data represent the 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.

Once this is determined, EPA decides where the best demonstrated technology is "available." EPA defines an available technology as follows:

- It is not a proprietary or patented process and can be purchased or licensed from the proprietor, and
- It substantially diminishes the waste's toxicity or substantially reduces the likelihood that hazardous contaminants will migrate from the waste (EPA, 1994a).

Although K174 wastes meet the definition of nonwastewaters as generated (40 CFR §268.2), EPA established treatment standards for both wastewater and nonwastewater forms to ensure that any waste streams that meet the definition of wastewater are also treated to meet appropriate treatment standards prior to land disposal.

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EPA determined the BDAT for the constituents requiring treatment in wastewater forms of K174. The constituents requiring treatment in K174 wastewaters are dioxins/furans and arsenic.

BDAT for Dioxins/Furans

EPA previously developed UTS for the following dioxin/furan classes, identifying biological treatment as BDAT (EPA, 1994b):

- HxCDDs (All Hexachlorodibenzo-*p*-dioxins)
- HxCDFs (All Hexachlorodibenzofurans)
- PeCDDs (All Pentachlorodibenzo-*p*-dioxins)
- PeCDFs (All Pentachlorodibenzofurans)
- TCDDs (All tetrachlorodibenzo-*p*-dioxins)
- TCDFs (All tetrachlorodibenzofurans)

EPA did not previously develop UTS for the remaining dioxin and furan congeners identified as the basis for listing K174. However, EPA expects that applicable treatment technologies and BDAT for the above congeners are appropriate for the remaining dioxin and furan congeners. Biological treatment is expected to perform equally well for these constituents as it does for the other congeners due to similarity in structure and properties of these compounds.

BDAT for Arsenic

In developing UTS for arsenic, EPA identified lime conditioning followed by sedimentation and filtration as BDAT (EPA, 1994b). The UTS was developed from a full-scale process. Lime treatment followed by sedimentation and filtration is a common method to remove metals in industrial wastewater, such as wastewaters from electroplating operations.

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BDAT for Wastewater Forms of K174: Conclusion

Biological treatment is a demonstrated method for treating wastewaters with low levels of dioxin/furan components. In data submitted by industry prior to promulgation of the Land Disposal Restrictions for Third Third Scheduled Wastes (55 *FR* 22520), wastewaters including hazardous waste landfill leachate were managed using biological treatment in both batch and full scale processes.[6] In general, biological treatment is a common full scale treatment method in the organic chemicals manufacturing and is particularly common to the chlorinated aliphatics manufacturing industry. However, biological treatment is expected to only slightly decrease the concentration of arsenic in the waste.

To adequately treat both metals and organics potentially present in wastewater forms of K174, EPA identifies a treatment train consisting of lime treatment followed by sedimentation and filtration (for metals treatment), followed by biological treatment (for organics treatment) as BDAT for the treatment of wastewater forms of K174.

4.2.4 Identification of Treatment Standards for Wastewater Forms of K174

EPA is finalizing numerical treatment standards for wastewater forms of K174. EPA is transferring UTS to most of the constituents selected for regulation in K174. Universal treatment standards have previously been promulgated for all but five of the constituents (i.e., hepta- and octa-congeners of dioxins and furans). For the three hepta-isomers constituents, the UTS promulgated for pentachlorodibenzofurans is proposed as the treatment standard for these three constituents. These three congeners are similar in chemical structure to pentachlorodibenzofurans and treatment to a similar level is therefore expected. Similarly, the UTS promulgated for tetrachlorodibenzo-*p*-dioxins and furans is proposed for OCDD and OCDF. More detailed discussion regarding the transfer of the existing UTS for pentachlorodibenzofurans to these five compounds is presented in Appendix A.

[6] Letter from Chemical Waste Management Incorporated, F-89-LD12-S0967. Letter from Dow Chemical USA, F-89-LD12-S0968.

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The treatment train identified as BDAT for treating these constituents in wastewater forms of K174 is expected to result in treated effluent with contaminant concentrations lower than the numerical treatment standards. Since numerical treatment levels are being finalized for wastewater forms of K174, the use of any technology (other than impermissible dilution) is allowed in complying with the treatment standards. Therefore, facilities are not required to use the suggested treatment train to manage wastewater forms of K174 and may use an alternative treatment train to meet the proposed numerical treatment standards.

EPA is also promulgating an alternative treatment standard of combustion (CMBST) for K174. Combustion is the basis for the dioxin/furan numerical limits in nonwastewaters, and properly conducted combustion should effectively destroy dioxin/furan constituents. If this method of treatment is used to treat K174 in certain specified combustion devices,[7] there would be no need to monitor compliance with numerical limits established for dioxin/furan constituents. However, all other constituents (i.e., arsenic) would require monitoring prior to land disposal.

4.3 Nonwastewater Forms of K174

4.3.1 Applicable and Demonstrated Technologies for Treating Dioxins/Furans

The technologies listed in this section are applicable and have been demonstrated to treat dioxin and furan congeners (or other organics) in nonwastewater forms of other hazardous wastes. EPA (1994a) presents a thorough discussion of these technologies. Those technologies deemed applicable to the physical and chemical characteristics of K174 are as follows:

- incineration
- fuel substitution
- solvent extraction

[7]The definition of CMBST is limited to: (1) combustion units operating under 40 CFR Part 266, (2) combustion units permitted under 40 CFR Part 264, Subpart O, or (3) combustion units operating under 40 CFR Part 265, Subpart O, which have obtained a determination of equivalent treatment under 40 CFR §268.42(b).

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- critical fluid extraction
- pressure filtration
- thermal drying of biological treatment sludge
- thermal desorption
- total recycle or reuse.

Except for total waste recycle and reuse, all of the treatment methods listed above generate additional wastes in liquid or solid form. Such wastes would require additional management, including additional treatment to meet applicable land disposal restriction treatment standards if necessary. Each technology is described below.

Incineration

Incineration is a destruction technology in which heat is transferred to the waste to destabilize chemical bonds and destroy hazardous organic constituents. Off-gases (following additional combustion in an afterburner) are fed to a scrubber system for cooling and for removal of entrained particles and acid gas. Three incineration technologies are applicable and demonstrated for organics in nonwastewaters: liquid injection, rotary kiln, and fluidized-bed. With the exception of liquid injection, incineration produces two residuals: scrubber water and ash. Only scrubber water is generated from liquid injection.

Fuel Substitution

Fuel substitution is a treatment technology in which heat is transferred to a waste to destabilize chemical bonds and destroy organic constituents. The process uses hazardous waste as fuel in industrial furnaces or boilers. The hazardous waste may be blended with other nonhazardous wastes and/or fossil fuels. It 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

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pharmaceuticals, pulp and paper, and pesticides. Fuel substitution generates two residuals: ash and scrubber water.

Solvent Extraction

Solvent extraction is a separation and recovery technology. The process 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 treated by this technology have a wide range of total organic content; selection of an appropriate solvent depends on the relative solubilities of the constituents to be removed and the other organic compounds in the waste. This technology generates two residuals: a treated waste residual and an extract.

Critical Fluid Extraction

This is a separation and recovery technology in which a solvent is brought to its critical state (liquified gas) to extract organic constituents from a waste. The solvents used are usually gases at ambient conditions. The solvent is converted from a gas to a liquid via pressurization. As a liquid, the solvent dissolved the organic constituents and extracts them from the waste matrix. Once it is extracted the solvent is returned to its original gaseous state. The technology generates two residuals: a treated waste residual and an extract. The extract is usually recycled or treated by incineration.

Pressure Filtration

Pressure filtration, also known as sludge dewatering, is a separation and recovery technology used for wastes that contain high concentrations (greater than 1 percent) of suspended solids. It separates particles from a fluid/particle mixture by passing the fluid through a medium that permits the flow of the fluid but retains particles. Pressure filtration generates two residuals: dewatered sludge and water.

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Thermal Drying

Thermal drying of biological treatment sludge is a destruction technology which uses controlled flame combustion or indirect heat transfer to elevate the temperature of the waste and, thereby volatilizes the organic constituents. Off-gas from the dryer is sent to an afterburner to complete combustion of the volatile component. This process generates two residuals: a treated waste residual and an extract.

Thermal Desorption

This is a separation and recovery technology in which direct or indirect heat exchange is used to volatilize organic constituents from wastes. Different from incineration, thermal desorption works by elevating the temperature of the organic constituents to effect a phase separation to a gaseous state without combustion. Thermal desorption units function by creating steam from the volatilization of the moisture in the waste from heating. The technology generates two residuals: a treated waste residual and an extract.

Total Recycle or Reuse

Total recycle or reuse within the same process or an external process eliminates waste generation. As a result of recycling, however, impurities may require removal from the system on a periodic or continuous basis.

4.3.2 Applicable and Demonstrated Technologies for Treating Arsenic

Applicable treatment technologies for metals include those that immobilize or reduce the total amount of metal constituents in a waste. The technologies discussed in this section are applicable and have been demonstrated to treat metal constituents in nonwastewater forms of other hazardous wastes. These technologies are commonly used to treat wastes which contain the metal constituents regulated

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by universal treatment standards. EPA (1994a) presents a thorough discussion of these technologies. The technologies applicable to the physical and chemical characteristics of K174 include the following:

- stabilization
- pyrometallurgical recovery process (high temperature metals recovery)
- hydrometallurgical recovery processes
- recycling
- slag vitrification.

Stabilization

Stabilization is a broad class of treatment technologies that reduces the mobility of metal constituents in a waste; the metals are chemically bound into a solid matrix that resists leaching when water or a mild acid solution comes into contact with the waste material. Organic materials usually are not stabilized effectively and may, in fact, inhibit the stabilization of metals. Hence, stabilization is applicable to nonwastewaters only after the organics have been removed by other treatment. (Additional discussion on stabilization technologies may be found in Section 5.2.1.)

Pyrometallurgical Recovery Processes (High Temperature Metals Recovery)

Pyrometallurgical recovery processes are those treatment technologies that use physical and chemical reactions at elevated temperatures for extraction/separation of metals, ores, salts, and other materials. For the purposes of the Land Disposal Restrictions Program, pyrometallurgical processes are referred to as High Temperature Metals Recovery (HTMR). Some examples of HTMR systems include rotary kilns, flame reactors, electric furnaces, plasma arc furnaces, slag reactors, and rotary hearth/electric furnaces. These thermal reduction processes use carbon, limestone, and silica (sand) as raw materials. The carbon acts as a reducing agent and reacts with metal oxides in a high temperature processing unit (e.g., kiln, furnace) to produce carbon dioxide and a free metal. This process yields a metal product for reuse and reduces the concentration of metals in the residuals.

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Hydrometallurgical Recovery Processes

Hydrometallurgical recovery processes extract and recover materials by using acidic solutions. These processes are most effective with wastes containing high concentrations of metals that are soluble in a strong acid solution or that can be converted by reaction with a strong acid to a soluble form. Some hydrometallurgical processes include chemical precipitation, leaching, ion exchange, solvent extraction, and electrowinning.

EPA is aware that some facilities are using a series of technologies, including chemical precipitation, ion exchange, and electrowinning, to recover metals from various metal-bearing waste streams. Some of these facilities claim that these hydrometallurgical processes, unlike other processes, generate no residuals for land disposal.

Recycling

For some metal-bearing wastes, recycling may be an applicable technology. For example, nonwastewater forms of K061 wastes, such as electric arc furnace dust, may by recycled directly back into the electric furnaces from which they were originally produced. Such practices facilitate the recovery of metals in steelmaking while reducing or eliminating the material designated for land disposal.

Slag Vitrification

The technology of slag vitrification is applicable to arsenic treatment. The vitrification process is demonstrated, commercially available, and achieves substantial treatment of arsenic. The vitrification process is capable of managing a wide variety of arsenic-bearing wastes. At the temperatures normally encountered in this process (1,100 to 1,400 EC), organoarsenic compounds will be combusted to arsenic oxide, carbon dioxide, and water. The arsenic oxide will react with the other glass-forming constituents present in the process, and become immobilized in the glass matrix.

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4.3.3 Identification of BDAT for Nonwastewater Forms of K174

EPA determines BDAT for individual constituents and wastes, upon review of all available performance data on treatment of the waste of concern or of similar wastes (EPA, 1994a). EPA determined the BDAT for the constituents requiring treatment in nonwastewater forms of K174. The constituents requiring treatment in K174 nonwastewaters are dioxins/furans and arsenic. For numerical treatment standards (such as being promulgated for arsenic), facilities may use any technology (other than impermissible dilution) to comply with the treatment standard and not necessarily the technology identified in this section as BDAT for arsenic. For nonwastewater forms of K174, EPA has identified a treatment train consisting of combustion followed by slag vitrification (if necessary to further immobilize arsenic) as BDAT. Such a treatment train would treat both organic and inorganic constituents.

In its development of UTS, identified incineration as BDAT for tetra, penta, and hexa dioxin/furan constituents (EPA, 1994a). Incineration is expected to perform equally well in treating hepta- and octa- dioxin and furan compounds, based on their similar structure to the other dioxin and furan constituents.

Slag vitrification was identified as BDAT for arsenic in developing the UTS. The vitrification process is capable of managing a wide variety of arsenic-bearing wastes.

4.3.4 Identification of Treatment Standards for Nonwastewater Forms of K174

EPA is finalizing numerical treatment standards for dioxins/furans and arsenic in nonwastewater forms of K174. EPA is transferring previously developed UTS for the following constituents:

- HxCDDs (All Hexachlorodibenzo-*p*-dioxins)
- HxCDFs (All Hexachlorodibenzofurans)
- PeCDDs (All Pentachlorodibenzo-*p*-dioxins)
- PeCDFs (All Pentachlorodibenzofurans)
- TCDDs (All tetrachlorodibenzo-*p*-dioxins)

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- TCDFs (All tetrachlorodibenzofurans)
- Arsenic.

EPA is promulgating numerical treatment standards for 1,2,3,4,6,7,8-HpCDD; 1,2,3,4,6,7,8-HpCDF; 1,2,3,4,7,8,9-HpCDF; OCDD; and OCDF. Treatment standards have been calculated based on the existing UTS and detection limit data for other dioxin congeners. Details of the numerical treatment standard development for these dioxins and furans is presented in Appendix A.

EPA expects the BDAT treatment train, described earlier, to result in treated waste with contaminant concentrations lower than the numerical treatment standards. Since numerical treatment levels are finalized for nonwastewater forms of K174, the use of any technology (other than impermissible dilution) is allowed in complying with the treatment standards. Therefore, facilities are not required to use the above treatment train to manage nonwastewater forms of K174 and may use an alternative treatment train to meet the final numerical treatment standards.

EPA is also promulgating an alternative treatment standard of combustion (CMBST) for K174. Combustion is the basis for the dioxin/furan numerical limits, and properly conducted combustion should effectively destroy dioxin/furan constituents. If this method of treatment is used to treat K174 in certain specified combustion devices,[8] there would be no need to monitor compliance with numerical limits established for dioxin/furan constituents. However, all other constituents (i.e., arsenic) would require monitoring prior to land disposal.

[8]The definition of CMBST is limited to: (1) combustion units operating under 40 CFR Part 266, (2) combustion units permitted under 40 CFR Part 264, Subpart O, or (3) combustion units operating under 40 CFR Part 265, Subpart O, which have obtained a determination of equivalent treatment under 40 CFR §268.42(b).

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5.0 TREATMENT STANDARD DEVELOPMENT FOR K175

This section describes the treatment standards that EPA is promulgating to best meet the requirements of RCRA Section 3004(m) for wastewater and nonwastewater forms of K175. As presented in Section 3, treatment standards are being developed for mercury in wastewater and nonwastewater forms of K175.

Treatment technologies applicable to mercury in wastewater and nonwastewater forms of K175 wastes are discussed in Sections 5.1.1 and 5.2.1, respectively. Identification of BDAT and the treatment standards for wastewater and nonwastewater forms of K175 are presented in Sections 5.1.2 and 5.2.2, respectively.

5.1 Wastewater Forms of K175

5.1.1 Applicable and Demonstrated Technologies for Treating Mercury

Technologies applicable for treatment of mercury-containing wastes are those that reduce the concentration of mercury metals and/or reduce the leachability of these metals leaving behind a treated residual for land disposal. This section describes applicable and demonstrated treatment technologies for mercury removal from wastewater forms of K175. These technologies are based on EPA's *Final Best Demonstrated Available Technology (BDAT) Background Document for Mercury-Containing Wastes D009, K106, P065, P092, and U151* (1990), and include the following:

- chemical precipitation and chemical reduction
- chemical oxidation of organomercury constituents
- carbon adsorption and ion exchange.

Applicable technologies for the treatment in mercury also include some of those described in Section 4, including activated sludge, chemically assisted clarification, lime conditioning, sedimentation, filtration, and trickling filter treatment systems.

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Chemical Precipitation and Chemical Reduction

EPA has identified chemical precipitation and chemical reduction, both followed by filtration, as applicable to treatment of mercury-containing wastewaters with high concentrations of inorganic mercury compounds. Chemical precipitation followed by filtration removes BDAT list metals and concentrates them in the wastewater treatment sludge. Chemical reduction (with reagents such as sodium borohydride) reduces mercury to the metallic state. The reduction step is then followed by filtration to remove mercury and other solids.

The applicability of chemical precipitation and chemical reduction technologies depends to some extent on the form of mercury in the waste (e.g., dissolved ionic, pure metal, and insoluble ionic). Mercury in the dissolved ionic form (soluble mercuric compounds, for example) may be reduced to the pure metal by the borohydride reduction process, while this process may not be effective in treatment of the insoluble mercury compounds. The borohydride process cannot remove the small amount of metallic mercury that is soluble in water. Chemical oxidation treatment may be required to oxidize metallic mercury to soluble ionic mercury prior to chemical precipitation treatment. The solids produced as a residual from chemical reduction processes are, in general, easier to treat by pyrometallurgical methods than are the solids produced in chemical precipitation treatment because they contain mercury in its elemental form rather than as mercuric salts.

Chemical precipitation (using sulfide) followed by filtration has been selected as BDAT for treatment of K071 wastewaters. Sulfide precipitation of mercury-containing wastewaters is widely used in the domestic chlor-alkali industry (EPA, Waste Specific Evaluation of RMERC Treatment Standard, 1998). It is also used by Borden Chemicals, the one facility identified as generating K175, for its treatment of mercury-containing wastewaters. In the treatment of other metals in wastewater forms of waste, discussed in Sections 4, lime is also used as a precipitation agent.

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Chemical Oxidation of Organomercury Constituents

EPA has identified chemical oxidation followed by chemical precipitation and filtration as an applicable technology for wastewaters containing organomercury constituents. Chemical oxidation breaks the bonds between the mercury and the organic components of these constituents. Chemical precipitation then treats the mercury in the inorganic form. Chemical oxidation technologies are also demonstrated for treatment of wastewaters containing oxidizable inorganic constituents (such as cyanide or cyanate).

Carbon Adsorption and Ion Exchange

Two other technologies, carbon adsorption and ion exchange, are also applicable to treatment of wastewaters containing relatively low concentrations of dissolved mercury. The mercury must be in the soluble mercuric (Hg^{+2}) form in order to be removed by these technologies. Thus, these technologies may require pretreatment by chemical oxidation to solubilize any insoluble inorganic mercury. Carbon adsorption will also remove mercury from wastes containing dissolved organomercury compounds.

Carbon adsorption and ion exchange produce both a wastewater residual (from regeneration of the ion exchange resin or activated carbon bed) and a nonwastewater residual (the spent carbon or ion exchange resin, when these are exhausted and must be discarded). The waste regenerant solutions (usually acid solutions) are more concentrated than the originally treated waste. This waste usually is treated for mercury removal by chemical precipitation followed by filtration if these regenerant solutions are not recyclable to the process originally generating the waste. Spent carbon can be incinerated (if mercury emissions are controlled) or processed in a retort to recover residual mercury. The spent resins may also be processed by retorting to recover residual mercury.

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Ion exchange is demonstrated (as of 1990) at many facilities in Europe for treatment of wastewaters generated from the mercury cell chlor-alkali process. Activated carbon adsorption is also used at several facilities for treatment of inorganic/organo mercury-containing wastewaters.

5.1.2 Identification of BDAT and Treatment Standards for Wastewater Forms of K175

In its development of UTS for wastewater forms of mercury, EPA identified lime conditioning followed by sedimentation and filtration as BDAT for treating mercury (EPA, 1994b). This treatment train was used to calculate the universal treatment standard for mercury in wastewaters of 0.15 mg/L. EPA is promulgating this numerical treatment standard of mercury for wastewater forms of K175.

5.2 Nonwastewater Forms of K175

The numerical treatment standard for mercury being promulgated for K175 represents a departure from those previously established for mercury-containing wastes, such as D009. Traditionally, EPA has promulgated technology-based treatment standards for the treatment of mercury in nonwastewater forms of hazardous wastes, when the mercury is present above 260 mg/kg. For example, 40 CFR §268.40 lists the treatment standard for organic-containing D009 as retorting or roasting (RMERC) or incineration in units operated in accordance with the technical operation requirements of 40 CFR Part 264, Subpart O and Part 265, Subpart O (IMERC).

The 1997 Mercury Study Report to Congress has identified sources that potentially release mercury to the air, as well as identifying subsequent human health and environmental effects from mercury in the environment. Pyrometallurgical processes, such as RMERC and incineration, are potential sources of airborne mercury in the environment. Additionally, EPA has published an advanced notice of proposed rulemaking (ANPRM) concerning alternative treatment technologies for mercury (with emphasis on nonwastewater forms of mercury); in the future, current land disposal restriction requirements for certain mercury-containing hazardous wastes may be changed. A principal

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reason for this re-examination is to investigate the environmental impacts of these technologies (64 *FR* 28949, May 28, 1999).

Recent events have heightened the Agency's awareness that the solubility of metals can be highly pH dependent and not adequately predicted by a single test. (See 63 FR 51225, September 24, 1998) Therefore, the Agency evaluated the mobility of mercury from this waste as a function of pH. Calculated solubilities of mercury sulfide (metacinnabar) as a function of pH have revealed that above pH 6.0 the presence of sulfide complexes results in significantly increased solubility.[9,10] Preliminary results from constant pH leaching measurements of the subject waste, as part of an on-going study, have shown similar results.[11] At pH 6.0 the waste tested leached 0.0058 mg/L. However, at pH 10, 1.63 mg/L mercury was solubilized. Current landfill disposal site conditions for this waste are reported to be pH 9.48-9.57.[12] Under these conditions, mercury in the waste would be expected to be mobilized especially if excess sulfides were present. To avoid significant mobilization of the mercury present in the VCM-A sludge, EPA proposed that both the waste itself and the waste disposal conditions would need to be restricted to codisposal with materials less than pH 6.0. Subsequent comments from industry regarding the feasibility of codisposing K175 wastewater treatment sludge in this manner have led EPA to consider other means of controlling the pH environment of K175 sludge. As an alternative to requiring that K175 be co-disposed with similar wastes with pH #6.0, EPA is alternatively requiring macroencapsulation, which would isolate K175 sludge from other wastes.

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[9]H. Lawrence Clever, Susan A. Johnson, and M. Elizabeth Derrick, *The Solubility of Mercury and Some Sparingly Soluble Mercury Salts in Water and Aqueous Electrolyte Solutions*, J. Phys. Chem. Ref. Data, Vol. 14, No. 3, 1985, page 652.

[10]In Chemical Equilibrium (Bard, A.J., Harper and Row, Publishers, New York, 1966).

[11] Paul Bishop, Renee A. Rauche, Linda A. Rieser, Markram T. Suidan, and Jain Zhang; "Stabilization and Testing of Mercury Containing Wastes," Draft, Department of Civil and Environmental Engineering, University of Cincinnati, March 31, 1999. Please note that this is a draft EPA document not yet peer reviewed. Also, data within the report is still undergoing QA/QC review, and the text, data, and conclusions in the report may change before the document is finalized.

[12] May 14, 1999, landfill parameters, e-mail from Mitch Hahn, Waste Management.

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5.2.1 Applicable and Demonstrated Technologies for Treating Mercury

EPA has identified the following technologies applicable for treatment of nonwastewaters containing mercury:

- incineration (with further treatment of the residue if necessary)
- thermal mercury recovery processes
- acid leaching process
- chemical oxidation
- stabilization
- macroencapsulation

Descriptions of each of these technologies are, in general, obtained from EPA (1990), with information for stabilization and thermal recovery supplemented with more recent information. Background information regarding macroencapsulation is found in EPA (1991). Discussion includes the effectiveness of these technologies in treating wastes with high levels of organics and with mercury in sulfide form, which are characteristics of K175.

Incineration

Incineration (e.g., IMERC as identified in 40 CFR §268.42) is applicable for treatment of nonwastewaters containing organomercury compounds or mercury in an organic waste matrix. Treatment using incineration technologies will destroy the organic constituents of the waste. As a consequence of destruction of the organics, incineration will break the organic-metal bond in the organometallic waste constituents. The metallic part of the organometallic constituents in the waste, as well as any metals present in a mixed metal/organic waste, will remain in the residual (ash) generated, will be removed from the gases exiting the incinerator by the air pollution control equipment, or will remain in the gases exiting the incineration system. The resulting residue would require further treatment using one of the technologies identified in this section (e.g., stabilization, thermal mercury recovery) to treat the mercury.

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Thermal Mercury Recovery Processes

The RMERC treatment standard includes retorting or roasting in a thermal processing unit capable of volatilizing mercury and subsequently condensing the volatilized mercury for recovery (40 CFR §268.42). Thermal mercury recovery processes volatilize mercury from the waste at high temperatures and then condense and collect it as the pure metal, reducing the mercury concentration in the treatment residual compared to that in the untreated waste.

Retorting and roasting processes can be operated as batch processes in a closed vessel or continuously in a furnace. In retorting processes the waste is heated, the mercury is vaporized, and then it is collected in a condenser. The vessel is usually kept either at a slightly negative pressure or under a strong vacuum. Air is not introduced from outside the vessel. Roasting processes are usually operated continuously, but may be operated in batch. In roasting, air is supplied to the system as a source of oxygen to enable decomposition of some mercury compounds. EPA (1990) and EPA (1998) present further discussion of retorting and high-temperature metals recovery technologies.

Distillation technologies are applicable to treatment of wastes containing high concentrations of metallic mercury, such as U151. The residuals from distillation technologies are a high-purity mercury as the "overhead" product and the remaining solid residual referred to as the "bottoms."

As of 1998, several chlorine production facilities effectively manage their sulfide-containing K106 in onsite RMERC units. As a consequence, EPA considers retorting to be demonstrated for K106. However, difficulties of mercury sulfide treatment were documented in the EPA "Waste Specific Evaluation of RMERC Treatment Standard" 1998 report and confirmed with recent (1999) EPA discussions with Bethlehem Apparatus, a commercial RMERC facility. Specifically, mercury sulfide is difficult to treat because elemental mercury condensed from the fuming process in mercury retorters easily recombines with the available sulfide ions. Additives are needed to prevent recombination, but this addition to the treatment train likely leads to an increase in waste treatment costs. Public comments received on the chlorinated aliphatics proposed rule also indicate that

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treatment of K175 using RMERC has not been demonstrated. While some reclamation facilities have successfully retorted wastes similar to K175, both technical and regulatory difficulties were identified by the generator of K175 as potential barriers to recovery.

The presence of organic material may also cause difficulties for treatment (for example, the sludge contains 43 percent organic matter and an oil and grease content of 4 percent), as well as the presence of chloride (not measured in EPA record sampling, but likely present in the waste because the waste is generated from vinyl chloride production). Difficulties associated with the presence of chloride and organic chloride include the formation of impurities and acids in the presence of steam that are corrosive to equipment. Further details are presented in the EPA "Waste Specific Evaluation of RMERC Treatment Standard" 1998 report.

Retorting is also demonstrated for treatment of nonsulfide-containing mercury nonwastewaters. U151 wastes and inorganic D009 wastes, such as mercury lamps, debris, contaminated equipment, and mercury cell batteries, are routinely treated by retorting, vacuum or scrap metal distillation.

Acid Leaching Process

Acid leaching solubilizes low concentrations of mercury in wastes, reducing the concentration of mercury in the nonwastewater treatment residual. The acid leaching process used for treatment of K071 wastes involves a chemical oxidation step followed by a step combining sludge dewatering and acid washing. This process generates an acid leachate (wastewater) that contains the mercury in soluble ionic form and requires treatment by chemical precipitation.

Acid leaching is demonstrated at chlor-alkali facilities generating K071 wastes. K071 wastes contain soluble mercuric chloride, insoluble mercuric oxide, and elemental mercury (EPA, 1988). This technology requires an additional step of oxidation to convert insoluble forms of mercury to the mercuric (+2) form, which is soluble. The soluble mercuric form can then be precipitated as sulfide salt.

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Chemical Oxidation of Organomercury Compounds

Chemical oxidation is applicable to the treatment of wastes containing organomercury constituents (such as phenyl mercuric acetate, P092). Chemical oxidation treatment of organomercury compounds involves addition of a chemical oxidizing agent such as chlorine, hypochlorite, permanganate, or ozone in an aqueous reaction medium. Chemical oxidation results in the breaking of the organic-mercury chemical bond, thereby generating a residual from which the organic contaminant can either be destroyed (by further oxidation or incineration) or recovered (by distillation). The inorganic mercury wastewaters resulting from chemical oxidation treatment can be treated by one of the technologies identified in Section 5.1.1 as applicable for wastewaters containing inorganic mercury compounds.

Stabilization

Stabilization is applicable for treatment of nonwastewaters containing metals, including mercury, in an inorganic waste matrix. Stabilization treatment involves mixing the waste with a binding agent that is designed to reduce the leachability of metals from the waste.

In 1990, stabilization was identified as potentially applicable for treatment of (mercury sulfide-containing) K106 nonwastewaters and possibly additional nonwastewaters. Stabilization typically binds BDAT list metals into a solid form that is more resistant to leaching than the metals in the untreated waste. EPA's testing of cement, kiln dust, and lime/fly ash stabilization for treatment of K106 nonwastewaters generated by sulfide precipitation indicates that the technology did not provide effective treatment. EPA believes the ineffectiveness of stabilization treatment of K106 in this EPA test may have resulted from the mercury sulfide behavior in alkaline media. Based on the available data, EPA has concluded that stabilization with alkaline materials may not be demonstrated for K106 wastes containing high concentrations of mercury sulfide. Other stabilizing agents, such as proprietary asphalt or silicate agents, may also be applicable, but data to enable such a determination have not been provided to EPA.

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In 1998, wastes from one facility that generates sulfide-stabilized K175 sludge were sampled for analysis of the mobility of mercury in these wastes (Bishop et al., 1999). Within an optimum pH range of 3.5 to 5.0, the facility applies sodium sulfide to stabilize the waste before sending the waste to a Subtitle C landfill. Some of the results from this study were summarized earlier in Section 5.2. Several analytical tests were used for characterizing the stability of the facility's sulfide-stabilized waste. A test of the waste stability under varying liquid:solid (or leachant:sample) ratios demonstrated that leaching rates are not controlled by the concentration gradient between the waste and the test leachant (deionized water). An acidity test confirmed that mercury leaching in the waste is not limited by diffusion. The acidity test also showed that characteristically this waste has a low buffer capacity which further diminishes above pH 6.0. The low buffer capacity could account for a wide variation in pH values reported for the waste and its landfill leachates. Six TCLP tests under low pH conditions demonstrated that the waste is well stabilized under simulated landfill conditions. A test of constant pH leaching showed that mercury leaches excessively at a pH higher than 6.0. Finally, an analysis of redox potential, using titration with hydrogen peroxide, showed that most oxidation occurs earlier (in the first 30 seconds). It also showed that almost no sulfide was oxidized to sulfate by hydrogen peroxide in solution, and this result meant that the chemistry of the waste was not appreciably changed by the addition of hydrogen peroxide.

From the test results described above, the importance of pH on minimizing mobilization of mercury in K175 wastes was identified. Mobilization may be controlled by adding an exact stoichiometric amount of sulfide to prevent formation of the more water soluble mercuric bisulfide compounds, which may be difficult to implement. Controlling the pH of the waste and co-disposed wastes may be a more feasible alternative.

EPA has other data documenting stabilization of wastes with similar mercury content using sulfide treatment. These are discussed below.

In November 1999, the Environmental Technology Council (ETC) provided comments on the chlorinated aliphatics proposed rule. ETC's comments referenced and reiterate the statements made in

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support of mercury stabilization technologies in the June 1993 "Petition For Rulemaking to Amend 40 C.F.R. Part 268 To Establish Alternative BDAT Treatment Standard For D009 Mercury Wastes Containing Greater Than 260 mg/kg Mercury," by the Hazardous Waste Treatment Council (later known as ETC). While the data presented in the petition do not demonstrate treatment of mercury wastes to less than 0.025 mg/L TCLP mercury, they claim that with minor modifications to this stabilization technology K175 mercury wastes containing 1 to 2 percent mercury can be treated to 0.025 ppm TCLP mercury.

This petition referenced other documents that provided waste treatment data for mercury wastes, including a petition filed by CyanoKEM Inc. in April 1993 ("Petition For Emergency LDR Rulemaking Requesting an Alternative BDAT Standard for D009 Mercury Wastes Containing Greater Than 260 ppm Mercury." CyanoKEM presented data from 1991 using chemical stabilization technology to treat inorganic mercury salts. This involves a step-wise mercury oxidation followed by sulfide precipitation. CyanoKEM states that the resulting mercuric sulfide product is then stabilized by conventional solidification and/or stabilization agents. Table 5-1 shows the TCLP leachate levels CyanoKEM achieved using this treatment method to treat such mixed batches of mercury waste.

Table 5-1. Selected Results of Chemical Stabilization and Spiked Mercury Quality Control Analyses Performed by CyanoKEM Labs

Batch number [A]	Total mercury in untreated/raw waste batch (ppm) [B]	TCLP mercury in treated/stabilized batch (ppm)	Mercury spike recovery @ 1 ppm conc. (percent)
RM1646	37,000	0.06	102.5
RM1651	37,000	<0.05	87
RM1793	26,418	0.05	101
RM2101	34,000	0.07	96
RM2196	61,400	0.16	93

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Table 5-1. Selected Results of Chemical Stabilization and Spiked Mercury Quality Control Analyses Performed by CyanoKEM Labs			
Batch number [A]	**Total mercury in untreated/raw waste batch (ppm) [B]**	**TCLP mercury in treated/stabilized batch (ppm)**	**Mercury spike recovery @ 1 ppm conc. (percent)**

Source: Petition for Emergency LDR Rulemaking Requesting an Alternative BDAT Standard for D009 Mercury Wastes Containing Greater Than 260 ppm Mercury. CyanoKEM Inc. April 26, 1993.
A. Sample numbers provided are the sample numbers that originally were assigned by CyanoKEM Inc.
B. Most of the batches were made up of various combinations of aqueous liquid, dry solids, sludge, acidic liquid, and vermiculite. The value presented here represents a weighted average. Species that went into some of the batches include mercury salts, mercuric chloride, mercurous chloride, mercurous nitrate, mercuric oxide, mercury sulfide, mercury sulfate, mercuric thiocyanate, high chromium and nickel solutions, ferric chloride, Hg(ClO3)2, and mixed metal solutions. The exception is the RM1793 batch which solely consisted of an aqueous liquid containing mercuric iodide.

ETC's 1999 comments also reference ETC's 1990 comments to EPA on the Third Third Rulemaking (Docket No. F-89-LD12-FFFFF). These comments included additional results of mercury stabilization testing data from member companies. (These data are not presented here because initial waste concentrations were not provided).

Macroencapsulation

Macroencapsulation is one of the promulgated treatment standard for hazardous debris (40 CFR 268.45 Table 1), which were finalized in 1992. Additionally, the treatment standard of 'MACRO' is the technology-specific treatment standard for the radioactive lead solids subcategory for characteristically hazardous D008 (TC lead) wastes. The definition of macroencapsulation in 40 CFR 268.45 Table 1 is "application of surface coating materials such as polymeric organics (e.g., resins and plastics) or use of a jacket of inert inorganic materials to substantially reduce surface exposure to potential leaching media." The technology code 'MACRO' as defined in 40 CFR 268.42 Table 1 adds that "macroencapsulation specifically does not include any material that would be classified as a tank or container according to 40 CFR 260.10."

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The purpose of macroencapsulation is to isolate a hazardous material to reduce the potential for leaching. The first step of the encapsulation is a pre-drying step, which removes all liquid from the waste. This can be conducted using a dehydrating agent such as lime, kiln dust or Portland cement. The sludge can be microencapsulated in a second step, prior to the coating (macroencapsulation) of the entire mass with a substance such as high-density polyethylene (EPA, 1991). Following this, the waste can be landfilled.

Macroencapsulation was not proposed as a treatment standard for K175 in the August 1999 rule. Rather, Borden Chemicals and Plastics (the generator of K175) suggested in its public comments that "one alternative to the co-disposal option would be macroencapsulation. Macroencapsulation involves enclosing the filter cake in an HDPE vault. This option would be valid for several reasons. First, the waste would be isolated from other materials thus eliminating concerns about mixture with higher pH wastes. Second, the vault would serve as tertiary containment and encapsulation, preventing both the infiltration of liquids into the filter cake and the migration of any liquids from the filter cake to the landfill."

Following the hazardous debris rules promulgated in 1992, macroencapsulation has been used successfully to contain hazardous debris. However, EPA lacks performance data on the use of macroencapsulation, particularly its long-term effectiveness. Nevertheless, EPA anticipates that the characteristics of K175 wastes are compatible with macroencapsulation treatment. For example, the long term effectiveness is expected to be affected by oxidizing agents, organic solvents, oil and grease, and chelating agents (EPA, 1991). Such characteristics are absent from K175, and the proposed requirement (August 25, 1999) to maintain the waste slightly acidic at pH less than 6 is also expected to be compatible. The waste as generated has a moisture content of 56 percent (Table 2-1), whereas macroencapsulation treatment typically requires a drier material to prevent interferences during the treatment process. EPA expects the previously identified moisture reduction mechanisms to be relatively easy to implement for K175, if necessary.

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5.2.2 Identification of BDAT and Treatment Standards for Nonwastewater Forms of K175

In conjunction with EPA's recent and ongoing activities of mercury in the environment, and uncertainties of the application of both mercury recovery technology and a restriction regarding co-disposed wastes for K175 (both of which were identified as possible treatment alternatives in the proposed rule), EPA is promulgating a treatment standard for nonwastewaster K175 that must meet several criteria. First, the waste must meet the numerical treatment standard of 0.025 mg/L mercury as measured by the TCLP. Second, the pH of the treated waste must be 6.0 or less. Third, the waste must either be macroencapsulated (in accordance with 40 CFR 268.45 Table 1), or be disposed in a monofill, or be disposed in a landfill cell that only receives wastes that have a pH less than or equal to 6.0.

These requirements are more extensive than simple application of the UTS. EPA has identified that K175 waste can leach elevated concentrations of mercury (i.e., above UTS) when subject to high pH (i.e., above 6), due to the properties of a mercuric sulfide / hydrogen sulfide complex. To ensure stability of the treated waste and proper long-term disposal, EPA is also promulgating a requirement that K175 wastes be additionally treated using macroencapsulation or are only co-disposed with similar wastes.

As identified in the preamble to the proposed rule, EPA is concerned that the co-disposal of other wastes (e.g., higher pH wastes) may affect the leaching characteristics of K175. As identified above, the mercury concentration in K175 leachate is pH dependent, with minimum solubility below pH 6. For this reason, EPA proposed to restrict disposal to landfill units that only accepted wastes with similar, pH<6 wastes. In response to commenter concerns by Borden that such a requirement could be problematic EPA is additionally promulgating a macroencapsulation requirement (as an alternative to finding a landfill with the characteristics described). EPA's intent remains to maintain a slightly acidic (pH<6) environment around the waste for as long as possible, and EPA anticipates that macroencapsulation will achieve this goal.

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EPA expects that encapsulation would significantly reduce the likelihood that K175 sludge would come in direct contact with high pH conditions that could promote the leaching of mercury through a landfill. Also, at Borden Chemical's suggestion, using macroencapsulation rather than co-disposal with other wastes below pH 6.0 would provide a more viable means of disposal for the relatively small amount of K175 waste generated. In light of the comments of Borden regarding the restrictive co-disposal requirement, EPA is finalizing macroencapsulation as one of the treatment standard requirements for K175 but is retaining co-disposal in a landfill cell with wastes with pH #6.0 should such a landfill be available in the future.

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APPENDIX A. NUMERICAL TREATMENT STANDARD DEVELOPMENT FOR HEPTA-/OCTA- DIOXINS AND FURANS

EPA has previously promulgated numerical treatment standards (i.e., universal treatment standards, or UTS) for all but five constituents proposed for inclusion in 40 CFR §268.40 for wastewater or nonwastewater forms of K174. These constituents, for which numerical treatment standards in K174 wastes are required, are as follows:

- 1,2,3,4,6,7,8-heptachlorodibenzo-*p*-dioxin
- 1,2,3,4,6,7,8-heptachlorodibenzofuran
- 1,2,3,5,7,8,9-heptachlorodibenzofuran
- 1,2,3,4,6,7,8,9-Octachlorodibenzo-*p*-dioxin (OCDD)
- 1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF).

Currently, UTS are available for tetra-, penta-, and hexa- dioxin and furan isomers, expressed, for example, as all pentachlorodibenzo-*p*-dioxins (40 CFR §268.48). Setting treatment standards for only the above three hepta-isomers and two octa-isomers, rather than the classes of all hepta-dioxins and furans, would satisfy the requirements of RCRA 3004(m) to substantially reduce the toxicity of the waste. This is due to the following reasons:

- The three hepta-isomer and two octa-isomer compounds contain chlorine atoms in the 2, 3, 7, and 8 positions of the dibenzo-*p*-dioxin and dibenzofuran structures. As a result, they exhibit the co-planar structure of the congeners of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin and 2,3,7,8-tetrachlorodibenzofuran and therefore represent the most toxic compounds in the hepta-dioxin and furan series. Other dioxin and furan isomers with chlorine atoms substitutions, but not in the 2, 3, 7, and 8 positions are not as toxic as the above compounds.

- A waste treated to achieve treatment standards for these compounds is also likely to exhibit lower concentrations of the other hexa-dioxin and furan isomers, because the other isomers are likely to be affected similarly in treatment.

- These five compounds are being included in 40 CFR 261 Appendix VII as the basis for listing hazardous wastes K174.

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Treatment Standard Development for Nonwastewaters

EPA has previously determined that BDAT for the tetra-, penta-, and hexa- dioxins and furans in nonwastewaters is incineration. See Table 4-1 in Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards: Volume A: Universal Standards for Nonwastewater Forms of Listed Hazardous Wastes, July 1994. EPA expects hazardous waste incineration to achieve at least 99.99 percent destruction of hazardous constituents such as dioxins and furans. In the Solvents and Dioxins Rule (i.e., Hazardous Waste Management System, Land Disposal Restrictions Final Rule, 51 FR 40572, November 7, 1986), EPA determined that destruction of these dioxins and furans to below the detection limit available at the time (1 ppb) could be expected (51 FR 40615).

Quantitation limits for dioxins and furans using SW-846 Method 8280A are dependent on the target compound. For example, the quantitation limit for 2,3,7,8-TCDD in fly ash is given as 1.0 µg/kg. The quantitation limit of 1,2,3,4,6,7,8-HpCDD in fly ash is given as 2.5 µg/kg (quantitation limits for 1,2,3,4,6,7,8-HpCDF and 1,2,3,4,7,8,9-HpCDF are also given as 2.5 µg/kg in fly ash). The quantitation limits of OCDD and OCDF in fly ash are given as 5.0 µg/kg. To account for this difference in method performance, EPA is promulgating a numerical treatment standard for these compounds which is higher than the existing UTS standard for TCDDs. EPA is therefore promulgating a treatment standard of 0.0025 mg/kg for 1,2,3,4,6,7,8-heptachlorodibenzo-*p*-dioxin; 1,2,3,4,6,7,8-heptachlorodibenzofuran; and 1,2,3,5,7,8,9-heptachlorodibenzofuran. Similarly, for OCDD and OCDF, EPA is finalizing a treatment standard of 0.0050 mg/kg.

A second basis for the treatment standard of 0.0025 mg/kg and 0.0050 mg/kg for the above compounds is as follows. EPA estimates that quantitation limits would approximate the values of 2.8 times the method detection limits normally used to develop treatment standards from detection limit data. By definition the quantitation limit is 3 to 4 times the method detection limit.

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Existing Treatment Data for Dioxins/Furans

EPA has no treatment data for HpCDDs, HpCDFs, or OCDF in nonwastewater forms of wastes using thermal processes; EPA has treatment data for OCDD in nonwastewater forms of wastes using thermal processes. EPA investigated the NRMRL data base [U.S. Environmental Protection Agency, National Risk Management Research Laboratory Treatability Database, Version 5, EPA/600/C-93/003a (1994)] for data demonstrating dioxin and furan removal using thermal processes. Treatment data were not available for incineration (the BDAT), however data were available for thermal destruction at pilot and full scale for dioxin and furan-containing wastes. Table A-1 summarizes these results. EPA expects incineration to achieve performance at least as effective as that shown here. Concentrations of tetrachlorodibenzo-*p*-dioxins and furans were reported as not detected in many of the samples, with a maximum detection limit of 38 ng/kg (38 ppt). When detected, the waste did not exceed concentrations of 16 ng/kg (16 ppt). For OCDD, concentrations in the soil residue were consistently detected, ranging from 2.4 to 23 ng/kg (up to 23 ppt). These data support EPA's conclusion that removal to 0.0025 mg/kg (2,500 ppt or 2,500 ng/kg) is feasible when using BDAT for HpCDDs and HpCDFs, and removal to 0.0050 mg/kg (5,000 ppt or 5,000 ng/kg) is also feasible when using BDAT for OCDD and OCDF. Further, the compounds can be quantified to this level in a matrix such as combustor or incinerator ash residue.

EPA did not use the treatment data for OCDD in calculating the proposed numerical treatment standard because the initial concentrations of the compound in the waste are much lower than levels expected to be present in K174 nonwastewaters. Specifically, concentrations of OCDD in nonwastewater forms of K174 range up to 6.48 ug/kg (6,480 ng/kg); see Table 3-1. However, the OCDD treatment data in Table A-1 result from the treatment of soil with initial OCDD concentrations ranging from 640 to 1,200 ng/kg.

Since Method 8280A was first developed, the more sensitive high-resolution mass spectrometry Method 8290 has been developed. Method 8290 may achieve detection limits three orders of magnitude more sensitive than Method 8280A. However, EPA lacks actual treatment

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performance data for these wastes using Method 8290. Further, because of the trace levels of dioxins/furans that Method 8290 is capable of detecting, EPA has no assurance that treatment would achieve the much lower non-detectable levels of Method 8290. Therefore, numerical treatment standards are being promulgated based on the more widely available Method 8280A.

Existing Data and Treatment Standard Development for Wastewaters

EPA has previously established UTS for dioxin and furan constituent classes in wastewater forms of hazardous wastes. The data used in developing these standards are described in Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards: Volume A: Universal Standards for Wastewater Forms of Listed Hazardous Wastes, July 1994. Treatment standards have been developed for the compounds presented in Table A-2. Table A-2 also presents the treatment data used in developing the standard, the source of the treatment data, and the resulting standard.

Treatment data for heptachlorodibenzo-*p*-dioxins were not available. Treatment data for heptachlorodibenzofurans were available using the treatment train of bench-scale dechlorination of toxics using an alkoxide formed by the reaction of potassium hydroxide with polyethylene glycol. Treatment data for OCDD were available using the technologies of activated sludge and sedimentation. Treatment data for OCDF were available using activated sludge, and the above mentioned dechlorination treatment train using potassium hydroxide and polyethylene glycol (NRMRL, 1994). These data are summarized in Table A-3.

EPA did not use any of the data in Table A-3 for treatment standard development. In regard to the dechlorination treatment train consisting of potassium hydroxide and polyethylene glycol treatment, EPA is not aware of any full scale process using this technology and thus did not use these data in developing numerical treatment standards. In regard to the remaining data based on available technologies of sedimentation and activated sludge, these data are from the treatment of domestic sewage, which may not represent the K174 wastewater matrices.

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EPA expects that hepta- and octa-forms of dioxins and furans can be adequately treated using biological treatment, based on the data presented in Table A-2. Specifically, effluent concentrations of 0.0025 µg/L can be expected based on performance data for pentachlorodibenzofurans. A treatment standard of 0.035 µg/L was developed for pentachlorodibenzofurans based on these data[13]. EPA is therefore requiring a treatment standard of 0.035 µg/L for 1,2,3,4,6,7,8-heptachlorodibenzo-*p*-dioxin; 1,2,3,4,6,7,8-heptachlorodibenzofuran; and 1,2,3,5,7,8,9-heptachlorodibenzofuran. For OCDD and OCDF , a treatment standard of 0.063 µg/L is being finalized based on the performance of TCDDs. The Method 8280 quantitation limit for OCDD and OCDF is 0.050 µg/L, which is lower than the new standard.

Table A-1. Treatment Data for Dioxins and Furans in Soil Using Thermal Destruction

Final Concentration in Soil	Destruction, %
Tetrachlorodibenzo-*p*-Dioxins	
< 190 pg/hr	>99.9999
<38 ng/kg	>99.98
<360 pg/hr	>99.9999
<33 ng/kg	>99.98
<1.5 ng/kg	>99.995
<1.5 ng/kg	>99.997
<890 pg/kg	>99.998
<2.2 ng/kg	>99.995
<2.5 ng/kg	>99.996
Tetrachlorodibenzofurans	
<85 pg/kg	>99.8
13 ng/kg	97
16 ng/kg	97

[13] U.S. Environmental Protection Agency. Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards: Volume B: Universal Standards for Wastewater Forms of Listed Hazardous Wastes. July 1994.

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Final Concentration in Soil	Destruction, %
6.7 ng/kg	99
11 ng/kg	99.1
Octachlorodibenzo-*p*-Dioxins	
2.4 ng/kg	99.7
4.4 ng/kg	99.3
19 ng/kg	97
23 ng/kg	97
12 ng/kg	99

Source: NRMRL, 1994. No other thermal treatment data are available for other dioxins and furans from this source.

Table A-2. Treatment Data for Dioxins and Furans (with Existing UTS) in Wastewaters

Constituent	BDAT	Treatment Data	Resulting Standard
Hexachlorodibenzo-*p*-dioxins	Biological Treatment	No data (transfer from TCDDs)	0.063 µg/L
Hexachlorodibenzofurans	Biological Treatment	No data (transfer from TCDDs)	0.063 µg/L
Pentachlorodibenzo-*p*-dioxins	Biological Treatment	No data (transfer from TCDDs)	0.063 µg/L
Pentachlorodibenzofurans	Biological Treatment	Average effluent concentration of 0.0025 µg/L. Based on 6 data points from industry-submitted data.	0.035 µg/L
Tetrachlorodibenzo-*p*-dioxins	Biological Treatment	Average effluent concentration of 0.0045 µg/L. Based on 6 data points from industry-submitted data.	0.063 µg/L
Tetrachlorodibenzofurans	Biological Treatment	No data (transfer from TCDDs)	0.063 µg/L

Source: Final Best Demonstrated Available Technology (BDAT) Background Document for Universal Standards: Volume A: Universal Standards for Wastewater Forms of Listed Hazardous Wastes, July 1994.

Table A-3. Treatment Data for Hepta- and Octa- Dioxins and Furans in Wastewaters

Constituent	Description of Treatment	Effluent Concentration	Influent Concentration	% Removal
Heptachlorodibenzo-*p*-dioxins	No data			
Heptachlorodibenzofurans	Bench scale KPEG	<1.1 µg/L	>1 to 10 mg/L	>99.98

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Constituent	Description of Treatment	Effluent Concentration	Influent Concentration	% Removal
Octachlorodibenzo-*p*-dioxin	Full scale activated sludge (domestic sewage)	1.5 µg/L	0 to 100 µg/L	0
		0.45 µg/L	0 to 100 µg/L	63
		0.26 µg/L	0 to 100 µg/L	95.1
	Full scale sedimentation (domestic sewage)	0.08 µg/L	0 to 100 µg/L	99.5
Octachlorodibenzofuran	Full scale activated sludge (domestic sewage)	0.25 µg/L	0 to 100 µg/L	86
	Bench scale KPEG	<2.6 µg/L	>1 to 10 mg/L	>99.96

Source: NRMRL, 1994. KPEG: treatment train of bench-scale dechlorination of toxics using an alkoxide formed by the reaction of potassium hydroxide with polyethylene glycol.

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