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FINAL WASTE FORMS PROJECT: PERFORMANCE CRITERIA FOR PHASE I TREATABILITY STUDIES

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TABLES

ACRONYMS

ANS	American Nuclear Society
ANSI	American National Standards Institute
ASTM	American Society of Testing and Materials
BDAT	best demonstrated available technology
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CCW	constituent concentrations in the waste
CCWE	constituent concentrations in the waste extract
DDT&E	Development, Demonstration, Testing and Evaluation
DOE	U.S. Department of Energy
DRE	destruction/removal efficiency
EPA	Environmental Protection Agency
EP Tox	Environmental Protection Toxicity Leaching Procedure
FFCA	Federal Facility Compliance Agreement
FR	*Federal Register*
HSWA	Hazardous and Solid Waste Amendments
ICR	ignitable, corrosive, and reactive
LDR	land disposal restriction
LLW	low-level radioactive waste
NRC	Nuclear Regulatory Commission
ORR	Oak Ridge Reservation
PCB	polychlorinated biphenyl
PCP	process control program
RCRA	Resource Conservation and Recovery Act
S/S	stabilization/solidification
SARA	Superfund Amendments and Reauthorization Act of 1986
TOC	total organic carbon
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substances Control Act
TSS	total suspended solids
TWA	Total Waste Analyses

PREFACE

The reader should note that, as a regulatory based document, this report represents a "snapshot in time" (current as of June 1, 1993) and is subject to change. For example, on September 25, 1992, the United States Court of Appeals for the District of Columbia Circuit ruled on the various petitions for review filed against the Third rule. [Chemical Waste Management, Inc., et al. v. EPA, 976 F. 2d 2 (58 FR 29861)]. On May 24, 1993, as part of its response to the September 25 decision, the EPA stated "The Agency plans to address issues which have been remanded by the court in future rulemaking." (58 FR 29865). Clearly, additional rulemakings that may impact the discussions related to performance criteria in this report are forthcoming.

In addition, the reader should note that many of the leachate-concentration-based standards discussed in this report were derived from the Environmental Protection Toxicity Characteristic Leaching Procedure (EP Tox). Although the EP Tox has been replaced by the Toxicity Characteristic Leaching Procedure (TCLP), the concentrations standards have not been updated. Consequently, in many cases the threshold concentrations were originally determined by the EP Tox—not the TCLP. However, throughout this report the conservative assumption is made that the threshold values must be met by the TCLP test; and the EP Tox is neither referred to nor utilized. In so doing, the authors believe the recommended performance criteria become more conservative.

ABSTRACT

This document defines the product performance criteria to be used in Phase I of the Final Waste Forms Project. In Phase I, treatability studies will be performed to provide "proof-of-principle" data to establish the viability of stabilization/solidification (S/S) technologies. This information is required by March 1995. In Phase II, further treatability studies, some at the pilot scale, will be performed to provide sufficient data to allow treatment alternatives identified in Phase I to be more fully developed and evaluated, as well as to reduce performance uncertainties for those methods chosen to treat a specific waste. Three main factors influence the development and selection of an optimum waste form formulation and hence affect selection of performance criteria. These factors are regulatory, process-specific, and site-specific waste form standards or requirements. Clearly, the optimum waste form formulation will require consideration of performance criteria constraints from each of the three categories. Phase I will focus only on the regulatory criteria. These criteria may be considered the minimum criteria for an acceptable waste form. In other words, a S/S technology is considered viable only if it meets applicable regulatory criteria. The criteria to be utilized in the Phase I treatability studies were primarily taken from Environmental Protection Agency regulations addressed in 40 CFR 260 through 265 and 268; and Nuclear Regulatory Commission regulations addressed in 10 CFR 61. Thus the majority of the identified criteria are independent of waste form matrix composition (i.e., applicable to cement, glass, organic binders etc.).

1. INTRODUCTION

On June 12, 1992, the Department of Energy (DOE) Oak Ridge Operations Office signed a Federal Facility Compliance Agreement (FFCA) with the U.S. Environmental Protection Agency Region IV (EPA-IV) regarding Oak Ridge Reservation (ORR) mixed wastes subject to the land disposal restriction (LDR) provisions of the Resource Conservation and Recovery Act (RCRA). The LDR FFCA establishes an aggressive schedule for conducting treatability studies and treatment methods development for those ORR mixed (radioactive and hazardous) wastes listed in Appendix B to the Agreement. These are wastes for which treatment methods and capabilities have yet to be defined. Compliance with Requirement 5 of the Agreement states that

> . . . DOE shall submit to EPA (Environmental Protection Agency) for review and approval a plan for the treatment of the LDR prohibited wastes identified in Appendices 1B, 2B, and 3B. This plan must identify the treatment strategy for such wastes to meet LDR treatment standards and must include a schedule, not to exceed two (2) years after the submittal of this plan (i.e., March 1995), for the evaluation and prioritization of treatment method options, treatability studies if required, and technology development.[1]

At an upper level, this requirement was satisfied by the "Strategic Plan."[2] In the Strategic Plan, the wastes are divided into two categories:

1. those wastes, listed in Appendices 1A, 2A, and 3A of the Agreement, for which treatment methods and facilities exist and

2. those wastes, listed in Appendices 1B, 2B, and 3B of the Agreement (hereafter referred to as Appendix B wastes), for which no treatment methods or facilities exist.

A Development, Demonstration, Testing and Evaluation (DDT&E) Program has been initiated to provide those efforts necessary to identify treatment methods for all the wastes that meet Appendix B criteria. The DDT&E Program has assembled project teams to address treatment development needs in a variety of areas, including that of Final Waste Forms [i.e., stabilization/solidification (S/S) processes]. As the waste data become more definitively characterized, any wastes newly classified as Appendix B wastes will be so identified in updates to the FFCA and will be included in treatment development programs.

In the context of this report, solidification refers to treatment that renders the waste a "solid." Solidification encompasses technologies that remove liquid such as filtration, drying, calcination, etc., which result in a dry or solid residue. Coating the dry waste with a polymer or the like would be considered solidification within the context of this project. Stabilization, which may also involve solidification, refers to treatment that involves reaction(s) with the waste constituents of concern to render them nonhazardous or to a chemical form that is less hazardous. Since most processes involving stabilization also involve solidification, they are referred to as S/S processes. The Final Waste Forms Project will give priority to the more traditional S/S processes, but it will not exclude such technologies as filtration, drying, etc.

Waste form types being actively considered by this project include grout (e.g., cement-based technology), glass (e.g., vitrification technology), and organic binders (e.g., polymer encapsulation). It is not clear at present what the final form and composition of the yet-to-be-determined treatment method residues will be and which waste streams will require, or are candidates for, S/S. In addition, ongoing waste characterization has not progressed to the point where potential waste candidates for direct S/S can be readily identified. This process consists of reviewing existing waste records, conducting generator interviews, and performing sampling and analysis, where required, to acquire more detailed information on waste matrices and contaminants. As these data are obtained, candidate waste forms will become more apparent, and regulatory requirements for treatment of specific wastes can be clearly defined.

Because of the time constraints in meeting the March 1995 deliverable as specified in the LDR FFCA, waste form treatability studies must be performed in parallel with data acquisition activities described in the previous paragraph. To perform these treatability studies, we must establish product performance criteria for these studies. Because of the parallel nature of activities being performed in support of the DDT&E Program, these waste form performance criteria must be generic rather than ORR-waste specific.

The purpose of this document is to define the product performance criteria to be used in Phase I of the Final Waste Forms Project. In Phase I, treatability studies will be performed to provide "proof-of-principle" data to establish the viability of S/S technologies. This information is required by March 1995. In Phase II, further treatability studies, some at the pilot scale, will be performed to provide sufficient data to allow treatment alternatives identified in Phase I to be more fully developed and evaluated, as well as to reduce performance uncertainties for those methods chosen to treat a specific waste. The focus of these Phase II efforts will be to obtain the necessary data to design the process module(s) and optimize the waste form formulation's ability to accommodate expected variations in both feed characteristics and process operations. While Phase I will concentrate primarily on laboratory- or bench-scale studies, Phase II will focus on laboratory-scale, as well as both bench-scale and pilot-scale, demonstrations.

2. RATIONALE FOR SELECTION OF PERFORMANCE CRITERIA

Three main factors influence the development and selection of an optimum waste form formulation and hence affect selection of performance criteria. These are regulatory, process-specific, and site-specific waste form standards or requirements. Regulatory requirements are those product performance criteria required by law or regulation and are typically site-, and may be process-, independent. For example, a waste form must meet certain concentration-based or technology-based treatment standards, or combinations thereof, in order to be land disposed. In general, these standards are independent of the process and waste form matrix ingredients employed (note that where the treatment standard requires use of a specified technology, the process would not be independent).

Process-specific requirements are those pertaining to process variables/constraints such as acceptable waste form fluid viscosity, ability to control the addition and blending/mixing of the formulation ingredients, temperature control, etc. For a grout formulation the process may place constraints on such properties as viscosity, set time, and gel strength.

Site-specific requirements are those pertaining to the storage, handling, and disposal of the waste form product. For example, the waste form may be placed in 55-gal drums, stacked four high, which may place compressive strength requirements on the product to support the intended load; or the product may be accumulated for a period of time awaiting shipment off-site and may thus require resistance to atmospheric temperature variations (freeze/thaw resistance). Note that, in addition to regulatory-driven performance criteria for the chemical components of a final waste form, allowable waste form radiological contaminant concentrations and/or activity would be a site-specific performance requirement, as defined by the performance assessment process for the individual disposal site.

Clearly, the optimum waste form formulation will require consideration of performance criteria constraints from each of the three categories. Phase I will focus only on the regulatory criteria. These criteria may be considered the minimum criteria for an acceptable waste form. In other words, a viable S/S technology must meet applicable regulatory criteria. Formulation optimization would be performed only on those selected technologies whose viability has been established through screening tests. Treatability studies conducted in Phase I aim to identify viable technologies. As stated previously, formulation optimization efforts are part of the Phase II treatability studies.

3. RESOURCE CONVERSATION AND RECOVERY ACT AND SUBSEQUENT REAUTHORIZATION AND AMENDMENTS

In 1976, Congress passed RCRA, which pertains to the definition, generation, transportation, treatment, storage, and disposal of hazardous wastes. The implementing regulations are found in Title 40 of the Code of Federal Regulations (CFR), Parts 260 through 265. In 1984, Congress passed the Hazardous and Solid Waste Amendments (HSWA) to RCRA, which placed stringent new restrictions on the land disposal of hazardous wastes. These restrictions, implemented in 40 CFR Part 268, require the hazardous wastes to meet concentration-based or technology-based treatment standards prior to land disposal. These restrictions, referred to as LDRs, have significantly expanded the scope and coverage of RCRA. As such, they have become a major regulatory driver in determining performance criteria for treatment (e.g., S/S) of hazardous wastes.

It is beyond the scope of this report to provide a detailed analysis of RCRA, HSWA, and LDRs. However, some discussion is appropriate to provide the rationale for selection of performance criteria applicable to the Final Waste Forms Project. Five "waste groups" under LDR are potentially applicable to the LDR FFCA Appendix B wastes under this project: (1) spent solvents and dioxins, (2) wastes that were banned from land disposal by the state of California (the "California List"), (3) wastes listed in 40 CFR Part 261, (4) characteristic wastes, and (5) hazardous debris. It is assumed that LDR regulations pertaining to underground injection (40 CFR Part 148) are not applicable to this project.

These waste categories and their potential impact on this project are discussed in subsequent sections of this report. However, as stated previously, it is beyond the scope of this report to provide a detailed discussion and review of all issues/data pertaining to LDR. Only selected information is presented. To understand the basis for this selection, it is important to understand the basis for LDR treatment standards. Treatment standards include (1) specified treatment technologies, (2) specified constituent concentrations in the waste extract (CCWE), as determined by the Toxicity Characteristic Leaching Procedure (TCLP) (TCLP SW846, Method 1311) and/or (3) specified total constituent concentrations in the waste (CCW). In the case where concentration-based treatment standards must be met, any treatment technology may be used; however, concentrations of hazardous constituents remaining in the treatment residuals cannot be higher than those present when best demonstrated available technology (BDAT) is employed. If a treatment technology is specified, that technology must be used.

These treatment standards provide a potential source of performance criteria for this project. However, within each waste category, treatment standards are generally specified for nonwastewaters and wastewaters. Wastewaters are aqueous wastes containing <1 wt % total organic carbon (TOC) <u>and</u> <1 wt % total suspended solids (TSS), with the following exceptions:

1. <u>F001, F002, F003, F004, and F005 wastewaters</u>: solvent-water mixtures containing <1 wt % TOC or <1 wt % total F001, F002, F003, F004, F005 solvent constituents listed in 40 CFR 268.41, Table CCWE;

2. K011, K013, and K014 wastewaters: containing <5 wt % TOC and <1 wt % TSS, as generated; and

3. K103 and K104 wastewaters: containing <4 wt % TOC and <1 wt % TSS.

Any waste or treatment residue not meeting this definition is a nonwastewater. For purposes of the Final Waste Forms Project, only nonwastewaters are assumed to be subject to S/S. *Consequently, treatment standards presented in this report are limited to those specified for nonwastewaters.*

3.1 SPENT SOLVENTS AND DIOXIN WASTES

Spent solvents are wastes listed in 40 CFR 261.31 with waste codes F001, F002, F003, F004, and F005. Constituents of concern and associated treatment standards are shown in Table 1. The majority of treatment standards are concentration based and primarily specify total CCW, as opposed to CCWE. Two notable exceptions are F005 spent solvent containing 2-ethoxyethanol or 2-nitropropane, for which a treatment standard of incineration is specified. Theoretically, with the exception of treatment for these two constituents in F005 wastes, or waste mixtures containing these constituents, any treatment technology (including S/S) can be used as a treatment method for these waste categories as long as the concentration-based standards are met. However, as shown in column 5 of Table 1, the specified concentrations were derived from using incineration as BDAT. Although incineration is not required for these wastes (with the two noted exceptions), the treatment utilized must be similar in performance to that of incineration in that the concentration of hazardous constituents in treatment residuals cannot be higher than those obtained using BDAT.

Dioxin wastes listed in 40 CFR 261.31 with Hazardous Waste Numbers F020-023 and F026-F028 have restrictions similar to those for spent solvents and are presented in Table 2. All treatment standards are concentration based and were derived from incineration data.

It should be noted that solids contaminated with these wastes, such as solvent-contaminated soil, are subject to the LDRs, as well. Theoretically, S/S processes could be used to treat these waste types, with the exception of constituents in F005, where incineration is the specified treatment technology. However, because the treatment standards are based on incineration as the BDAT technology, it is questionable whether simple S/S will result in a waste form meeting these concentration-based treatment standards. Nevertheless, if S/S processes are applied to these wastes, the product performance criteria will be the concentration-based standards listed in Tables 1 and 2, with the exceptions discussed in Sect. 3.3.2.

3.2 CALIFORNIA LIST WASTES

Wastes referred to as the California List became regulated on July 8, 1987. These wastes consisted of specific liquids and nonliquids containing halogenated organic compounds, hazardous waste liquids containing specific levels of polychlorinated biphenyls (PCBs), acid wastes with a pH less than or equal to 2.0, and liquids containing free cyanides or certain metals. The California List has essentially become obsolete, since the new LDR treatment

Table 1. Treatment standards for spent solvent wastes (nonwastewater)

Hazardous waste description	Constituents of concern	Treatment standards: Total composition (mg/kg)	Treatment standards: TCLP (mg/L)	BDAT used to derive treatment standards
F001—Spent halogenated solvents used in degreasing	Carbon tetrachloride	5.6		Incineration
	Methylene chloride	33		Incineration
	Tetrachloroethylene	5.6		Incineration
	1,1,1-Trichoroethane	5.6		Incineration
	Trichloroethylene	5.6		Incineration
	1,1,2-Trichloro-1,2,2-trifluoroethane	28		Incineration
	Trichloromonofluoromethane	33		Incineration
F002—Spent halogenated solvents	Chlorobenzene	5.7		Incineration
	o-Dichlorobenzene	6.2		Incineration
	Methylene chloride	33		Incineration
	Tetrachloroethylene	5.6		Incineration
	1,1,1-Trichloroethane	5.6		Incineration
	1,1,2-Trichloroethane	7.6		Incineration
	Trichloroethylene	5.6		Incineration
	1,1,2-Trichloro-1,2,2-trifluoroethane	28		Incineration
	Trichloromonofluoromethane	33		Incineration
F003—Spent nonhalogenated solvents	Acetone	160		Incineration
	n-Butyl alcohol	2.6		Incineration
	Cyclohexanone		0.75	Incineration
	Ethyl acetate	33		Incineration
	Ethyl benzene	6.0		Incineration
	Ethyl ether	160		Incineration
	Methanol		0.75	Incineration
	Methyl isobutyl ketone	33		Incineration
	Xylenes (total)	28		Incineration

Table 1 (continued)

Hazardous waste description	Constituents of concern	Treatment standards		BDAT used to derive treatment standards
		Total composition (mg/kg)	TCLP (mg/L)	
F004—Spent nonhalogenated solvents	Cresol (m- and p- isomers)	3.2		Incineration
	o-Cresol	5.6		Incineration
	Nitrobenzene	14		Incineration
F005—Spent nonhalogenated solvents	Benzene	3.7		Incineration
	Carbon disulfide		4.8	Incineration
	2-Ethoxyethanol	Incineration		Specified
	Isobutyl alcohol	170		Incineration
	Methyl ethyl ketone	36		Incineration
	2-Nitropropane	Incineration		Specified
	Pyridine	16		Incineration
	Toluene	28		Incineration

Table 2. Treatment standards for dioxin wastes (nonwastewater)

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
F020—F023	HxCDD-All Hexachlorodibenzo-p-dioxins		<1 ppb	Incineration
	HxCDF-All Hexachlorodibenzo-furans		<1 ppb	Incineration
	PeCDD-All Pentachlorodibenzo-p-dioxins		<1 ppb	Incineration
	PeCDF-All Pentachlorodibenzo-furans		<1 ppb	Incineration
	TCDD-All Tetrachlorodibenzo-p-dioxins		<1 ppb	Incineration
	TCDF-All Tetrachlorodibenzo-furans		<1 ppb	Incineration
	2,4,5-Trichlorophenol		<0.05 ppm	Incineration
	2,4,6-Trichlorophenol		<0.05 ppm	Incineration
	2,3,4,6-Tetrachlorophenol		<0.05 ppm	Incineration
	Pentachlorophenol		<0.01 ppm	Incineration
F026—F028	HxCDD-All Hexachlorodibenzo-p-dioxins		<1 ppb	Incineration
	HxCDF-All Hexachlorodibenzo-furans		<1 ppb	Incineration
	PeCDD-All Pentachlorodibenzo-p-dioxins		<1 ppb	Incineration
	PeCDF-All Pentachlorodibenzo-furans		<1 ppb	Incineration
	TCDD-All Tetra-chlorodibenzo-p-dioxins		<1 ppb	Incineration
	TCDF-All Tetra-chlorodibenzo-furans		<1 ppb	Incineration
	2,4,5-Trichlorophenol		<0.05 ppm	Incineration
	2,4,6-Trichlorophenol		<0.05 ppm	Incineration
	2,3,4,6-Tetrachlorophenol		<0.05 ppm	Incineration
	Pentachlorophenol		<0.01 ppm	Incineration

standards EPA has promulgated since 1987 take precedent over the original California list treatment standards. However, three exceptions exist for which the original California List treatment standards are still applicable. One is for liquid characteristic hazardous wastes containing ≥50 ppm PCBs. The second is for certain characteristically hazardous wastes (solids and liquids) that contain ≥1000 ppm halogenated organic compounds, as specifically defined in 40 CFR Part 268, Appendix III. These two special cases will be discussed in Sect. 4.

The third exception is characteristically hazardous liquid waste containing ≥134 mg/L nickel and/or 130 mg/L thallium. Neither nickel nor thallium is designated as a characteristically hazardous constituent (see Sect. 3.4) and therefore is not subject to more specific treatment standards applicable to characteristically hazardous wastes. Any treatment technology can be used to treat the waste to reduce nickel and/or thallium concentrations to below the specified threshold concentrations, or the waste can be rendered a solid through an S/S process.

Note that a solid is defined by the EPA to be a material that passes the Paint Filter Liquid Test (SW846, Method 9095). This definition will be used as a Final Waste Form performance criterion. That is, all waste form products must be classified as a solid according to this test.

3.3 LISTED WASTES

Listed wastes are wastes that are specifically classified as hazardous because of their source or for other properties, such as ignitability, corrosivity, reactivity, or toxicity. These wastes, listed in 40 CFR 261.31-261.33, are sometimes referred to as the first-, second-, and third-thirds because of the way in which their LDR treatment standards were promulgated. The "derived-from" rule [40 CFR 261.3(c)(2)] requires that residues from the treatment of RCRA listed waste must themselves be considered listed wastes until delisted. These treatment residues may have to meet the same treatment standards as the original waste, depending on the treatability group to which they belong and whether or not the residues qualify as a wastewater or nonwastewater. Consequently, whenever a concentration-based treatment standard exists for a listed waste, then residues generated from the treatment of that waste will be subject to the applicable constituent standards for wastewaters or nonwastewaters, as appropriate.

3.3.1 Treatment Standards

As described previously, treatment standards can be either concentration based or technology based. Treatment standards for listed wastes are presented in Appendix A. Detailed descriptions of technology codes used in Appendix A are provided in Appendix B. As noted in Appendix A, stabilization is BDAT for only a few select wastes. However, if stabilization is used as a treatment method, then the specified concentration limits become final waste form product performance criteria (with the exception noted in Sect. 3.3.2.).

3.3.1.1 Electroplating wastes (F006–F009)

Wastes from electroplating operations typically are associated with a high iron content that can form stable iron/cyanide complexes. Because these complexes degrade with time to evolve free cyanide, the treatment standard is based on total cyanide concentration in the waste rather than leachable cyanide based on TCLP. EPA has specifically stated that stabilization of cyanides is impermissible dilution. Therefore, the assumption is made that S/S (in the absence of cyanide destruction) is not a viable treatment for cyanides regardless of waste code and that any such waste will be pretreated for cyanide removal by the specified BDAT, or equivalent, prior to S/S.

3.3.1.2 Stabilization as specified BDAT

As shown in Appendix A, the majority of listed wastes have concentration-based treatment standards. However, a few have specified treatment technologies as the required treatment standard, and fewer still have stabilization as the specified BDAT. Stabilization, as defined by the EPA,[3] means "stabilization with the following reagents (or waste reagents) or combinations of reagents: (1) Portland cement; or (2) lime/pozzolans (e.g., fly ash and cement kiln dust). . . this does not preclude the addition of reagents (e.g., iron salts, silicates, and clays) designed to enhance the set/cure time and/or compressive strength, or to overall reduce the leachability of the metal or inorganic." In the context of the Final Waste Forms Project, this definition corresponds to grout. Thus, grout is the reagent of choice for stabilization of the following wastes: P113, P115, P119, P120, U214, U215, U216, and U217, and stabilization in grout is a performance criterion for these waste categories.

3.3.1.3 Amalgamation as specified BDAT

As defined by the EPA[3], amalgamation means "amalgamation of liquid, elemental mercury contaminated with radioactive materials utilizing inorganic reagents such as copper, zinc, nickel, gold, and sulfur that result in a nonliquid, semi-solid amalgam and thereby reducing potential emissions of elemental mercury vapors to the air." Amalgamation is the specified treatment technology for the U151 waste subcategory, "mercury contaminated with radioactive materials." Because the treatment standard is a specified technology, amalgamation would have to occur prior to any further S/S of the waste containing the mercury. However, two S/S techniques are under investigation that potentially incorporate amalgamation as part of the S/S process (i.e., without separate amalgamation pretreatment). If results of further tests are promising, a regulatory determination will be made as to whether an "Equivalent Technology" demonstration (40 CFR 268.42) should be pursued for one or both of these technologies. If successful, one of the two identified processes for the direct S/S of this waste category would then become a performance criterion. If not, separate amalgamation pretreatment will be required.

3.3.1.4 Basis for specified concentration limits

It is important to note that where concentrations are specified as the treatment standards for nonwastewaters (to which this document applies), these limits were derived from performance data from technologies EPA considers BDAT. Concentration limits specified for organic constituents were derived from technologies other than stabilization, while, in many cases, the concentration limits for inorganic constituents (including those contained in residues from organic waste treatment) are based on stabilization. Collectively, this information provides guidance to this project in two important areas: (1) identification of wastes that are amenable (in a regulatory context) to stabilization and (2) definition of expected performance, as defined by TCLP leachate concentrations for nonwastewaters, from the stabilized product.

Table 3 summarizes the waste codes (from Appendix A) fo: which stabilization was used to determine required TCLP concentration treatment standards. Because these are nonwastewaters, no total waste concentration treatment standards are associated with these wastes. For the Final Waste Forms Project, Table 3 lists wastes amenable to stabilization, and the TCLP limits become product performance criteria. Note also that many species have different TCLP concentration limits, depending on the applicable waste code. (Although Energy Systems does not generate "K" wastes on the ORR, these codes were included for completeness of this table and those that follow.)

Table 3. Treatment standards for listed wastes (nonwastewater) based on stabilization as BDAT

Waste code[a]	TCLP concentration standard (mg/L)					
	Cd	Pb	Se	Ag	Cr	Ni
K061	0.19	0.37	0.16	0.3	0.33	5
K069—Calcium sulfate category	0.14	0.37				
K100	0.066	0.51			5.2	
K115						0.32
P073						0.32
P103			5.7			
P114			5.7			
U204			5.7			
U205			5.7			

[a]Although Energy Systems does not generate "K" wastes on the ORR, these standards are included for completeness of the table.

Although vitrification was the treatment technology used (i.e., BDAT) in establishing the constituent concentration in the waste extract standard of 5.6 mg/L for numerous nonwastewater waste categories containing arsenic, any stabilization method may be used as long as the concentration-based standards are met. These wastes include: K031, K084, K101, K102, P010, P011, P012, P036, P038, and U136. In the context of the Final Waste Forms Projec*, these wastes are amenable to S/S, and a TCLP concentration of 5.6 mg/L for arsenic becomes a waste form product performance criterion for these waste categories. Note also (Appendix A) that none of these nonwastewater waste categories have a specified maximum total CCW with respect to arsenic.

Table 4 highlights the concentration-based treatment standards for selected nonwastewater treatment residues. As stated previously, in all cases the BDAT treatment of organic species in listed wastes is by some method(s) other than stabilization. However, the concentration limits in Table 4 were derived from use of stabilization processes as the BDAT for the treatment of the inorganic species remaining in the residue generated following

Table 4. TCLP treatment standards based on stabilization as BDAT for treatment residues of listed wastes (nonwastewater)

Waste code[a]	TCLP concentration standard (mg/L)									
	Cd	Cr	Pb	Ni	Ag	Sb	As	Ba	Hg	Se
F006	0.066	5.2	0.51	0.32	0.072					
F007	0.066	5.2	0.51	0.32	0.072					
F008	0.066	5.2	0.51	0.32	0.072					
F009	0.066	5.2	0.51	0.32	0.072					
F011	0.066	5.2	0.51	0.32	0.072					
F012	0.066	5.2	0.51	0.32	0.072					
F019		5.2								
F024		0.073	—	0.088						
F039	0.066	5.2	0.51	0.32	0.072	0.23	5.0	52	0.025	5.7
K001			0.51							
K006		0.094	0.37							
K015		1.7		0.2						
K021						0.23				
K022		5.2		0.32						
K024[b]										
K028	.	0.073	0.021	0.088						
K046			0.18							
K048		1.7		0.2						
K049		1.7		0.2						

Table 4 (continued)

Waste code[a]	TCLP concentration standard (mg/L)									
	Cd	Cr	Pb	Ni	Ag	Sb	As	Ba	Hg	Se
K050		1.7		0.2						
K051		1.7		0.2						
K052		1.7		0.2						
K083				0.088						
K087			0.51							
P013				0.32				52		
P074										
P099					0.072					
U051			0.51							
U144			0.51							
U145			0.51							
U146			0.51							

[a]Energy Systems does not generate "K" wastes: they are included for completeness of the table.
[b]Stabilization of ash residue.

pretreatments for organic destruction/removal from these waste categories. In the context of the Final Waste Forms Project, inorganic residues remaining after treatment for destruction/removal of organics for these waste categories (or codes) are amenable to S/S, and the waste form product performance criteria are the TCLP limits listed in Table 4.

3.3.2 Organics

As shown in Appendix A, a significant portion of listed wastes has total waste composition treatment standards specified for organic constituents. Although these standards are requirements for land disposal of a waste form containing these constituents, they are NOT waste form product performance criteria for grout and organic binder products in the Phase I treatability studies to be performed under the Final Waste Forms Project. Per 40 CFR 268.3(a), the EPA specifically prohibits dilution of a listed waste or its treatment residues in order to meet treatment standards. Both grout and organic binders would be considered dilution if used to meet the total concentration limits for organics. Consequently, listed wastes that have organic constituents at concentration levels above the treatment standards are not amenable to direct S/S and therefore require pretreatment.

However, these total concentration limits can be used to define the maximum concentration of organic constituents allowed in the waste fed to S/S operations and hence the Phase I treatability studies. For purposes of designing Final Waste Form treatability studies, it will be assumed (subject to verification by sampling and analysis) that the waste feed to be addressed by S/S studies has been, or will be, pretreated to meet the applicable total concentration treatment standards for organics prior to being introduced to the S/S process.

It should be noted that there is one possible exception to this discussion. Vitrification, a waste form technology within this project, is considered a "thermal treatment" technology by the EPA (57 FR 37240). Consequently, vitrification may be an option for direct stabilization of listed wastes in these categories. If the treatability studies evaluate this option, then the applicable organic constituents' total concentration standards become performance criteria for the study. However, in this case the performance criteria are related to organic destruction/removal efficiency (DRE) in the melting process rather than to the product waste form and would therefore not be considered dilution.

3.4 CHARACTERISTIC WASTES

Treatment standards for characteristically hazardous wastes are shown in Table 5. They are similar in nature to those discussed for listed wastes. Characteristic wastes are those which exhibit the characteristic of ignitability, corrosivity, reactivity, or toxicity, as defined in 40 CFR 261.21-261.24.

Macroencapsulation with a surface coat or jacket is a performance criterion for the subcategory of D008, "Radioactive lead solids" (see Table 5). Macroencapsulation, as defined by the EPA,[3] means "macroencapsulation with surface coating materials such as polymeric organics (e.g., resins and plastics) or with a jacket of inert inorganic materials to substantially reduce the surface exposure to potential leaching media. This definition corresponds to organic binders in the context of the Final Waste Forms Project. Macroencapsulation specifically does not include any material that would be classified as a tank or container according to 40 CFR 260.10."

Table 5. Treatment standards for characteristic wastes (nonwastewater)

Hazardous waste description[a]	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
D001—Ignitable liquids—High TOC (TOC ≥10%)		Fuel substitution, recovery of organics, or incineration		
D001—Ignitables (except high TOC) managed in CWA,[b] CWA-equivalent, or Class I SDWA[c] systems		Deactivation		Recovery of organics, incineration, wet-air oxidation, chemical/ electrolytic oxidation, biodegradation
D001—Ignitables (except high TOC) managed in non-CWA/non-CWA-equivalent/non-Class I SDWA systems		Deactivation and meet F039; fuel substitution; recovery of organics; or Incineration		Recovery of organics, incineration, wet-air oxidation, chemical/ electrolytic oxidation, biodegradation
D002—Acids, alkalines, and other corrosives managed in non-CWA/non-CWA-equivalent/non-Class I SDWA systems		Deactivation and meet F039		Recovery, neutralization, incineration
D002—Acids, alkalines, and other corrosives managed in CWA, CWA-equivalent, or Class I SDWA systems		Deactivation		Neutralization, incineration
D003—Reactive cyanides subcategory	Cyanides (total)	590		Alkaline chlorination, wet air oxidation, or electrolytic oxidation
	Cyanides (amenable)	30		
D003—Reactive sulfides subcategory		Deactivation		
D003—Explosives subcategory		Deactivation		Incineration, chemical/electrolytic oxidation, chemical reduction
D003—Water reactives subcategory		Deactivation		Incineration, controlled reaction with water, chemical/electrolytic oxidation, chemical reduction

Table 5 (continued)

Hazardous waste description[a]	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
D003—Other reactives subcategory		Deactivation		Incineration, chemical/electrolytic oxidation, chemical reduction
D004—Arsenic	Arsenic		5.0	Vitrification
D004—Radioactive high-level wastes generated during the reprocessing of fuel rods subcategory		Vitrification		
D005—Barium	Barium		100	Stabilization
D005—Radioactive high-level wastes generated during the reprocessing of fuel rods subcategory		Vitrification		
D006—Cadmium	Cadmium		1.0	Stabilization or metal recovery
D006—Cadmium batteries subcategory		Thermal recovery		
D006—Radioactive high-level wastes generated during the reprocessing of fuel rods subcategory		Vitrification		
D007—Chromium	Chromium (total)		5.0	Chromium reduction, stabilization
D007—Radioactive high-level wastes generated during the reprocessing of fuel rods subcategory		Vitrification		
D008—Lead	Lead		5.0	Stabilization
D008—Radioactive lead solids		Macroencapsulation		
D008—Radioactive high-level wastes generated during the reprocessing of fuel rods subcategory		Vitrification		

Table 5 (continued)

Hazardous waste description[a]	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
D008—Lead acid batteries		Thermal recovery of lead in secondary lead smelters		
D009—Low-mercury subcategory (<260 mg/kg total mercury)	Mercury		0.20	Acid leaching followed by chemical precipitation, dewatering
D009—High-mercury subcategory (≥260 mg/kg total mercury)		Roasting or retorting or incineration followed by roasting or retorting of incinerator nonwastewater residues	0.20	(Treatment method specified)
D009—Hydraulic oil contaminated with mercury and radioactive materials subcategory		Incineration followed by treatment of residues according to high- or low-mercury subcategory		
D009—Elemental mercury contaminated with radioactive materials		Amalgamation		
D009—Radioactive high-level wastes generated during the reprocessing of fuel rods subcategory		Vitrification		
D010—Selenium	Selenium		5.7	Stabilizaiton
D010—Radioactive high-level wastes generated during the reprocessing of fuel rods subcategory		Vitrification		
D011—Silver	Silver		5.0	Stabilization or recovery
D011—Radioactive high-level wastes generated during the reprocessing of fuel rods subcategory		Vitrification		

Table 5 (continued)

Hazardous waste description[a]	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
D012—Endrin	Endrin	0.13		Incineration
D013—Lindane	Lindane	0.066		Incineration
D014—Methoxychlor	Methoxychlor	0.18		Incineration
D015—Toxaphene	Toxaphene	1.3		Incineration
D016—2,4-D	2,4-D	10.0		Incineration
D017—2,4,5-TP (Silvex)	2,4,5-TP	7.9		Incineration
D018—Benzene	Benzene	10.0		Incineration
D019—Carbon tetrachloride	Carbon tetrachloride	6.0		Incineration
D020—Chlordane	Chlordane	0.26		Incineration
D021—Chlorobenzene	Chlorobenzene	6.0		Incineration
D022—Chloroform	Chloroform	6.0		Incineration
D023—o-Cresol	o-Cresol	5.6		Incineration
D024—m-Cresol	m-Cresol	3.2		Incineration
D025—p-Cresol	p-Cresol	3.2		Incineration
D026—Cresol	Cresol	8.8		Incineration
D027—1,4 Dichlorobenzene	1,4 Dichlorobenzene	6.0		Incineration
D028—1,2 Dichloroethane	1,2 Dichloroethane	6.0		Incineration
D029—qxl 1,1 Dichloroethylene	qxl 1,1 Dichloroethylene	6.0		Incineration
D030—2,4 Dinitrotoluene	2,4 Dinitrotoluene	140.0		Incineration
D031—Heptachlor	Heptachlor	0.066		Incineration
D031—Heptachlor epoxide	Heptachlor epoxide	0.066		Incineration

Table 5 (continued)

Hazardous waste description[a]	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
D032—Hexachlorobenzene	Hexachlorobenzene	10.0		Incineration
D033—Hexachloro 1,3 butadiene	Hexachloro 1,3 butadiene	5.6		Incineration
D034—Hexachloroethane	Hexachloroethane	30.0		Incineration
D035—Methyl ethyl ketone	Methyl ethyl ketone	36.0		Incineration
D036—Nitrobenzene	Nitrobenzene	14.0		Incineration
D037—Pentachlorophenol	Pentachlorophenol	7.4		Incineration
D038—Pyridine	Pyridine	16.0		Incineration
D039—Tetrachloroethylene	Tetrachloroethylene	6.0		Incineration
D040—Trichloroethylene	Trichloroethylene	6.0		Incineration
D041—2,4,5 Trichlorophenol	2,4,5 Trichlorophenol	7.4		Incineration
D042—2,4,6 Trichlorophenol	2,4,6 Trichlorophenol	7.4		Incineration
D043—Vinyl chloride	Vinyl Chloride	6.0		Incineration

[a]Waste Codes D018 through D043 for TCLP Program have proposed treatment standards and are subject to final approval and promulgation (58 FR 48092-48204).
[b]Regulated under Clean Water Act (CWA).
[c]Regulated under Safe Drinking Water Act (SWDA).

For the subcategory of D009, "Elemental mercury contaminated with radioactive materials," amalgamation is specified as the required treatment technology. As previously discussed, any other S/S required would have to occur following amalgamation. However, two stabilization techniques are under investigation which potentially incorporate amalgamation as part of the S/S process (i.e., without separate amalgamation pretreatment). If results of further tests are promising, a regulatory determination will be made as to whether an "Equivalent Technology" demonstration (40 CFR 268.42) should be pursued for one or both of these technologies. If successful, the performance criterion would then become the use of one of the two identified processes. If not, separate amalgamation pretreatment will be required. It should be noted that the treatment standards for the majority of the remaining D009 subcategories involve either a chemical or thermal treatment. Consequently, these waste categories are not amenable to direct S/S with the possible exception of vitrification technology. Although vitrification is a waste form technology within this project, it is considered by the EPA to be a thermal treatment technology.

Table 6 summarizes the characteristic wastes (from Table 5) for which stabilization was used to determine required nonwastewater concentration-based treatment standards. Note that there are no total composition (CCW) standards associated with these nonwastewater species; rather, concentration standards are expressed as CCWE, as determined by TCLP. The specified nonwastewater treatment standard for waste category D007 of a chromium concentration of 5.0 mg/L, as CCWE, is based on chromium reduction and/or stabilization. Consequently, if this waste category were subjected to direct stabilization, the technology should incorporate chromium reduction as part of the stabilization process. One example of this approach would be the use of a grout-containing granulated blast furnace slag. In the context of the Final Waste Forms Project, Table 6 provides a list of characteristic nonwastewater wastes that are amenable to stabilization, in grout or other media, and the TCLP limits become product performance criteria.

Table 6. TCLP concentration standards for characteristic wastes based on stabilization as BDAT

Waste code	TCLP concentration standard (mg/L)					
	Ba	Cd	Cr	Pb	Se	Ag
D005	100					
D006		1.0				
D007			5.0			
D008—Lead category				5.0		
D010					5.7	
D011						5.0

Although vitrification was the treatment technology used (i.e., BDAT) in establishing the treatment standard for D004—arsenic nonwastewaters of 5.0 mg/L in the waste extract (CCWE), any stabilization method may be used as long as the concentration-based standards are met. In the context of the Final Waste Forms Project, this waste category is amenable to stabilization, in glass or other media, and a TCLP concentration of 5.0 mg/L becomes a waste form product performance criterion for this waste category. Note also that this waste category (nonwastewater) does not have a specified maximum total CCW for arsenic.

With the exception of the waste subcategory D001—High TOC Ignitable Liquids, the specified treatment standard for D001 and D002 waste categories includes deactivation (Table 5). EPA defines stabilization as one of the BDATs for deactivation for these two waste categories. Consequently, these two waste categories can be considered candidates for stabilization, provided that the S/S process used effectively deactivates the waste and that dilution is not used as a substitute for adequate treatment. One important point to consider is the required TCLP treatment standard for characteristic selenium nonwastewaters (D010). The treatment standard of 5.7 mg/L in the TCLP leachate is consistent with selenium standards for listed wastes (see Sect. 3.3). However, the hazardous characteristic toxicity level, as CCWE, for selenium is 1.0 mg/L. Therefore, at the higher concentration standard (5.7 mg/L) the waste material would still require management as a hazardous waste, although the material could be land disposed. Consequently, if a waste is only hazardous because of its characterization as D010, then a performance criterion of 1.0 mg/L, which would render the waste nonhazardous, will be specified.

3.5 CONTAMINATED DEBRIS

Contaminated debris (i.e., hazardous debris as defined by the EPA) represents a unique waste category. As defined by the EPA [40 CFR 268.2(g)],

> debris means any solid material exceeding a 60 mm particle size that is intended for disposal and that is: 1) a manufactured object; or 2) plant or animal matter; or 3) natural geologic material. However, the following materials are not debris: 1) any material for which a specific treatment standard is provided in Subpart D, Part 268; 2) process residuals such as smelter slag and residues from the treatment of waste, wastewater, sludges or air emission residues; and 3) intact containers of hazardous waste that are not ruptured and that retain at least 75% of their original volume. A mixture of debris that has not been treated to the standards provided by 40 CFR 268.45 and other material (such as soils and sludge) is subject to regulation as debris if the mixture is comprised primarily of debris, by volume, based on visual inspection.

Note that while concrete generally may be classified as debris, cementitious or pozzolanic stabilized hazardous wastes are specifically excluded from this waste category.

Per 40 CFR 268.2(h),

> hazardous debris means debris that contains a hazardous waste listed in subpart D of part 261, or that exhibits a characteristic of hazardous waste identified in subpart C of part 261.

Certain debris that is contaminated with a listed waste (per subpart D of 40 CFR 261) for which EPA has established a treatment standard (but no required specific treatment technology) and debris exhibiting the characteristic(s) (per Subpart C of 40 CFR 261) of ignitability, corrosivity, reactivity, or toxicity may be treated to meet the alternative debris treatment standards adopted under the debris rule.

Per 40 CFR 268.40(b),

> a restricted waste for which a treatment technology is specified under 40 CFR 268.42(a) ("Treatment Standards Expressed as Specified Technologies") or hazardous debris for which a treatment technology is specified under 40 CFR 268.45 ("Treatment Standards for Hazardous Debris") may be land disposed after it is treated using that specified technology or an equivalent method approved ... under the procedures set forth in 40 CFR 268.42(b).

These treatment standards are summarized in Appendix A, Table 5, and Appendix C.

Under the rule, EPA has identified 17 alternative treatment technologies as BDAT for hazardous debris (Appendix C). These are variants of the following technology groups: (1) extraction; (2) destruction; and (3) immobilization, for which performance and/or design requirements for the technologies designated as BDAT are established. Hazardous debris can be treated by one or more of the specified technologies for each "contaminant subject to treatment" defined as (1) the constituents for the listed waste that are subject to the LDRs found in 40 CFR 268.41 ("Treatment Standards Expressed as Concentrations in Waste Extract") and 268.43 ("Treatment Standards Expressed as Waste Concentrations"), as summarized in Appendix A; (2) the RCRA hazardous waste constituent(s) for which the debris fails the Extraction Procedure toxicity characteristic, in addition to any other characteristic that causes the debris to be hazardous (ignitability, corrosivity, reactivity), as summarized in Table 5; and (3) cyanide or sulfide if debris exhibits reactivity because of the presence of those constituents.

Hazardous debris that is treated by a prescribed extraction or destruction technology and that subsequently does not exhibit a characteristic is excluded from Subtitle C regulation (i.e., may be considered as no longer hazardous and therefore solely a radioactive waste). Separation of treated debris from all treatment residues, including soil, waste, or other nondebris material that could adhere to the debris surface, is required prior to exclusion from Subtitle C. However, for debris treated by thermal desorption, biodegradation, chemical oxidation and reduction and for thermal destruction of debris contaminated with dioxin-listed wastes, the treated debris remains subject to Subtitle C unless a successful "Equivalent Technology" demonstration is made under 40 CFR 268.42. Hazardous debris treated solely by a prescribed immobilization technology remains regulated by Subtitle C.

Alternatively, hazardous debris may be treated to meet the existing waste-specific treatment standards for the waste contaminating the debris (i.e., LDRs), but, with the noted exception of debris that is hazardous because of the presence of a characteristic waste and no longer exhibits a hazardous characteristic, the treated debris must then still be managed and disposed of as hazardous waste (in a Subtitle C facility). Thus, hazardous debris must either be treated by specified technologies based on the type of debris and type of contaminant present (see Appendix C) or, as an alternative, meet the LDRs treatment standards for the specified prohibited listed or characteristic waste with which it is contaminated (see Appendix A and Table 5), or the regulatory agency may determine that the treated debris no longer contains hazardous constituents. The primary difficulty of implementing waste-specific treatment standards lies in obtaining representative sampling of the treated debris to document compliance with the concentration-based waste-specific standards prior to disposal in a Subtitle C land disposal unit.

Note that residues (soil, wastewater, and nonwastewater) from the treatment of hazardous debris are subject to the waste-specific treatment standards (LDRs) for the waste contaminating the debris. The residual must be treated to these standards for all BDAT constituents specified in 40 CFR 268.41, 268.42, and 268.43 for the waste (see Appendix A and Table 5). Liquids that separate from debris prior to treatment must be managed as hazardous waste. Free liquids cannot be present in debris that is macroencapsulated or sealed and cannot be present in debris that has been microencapsulated. (Note that the term "microencapsulation" used in this section corresponds to the term "stabilization" in the context of the Final Waste Forms Project.)

Radioactive hazardous (i.e., mixed waste) debris is subject to debris treatment standards, except in the case where specific treatment standards have been established in 40 CFR 268.42 [e.g., for radioactive lead solids >60 mm, which are excluded per 40 CFR 268.2(g) from definition as debris and are thus subject to waste-specific treatment standards]. Per 40 CFR 268.42(d), radioactive hazardous mixed wastes with treatment standards specified in Table 3 of that section ("Technology-Based Standards for Specific Radioactive Hazardous Mixed Waste") are not subject to any treatment standards specified in 40 CFR 268.41 or 268.43 or Table 2 of 268.42 ("Technology-Based Standards by RCRA Waste Code"). Radioactive hazardous mixed wastes not subject to treatment standards in Table 3 of 40 CFR 268.42 remain subject to all applicable standards specified in 40 CFR 268.41, 268.43, and Table 2 of 268.42. Hazardous debris containing radioactive waste is not subject to the treatment standards specified in Table 3 of 40 CFR 268.42 but is subject to the treatment standards specified in 40 CFR 268.45.

In summary, based on these definitions, hazardous waste for which EPA has established a specified treatment technology is not debris. For example, the waste category D008—Radioactive lead solids (Table 5)—has a specified treatment technology (macroencapsulation) and therefore is not debris regardless of particle size. The LDRs, discussed in Sects. 3.1–3.4, apply only to debris contaminated with hazardous wastes for which treatment standards have been established or that exhibits a characteristic for which a treatment standard has been established.

Numerous options for treatment are available for debris, depending on the type of debris and waste contaminant. The most desirable option is to treat debris so as to allow its reclassification as nonhazardous waste. Most listed and/or characteristically hazardous debris can be treated using specified debris treatment technologies: extraction, destruction, or immobilization (Appendix C). After treatment to meet the performance, design, and operating standards of an approved extraction or destruction technology and provided that the treated debris exhibits no characteristics of hazardous waste (see Sect 3.4), the debris may not subsequently have to be managed as a hazardous waste and can therefore be land disposed in a Subtitle D facility or returned to the natural environment. This scenario does not apply to hazardous debris contaminated with waste(s) for which a specified technology has been established as the treatment standard.

Alternatively, debris may be treated to meet the existing treatment standards (i.e., concentration-based limits) for the specific waste or waste constituent(s) with which it is contaminated. However, in this case the treated debris must still be managed as a hazardous waste. A third option is for the debris to be managed as a hazardous waste in accordance with the contained-in policy. Although numerous treatment/disposal options are potentially available for contaminated debris, the options with respect to S/S are actually quite limited and are dependent on the waste code.

3.5.1 Debris Containing Listed Waste with Specified Treatment Technologies as Treatment Standards

If the debris is contaminated with one (or more) listed wastes that must be treated using a specified treatment technology (40 CFR 268.42), then the treatment options in Appendix C are not applicable. In this case, the debris must be treated using the specified technology, and the resulting product(s) must be disposed of as a hazardous waste.

3.5.2 Debris Containing Listed Wastes with Specified Concentration-Based Treatment Standards

If the debris is contaminated with one (or more) listed wastes with concentration-based treatment standards, then the debris can be treated using technologies presented in Appendix C. The treated debris must be treated by the specified technologies (Appendix C) based on the type of debris and type of contaminant(s) present or, as an alternative, meet the LDRs for the specified prohibited listed or characteristic waste with which it is contaminated. If the alternative treatment method (Appendix C) is used, the debris must be sampled and analyzed to ensure compliance with the treatment standards prior to disposal in a Subtitle C land disposal unit. Further, residues from treated debris are subject to the waste-specific concentration-based treatment standards for the waste contaminating debris.

Immobilization, as defined in the regulations pertaining to debris, corresponds to grout and organic binders under the Final Waste Forms Project. Treatment of hazardous debris by these two S/S technologies without prior treatment using prescribed extraction or destruction technologies, although acceptable, would result in a waste that would still have to be managed as hazardous waste within the waste codes of the original contaminants; that is, any debris contaminated with listed waste(s) that is treated solely by immobilization would have to be managed as hazardous waste unless delisted.

As discussed previously in this report and stated explicitly in Appendix C, EPA considers vitrification a thermal treatment technology. Consequently, it would appear that vitrification could potentially be used to render debris nonhazardous. However, prior to disposal as a nonhazardous waste, the treated debris must first be separated from treatment residues, and the treatment residues must continue to be treated as hazardous waste within the waste codes of the untreated wastes [40 CFR 268.45(d)(1)]. The EPA clearly defines treatment residues to include the vitrified product or waste form (57 FR 37234) utilizing the logic that ". . .the original debris no longer exists and the residuals from soil or waste contaminating the debris are integral components of the slag and vitrified residue" (57 FR 37241). Consequently, as with immobilization (i.e., grout and organic binders), vitrification is an acceptable treatment method for hazardous debris but results in a waste form that would still have to be managed as hazardous according to the original contaminants' waste codes.

3.5.3 Debris Contaminated with Characteristic Waste

The treatment standard for characteristically ignitable, corrosive, and reactive hazardous debris is deactivation. However, the standard must be achieved by use of treatment methods specific for other debris unless it can be demonstrated that the debris does not contain characteristically toxic constituents. Thus the same treatment standards apply for ignitable, corrosive, and reactive (ICR) debris as for other hazardous debris. Existing treatment standards, which may allow dilution for some characteristic wastes, may not be used for ICR debris: dilution is prohibited other than may occur as a result of using one of the designated treatment methods (see Appendix C). Identification of the hazardous constituents present is not required, as use of the specified technology is assumed to result in their adequate treatment.

Debris contaminated with material that is hazardous solely because of a characteristic (see Table 5) can be treated by either vitrification or immobilization (i.e., glass, grout, and organic binder); however, debris that contains a listed hazardous waste or contaminants that exhibit the Toxicity Characteristic in 40 CFR 261.24 must be treated by extraction or destruction technology. It must be treated to the performance, design, and operating standards specified for the type of alternate treatment standard utilized. If the treated hazardous debris and its residue meet these treatment standards and no longer exhibit a hazardous characteristic, then the debris may be disposed of as a nonhazardous waste (but still a radioactive waste).

Two notable exceptions to this scenario exist:

1. Any debris considered reactive because of the presence of cyanides (e.g., D003—Reactive cyanides category) must be treated by one of the specified technologies for which the treatment standards can be achieved for cyanides (i.e., deactivation). Any residue from such treatment may not be land disposed until cyanide is treated to levels established in Table CCW of 40 CFR 268.43 (see Table 5). One option is pretreatment by a chemical destruction method such as alkaline chlorination (Appendix C). Vitrification may represent a potential direct stabilization option, in that the process of vitrification, which is considered a thermal destruction technology in this context and would therefore be expected to destroy cyanides, may be acceptable to EPA under an "Equivalent Technology" demonstration. In the event this is not the case, vitrification and other direct stabilization options would be considered to constitute impermissible dilution.

2. The other exception is debris that is considered by the EPA to be inherently hazardous (57 FR 37236-37237). Inherently hazardous debris includes debris that has been fabricated from D004-D011 metals and that is toxic per the TCLP in its original state. In this case, only two options are available:

    a. *Treatment by immobilization followed by disposal, as a hazardous waste, in a Subtitle C facility.* If contaminated by listed waste, that waste must also be treated by one of the prescribed treatment methods. Pretreatment for these contaminants may not be required prior to immobilization if the performance standards for the immobilization technology can be achieved without such prior treatment. Residues from treating inherently hazardous debris require no further treatment unless (1) they exhibit a prohibited hazardous waste characteristic or (2) they result from treating listed constituents, in which case the residues are subject to the concentration-based standards applicable to that listed waste. If debris is pretreated by a prescribed technology to destroy/remove the listed waste prior to immobilization, residues from that pretreatment would require subsequent treatment to applicable concentration-based standards, but residues from subsequent immobilization would not, unless they exhibit a characteristic.

b. *Recycling as Scrap Metal.* LDRs do not apply to inherently hazardous debris that is scrap metal being recycled, even if contaminated with listed constituents. Recycled metal residues from processing remain regulated under the derived-from rule and are subject to LDRs before disposal, unless the debris has first been treated by a prescribed technology (whose residues would themselves still be considered hazardous), in which case subsequent processing residues would be nonhazardous unless they exhibit a characteristic.

3.5.4 Impact on Phase I Performance Criteria

Stabilization/solidification (i.e., "immobilization" in glass, grout, and/or organic binders) cannot be used to render contaminated debris nonhazardous for listed wastes and therefore cannot be a primary treatment option. On the other hand, S/S can be used to render debris contaminated with characteristic waste nonhazardous. It must be noted that the generator or treater of the debris must demonstrate to the regulatory agency that the debris does not contain toxic constituents for the treated debris to be excluded from Subtitle C management.

Clearly, however, the waste form technologies being addressed by this project are considered potentially acceptable treatment options for contaminated debris, although the product may remain a hazardous waste. The performance criteria (with respect to the Final Waste Forms Project) for the resulting waste form becomes the same as that for the waste categories of the debris contaminant(s) that have been discussed previously.

4. TOXIC SUBSTANCES CONTROL ACT

The special category of waste contaminated with PCBs is regulated under the Toxic Substances Control Act (TSCA) (40 CFR 761). The effective treatment standard for PCB wastes is ≤2 ppm PCBs for solids and nonaqueous liquids and ≤3 ppb PCBs in aqueous wastewaters.

A major precept of the PCB regulations is the antidilution provision found in 40 CFR 761.1, which states "No provision [of the PCB regulations, especially disposal] may be avoided as a result of any dilution [intentional or not]..." Thus, dilution of any kind to avoid disposal requirements for PCBs is not allowed. Wastes known to be derived from a 50-ppm or greater PCB source must be disposed of as prescribed in 40 CFR 761, Subpart D, although actual concentrations in the waste stream may be <50 ppm or even nondetectable. Thus, PCB wastes must be managed based on the source concentration. Rinsing of PCB containers or equipment for decontamination purposes is authorized under 40 CFR 761.79, provided the rinsates are managed as liquid PCB waste based on the source concentration.

4.1 PCB LIQUIDS

In general, PCB liquids (e.g., mineral oil dielectric fluid, liquid PCBs) at concentrations of 50 ppm or greater but <500 ppm must be disposed of either by

1. combustion in an EPA TSCA-approved incinerator that conforms to the requirements of 40 CFR 761.70;

2. combustion in an EPA TSCA-approved high-efficiency boiler that conforms to the operational performance requirements of

    a. 40 CFR 761.60(a)(2)(iii), for mineral oil dielectric fluid, or

    b. 40 CFR 761.60(a)(3)(iii), for PCB liquids; or

3. in a chemical landfill that conforms to the requirements of 40 CFR 761.75.

Used oil to be burned for energy recovery is assumed to contain quantifiable levels of PCBs (i.e., 2 ppm) unless analysis shows otherwise. Per EPA Policy 6-PCB-4, industrial sludges or slurries containing PCBs at 500 ppm or greater must be disposed of by incineration. PCB industrial sludges or slurries generated by processing liquid PCBs must be disposed of in the same manner as required for the original liquid PCBs (i.e., high concentration requirements).

PCB liquids containing >500 ppm PCBs or wastes that were derived from a PCB source with PCB concentration >500 ppm must be incinerated or else disposed of by an EPA TSCA-approved alternate method of disposal.

Bulk liquids not exceeding 500 ppm may be disposed of provided such waste is pretreated and/or stabilized (e.g., chemically fixed, evaporated, mixed with dry inert absorbant) to reduce its liquid content or increase its solids content so that a nonflowing consistency is achieved to eliminate the presence of free liquids prior to final disposal. A PCB container of liquid PCBs with a concentration between 50 and 500 ppm may be disposed of if each container is surrounded by an amount of inert sorbant material capable of absorbing all of the liquid contents of the container. While landfill disposal of liquid PCBs wastes is thus theoretically possible under the regulations, as a practical matter, few, if any, such permitted outlets exist, and such disposal will not be further considered as a viable option under this project.

4.2 PCB SOLIDS

Nonliquid PCBs (e.g., equipment, contaminated soil, rags, debris, dredged materials, and municipal sewage treatment sludges) at PCB concentrations of 50 ppm or greater or which originate from a PCB source of 50 ppm or greater must be disposed of either by incineration or in chemical landfills. PCB Items (e.g., transformers, capacitors, hydraulic machines, electrical equipment, and containers) with concentrations at 500 ppm or greater must either be incinerated or disposed of in a chemical waste landfill, provided that all free-flowing liquids have been thoroughly drained prior to the article's disposal and that the drained liquids are disposed of in an incinerator. PCB Articles with a concentration between 50 to 500 ppm must be disposed of by draining all free liquid and disposing of the liquid in an incinerator, high-efficiency boiler, or chemical waste landfill (see requirements for PCB liquids, above). The drained article is not regulated under TSCA and may be disposed of in a municipal landfill. However, this wording is being changed in the PCB regulations. The PCB Article will be regulated under TSCA. Additional options, such as smelting, are allowed for drained <500-ppm PCB Articles. It is unlikely any municipal landfill would or could accept these Articles.

Chemical waste landfills must meet the siting and design requirements of 40 CFR 761.75(b) prior to acceptance of PCB wastes for disposal. PCBs and PCB Items shall be placed in a landfill in a manner that prevents their damage and such that chemically incompatible wastes (including organic solvents) will be segregated from the PCBs.

4.3 PCB SPILL CLEANUP POLICY REQUIREMENTS

The EPA PCB spill cleanup policy, established in 40 CFR 761, Subpart G, applies to spills of 50 ppm or greater or from a source of PCBs of 50 ppm or greater (because of the antidilution rules). The concentration of PCBs spilled is determined by the PCB concentration in the material spilled as opposed to the concentration of PCBs in the material onto which the PCBs were spilled. Where a spill of untested mineral oil occurs, the oil is presumed to contain >50 ppm but <500 ppm PCBs. The policy does not affect cleanup standards imposed under other federal statutory authorities, including, but not limited to, the Clean Water Act, RCRA, and the Comprehensive Environmental Response, Compensation, and Liability Act/Superfund Amendments and Reauthorization Act (CERCLA/SARA). Where more than one requirement applies, the more stringent standard must be met.

For spills involving <1 lb of low-concentration (<500-ppm) PCBs by weight (equivalent to <270 gal of untested mineral oil containing <500-ppm PCBs), solid surfaces must be double washed/rinsed (per 761.123) and indoor residential surfaces (other than vault areas) cleaned to 10 $\mu g/100\ cm^2$; all soil with visible traces plus one lateral foot must be excavated and the ground returned to its original configuration by backfilling with clean soil (i.e., containing <1 ppm PCB).

Requirements for cleanup of high-concentration (>500-ppm) PCB spills and low-concentration soils involving 1 lb or more by weight are as follows:

1. For outdoor electrical substations (per 761.123): Contaminated solid surfaces must be cleaned to 100 $\mu g/100\ cm^2$; soil contaminated must be cleaned to either 25 ppm PCBs by weight or to 50 ppm by weight provided that a label or notice is visibly placed on the area. EPA may establish an alternative level based on potential impacts of meeting the above standards to the integrity of the equipment at the facility. At the time the facility is converted to another use, the spill site must be cleaned to the unrestricted access requirements below.

2. For restricted access areas (per 761.123): High-contact solid surfaces (see 761.123) and low-contact, indoor, impervious solid surfaces must be cleaned to 10 $\mu g/100\ cm^2$; low-contact, indoor, nonimpervious solid surfaces must be cleaned to either 10 $\mu g/100\ cm^2$ or to 100 $\mu g/100\ cm^2$ and encapsulated (the encapsulation option must be approved by the EPA, who has the authority to disallow the encapsulation option); low-contact outdoor surfaces must be cleaned to 100 $\mu g/100\ cm^2$; and soil contaminated by the spill must be cleaned to 25-ppm PCBs by weight. At the time the facility is converted to another use, the spill site must be cleaned to the unrestricted access requirements below.

3. For nonrestricted access areas (per 761.123): Indoor solid surfaces and high-contact outdoor solid surfaces must be cleaned to 10 $\mu g/100\ cm^2$; indoor vault areas and low-contact, outdoor, impervious solid surfaces must be cleaned to 10 $\mu g/100\ cm^2$; low-contact, outdoor, nonimpervious solid surfaces must be cleaned to either 10 $\mu g/100\ cm^2$ or cleaned to 100 $\mu g/100\ cm^2$ and encapsulated (the encapsulation option must be approved by the EPA, who has the authority to disallow the encapsulation option); and soil contaminated by the spill must be decontaminated to 10-ppm PCBs by weight provided that the soil is excavated to a depth of 10 in. The excavated soil will be replaced by clean soil, that is, soil containing <1 ppm PCBs, and the spill site will be restored.

4.4 PCB-CONTAMINATED DEBRIS

Hazardous debris that is also a PCB waste under 40 CFR Part 761 must comply with applicable PCB requirements and debris treatment standards by satisfying the more stringent applicable requirements. Thus, treatment standards for hazardous debris apply to debris contaminated with PCBs and RCRA hazardous waste.

Debris treated to performance standards by Extraction or Destruction technology (and which does not exhibit a characteristic) remains subject only to TSCA regulation. Debris treated solely by immobilization remains subject to RCRA and TSCA. Disposal of debris contaminated by PCBs is regulated under 40 CFR 761.60, and debris resulting from cleanup of PCB spills is subject to PCB Spill Cleanup Policy under 40 CFR 761.125.

4.5 IMPACT ON PERFORMANCE CRITERIA

Based on this brief summary of TSCA, it is clear that the preferred treatment option for PCB-contaminated waste is thermal destruction. Because of the antidilution provisions of TSCA and based on past policy, it is doubtful that generic approaches to S/S as sole treatment methods would receive approval as a disposal option for PCBs. Typically, EPA disposal approvals under TSCA are specific not only to the type of PCB waste, but also to the person, location, and formal approval application. However, alternative methods specific to the type of PCB waste may be approved by EPA under the provisions of 40 CFR 761.60(e) for disposal of PCB wastes.

Other PCB-contaminated waste is not inherently a RCRA hazardous waste. Disposal of PCB-containing dielectric fluid and equipment regulated under 40 CFR 761 that are hazardous only due to failure to pass TCLP (i.e., characteristically toxic) are exempt from regulation under RCRA. However, PCB waste can become regulated under RCRA if

1. the waste is mixed with (or contains) a listed hazardous waste (Sect. 3.3) and/or
2. the waste exhibits a characteristic of a hazardous waste (Sect. 3.4).

In either of these two cases, the waste becomes a "California List Waste" (Sect. 3.2) provided that the waste is a liquid as determined in a Paint Filter Test and the PCB concentration is $\geq$50 ppm. The PCBs must be disposed of (i.e., treated) per TSCA requirements, and the RCRA hazardous constituents must be treated according to requirements in 40 CFR Parts 264, 265, and 268.

The assumption is made in this report that PCBs will be destroyed to acceptable levels as prescribed in TSCA prior to becoming a feed stream to the Final Waste Forms Project. Performance criteria of the residue will be determined by its RCRA waste codes (or categories), which have been discussed previously. Alternative methods of PCB disposal may be pursued through submission of an application for disposal approval with the EPA Regional Administrator, through submission of an alternative disposal proposal by means of an existing compliance agreement (e.g., the Uranium Enrichment Federal Facility Compliance Agreement for PCBs), or through comments to the anticipated PCB rulemaking under TSCA, expected in mid-1994. Such alternative methods are being considered by EPA to be codified in this rulemaking. Treatment to meet LDRs could be pursued for approval as PCB disposal provided the treatment achieved the performance standard (<2 ppm) for PCB disposal under 40 CFR 761.60(e) and did not constitute dilution. Other alternative methods to dispose of PCBs prior to treatment to meet LDRs may also be pursued by the means described above.

5. NUCLEAR REGULATORY COMMISSION REGULATIONS

It is recognized that DOE is not specifically regulated by the Nuclear Regulatory Commission (NRC). However, it is appropriate to address applicable NRC regulations in this report for three reasons:

1. The disposal plans for ORR mixed wastes have not been finalized at this time. One option being considered is off-site commercial disposal. Commercial disposal facilities will be directly regulated by the NRC.

2. Many DOE sites (e.g., Hanford), although not directly regulated by NRC, are utilizing NRC performance criteria for waste forms, and ORR should consider consistency with this approach.

3. EPA is beginning to specifically address mixed wastes (e.g., D008—Radioactive lead solids). Although it is impossible to predict the future course of regulations, it is reasonable to assume that EPA will utilize NRC requirements/regulations as resource documents in the development of future regulations.

This section will present the waste form performance criteria that are derived from the NRC regulations on the low-level radioactive waste (LLW) portion of mixed waste (10 CFR 61.1–61.83). First, applicable definitions are reviewed, including regulations that apply to each LLW classification. Next, the specific waste form performance criteria are detailed.

The goal of the NRC regulations is to limit public exposure to levels that present no unacceptable health risks. "Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in annual dose levels" that exceed acceptable values (10 CFR 61.41). Stabilizing LLW forms can reduce radioactive constituent release rates and thereby prevent acceptable environmental concentrations from being exceeded.

5.1 LLW CLASSIFICATIONS

5.1.1 General Description

This section discusses the basis for the LLW classification and disposal regulations (10 CFR 61.55–61.56). LLW is radioactive material that is not high level waste, spent fuel, uranium or thorium mill tailings, or transuranic waste. Concentration limits for radionuclides of particular concern are listed in Tables 7 and 8. These concentration limits are used to differentiate between the different classes of LLW. LLW is divided into Class A, B, C, or not suitable for disposal (i.e., Greater-than-Class C) classification categories. The specific waste form performance and disposal criteria applicable to an individual waste are determined by the waste's classification. The purpose of this classification system is to correlate the safety requirements to the relative risk of each specific waste type.

Table 7. NRC radionuclide concentrations used to classify low-level radioactive wastes: long-lived radionuclides

Long-lived radionuclides	Concentration (Ci/m^3)
^{14}C	8
^{14}C in activated metal	80
^{59}Ni in activated metal	220
^{94}Nb in activated metal	0.2
^{99}Tc	3
^{129}I	0.08
Alpha-emitting transuranic nuclides with a half-life greater than 5 years	100[a]
^{241}Pu	3,500[a]
^{242}Cm	20,000[a]

[a]Units are nanocuries per gram.
Source: 10 CFR 61.55, Table 1.

Table 8. NRC radionuclide concentrations used to classify low-level radioactive wastes: short-lived radionuclides

Short-lived radionuclides	Concentration (Ci/m^3)		
	Col. 1	Col. 2	Col. 3
Total of all nuclides with <5-year half-life	700	*a*	*a*
^{3}H	40	*a*	*a*
^{60}Co	700	*a*	*a*
^{63}Ni	3.5	70	700
^{63}Ni in activated metal	35	700	7000
^{90}Sr	0.04	150	7000
^{137}Cs	1	44	4600

[a]There are no limits established for these radionuclides in Class B or C. Practical considerations, such as the effects of external radiation and internal heat generation on transportation, handling, and disposal, will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 8 determine the waste to be Class C independent of these nuclides.
Source: 10 CFR 61.55, Table 2.

The Class A waste category includes those LLW wastes that present the least hazard to the public. From among the radionuclides of concern, Class A wastes contain insignificant amounts of the longer- and shorter-lived radionuclides found in Tables 7 and 8 respectively. Class A waste only requires predisposal stabilization (i.e., raw waste treatment to produce a stable waste form) if it has an unacceptable liquid content, as defined in Sect. 5.2.1, or is to be disposed of without segregation from Class B or C wastes. Class B waste also contains insignificant concentrations of the longer-lived radionuclides of concern but contains higher concentrations of the shorter-lived radionuclides than Class A waste and therefore presents a greater potential risk to the public. Consequently, Class B wastes must be stabilized prior to disposal. The radionuclide concentrations of Class A and B wastes decay to levels that no longer represent a significant radiation hazard 100 years after disposal. Consequently, there is a corresponding requirement for 100 years of disposal site institutional control in order to prevent an individual from inadvertently entering the buried LLW and being exposed to it.

A waste is classified as Class C waste if it contains any one of the following:

1. Significant amounts of the longer-lived radionuclides of concern.
2. A relatively large concentration of the shorter-lived radionuclides of concern.
3. A mixture of short-lived radionuclides whose associated sum total risk exceeds that allowable in Class B waste.

Class C wastes require 500 years to decay to levels that present an acceptable hazard to an intruder. Consequently, Class C waste requires special disposal precautions in addition to predisposal stabilization. Such disposal precautions may include deeper burial or 500-year inadvertent intrusion barriers. The stabilized waste forms for both Class B and C wastes should be designed to maintain "gross physical properties and identity, over 300 years."

Finally, wastes whose long- or short-lived radionuclide content exceeds the maximum allowable for Class C waste is designated unsuitable for shallow land burial regardless of waste stability. Proposals for disposal of these wastes may be submitted to the NRC for approval pursuant to 10 CFR 61.58.

5.1.2 Technical Definitions (10 CFR 61.55)

Appropriate waste classification categories are assigned by a two-step sequential comparison of the waste's radionuclide content to the concentration limits listed in Tables 7 and 8. The overall waste classification assigned is the more restrictive result of the two steps. For example, if a waste is Class A per step one and unsuitable for near-surface disposal per step two, then the waste must be treated as unsuitable for near-surface disposal. Each individual waste radionuclide concentration is compared to the corresponding concentration limit found in the tables. For wastes containing two or more of the radionuclides listed in Tables 7 and 8, the sum of the fractions rule must be applied, as described in Sect. 5.1.2.3.

5.1.2.1 First classification step

The first step in classifying waste is to compare the waste's radionuclide concentrations to the long-lived radionuclide concentration limits listed in Table 7. If the waste does not contain any Table 7 radionuclides, then the waste is Class A per step one. If the waste contains radionuclides listed in Table 7, classification shall be determined as follows:

1. If the concentration does not exceed 0.1 times that listed in Table 7, then the waste is Class A per step one.

2. If the waste exceeds 0.1 times the concentration found in Table 7 but does not exceed the listed value, the waste is, at a minimum, Class C per step one but may be unsuitable for disposal depending upon classification step two, described in Sect. 5.1.2.2.

3. If the waste exceeds the value listed in Table 7, it is not suitable for near-surface disposal regardless of the results of classification step two.

4. For wastes that contain a mixture of more than one of the radionuclides listed in Table 7, the sum of the fractions rule must be invoked to determine classification per step one (see Sect. 5.1.2.3).

5.1.2.2 Second classification step

The second classification step requires comparison of the waste's radionuclide concentrations with the short-lived radionuclide concentrations listed in Table 8. Waste not already classified in step one, per Sect. 5.1.2.1, as unsuitable for disposal must be further classified by comparison with Table 8 concentrations as follows:

1. If the waste does not contain any of the radionuclides listed in Table 8, then it is Class A waste per step two.

2. If the waste contains Table 8 individual radionuclide concentrations less than the values listed in column 1 **and** the sum of the fractions (see Sect. 5.1.2.3) is less than 1.0 (using column 1 concentrations as the divisor) for wastes with two or more of the Table 8 radionuclides, then the waste is still Class A per step two.

3. If the waste contains Table 8 individual radionuclide concentrations between the values listed in columns 1 and 2 **and** the sum of the fractions (see Sect. 5.1.2.3) is less than 1.0 (using column 2 concentrations as the divisor) for wastes with two or more of the Table 8 radionuclides, then the waste is Class B per step two.

4. If the waste contains Table 8 individual radionuclide concentrations between the values listed in columns 2 and 3 **and** the sum of the fractions (see Sect. 5.1.2.3) is less than 1.0 (using column 3 concentrations as the divisor) for wastes with two or more of the Table 8 radionuclides, then the waste is Class C per step two.

5. If the waste contains Table 8 individual radionuclide concentrations greater than the values listed in column 3 **or** the sum of the fractions (see Sect. 5.1.2.3) is greater than 1.0 (using column 3 concentrations as the divisor) for wastes with two or more of the Table 8 radionuclides, then the waste is classified as not generally acceptable for near-surface disposal.

5.1.2.3 Sum of fractions

For a waste with a combination of two or more of the radionuclides listed in a single table (i.e., each table is treated separately), the sum of the fractions method is used. The fractional contribution of a given radionuclide is calculated by dividing its concentration in the waste by the limiting concentration of interest listed in the table (i.e., the corresponding concentration in a chosen column). This calculation is repeated for each radionuclide in turn, using a consistent set of table concentrations limits as divisors (i.e., all found in a single column of the table). If an individual fraction is greater than 1.0, then the next higher column of limits must be used as the divisor for all the radionuclides. All the fractions are then summed. This sum must also be less than 1.0 if the waste is to be classified by the limits of the column used. If the sum is greater than 1.0, the next higher column of concentration limits must be used and the process repeated until the sum of the fractions is less than 1.0. The column with the lowest concentration levels, which result in a sum of the fractions less than 1.0, is the column to be used to classify the waste.

5.2 REQUIRED LLW WASTE FORM CHARACTERISTICS

To satisfy the NRC that a waste treatment process will consistently produce acceptable waste forms, a treatment plant-specific process control program (PCP) must be submitted and approved. A detailed description of the NRC requirements for a PCP is beyond the scope of this document. However, there are specific waste form performance criteria that can be gleaned from the regulations and used to determine the feasibility of a technology for treating a waste to produce a potentially acceptable waste form. This section summarizes the NRC waste form requirements presented in 10 CFR 61.55-61.56 and the NRC Waste Form Technical Position Paper.[4] The position paper provides guidelines for quantifying requirements set forth in 10 CFR 61.56. The requirements presented are for the waste or waste container. For the purposes of this document, the requirements are interpreted to be properties that the waste form itself should possess in order to be considered acceptable. The intent is to provide specific performance criteria by which candidate waste forms can be evaluated for Phase I treatability studies.

The first set of requirements discussed apply to all LLW, while the second set, stability requirements, apply only to Class B and C wastes, with the addition of Class A waste that is to be disposed of without segregation from Class B and C wastes. LLW management and disposal regulations are designed to protect public health by minimizing public exposure through isolation and containment of waste. Thus, stabilization of the waste is a tool to minimize exposure.

5.2.1 Requirements for All LLW Classifications

The following are minimum required waste form characteristics for all classes of LLW:

1. Liquid waste must be solidified or packaged in sufficient absorbant material to absorb twice the volume of liquid [10 CFR 61.56(a)(2)].

2. Solid waste must contain as little free-standing and corrosive liquids as is practicable. At a maximum, free-standing and corrosive liquids will not exceed 1% of the waste volume when the waste is disposed of in a container designed to provide stability or 0.5% of the waste volume when solidified [10 CFR 61.56(a)(3) and 61.56(b)(2)]. Free-standing liquid measurements should be made in accordance with test method American Nuclear Society (ANS) 55.1.[5]

3. The waste must not readily be explosive or predisposed to rapid decomposition reactions at normal operating pressures and temperatures [10 CFR 61.56(a)(4)].

4. To protect personnel during waste handling, waste forms cannot contain, or be able to generate, toxic gases. Properly packaged waste gases are an exception to this rule [10 CFR 61.56(a)(5) and 61.56(a)(7)].

5. Waste forms shall be nonflammable [10 CFR 61.56(a)(6)].

6. Gaseous wastes must be packaged at pressures not to exceed 1.5 atm at 20°C. The total activity per package may not exceed 100 Ci [10 CFR 61.56(a)(7)].

7. Waste forms must minimize the hazards from biological, pathogenic, or infectious materials found in the untreated waste [10 CFR 61.56(a)(8)].

5.2.2 Waste Form Stability Requirements

Stabilized wastes must have structural stability as defined in the guidelines below. "Structural stability is intended to ensure that the waste does not degrade and (a) promote slumping, collapse, or other failure of the cap or cover over a near-surface disposal unit and thereby lead to water infiltration, or (b) impart a substantial increase in surface area of the waste form that could lead to an increase in leach rates."[4] It should be noted that [10 CFR 61.56(b)(1)] structural stability can be provided by placing the waste in a disposal container or structure that provides stability after disposal or by the waste form itself. In 10 CFR 61.56(b)(1), a structurally stable waste form is defined as one that "will generally maintain its physical dimensions and its form under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture and microbial activity, and internal factors such as radiation effects and chemical changes." Class A waste need only meet the minimum requirements described in 10 CFR 61.56(a) (see Sect. 5.2.1). However, Class B and C wastes must meet the minimum requirements in 10 CFR 61.56(a) and the stability requirements in 10 CFR 61.56(b) (described in this section). If Class A wastes also meet the stability requirements, then it need not be segregated from Class B and C wastes for disposal [10 CFR 61.55(a)(2)(ii)]. Specific test methods, presented in this and subsequent sections, to determine waste form stability are taken from the technical position paper.[4]

1. **Compressive Strength:** Solidified waste should have the maximum compressive strength practicable but, at a minimum, must have a compressive strength of 60 psi when tested in accordance with ASTM C39 (Ref. 6) (see Sect. 5.2.3 for standards specific to cementitious waste forms). Bituminous products should be tested in accordance with ASTM D1074.[7]

2. **Resistance to Thermal Degradation:** Waste specimens should be resistant to thermal cycle degradation. Samples suitable for ASTM C39 or D1074 testing must be subjected to 30 thermal cycles, from −40 to +60°C, in a heating and cooling chamber in accordance with ASTM B553.[8] Following the thermal cycling, the samples must demonstrate retention of their compressive strength (60 psi minimum).

3. **Radiation Stability:** Wastes must demonstrate the ability to retain their compressive strength after being subjected to 10E+8 rads or the maximum expected exposure level, whichever is greater.

4. **Resistance to Biodegradation:** Samples must retain their compressive strength after being tested in accordance with ASTM G21 (Ref. 9) and G22 (Ref. 10) and should also exhibit no visible culture growth.

   For polymeric or bitumen waste forms, some culture growth is acceptable provided that

   a. The growth does not relate to overall substrate integrity.

   b. After removal of growth and drying of the samples, followed by repetition of ASTM G22 and G21, the G22 specimen shows no observable growth and the G21 specimen shows no growth greater than for the first G21 test.

   c. After completion of the second test, compressive strength testing demonstrates that the samples retain the minimum compressive strength.

   d. If unsatisfactory growth is observed, a 6-month test in accordance with the Bartha-Pramer method[11] employing disposal representative soils must produce less than a 10% total carbon loss when extrapolated to 300 years and a full-size waste form.

5. **Chemical Durability:** Samples of sizes suitable for ASTM C39 and D1074 testing must demonstrate a 90-day leachability index greater than 6.0 and a subsequent retention of their compressive strength. The leach test should be performed in accordance with ANS 16.1,[12] with the addition of the following provisions:

   a. Other leachates, including synthesized seawater (listed in ANS 16.1), should be used in addition to demineralized water.

   b. All leach tests are performed for a minimum of 90 days.

   c. Where practicable, radioactive tracers should be used in performing the leach tests.

6. **Immersion Testing:** Waste specimens must retain maximum practical compressive strength following immersion for a minimum period of 90 days. Immersion testing may be done in conjunction with leach testing.[13]

7. **Free-Standing Liquid:** Specimens must have less than 0.5 vol % free liquid, as measured by ANS 55.1. The liquid should have a pH between 4 and 11.

8. **Test Specimen-Actual Waste Form Correlation:** The following testing of full-scale products, which may be fabricated with nonradioactive waste, must be performed to validate laboratory predictions:

   a. Core Testing: Test sections from cores of the anticipated full-scale products must be obtained and tested to determine the correlation to the small laboratory sample. Correlation testing must include 90-day immersion tests on waste products formed from problem wastes, defined as those wastes that are the most to difficult incorporate into a consistent product.

b. Destructive Analysis: Full-scale waste products must be destructively analyzed to ensure that they are homogeneous "to the extent that all regions in the product can be expected to have compressive strengths comparable to lab scale specimens."[4]

5.2.3 Requirements Particular to Cement Waste Forms

Unique chemical and physical interactions occur in cement-stabilized waste forms (i.e., grout in the context of this project). Therefore, the NRC has promulgated, in Appendix A to the Waste Form Technical Position Paper,[4] a set of cement-specific waste form qualification criteria to supplement those discussed above. Only a summary of these requirements is presented here. To better understand the events and rationale leading to these requirements, the reader is encouraged to review the discussion found in the appendix to that document.

1. **Compressive Strength:** An ASTM C39 mean compressive strength of 500 psi is recommended for cementitious waste forms cured for a minimum of 28 days. The following requirements are stipulated in addition to ASTM C39:

   a. Test specimens must be cylindrical with a 2- to 3-in. diam.

   b. The length-to-diameter ratio (L/D) should be approximately equal to 2.

   c. A minimum of ten as-cured test specimens must be tested to determine the mean.

   d. Compressive strength and/or penetrometer tests should be made after 24 h of curing for later comparison with actual PCP specimens.

2. **Thermal Cycling:** Specimens should be tested bare (i.e., not in a container). Specimens should be allowed to come to thermal equilibrium, as evidenced by the center temperature of at least one specimen per test group. Three specimens per waste formulation should be tested. Following 30 thermal cycles, the specimens should be examined visually and should be free of any evidence of significant cracking, spalling, or bulk disintegration. Visible evidence of significant degradation would be indicative of a failure of the test. Because it is not possible to provide *a priori* assessment of the significance of the visible defects, no definition of significant degradation is provided—assessment of the significance of defects is left up to the tester. Photographic records of the defects should be kept. If no significant defects are visible, the specimen should be compression strength tested.

3. **Irradiation Durability:** Experience has shown that cementatious material is not significantly degraded by radiation exposure of less than 10E+9 rads. Consequently, cement-stabilized waste forms need not be tested unless

   a. the waste forms contain ion-exchange resins or other organic media or
   b. the expected cumulative waste form dose exceeds 10E+9 rads.

In these cases, irradiation testing is warranted at the expected exposure rate or 10E+8 rads, whichever is greater, on a minimum of three waste forms for each waste stream formulation being qualified.

Following the irradiation testing, the specimens should be examined visually and should be free of any evidence of significant cracking, spalling or bulk disintegration. Visible evidence of significant degradation would be indicative of a failure of the test. Because it is not possible to provide *a priori* assessment of the significance of the visible defects, no definition of significant degradation is provided; assessment of the significance of defects is left up to the tester. Photographic records of the defects should be kept. If no significant defects are visible, the specimen should be compression strength tested.

4. **Biodegradation Resistance:** Since culture growth usually requires a source of carbon, which is not normally present in cement stabilized wastes, biodegradation qualification is not required unless waste forms contain carbonaceous materials. For wastes with carbonaceous materials, there should be no visible culture growth as a result of ASTM G21 and G22 testing. A minimum of three specimens for each carbon waste stream must be tested. The test specimens should also be free from any evidence of significant cracking, spalling, or bulk disintegration. Following the test, specimens without significant visible defects should be compression strength tested.

5. **Leach Testing:** The 90-day leach test period specified in ANS 16.1 and called out in the regulations is based on the concern that, over time, there could be a change in the leach mechanism that may alter the leach rate. Thus the 90 days allows for that change in rate to be observed. However, any leaching that involves mechanisms such as erosion, dissolution, or corrosion would most likely be readily observed visually during the 90-day immersion test. Also, experience has shown that there is usually little difference between the observed leach rates of 5- and 90-day leach tests. Consequently, a 5-day leach test is sufficient.

If it can be shown that a chosen leachate is the most aggressive one through a 24-h leach testing comparison of candidate leachates, single leachate testing is appropriate.

6. **Immersion Testing:** Immersion testing should be performed in either deionized water or synthesized seawater. The immersion liquid should be the most aggressive leachate found in the short-term 24-h leachate testing described previously. At least three specimens, cured for a minimum of 28 days, per waste stream should be tested. Following the immersion testing, the specimens should be examined visually and should be free of any evidence of significant cracking, spalling, or bulk disintegration. Visible evidence of significant degradation would be indicative of a failure of the test. Because it is not possible to provide *a priori* assessment of the significance of the visible defects, no definition of significant degradation is provided—assessment of the significance of defects is left up to the tester. Photographic records of the defects should be kept. If no significant defects are visible, the specimen should be compression strength tested. Postimmersion strength should be at least 75% of the preimmersion value and should have a mean no less than 500 psi. If postimmersion compressive strength is less than 75% of the preimmersion value but with a mean greater than 500 psi, the immersion testing interval should be extended to 180 days with periodic compression strength testing to verify that the strength does not continue to decline. The strength should be observed to level off at a mean above 500 psi.

For specimens with known complex relationships between cure time and immersion resistance (such as waste forms containing resin beads, chelates, and sludges), additional immersion testing should be performed on specimens that have been cured, in sealed containers, for a minimum of 180 days. The immersion period should be a minimum of 7 days, followed by a drying period of 7 days at 20°C. After these complex cure-time specimens have dried, they should meet the above-mentioned postimmersion visual and strength test criteria.

7. **Free-Standing Liquids:** Since cement is an alkaline material, any acidic free-standing liquid is indicative of improper waste preparation. No more than 0.5% of the volume of cemented waste forms may be free-standing liquid, for which the pH must be 9 or greater.

8. **Mixing/Preparation:** Past experience has shown that the method employed in mixing the grout can have a dramatic impact on the resultant properties of the waste form. In preparing laboratory-scale specimens for waste form qualification, it must be shown that the type of equipment used, the mixing time, the speed of the mixer, etc., will, in combination, impart the same degree of mixing and homogeneity that will be imparted to the full-scale waste form.

9. **Curing:** The curing conditions for the laboratory specimens should be the same as those anticipated for the full-scale operations. Of particular concern is the peak curing centerline temperature profile difference between the laboratory specimen and the full-scale monolith. An acceptable method is to cure the specimens in a suitable oven for a period equivalent to the time it takes for the full-scale waste to decrease in temperature to near ambient temperature (~30°C).

10. **Storage:** Test specimens should be kept in sealed containers during curing and pretesting storage. This is intended to simulate the environment of a full-scale operation and will also prevent the loss of water, which could affect the performance of the waste.

11. **Statistical Sampling Requirements:**

    a. Compressive Strength: There is usually considerable scatter in compressive strength test data. Therefore, a sufficient number of samples should be tested (at least 10 or more for each formulation) to establish a mean and a standard deviation.

    b. Leachability Index: ANSI/ANS 16.1 uses the confidence range and correlation as measures of variability in the reported leachability index values. However, neither ASTM C39 nor the leachability standard have established specific precision criteria. Such criteria will be selected and documented in subsequent project reports related to project quality assurance and procedures.

12. **Known Problem Wastes:** Table 9 presents several wastes that are known to be problematic to cement waste forms. These wastes should be avoided in grout formulations, or specific adjustments should be made to compensate for and mitigate their effects.

Table 9. Known problematic wastes

Inorganic constituents	Organic constituents
1. Borates	1. Organic acids a. Formic acid
2. Phosphates	2. Chelates a. Oxalic acid b. Citric acid (citrates) c. Picolinic acid (picolinates) d. EDTA[a] (and its salts) e. NTA[a] (and its salts)
3. Lead salts	3. Decon solutions
4. Zinc salts	4. Soaps and detergents
5. Ammonia and ammonium salts	5. Oily wastes a. Benzene b. Toluene c. Hexane d. Vegetable oils additives
6. Ferric salts	6. Acetone
7. Oxidizing agents a. Permanganates b. Chromates	7. Methyl ethyl ketone
8. Nitrates	8. Trichloroethane
9. Sulfates	9. Trichlorotriflouroethane
10. Sodium hypochlorite	10. Xylene
	11. Dichlorobenzene

[a]EDTA = ethylenediaminetetraacetic acid; NTA = nitrilotriacetic acid.

5.2.4 Summary of NRC Waste Form Requirements

Class A wastes are only required to meet the first set of general criteria discussed in Sect. 5.2.1 and are exempt from the stability testing criteria unless they are disposed of without being segregated from Class B and C wastes. Stability requirements apply to Class B and C wastes. Table 10 correlates the stability requirement categories with the applicable NRC-recommended test procedure. Substitute test procedure(s) may be used, provided their applicability and validity can be proven.

5.3 IMPACT ON PHASE I WASTE FORM PERFORMANCE CRITERIA

NRC performance criteria are significantly different from those of the EPA. While the EPA relies heavily on the TCLP as the major performance criterion for nonwastewaters, NRC relies more heavily on tests related to maintaining the waste form's structural integrity. In addition, the NRC test for free liquids (ANS 55.1) is also different from that used by the EPA [Paint Filter Test (SW846, Method 9095)]. Experience has shown that the ANS 55.1 test is more conservative than the paint filter test. ANS 55.1 will therefore become a performance criterion for this project.

Table 10. Stability criterion vs test procedures

Stability criterion	Test procedure (reference)
Compressive strength	ASTM C39 or D1074 (6 or 7)
Biodegradation	ASTMs G21, G22, and Bartha Persistence Test (9, 10, and 11)
Leachability	ANS 16.1 (12)
Thermal degradation	ASTM B553 (8)
Free-standing liquid	ANS 55.1 (5)

However, the majority of NRC tests related to structural integrity will not be performed during the Phase I treatability studies. There are three reasons for this decision:

1. The majority of structural integrity tests are time consuming and costly. Since it is not certain that NRC criteria will be applied to the final waste form, the expenditures in cost and time are not justified in the Phase I studies.

2. Unlike the applicable EPA test methods, the test methods are recommended by the NRC and are not codified in the regulations.

3. Even in the case where NRC regulations are applicable, the majority of the tests can be performed as certification tests rather than proof-of-principle. Certification tests are more appropriate for the Phase II studies, as described in Sect. 1.

The NRC tests should not, however, be completely ignored during the Phase I studies. Accordingly, compressive strength will be measured on the products produced in Phase I. Although compressive strength is not quantitatively related to the structural test values, it has been demonstrated to be qualitatively related. It is therefore appropriate to determine compressive strengths during Phase I studies in order to acquire data to assist prediction of Phase II product performance.

6. SUMMARY

The purpose of this document is to define the product performance criteria to be used in Phase I of the Final Waste Forms Project. In Phase I, treatability studies will be performed to provide "proof-of-principle" data to establish the viability of S/S technologies. This information is required for the March 1995 deliverable. In Phase II, further treatability studies, some at the pilot scale, will be performed to provide sufficient data to allow treatment alternatives identified in Phase I to be fully developed and evaluated, as well as to reduce performance uncertainties for those methods chosen to treat a specific waste. The focus of these Phase II efforts will be to obtain the necessary data to design the process module(s) and optimize the waste form formulation's ability to accommodate expected variations in both feed characteristics and process operations. While Phase I will be concentrated primarily on laboratory- or bench-scale studies, Phase II will be focused on laboratory-scale studies as well as both bench-scale and pilot-scale demonstrations.

Three main factors influence the development and selection of an optimum waste form formulation and hence affect selection of performance criteria. These are regulatory, process-specific, and site-specific waste form standards or requirements. Regulatory requirements are those product performance criteria that are required by law or regulation and are typically site independent and may be process independent. For example, a waste form must meet certain concentration-based or technology-based treatment standards, or combinations thereof, in order to be land disposed. In general, these standards are independent of the process and waste form matrix ingredients employed (note, however, that where the treatment standard requires use of a specified technology, the process would not, therefore, be independent).

Process-specific requirements are those pertaining to process variables/constraints such as acceptable waste form fluid viscosity, ability to control the addition and blending/mixing of the formulation ingredients, temperature control, etc. For a grout formulation the process may place constraints on such properties as viscosity, set time, and gel strength.

Site-specific requirements are those pertaining to the storage, handling, and disposal of the waste form product. For example, the waste form may be placed in 55-gal drums, stacked four high, which may place compressive strength requirements on the product to support the intended load. On the other hand, the product may be accumulated for a period of time awaiting shipment off-site and would thus require resistance to atmospheric temperature variations (freeze/thaw resistance). Note that, in addition to regulatory-driven performance criteria for the chemical components of a final waste form, allowable waste form radiological contaminant concentrations and/or activity would be a site-specific performance requirement, as defined by the performance assessment process for the individual disposal site.

Clearly, the optimum waste form formulation will require consideration of performance criteria constraints from each of the three categories. Phase I will focus only on the regulatory criteria. These criteria may be considered the minimum criteria for an acceptable waste form. In other words, an S/S technology is considered viable only if it meets applicable regulatory criteria. Formulation optimization would be performed only on those selected technologies whose viability has been established through screening tests. Identification of viable technologies is the purpose of the treatability studies conducted in Phase I. As stated previously, formulation optimization efforts are part of the Phase II treatability studies.

The criteria to be used in the Phase I treatability studies were primarily taken from EPA regulations addressed in 40 CFR 260 through 265 and 268 and NRC regulations addressed in 10 CFR 61. Although acceptable performance values are waste stream specific, the test methods to evaluate the performance are generic and are summarized in Table 11. The goal of both agencies is the protection of human health and the environment. However, as shown in Table 11, there are differences in the implementation of this goal. Regardless, Table 11 forms the basis for selection of the performance criteria/test methods to be applied in Phase I treatability studies.

Table 11. Comparison of EPA and NRC waste form evaluation methods

Property/parameter	EPA method	NRC method
Leachability	SW846, Method 1310 (TCLP)	ANS 16.1
Free liquid	SW846, Method 9095 (Paint Filter Test)	ANS 55.1
Compressive stength	NA	ASTM C39
Biodegradation	NA	ASTM G21, G22
Thermal degradation	NA	ASTM B553

As discussed in Sect. 5.3, the EPA test methods will be given priority in the Phase I Treatability Studies. As such, the first performance criterion becomes acceptable leachate concentrations as determined by the TCLP (both acceptable concentrations and the constituents of interest are waste specific). Although S/S products must be designated as a solid per the Paint Filter Test, internal studies (to Energy Systems) have shown that the ANS 55.1 test is more conservative. In addition, these internal studies have shown that modifications to ANS 55.1 in terms of sample size are acceptable. Consequently, the second performance criterion becomes no drainable water as determined by a modified ANS 55.1 test. As discussed in Sect. 5.3, it is appropriate to determine compressive strengths during Phase I studies. Although NRC recommends test method ASTM C39 or equivalent, ASTM C109 (Ref. 14) has been shown in internal studies to be an acceptable substitute and has the added benefit of a smaller sample size, which, in turn, requires less waste material for testing. Consequently, compressive strength will be determined during Phase I studies but will not be assigned a minimum acceptable value.

Throughout Sect. 3 of the text, waste categories and their residues for which stabilization is the specified BDAT are highlighted. For purposes of the Final Waste Forms Project, when stabilization is the specified treatment method, then that waste/waste residue becomes a priority candidate for Phase I treatability studies.

In addition, a key assumption guiding this project is that all applicable treatment standards for organic species subject to LDR and TSCA treatment standards are met by pretreatment prior to S/S. However, S/S is not precluded as a treatment option for wastes/waste residues for which S/S is not the specified BDAT or for wastes contaminated with multiple waste codes, including organics. Indeed, the EPA has established a precedent for use of reduction in TCLP levels instead of CCW levels "when evaluating waste in which organics are not a principal constituent that have been treated through an immobilization (i.e., S/S, in the context of this report) process."[15] In addition, in a recent draft engineering bulletin[16] the EPA has stated that:

> The Superfund Policy on use of immobilization is as follows: immobilization is generally appropriate as a treatment alternative only for material containing inorganics, semi-volatile and/or non-volatile organics. Based on present information, the Agency does not believe that immobilization is an appropriate treatment alternative for volatile organics. Selection of immobilization of semi-volatile and non-volatile organics generally requires the performance of a site-specific treatability study or non-site-specific treatability study data generated on waste which is very similar (in terms of type of contaminant, concentration, and waste matrix) to that to be treated and that demonstrates through Total Waste Analyses (TWA), a significant reduction (e.g., a 90 to 99 percent reduction) in the concentration of chemical constituents of concern. The 90 to 99 percent reduction in contaminant concentration is a general guidance and may be varied within a reasonable range considering the effectiveness of the technology and the cleanup goals for the site. Although this policy represents EPA's strong belief that TWA should be used to demonstrate effectiveness of immobilization, other leachability tests may also be appropriate in addition to TWA to evaluate the protectiveness under a specific management scenario.

In addition, the reader should also note that, as a regulatory-based document, this report represents a "snapshot in time" (current as of December 1, 1993) and is subject to change. For example, on September 25, 1992, the U.S. Court of Appeals for the District of Columbia Circuit ruled on the various petitions for review filed against the Third rule [Chemical Waste Management, Inc., et al. v. EPA, 976 F. 2d 2 (58 FR 29861)]. On May 24, 1993, as part of its response to the September 25 decision, the EPA stated, "The Agency plans to address issues which have been remanded by the court in future rulemaking" (58 FR 29865). Clearly, additional rulemakings that may impact the discussions related to performance criteria in this report are forthcoming.

7. REFERENCES

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5. ANS 55.1, "American National Standard for Solidified Radioactive Waste Processing for Light Water Cooled Reactor Plants," American Nuclear Society, 1979.

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15. U.S. EPA, "Superfund LDR Guide #6B," Superfund Publication: 9347.3-06BFS, September 1990.

16. U.S. EPA, "Engineering Bulletin: Solidification/Stabilization of Inorganics and Organics," November 1991.

8. ACKNOWLEDGMENTS

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Appendix A.

TREATMENT STANDARDS FOR LISTED WASTES

Appendix A. TREATMENT STANDARDS FOR LISTED WASTES (NONWASTEWATER)

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
F001—Spent halogenated solvents used in degreasing	Carbon tetrachloride	5.6		Incineration
	Methylene chloride	33.0		
	Tetrachloroethylene	5.6		
	1,1,1-Trichloroethane	5.6		
	Trichloroethylene	5.6		
	1,1,2-Trichloro-1,2,2-trifluoroethane	28.0		
	Trichloromonofluoro-methane	33.0		
F002—Spent halogenated solvents	Chlorobenzene	5.7		Incineration
	o-Dichlorobenzene	6.2		
	Methylene chloride	33.0		
	Tetrachloroethylene	5.6		
	1,1,1-Trichloroethane	5.6		
	1,1,2-Trichloroethane	7.6		
	Trichloroethylene	5.6		
	1,1,2-Trichloro-1,2,2-trifluoroethane	28.0		
	Trichloromonofluoro-methane	33.0		
F003—Spent nonhalogenated solvents	Acetone	160.0		Incineration
	n-Butyl alcohol	2.6		
	Cyclohexanone		0.75	

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Ethyl acetate	33.0		
	Ethyl benzene	6.0		
	Ethyl ether	160.0		
	Methanol		0.75	
	Methyl isobutyl ketone	33.0		
	Xylenes (total)	28.0		
F004—Spent nonhalogenated solvents	Cresol (m- and p- isomers)	3.2		Incineration
	o-Cresol	5.6		
	Nitrobenzene	14.0		
F005—Spent nonhalogenated solvents	Benzene	3.7		Incineration
	Carbon disulfide		4.8	
	2-Ethoxyethanol	INCIN		
	Isobutyl alcohol	170.0		
	Methyl ethyl ketone	36.0		
	2-Nitropropane	INCIN		
	Pyridine	16.0		
	Toluene	28.0		
F006—Wastewater treatment sludges from electroplating operations	Cadmium		0.066	Alkaline chlorination (cyanides); chemical precipitation, settling, filtration, and stabilization (metals)
	Chromium (total)		5.2	
	Lead		0.51	
	Nickel		0.32	
	Silver		0.072	
	Cyanides (total)	590.0		
	Cyanides (amenable)	30.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
F006—Alternative standards for nonwastewaters based on high-temperature metals recovery	Antimony		2.1	Alternative standards based on high-temperature metals recovery
	Arsenic		0.055	
	Barium		7.6	
	Beryllium		0.014	
	Cadmium		0.19	
	Chromium (total)		0.33	
	Lead		0.37	
	Mercury		0.009	
	Nickel		5.0	
	Selenium		0.16	
	Silver		0.30	
	Thallium		0.078	
	Zinc		5.3	
	Cyanides (total)	1.8		
F007—Spent cyanide plating bath solutions from electroplating operations	Cadmium		0.066	Alkaline chlorination (cyanides); chemical precipitation, settling, filtration, and stabilization (metals)
	Chromium (total)		5.2	
	Cyanides (total)	590.0		
	Cyanides (amendable)	30.0		
	Lead		0.51	
	Nickel		0.32	
	Silver		0.072	

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
F008—Plating bath sludges from the bottom of plating baths from electroplating operations where cyanides are used in the process	Cadmium		0.066	Alkaline chlorination (cyanides); chemical precipitation, settling, filtration, and stabilization (metals)
	Chromium (total)		5.2	
	Cyanides (total)	590.0		
	Cyandies (amendable)	30.0		
	Lead		0.51	
	Nickel		0.32	
	Silver		0.072	
F009—Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process	Cadmium		0.066	Alkaline chlorination (cyanides); chemical precipitation, settling, filtration, and stabilization (metals)
	Chromium (total)		5.2	
	Cyanides (total)	590.0		
	Cyanides (amenable)	30.0		
	Lead		0.51	
	Nickel		0.32	
	Silver		0.072	
F010—Quenching bath sludge from oil baths from metal heat treating operations where cyanides are used in the process	Cyanides (total)	1.5		Incineration (cyanides)
	Cyanides (amenable)			
F011—Spent cyanide solutions from salt bath pot cleaning from metal heat treating operations	Cadmium		0.066	Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration, and stabilization (metals)
	Chromium (total)		5.2	
	Cyanides (total)	110.0		
	Cyanides (amenable)	9.1		
	Lead		0.51	
	Nickel		0.32	
	Silver		0.072	

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
F012—Quenching wastewater treatment sludges from metal heat treating operations where cyanides are used in the process	Cadmium		0.066	Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration, and stabilization (metals)
	Chromium (total)		5.2	
	Cyanides (total)	110.0		
	Cyanides (amenable)	9.1		
	Lead		0.51	
	Nickel		0.32	
	Silver		0.072	
F019—Wastewater treatment sludges from the chemical conversion coating of aluminum	Cyanides (total)	590.0		Alkaline chlorination (cyanides); stabilization (chromium)
	Cyanides (amenable)	30.0		
	Chromium (total)		5.2	
F020–F023—Dioxin-containing wastes	HxCDD-All Hexachlorodi-benzo-p-dioxins		<1 ppb	Incineration
	HxCDF-All Hexachlorodi-benzofurans		<1 ppb	
	PeCDD-All Pentachlorodi-benzo-p-dioxins		<1 ppb	
	PeCDF-All Pentachlorodi-benzofurans		<1 ppb	
	TCDD-All Tetrachlorodi-benzo-p-dioxins		<1 ppb	
	TCDF-All Tetrachlorodi-benzofurans		<1 ppb	
	2,4,5-Trichlorophenol		<0.05 ppm	
	2,4,6-Trichlorophenol		<0.05 ppm	
	2,3,4,6-Tetrachlorophenol		<0.05 ppm	
	Pentachlorophenol		<0.01 ppm	

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
F024—Wastes from the production of chlorinated aliphatic hydrocarbons	2-Chloro-1,3-butadiene	INCIN and 0.28		Rotary kiln incineration; stabilization of incinerator ash (metals)
	3-Chloropropene	INCIN and 0.28		
	1,1-Dichloroethane	INCIN and 0.014		
	1,2-Dicholoroethane	INCIN and 0.014		
	1,2-Dichloropropane	INCIN and 0.014		
	cis-1,3-Dichloropropene	INCIN and 0.014		
	trans-1,3-Dichloropropene	INCIN and 0.014		
	Bis(2-ethylhexyl) phthalate	INCIN and 1.8		
	Hexachloroethane	INCIN and 1.8		
	Chromium (total)		0.073	
	Lead		Reserved	
	Nickel		0.088	
F025—Condensed light ends, spent filters and filter aids, and spent desiccant wastes from the production of chlorinated aliphatics—Light ends subcategory	Chloroform	6.2		Incineration
	1,2-Dichloroethane	6.2		
	1,1-Dichloroethylene	6.2		
	Methylene chloride	31.0		
	Carbon tetrachloride	6.2		
	1,1,2-Trichloroethane	6.2		
	Trichloroethylene	5.6		
	Vinyl chloride	33.0		
F025—Spent filters/aids and desiccants subcategory	Chloroform	6.2		Incineration
	Methylene chloride	31.0		
	Carbon tetrachloride	6.2		
	1,1,2-Trichloroethane	6.2		
	Trichloroethylene	5.6		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Vinyl chloride	33.0		
	Hexachlorobenzene	37.0		
	Hexachlorobutadiene	28.0		
	Hexachloroethane	30.0		
F026–F028—Dioxin-containing wastes	HxCDD-All Hexachloro-dibenzo-p-dioxins		<1 ppb	Incineration
	HxCDF-All Hexachloro-dibenzofurans		<1 ppb	
	PeCDD-All Pentachloro-dibenzo-p-dioxins		<1 ppb	
	PeCDF-All Pentachloro-dibenzofurans		<1 ppb	
	TCDD-All Tetrachloro-dibenzo-p-dioxins		<1 ppb	
	TCDF-All Tetrachloro-dibenzofurans		<1 ppb	
	2,4,5-Trichlorophenol		<0.05 ppm	
	2,4,6-Trichlorophenol		<0.05 ppm	
	2,3,4,6-Tetrachlorophenol		<0.05 ppm	
	Pentachlorophenol		<0.01 ppm	

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
F037—Petroleum refinery primary oil/water/solids separation sludge	Anthracene	28.0		Solvent extraction or incineration (organics); incineration (cyanides); stabilization (metals)
	Benzene	14.0		
	Benzo(a)anthracene	20.0		
	Benzo(a)pyrene	12.0		
	Bis(2-ethylhexyl)phthalate	7.3		
	Chrysene	15.0		
	Di-n-butyl phthalate	3.6		
	Ethylbenzene	14.0		
	Naphthalene	42.0		
	Phenanthrene	34.0		
	Phenol	3.6		
	Pyrene	36.0		
	Toluene	14.0		
	Xylene(s)	22.0		
	Cyanides (total)	1.8		
	Chromium (total)		1.7	
	Nickel		0.20	
F038—Petroleum refinery secondary (emulsified) oil/water/solids separation sludge	Benzene	14.0		Solvent extraction or incineration (organics); incineration (cyanides); stabilization (metals)
	Benzo(a)pyrene	12.0		
	Bis(2-ethylhexyl)phthalate	7.3		
	Chrysene	15.0		
	Di-n-butyl phthalate	3.6		
	Ethylbenzene	14.0		
	Naphthalene	42.0		
	Phenanthrene	34.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Phenol	3.6		
	Pyrene	36.0		
	Toluene	14.0		
	Xylene(s)	22.0		
	Cyanides (total)	1.8		
	Chromium (total)		1.7	
	Nickel		0.20	
F039[a]—Multisource leachate organics (see also F039 multisource leachate inorganics)	Acetone	160.0		Incineration (organics)
	Acenaphthalene	3.4		
	Acenaphthene	4.0		
	Acetophenone	9.7		
	2-Acetylaminofluorene	140.0		
	Acrylonitrile	84.0		
	Aldrin	0.066		
	Aniline	14.0		
	Anthracene	4.0		
	Aroclor 1016	0.92		
	Aroclor 1221	0.92		
	Aroclor 1232	0.92		
	Aroclor 1242	0.92		
	Aroclor 1248	0.92		
	Aroclor 1254	1.8		
	Aroclor 1260	1.8		
	alpha-BHC	0.066		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	beta-BHC	0.066		
	delta-BHC	0.066		
	gamma-BHC	0.066		
	Benzene	36.0		
	Benz(a)anthracene	8.2		
	Benzo(b)fluoranthene	3.4		
	Benzo(k)fluoranthene	3.4		
	Benzo(g,h,i,)perylene	1.5		
	Benzo(a)pyrene	8.2		
	Bromodichloromethane	15.0		
	Bromoform (tribromomethane)	15.0		
	Bromomethane (methyl bromide)	15.0		
	4-Bromophenyl phenyl ether	15.0		
	n-Butyl alcohol	2.6		
	Butyl benzyl phthalate	7.9		
	2-sec-Butyl-4,6-dinitrophenol	2.5		
	Carbon tetrachloride	5.6		
	Chlordane	0.13		
	p-Chloroaniline	16.0		
	Chlorobenzene	5.7		
	Chlorodibromomethane	15.0		
	Chloroethane	6.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	bis(2-Chloroethoxy)methane	7.2		
	bis(2-Chloroethyl)ether	7.2		
	Chloroform	5.6		
	bis(2-Chloroisopropyl)ether	7.2		
	p-Chloro-m-cresol	14.0		
	Chloromethane (methyl chloride)	33.0		
	2-Chloronaphthalene	5.6		
	2-Chlorophenol	5.7		
	3-Chloropropene	28.0		
	Chrysene	8.2		
	o-Cresol	5.6		
	Cresol (m- and p-isomers)	3.2		
	1,2-Dibromo-3-chloropropane	15.0		
	1,2-Dibromoethane (ethylene dibromide)	15.0		
	Dibromomethane	15.0		
	2,4-Dichlorophenoxyacetic acid (2,4-D)	10.0		
	o,p'-DDD	0.087		
	p,p'-DDD	0.087		
	o,p'-DDE	0.087		
	p,p'-DDE	0.087		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	o,p′-DDT	0.087		
	p,p′-DDT	0.087		
	Dibenz(a,h)anthracene	8.2		
	m-Dichlorobenzene	6.2		
	o-Dichlorobenzene	6.2		
	p-Dichlorobenzene	6.2		
	Dichlorodifluoromethane	7.2		
	1,1-Dichloroethane	7.2		
	1,2-Dichloroethane	7.2		
	1,1-Dichloroethylene	33.0		
	trans-1,2-Dichloroethylene	33.0		
	2,4-Dichlorophenol	14.0		
	2,6-Dichlorophenol	14.0		
	1,2-Dichloropropane	18.0		
	cis-1,3-Dichloropropene	18.0		
	trans-1,3-Dichloropropene	18.0		
	Dieldrin	0.13		
	Diethyl phthalate	28.0		
	2,4-Dimethyl phenol	14.0		
	Dimethyl phthalate	28.0		
	Di-n-butyl phthalate	28.0		
	1,4-Dinitrobenzene	2.3		
	4,6-Dinitro-o-cresol	160.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	2,4-Dinitrophenol	160.0		
	2,4-Dinitrotoluene	140.0		
	2,6-Dinitrotoluene	28.0		
	Di-n-octyl phthalate	28.0		
	Di-n-propylnitrosoamine	14.0		
	1,4-Dioxane	170.0		
	Disulfoton	6.2		
	Endosulfan I	0.066		
	Endosulfan II	0.13		
	Endosulfan sulfate	0.13		
	Endrin	0.13		
	Endrin aldehyde	0.13		
	Ethyl acetate	33.0		
	Ethyl cyanide	360.0		
	Ethyl benzene	6.0		
	Ethyl ether	160.0		
	bis-(2-Ethylhexyl)phthalate	28.0		
	Ethyl methacrylate	160.0		
	Famphur	15.0		
	Fluoranthene	8.2		
	Fluorene	4.0		
	Fluorotrichloromethane	33.0		
	Heptachlor	0.066		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Heptachlor epoxide	0.066		
	Hexachlorobenzene	37.0		
	Hexachlorobutadiene	28.0		
	Hexachlorocyclopentadiene	3.6		
	Hexachlorodibenzo-furans	0.001		
	Hexachlorodibenzo-p-dioxins	0.001		
	Hexachloroethane	28.0		
	Hexachloropropene	28.0		
	Indeno(1,2,3-c,d)pyrene	8.2		
	Iodomethane	65.0		
	Isobutanol	170.0		
	Isodrin	0.066		
	Isosafrole	2.6		
	Kepone	0.13		
	Methacrylonitrile	84.0		
	Methapyrilene	1.5		
	Methoxychlor	0.18		
	3-Methylcholanthrene	15.0		
	4,4-Methylene-bis-(2-chloroaniline)	35.0		
	Methylene chloride	33.0		
	Methyl ethyl ketone	36.0		
	Methyl isobutyl ketone	33.0		
	Methyl methacrylate	160.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Methyl parathion	4.6		
	Naphthalene	3.1		
	p-Nitroaniline	28.0		
	Nitrobenzene	14.0		
	5-Nitro-o-toluidine	28.0		
	4-Nitrophenol	29.0		
	N-Nitrosodiethylamine	28.0		
	N-Nitroso-di-n-butylamine	17.0		
	N-Nitrosomethylethylamine	2.3		
	N-Nitrosomorpholine	2.3		
	N-Nitrosopiperidine	35.0		
	N-Nitrosopyrrolidine	35.0		
	Parathion	4.6		
	Pentachlorobenzene	37.0		
	Pentachlorodibenzo-furans	0.001		
	Pentachlorodibenzo-p-dioxins	0.001		
	Pentachloronitrobenzene	4.8		
	Pentachlorophenol	7.4		
	Phenacetin	16.0		
	Phenanthrene	3.1		
	Phenol	6.2		
	Phorate	4.6		
	Pronamide	1.5		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Pyrene	8.2		
	Pyridine	16.0		
	Safrole	22.0		
	Silvex (2,4,5-TP)	7.9		
	2,4,5-T	7.9		
	1,2,4,5-Tetrachlorobenzene	19.0		
	Tetrachlorodibenzo-furans	0.001		
	Tetrachlorodibenzo-p-dioxins	0.001		
	1,1,1,2-Tetrachloroethane	42.0		
	1,1,2,2-Tetrachloroethane	42.0		
	Tetrachloroethylene	5.6		
	2,3,4,6-Tetrachlorophenol	37.0		
	Toluene	28.0		
	Toxaphene	1.3		
	1,2,4-Trichlorobenzene	19.0		
	1,1,1-Trichloroethane	5.6		
	1,1,2-Trichloroethane	5.6		
	Trichloroethylene	5.6		
	2,4,5-Trichlorophenol	37.0		
	2,4,6-Trichlorophenol	37.0		
	1,2,3-Trichloropropane	28.0		
	1,1,2-Trichloro-1,2,2-trifluoroethane	28.0		
	Vinyl chloride	33.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Xylene(s)	28.0		
F039[a]—Multisource leachate inorganics	Cyanides (total)	1.8		Stabilization (metals)
	Antimony		0.23	
	Arsenic		5.0	
	Barium		52.0	
	Cadmium		0.066	
	Chromium (total)		5.2	
	Lead		0.51	
	Mercury		0.025	
	Nickel		0.32	
	Selenium		5.7	
	Silver		0.072	
K001—Bottom sediment sludge from the treatment of wastewaters from wood-preserving processes that use creosote and/or pentachlorophenol	Naphthalene	1.5		Rotary kiln incineration, followed by stabilization of the ash
	Pentachlorophenol	7.4		
	Phenanthrene	1.5		
	Pyrene	1.5		
	Toluene	28.0		
	Xylenes (total)	33.0		
	Lead		0.51	
K002—Wastewater treatment sludge from the production of chrome yellow and orange pigments	Chromium (total)		0.094	Chemical precipitation, filtration, sludge dewatering (metals)
	Lead		0.37	

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
K003—Wastewater treatment sludge from the production of molybdate orange pigments	Chromium (total) Lead		0.094 0.37	Chemical precipitation, filtration, sludge dewatering (metals)
K004—Wastewater treatment sludge from the production of zinc yellow pigments	Chromium (total) Lead		0.094 0.37	Chemical precipitation, filtration, sludge dewatering (metals)
K005—Wastewater treatment sludge from the production of chrome green pigments	Chromium (total) Lead Cyanides (total)	Reserved	0.094 0.37	Chemical precipitation, filtration, sludge dewatering (metals)
K006—Wastewater treatment sludge from the production of chrome oxide green pigments -Anhydrous -Hydrated	Chromium (total) Lead Chromium (total)		0.094 0.37 5.2	Chemical precipitation, filtration, stabilization (chromium)
K007—Wastewater treatment sludge from the production of iron blue pigments	Chromium (total) Lead Cyanides (total)	Reserved	0.094 0.37	Chemical precipitation, filtration, sludge dewatering (metals)
K008—Oven residue from the production of chrome oxide green pigments	Chromium (total) Lead		0.094 0.37	Chemical precipitation, filtration, sludge dewatering (metals)
K009—Distillation bottoms from the production of acetaldehyde from ethylene	Chloroform	6.0		Rotary kiln incineration
K010—Distillation side cuts from the production of acetaldehyde from ethylene	Chloroform	6.0		Rotary kiln incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
K011—Bottom stream from the wastewater stripper in the production of acrylonitrile	Acetonitrile	1.8		Incineration
	Acrylonitrile	1.4		
	Acrylamide	23.0		
	Benzene	0.03		
	Cyanides (total)	57.0		
K013—Bottom stream from the acetonitrile column in the production of acrylonitrile	Acetonitrile	1.8		Incineration
	Acrylonitrile	1.4		
	Acrylamide	23.0		
	Benzene	0.03		
	Cyanides (total)	57.0		
K014—Bottoms from the acetonitrile purification column in the production of acrylonitrile	Acetonitrile	1.8		Incineration
	Acrylonitrile	1.4		
	Acrylamide	23.0		
	Benzene	0.03		
	Cyanides (total)	57.0		
K015—Still bottoms from the distillation of benzyl chloride	Anthracene	3.4		Incineration (organics), stabilization (metals)
	Benzal chloride	6.2		
	Sum of Benzo(b)-fluoranthene and Benzo(k)fluoranthene	3.4		
	Phenanthrene	3.4		
	Toluene	6.0		
	Chromium (total)		1.7	
	Nickel		0.2	

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
K016—Heavy ends or distillation residues from the production of carbon tetrachloride	Hexachlorobenzene	28.0		Rotary kiln incineration
	Hexachlorobutadiene	5.6		
	Hexachlorocyclopentadiene	5.6		
	Hexachloroethane	28.0		
	Tetrachloroethene	6.0		
K017—Heavy ends (still bottoms) from the purification column in the production of epichlorohydrin	1,2-Dichloropropane	18.0		Incineration
	1,2,3-Trichloropropane	28.0		
	Bis(2-Chloroethyl)ether	7.2		
K018—Heavy ends from the fractionation column in ethyl chloride production	Chloroethane	6.0		Rotary kiln incineration
	1,1-Dichloroethane	6.0		
	1,2-Dichloroethane	6.0		
	Hexachlorobenzene	28.0		
	Hexachlorobutadiene	5.6		
	Hexachloroethane	28.0		
	Pentachloroethane	5.6		
	1,1,1-Trichloroethane	6.0		
K019—Heavy ends from the distillation of ethylene dichloride in ethylene dichloride production	Chlorobenzene	6.0		Rotary kiln incineration
	bis(2-Chloroethyl)ether	5.6		
	Chloroform	6.0		
	1,2-Dichloroethane	6.0		
	Hexachloroethane	28.0		
	Naphthalene	5.6		
	Phenanthrene	5.6		
	Tetrachloroethene	6.0		
	1,2,4-Trichlorobenzene	19.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	1,1,1-Trichloroethane	6.0		
K020—Heavy ends from the distillation of vinyl chloride in vinyl chloride monomer production	1,2-Dichloroethane	6.0		Rotary kiln incineration
	1,1,2,2-Tetrachloroethane	5.6		
	Tetrachloroethene	6.0		
K021—Aqueous spent antimony catalyst waste from fluoromethane production	Chloroform	6.2		Incineration (organics) and stabilization (inorganics)
	Carbon tetrachloride	6.2		
	Antimony		0.23	
K022—Distillation bottom tars from the production of phenol/acetone from cumene	Acetophenone	19.0		Incineration or fuel substitution, solidification of ash
	Phenol	12.0		
	Toluene	0.034		
	Sum of diphenylamine and diphenylnitrosamine	13.0		
	Chromium (total)		5.2	
	Nickel		0.32	
K023—Distillation light ends from the production of phthalic anhydride from naphthalene	Phthalic anhydride (measured as phthalic acid)	28.0		Rotary kiln incineration
K024—Distillation bottoms from the production of phthalic anhydride from naphthalene	Phthalic anhydride (measured as phthalic acid)	28.0		Incineration or fuel substitution, solidification of ash
K025—Distillation bottoms from the production of nitrobenzene by the nitration of benzene		INCIN		
K026—Stripping still tails from the production of methyl ethyl pyridines		INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
		INCIN		
K027—Centrifuge and distillation residues from toluene diisocyanate production.				
K028—Spent catalyst from the hydrochlorinator reactor in the production of 1,1,1-trichloroethane	1,1-Dichloroethane	6.0		Rotary kiln incineration (organics); stabilization (metals)
	trans-1,2-Dichloroethane	6.0		
	Hexachlorobutadiene	5.6		
	Hexachloroethane	28.0		
	Pentachloroethane	5.6		
	1,1,1,2-Tetrachloroethane	5.6		
	1,1,2,2-Tetrachloroethane	5.6		
	Tetrachloroethylene	6.0		
	1,1,1-Trichloroethane	6.0		
	1,1,2-Trichloroethane	6.0		
	Chromium (total)		0.073	
	Lead		0.021	
	Nickel		0.088	
K029—Waste from the product steam stripper in the production of 1,1,1-trichloroethane	Chloroform	6.0		Rotary kiln incineration
	1,2-Dichloroethane	6.0		
	1,1-Dichloroethylene	6.0		
	1,1,1-Trichloroethane	6.0		
	Vinyl chloride	6.0		
K030—Column bottoms or heavy ends from the combined production of trichloroethylene and perchloroethylene	Hexachlorobutadiene	5.6		Rotary kiln incineration
	Hexachloroethane	28.0		
	Hexachloropropene	19.0		
	Pentachlorobenzene	28.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Pentachloroethane	5.6		
	1,2,4,5-Tetrachlorobenzene	14.0		
	Tetrachloroethene	6.0		
	1,2,4-Trichlorobenzene	19.0		
K031—By-products salts generated in the production of MSMA and cacodylic acid	Arsenic		5.6	Vitrification
K032—Wastewater treatment sludge from the production of chlordane	Hexachloropentadiene	2.4		Incineration
	Chlordane	0.26		
	Heptachlor	0.066		
	Heptachlor epoxide	0.066		
K033—Wastewater and scrub water from the chlorination of cyclopentadiene in the production of chlordane	Hexachlorocyclopentadiene	2.4		Incineration
K034—Filter solids from the hexachlorocyclopentadiene in the production of chlordane	Hexachlorocyclopentadiene	2.4		Incineration
K035—Wastewater treatment sludges generated in the production of creosote	Acenaphthene	3.4		Incineration
	Anthracene	3.4		
	Benz(a)anthracene	3.4		
	Benzo(a)pyrene	3.4		
	Chrysene	3.4		
	Dibenz(a,h)anthracene	3.4		
	Fluoranthene	3.4		
	Fluorene	3.4		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Ideno(1,2,3-cd)pyrene	3.4		
	Naphthalene	3.4		
	Phenanthrene	3.4		
	Pyrene	8.2		
K036—Still bottoms from toluene reclamation distillation in the production of disulfoton	Disulfoton	0.1		Incineration
K037—Wastewater treatment sludge from the production of disulfoton	Disulfoton Toluene	0.1 28.0		Rotary kiln incineration
K038—Wastewater from the washing and stripping of phorate production	Phorate	0.1		Rotary kiln incineration
K039—Filter cake from the filtration of diethylphosphoro-dithioic acid in the production of phorate		FSUBS; or INCIN		
K040—Wastewater treatment sludge from the production of phorate	Phorate	0.1		Rotary kiln incineration
K041—Wastewater treatment sludge from the production of toxaphene	Toxaphene	2.6		Incineration
K042—Heavy ends or distillation residues from the distillation of tetrachlorobenzene in the production of 2,4,5-T	1,2,3,5-Tetrachlorobenzene o-Dichlorobenzene p-Dichlorobenzene Pentachlorobenzene	4.4 4.4 4.4 4.4		Incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	1,2,4-Trichlorobenzene	4.4		
K043—2,6-Dichlorophenol waste from the production of 2,4-D	2,4-Dichlorophenol	0.38		Incineration
	2,6-Dichlorophenol	0.34		
	Pentachlorophenol	1.9		
	Tetrachloroethene	1.7		
	Tetrachlorophenols (total)	0.68		
	2,4,5-Trichlorophenol	8.2		
	2,4,6-Trichlorophenol	7.6		
	Hexachlorodibenzo-p-dioxins	0.001		
	Hexachlorodibenzofurans	0.001		
	Pentachlorodibenzo-p-dioxins	0.001		
	Pentachlorodibenzofurans	0.001		
	Tetrachlorodibenzo-p-dioxins	0.001		
	Tetrachlorodibenzofurans	0.001		
K044—Wastewater treatment sludges from the manufacturing and processing of explosives		DEACT		
K045—Spent carbon from the treatment of wastewater containing explosives		DEACT		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
K046—Wastewater treatment sludges from the manufacturing, formulation, and loading of lead-based initiating compounds	Lead		0.18	Stabilization (nonreactive subcategory); deactivation followed by stabilization (reactive subcategory)
K047—Pink/red water from TNT operations		DEACT		
K048—Dissolved air flotation (DAF) float from the petroleum refining industry	Benzene	14.0		Solvent extraction or incineration (organics), stabilization of ash
	Benzo(a)pyrene	12.0		
	Bis(2-ethylhexyl)phthalate	7.3		
	Chrysene	15.0		
	Di-n-butyl phthalate	3.6		
	Ethylbenzene	14.0		
	Naphthalene	42.0		
	Phenanthrene	34.0		
	Phenol	3.6		
	Pyrene	36.0		
	Toluene	14.0		
	Xylene(s)	22.0		
	Cyanides (total)	1.8		
	Chromium (total)		1.7	
	Nickel		0.20	
K049—Slop oil emulsion solids from the petroleum refining industry	Anthracene	28.0		Solvent extraction or incineration (organics), stabilization of ash
	Benzene	14.0		
	Benzo(a)pyrene	12.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Bis(2-ethylhexyl)phthalate	7.3		
	Chrysene	15.0		
	Ethylbenzene	14.0		
	Naphthalene	42.0		
	Phenanthrene	34.0		
	Phenol	3.6		
	Pyrene	36.0		
	Toluene	14.0		
	Xylene(s)	22.0		
	Cyanides (total)	1.8		
	Chromium (total)		1.7	
	Nickel		0.20	
K050—Heat exchanger bundle cleaning sludge from the petroleum refining industry	Benzo(a)pyrene	12.0		Solvent extraction or incineration (organics), stabilization of ash
	Phenol	3.6		
	Cyanides (total)	1.8		
	Chromium (total)		1.7	
	Nickel		0.20	
K051—API separator sludge from the petroleum refining industry	Anthracene	28.0		Solvent extraction or incineration (organics), stabilization (lead)
	Benzene	14.0		
	Benzo(a)anthracene	20.0		
	Benzo(a)pyrene	12.0		
	Bis(2-ethylhexyl)phthalate	7.3		
	Chrysene	15.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Di-n-butyl phthalate	3.6		
	Ethylbenzene	14.0		
	Naphthalene	42.0		
	Phenanthrene	34.0		
	Phenol	3.6		
	Pyrene	36.0		
	Toluene	14.0		
	Xylene(s)	22.0		
	Cyanides (total)	1.8		
	Chromium (total)		1.7	
	Nickel		0.20	
K052—Tank bottoms (leaded) from the petroleum refining industry	Benzene	14.0		Solvent extraction or incineration (organics), stabilization of ash
	Benzo(a)pyrene	12.0		
	o-Cresol	6.2		
	p-Cresol	6.2		
	Ethylbenzene	14.0		
	Naphthalene	42.0		
	Phenanthrene	34.0		
	Phenol	3.6		
	Toluene	14.0		
	Xylene(s)	22.0		
	Cyanides (total)	1.8		
	Chromium (total)		1.7	

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Nickel		0.20	
K060—Ammonia-still lime sludge from coking operations	Benzene	0.071		Incineration
	Benzo(a)pyrene	3.6		
	Naphthalene	3.4		
	Phenol	3.4		
	Cyanides (total)	1.2		
K061—Emission control dust/ sludge from the primary production of steel in electric furnaces	Antimony		2.1	High-temperature metals recovery
	Arsenic		0.055	
	Barium		7.6	
	Beryllium		0.014	
	Cadmium		0.19	
	Chromium (total)		0.33	
	Lead		0.37	
	Mercury		0.009	
	Nickel		5.0	
	Selenium		0.16	
	Silver		0.3	
	Thallium		0.078	
	Zinc		5.3	
K062—Spent pickle liquor generated by steel finishing operations at facilities within the iron and steel industry (SIC codes 331 and 332)	Chromium (total)		0.094	Chromium reduction, chemical precipitation, filtration, sludge dewatering
	Lead		0.37	

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
K062—Alternative standards for nonwastewaters based on high-temperature metals recovery	Antimony		2.1	High-temperature metals recovery
	Arsenic		0.055	
	Barium		7.6	
	Beryllium		0.014	
	Cadmium		0.19	
	Chromium (total)		0.33	
	Lead		0.37	
	Mercury		0.009	
	Nickel		5.0	
	Selenium		0.16	
	Silver		0.30	
	Thallium		0.078	
	Zinc		5.3	
K069—Emission control dust/sludge from secondary lead smelting—calcium sulfate subcategory	Cadmium		0.14	Stabilization
	Lead		0.24	
—Noncalcium sulfate subcategory	Cadmium	RLEAD		(Treatment method specified)
K071—Brine purification muds from the mercury cell process in chlorine production, where separately prepurified brine is used	Mercury		0.025	Acid leaching, chemical oxidation, dewatering

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
K073—Chlorinated hydrocarbon wastes from the purification step of the diaphragm cell process using graphite anodes	Carbon tetrachloride	6.2		Incineration
	Chloroform	30.0		
	Hexachloroethane	6.2		
	Tetrachloroethene	6.2		
	1,1,1-Trichloroethane	6.2		
K083—Distillation bottoms from aniline production	Benzene	6.6		Incineration (organics), stabilization (metals)
	Aniline	14.0		
	Sum of diphenylamine and diphenylnitrosamine	14.0		
	Nitrobenzene	14.0		
	Phenol	5.6		
	Nickel		0.088	
K084—Wastewater treatment sludges generated during the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds	Arsenic		5.6	Vitrification
K085—Distillation of fractionation column bottoms from the production of chlorobenzenes	Benzene	4.4		Incineration
	Chlorobenzene	4.4		
	o-Dichlorobenzene	4.4		
	m-Dichlorobenzene	4.4		
	p-Dichlorobenzene	4.4		
	1,2,4-Trichlorobenzene	4.4		
	1,2,4,5-Tetrachlorobenzene	4.4		
	Pentachlorobenzene	4.4		
	Hexachlorobenzene	4.4		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Arochlor 1016	0.92		
	Arochlor 1221	0.92		
	Arochlor 1232	0.92		
	Arochlor 1242	0.92		
	Arochlor 1248	0.92		
	Arochlor 1254	1.8		
	Arochlor 1260	1.8		
K086—Solvent washes and sludges; caustic washes and sludges, or water washes and sludges from cleaning tubs and equipment used in the formulation of ink from pigments, driers, soaps, and stabilizers containing chromium and lead	Acetone	160.0		Incineration (organics); chromium reduction, lime precipitation, filtration (metals)
	Acetophenone	9.7		
	Bis(2-ethylhexyl)phthalate	28.0		
	n-Butyl alcohol	2.6		
	Butylbenzylphthalate	7.9		
	1,2-Dichlorobenzene	6.2		
	Diethyl phthalate	28.0		
	Dimethyl phthalate	28.0		
	Di-n-butyl phthalate	28.0		
	Di-n-octyl phthalate	28.0		
	Ethyl acetate	33.0		
	Ethylbenzene	6.0		
	Methyl isobutyl ketone	33.0		
	Methyl ethyl ketone	36.0		
	Methylene chloride	33.0		
	Naphthalene	3.1		
	Nitrobenzene	14.0		
	Toluene	28.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	1,1,1-Trichloroethane	5.6		
	Trichloroethylene	5.6		
	Xylenes (total)	28.0		
	Cyanides (total)	1.5		
	Chromium (total)		0.094	
	Lead		0.37	
K087—Decanter tank tar sludge from coking operations	Acenaphthalene	3.4		Rotary kiln incineration, stabilization of ash
	Benzene	0.071		
	Chrysene	3.4		
	Fluoranthene	3.4		
	Indeno(1,2,3-cd)pyrene	3.4		
	Naphthalene	3.4		
	Phenanthrene	3.4		
	Toluene	0.65		
	Xylenes	0.07		
	Lead		0.51	
K093—Distillation light ends from the production of phthalic anhydride from ortho-xylene	Phthalic anhydride (measured as phthalic acid)	28.0		Rotary kiln incineration
K094—Distillation bottoms from the production of phthalic anhydride from ortho-xylene	Phthalic anhydride (measured as phthalic acid)	28.0		Rotary kiln incineration
K095—Distillation bottoms from the production of 1,1,1-trichloroethane	1,1,1,2-Tetrachloroethane	5.6		Rotary kiln incineration
	1,1,2,2-Tetrachloroethane	5.6		
	Tetrachloroethene	6.0		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	1,1,2-Trichloroethane	6.0		
	Trichloroethylene	5.6		
	Hexachloroethane	28.0		
	Pentachloroethane	5.6		
K096—Heavy ends from the heavy ends column from the production of 1,1,1-trichloroethane	1,1,1,2-Tetrachloroethane	5.6		Rotary kiln incineration
	1,1,2,2-Tetrachloroethane	5.6		
	Tetrachloroethene	6.0		
	1,1,2-Trichloroethane	6.0		
	Trichloroethene	5.6		
	Trichloroethylene	5.6		
	1,3-Dichlorobenzene	5.6		
	Pentachloroethane	5.6		
	1,2,4-Trichlorobenzene	19.0		
K097—Vacuum stripper discharge from the chlordane chlorinator in the production of chlordane	Hexachlorocyclopentadiene	2.4		Incineration
	Chlordane	0.26		
	Heptachlor	0.066		
	Heptachlor epoxide	0.066		
K098—Untreated process wastewater from the production of toxaphene	Toxaphene	2.6		Incineration
K099—Untreated wastewater from the production of 2,4-dichlorophenoxyacetic acid (2,4-D)	2,4-Dichlorophenoxyacetic acid	1.0		Chlorine oxidation
	Hexachlorodibenzo-p-dioxins	0.001		
	Hexachlorodibenzofurans	0.001		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Pentachlorodibenzo-p-dioxins	0.001		
	Pentachlorodibenzofurans	0.001		
	Tetrachlorodibenzo-p-dioxins	0.001		
	Tetrachlorodibenzofurans	0.001		
K100—Waste leaching solution from acid leaching of emission control dust/sludge from secondary lead smelting	Cadmium		0.066	Stabilization
	Chromium (total)		5.2	
	Lead		0.51	
K101—Distillation tar residues from the distillation of aniline-based compounds in the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds	o-Nitroaniline	14.0		Vitrification
	Arsenic		5.6	
K102—Residue from the use of activated carbon for decolorization in the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds	o-Nitrophenol	13.0		Vitrification
	Arsenic		5.6	
K103—Process residues from aniline extraction from the production of aniline	Aniline	5.6		Solvent extraction, followed by steam stripping, followed by carbon adsorption
	Benzene	6.0		
	2,4-Dinitrophenol	5.6		
	Nitrobenzene	5.6		
	Phenol	5.6		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
K104—Combined wastewater streams generated from nitrobenzene/aniline production	Aniline	5.6		Solvent extraction, followed by incineration, followed by carbon adsorption, followed by carbon regeneration
	Benzene	6.0		
	Cyanides (total)	1.8		
	2,4-Dinitrophenol	5.6		
	Nitrobenzene	5.6		
	Phenol	4.4		
K105—Separated aqueous stream from the reactor product washing step in the production of chlorobenzenes	Benzene	4.4		Incineration
	Chlorobenzene	4.4		
	o-Dichlorobenzene	4.4		
	p-Dichlorobenzene	4.4		
	2,4,5-Trichlorophenol	4.4		
	2,4,6-Trichlorophenol	4.4		
	2-Chlorophenol	4.4		
	Phenol	4.4		
K106—Wastewater treatment sludge from the mercury cell process in chlorine production—low-mercury subcategory (<260 mg/kg)	Mercury		0.025 or 0.020	Acid leaching and chemical precipitation
—high-mercury subcategory (≥260 mg/kg)	Mercury	RMERC		(Treatment method specified)
K107—Column bottoms from product separation from the production of 1,1-dimethyl-hydrazine (UDMH) from carboxylic acid hydrazides		INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
K108—Condensed column overheads from product separation and condensed reactor vent gases from the production of 1,1-dimethyl-hydrazine (UDMH) from carboxylic acid hydrazides		INCIN		
K109—Spend filter cartridges from product purification from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides		INCIN		
K110—Condensed column overheads from intermediate separation from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides		INCIN		
K111—Product washwaters from the production of dinitrotoluene via nitration of toluene	2,4-Dinitrotoluene 2,6-Dinitrotoluene	140.0 28.0		Incineration
K112—Reaction by-product water from the drying column in the production of toluenediamine via hydrogenation of dinitrotoluene		INCIN		
K113—Condensed liquid light ends from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene		FSUBS; or INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
K114—Vicinals from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene		FSUBS; or INCIN		
K115—Heavy ends from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene	Nickel	FSUBS; or INCIN	0.32	Stabilization (nickel)
K116—Organic condensate from the solvent recovery column in the production of toluene diisocyanate via phosgenation of toluenediamine		FSUBS; or INCIN		
K117—Wastewater from the reactor vent gas scrubber in the production of ethylene dibromide via bromination of ethene	Chloroform Ethylene dibromide Methyl bromide	5.6 15.0 15.0		Incineration
K118—Spent adsorbent solids from purification of ethylene dibromide in the production of ethylene dibromide via bromination of ethene	Chloroform Ethylene dibromide Methyl bromide	5.6 15.0 15.0		Incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
K123—Process wastewater (including supernates, filtrates, and washwaters) from the production of ethylenebisdithiocarbamic acid and its salts		INCIN		
K124—Reactor vent scrubber water from the production of ethylene-bisdithiocarbamic acid and its salts		INCIN		
K125—Filtration, evaporation, and centrifugation solids from the production of ethylenebisdithiocarbamic acid and its salts		INCIN		
K126—Baghouse dust and floor sweepings in milling and packaging operations from the production or formulation of ethylenebisdithiocarbamic acid and its salts		INCIN		
K131—Wastewater from the reactor and spent sulfuric acid from the acid dryer from the production of methyl bromide	Methyl bromide	15.0		Incineration
K132—Spent absorbent and wastewater separator solids from the production of methyl bromide	Methyl bromide	15.0		Incineration

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Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
K136—Still bottoms from the purification of ethylene dibromide in the production of ethylene dibromide via bromination of ethene	Chloroform Ethylene dibromide Methyl bromide	5.6 15.0 15.0		Incineration
P001—Warfarin, when present at concentration greater than 0.3%		FSUBS; or INCIN		
P002—1-Acetyl-2-thiourea		INCIN		
P003—Acrolein		FSUBS; or INCIN		
P004—Aldrin	Aldrin	0.066		Incineration
P005—Allyl alcohol		FSUBS; or INCIN		
P006—Aluminum phosphide		CHOXD; CHRED; or INCIN		
P007—5-Aminoethyl-3-isoxazolol		INCIN		
P008—4-Aminopyridine		INCIN		
P009—Ammonium picrate		FSUBS; CHOXD; CHRED; or INCIN		
P010—Arsenic acid H_3AsO_4	Arsenic		5.6	Vitrification
P011—Arsenic oxide As_2O_5	Arsenic		5.6	Vitrification
P012—Arsenic oxide As_2O_3	Arsenic		5.6	Vitrification

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
P013—Barium cyanide	Barium Cyanide (total) Cyanide (amendable)	 110.0 9.1	52.0	Electrolyte oxidation followed by alkaline chlorination (cyanides); stabilization (metals)
P014—Thiophenol (Benzene thiol)		INCIN		
P015—Beryllium dust		RMETL; or RTHRM		
P016—Bis(chloromethyl)ether		INCIN		
P017—Bromoacetone		INCIN		
P018—Brucine		INCIN		
P020—Dinoseb	2-sec-Butyl-4,6-dinitrophenol (Dinoseb)	2.5		Incineration
P021—Calcium cyanide	Cyanide (total) Cyanide (amenable)	110.0 9.1		Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration (metals)
P022—Carbon disulfide		INCIN		(Treatment method specified)
P023—Chloroacetaldehyde		INCIN		
P024—p-Chloroaniline	p-Chloroaniline	16.0		Incineration
P026—1-(o-Chlorophenyl)thiourea		INCIN		
P027—3-Chloropropionitrile		INCIN		
P028—Benzyl chloride		INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
P029—Copper cyanides	Cyanide (total) Cyanide (amenable)	110.0 9.1		Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration (metals)
P030—Cyanides (soluble salts and complexes)	Cyanide (total) Cyanide (amendable)	110.0 9.1		Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration (metals)
P031—Cyanogen		CHOXD; WETOX; or INCIN		
P033—Cyanogen chloride		CHOXD; WETOX; or INCIN		
P034—2-Cyclohexyl-4,6-dinitrophenol		INCIN		
P036—Dichlorophenylarsine	Arsenic		5.6	Vitrification
P037—Dieldrin	Dieldrin	0.13		Incineration
P038—Diethylarsine	Arsenic		5.6	Vitrification
P039—Disulfoton		0.10		Rotary kiln incineration
P040—O,O-Diethyl-o-pyrazinyl phosphorothioate		FSUBS; or INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
P041—Diethyl-p-nitrophenyl phosphate		FSUBS; or INCIN		
P042—Epinephrine		INCIN		
P043—Diisopropyl fluorophosphate (DPF)		FSUBS; or INCIN		
P044—Dimethoate		FSUBS; or INCIN		
P045—Thiofanox		INCIN		
P046—Alpha, alpha-Dimethylphenethylamine		INCIN		
P047—4,6-Dinitrocresol	4,6-Dinitro-o-cresol	160.0		Incineration
P047—4,6-Dinitrocresol salts		INCIN		
P048—2,4-Dinitrophenol	2,4-Dinitrophenol	160.0		Incineration
P049—2,4-Dithiobiuret		INCIN		
P050—Endosulfan	Endosulfan I	0.066		Incineration
	Endosulfan II	0.13		
	Endosulfan sulfate	0.13		
P051—Endrin	Endrin	0.13		Incineration
	Endrin aldehyde	0.13		
P054—Aziridine		INCIN		
P056—Fluorine	Fluoride	ADGAS fb NEUTR		(Treatment method specified)
P057—Fluoracetamide		INCIN		
P058—Fluoracetic acid, sodium salt		INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
P059—Heptachlor	Heptachlor	0.066		Incineration
	Heptachlor epoxide	0.066		
P060—Isodrin	Isodrin	0.066		Incineration
P062—Hexaethyltetraphosphate		FSUBS; or INCIN		
P063—Hydrogen cyanide	Cyanide (total)	110.0		Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration (metals)
	Cyanide (amenable)	9.1		
P064—Isocyanic acid, ethyl ester		INCIN		
P065—Mercury fulminate				
—High-mercury subcategory (≥260 mg/kg mercury)	Mercury	RMERC; or IMERC		
—Low-mercury subcategory (<260 mg/kg mercury)	Mercury	RMERC; or IMERC		Acid leaching, chemical precipitation
P066—Methomyl		INCIN		
P067—2-Methylaziridine		INCIN		
P068—Methyl hydrazine		FSUBS; CHOXD; CHRED; or INCIN		
P069—Methyllactonitrile		INCIN		
P070—Aldicarb		INCIN		
P071—Methyl parathion	Methyl parathion	0.1		Rotary kiln incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
P072—1-Naphthyl-2-thiourea		INCIN		
P073—Nickel carbonyl	Nickel		0.32	Stabilization
P074—Nickel cyanide	Cyanide (total)	110.0		Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration, stabilization (metals)
	Cyanide (amendable)	9.1		
	Nickel		0.32	
P075—Nicotine and salts		INCIN		
P076—Nitric oxide		ADGAS		
P077—p-Nitroaniline	p-Nitroaniline	28.0		Incineration
P078—Nitrogen dioxide		ADGAS		
P081—Nitroglycerine		FSUBS; CHOXD; CHRED: or INCIN		
P082—N-Nitrosodimethylamine	N-Nitrosodimethylamine	INCIN		(Treatment method specified)
P084—N-Nitrosomethylvinylamine		INCIN		
P085—Octamethylpyrophosphoramide		FSUBS; or INCIN		
P087—Osmium tetraoxide		RMETL; or RTHRM		
P088—Endothall		FSUBS; or INCIN		
P089—Parathion	Parathion	0.1		Rotary kiln incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
P092—Phenylmercuric acetate				
—High-mercury subcategory (≥260 mg/kg mercury)	Mercury	RMERC		
—Low-mercury subcategory (<260 mg/kg mercury)	Mercury	RMERC; or IMERC	0.20 0.025	Acid leaching, chemical precipitation
P093—N-Phenylthiourea		INCIN		
P094—Phorate	Phorate	0.1		Rotary kiln incineration
P095—Phosgene		INCIN		
P096—Phosphine		CHOXD; CHRED; or INCIN		
P097—Famphur	Famphur	0.1		Rotary kiln incineration
P098—Potassium cyanide	Cyanide (total) Cyanide (amenable)	110.0 9.1		Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration (metals)
P099—Potassium silver cyanide	Silver Cyanide (total) Cyanide (amenable)	 110.0 9.1	0.072	Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration, stabilization (metals)
P101—Propanenitrile	Ethyl cyanide (propanenitrile)	360.0		Incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
P102—Propargyl alcohol		FSUBS; or INCIN		
P103—Selenourea	Selenium		5.7	Stabilization
P104—Silver cyanide	Cyanide (total) Cyanide (amenable) Silver	110.0 9.1 	 0.072	Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration, stabilization (metals)
P105—Sodium azide		FSUBS; CHOXD; CHRED; or INCIN		
P106—Sodium cyanide	Cyanide (total) Cyanide (amenable)	110.0 9.1		Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration (metals)
P108—Strychnine and salts		INCIN		
P109—Tetraethyldithio-pyrophosphate		FSUBS; or INCIN		
P110—Tetraethyl lead	Lead		0.51	Incineration (organics); stabilization (lead)
P111—Tetraethylpyrophosphate		FSUBS; or INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
P112—Tetranitromethane		FSUBS; CHOXD; CHRED; or INCIN		
P113—Thallic oxide	Thallium	RTHRM; or STABL		(Treatment method specified)
P114—Thallium (I) selenite	Selenium		5.7	Stabilization, vitrification or recovery
P115—Thallium (I) sulfate	Thallium	RTHRM; or STABL		(Treatment method specified)
P116—Thiosemicarbazide		INCIN		
P118—Trichloromethanethiol		INCIN		
P119—Ammonium vanadate	Vanadium	STABL		(Treatment method specified)
P120—Vanadium pentoxide	Vanadium	STABL		(Treatment method specified)
P121—Zinc cyanide	Cyanide (total) Cyanide (amenable)	110.0 9.1		Electrolytic oxidation followed by alkaline chlorination (cyanides); chemical precipitation, settling, filtration (metals)
P122—Zinc phosphide, when present at concentrations >10%		CHOXD; CHRED; or INCIN		
P123—Toxaphene	Toxaphene	1.3		Incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U001—Acetaldehyde		INCIN		
U002—Acetone	Acetone	160.0		Incineration or fuel substitution
U003—Acetonitrile	Acetonitrile	INCIN and 0.17		(Treatment method specified)
U004—Acetophenone	Acetophenone	9.7		Incineration
U005—o-Acetylaminofluorene	2-Acetylaminofluorene	140.0		Incineration
U006—Acetyl chloride		INCIN		
U007—Acrylamide		INCIN		
U008—Acrylic acid		FSUBS; or INCIN		
U009—Acrylonitrile	Acrylonitrile	84.0		Incineration
U010—Mitomycin C		INCIN		
U011—Amitrole		INCIN		
U012—Aniline	Aniline	14.0		Incineration
U014—Auramine		INCIN		
U015—Azaserine		INCIN		
U016—Benz(c)acridine		FSUBS; or INCIN		
U017—Benzal chloride	Benzal chloride	INCIN		
U018—Benz(a)anthracene	Benz(a)anthracene	8.2		Incineration
U019—Benzene	Benzene	36.0		Incineration
U020—Benzenesulfonyl chloride		INCIN		
U021—Benzidine		INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U022—Benzo(a)pyrene	Benzo(a)pyrene	8.2		
U023—Benzotrichloride		FSUBS; CHOXD; CHRED; or INCIN		
U024—Bis(2-chloroethyoxy)-methane	Bis(2-chloroethyoxy)-methane	7.2		Incineration
U025—Dichloroethyl ether	Bis(2-chloroethyl)ether	7.2		Incineration
U026—Chlonaphazine		INCIN		
U027—Bis(2-chloroisopropyl)ether	Bis(2-chloroisopropyl)ether	7.2		Incineration
U028—Bis-(2-ethylhexyl)phthalate	Bis-(2-ethylhexyl)phthalate	28.0		Rotary kiln incineration
U029—Methyl bromide	Bromomethane (Methyl bromide)	15.0		Incineration
U030—Benzene, 1-bromo-4-phenoxy	4-Bromophenyl phenyl ether	15.0		Incineration
U031—n-Butanol	n-Butyl alcohol	2.6		Incineration or fuel substitution
U032—Calcium chromate	Chromium (total)		0.094	Chromium reduction, lime or sulfide precipitation, sludge dewatering
U-33—Carbonyl fluoride		INCIN		
U034—Chloral		INCIN		
U035—Chlorambucil		INCIN		
U036—Chlordane, technical	Chlordane, alpha and gamma	0.13		Incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U037—Chlorobenzene	Chlorobenzene	5.7		Incineration
U038—Chlorobenzilate		INCIN		(Treatment method specified)
U039—4-Chloro-m-cresol	p-Chloro-m-cresol	14.0		Incineration
U041—1-Chloro-2,3-epoxypropane		INCIN		
U042—Vinyl ether, 2-chloroethyl	2-Chloroethyl vinyl	INCIN		
U043—Vinyl chloride	Vinyl chloride	33.0		Incineration
U044—Chloroform	Chloroform	5.6		Incineration
U045—Chloromethane (methyl chloride)	Chloromethane	33.0		Incineration
U046—Chloromethyl methyl ether		INCIN		
U047—2-Chloronaphthalene	2-Chloronaphthalene	5.6		Incineration
U048—o-Chlorophenol	2-Chlorophenol	5.7		Incineration
U049—4-Chloro-o-toluidine, hydrochloride		INCIN		
U050—Chrysene	Chrysene	8.2		Incineration
U051—Creosote	Naphthalene	1.5		Incineration (organics); stabilization (lead)
	Pentachlorophenol	7.4		
	Phenanthrene	1.5		
	Pyrene	1.5		
	Toluene	28.0		
	Xylenes (total)	33.0		
	Lead		0.51	
U052—Cresols (cresylic acid)	o-Cresol	5.6		Incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	Cresols (m- and p-isomers)	3.2		
U053—Crotonaldehyde		FSUBS; or INCIN		
U055—Cumene		FSUBS; or INCIN		
U056—Cyclohexane		FSUBS; or INCIN		
U057—Cyclohexanone	Cyclohexanone	FSUBS; or INCIN		(Treatment method specified)
U058—Cyclophosphamide		FSUBS; or INCIN		
U059—Daunomycin		INCIN		
U060—DDD	o,p′-DDD	0.087		Incineration
	p,p′-DDD	0.087		
U061—DDT	o,p′-DDT	0.087		Incineration
	p,p′-DDT	0.087		
	o,p′-DDD	0.087		
	p,p′-DDD	0.087		
	o,p′-DDE	0.087		
	p,p′-DDE	0.087		
U062—Diallate		INCIN		
U063—Dibenzo(a,h)anthracene	Dibenz(a,h)anthracene	8.2		Incineration
U064—1,2,7,8-Dibenzopyrene		FSUBS; or INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U066—1,2-Dibromo-3-chloropropane	1,2-Dibromo-3-chloropropane	15.0		Incineration
U067—Ethylene dibromide	1,2-Dibromoethane	15.0		Incineration
U068—Dibromomethane	Dibromomethane	15.0		Incineration
U069—Dibutyl phthalate	Di-n-butyl phthalate	28.0		Rotary kiln incineration
U070—o-Dichlorobenzene	o-Dichlorobenzene	6.2		Incineration
U071—m-Dichlorobenzene	m-Dichlorobenzene	6.2		Incineration
U072—p-Dichlorobenzene	p-Dichlorobenzene	6.2		Incineration
U073—Dichlorobenzidine,3,3′-		INCIN		
U074—1,4-Dichloro-2-butene	cis-1,4-Dichloro-2-butene	INCIN		
	trans-1,4-Dichloro-2-butene	INCIN		
U075—Dichlorodifluoromethane	Dichlorodifluoromethane	7.2		Incineration
U076—1,1-Dichloroethane	1,1-Dichloroethane	7.2		Incineration
U077—1,2-Dichloroethane	1,2-Dichloroethane	7.2		Incineration
U078—1,1-Dichloroethylene	1,1-Dichloroethylene	33.0		Incineration
U079—1,2-Dichlorethylene	trans-1,2-Dichloroethylene	33.0		Incineration
U080—Methylene chloride	Methylene chloride	33.0		Incineration
U081—2,4-Dichlorophenol	2,4-Dichlorophenol	14.0		Incineration
U082—2,6-Dichlorophenol	2,6-Dichlorophenol	14.0		Incineration
U083—1,2-Dichloropropane	1,2-Dichloropropane	18.0		Incineration
U084—cis-1,3-Dichloropropene	cis-1,3-Dichloropropene	18.0		Incineration
	trans-1,3-Dichloropropene	18.0		
U085—2,2′-Bioxirane	1,2,3,4-Diepoxybutane	FSUBS; or INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U086—N,N-Diethylhydrazine		FSUBS; CHOXD; CHRED; or INCIN		
U087—O,O-Diethyl-S-methyldithiophosphate		FSUBS; or INCIN		
U088—Diethyl phthalate	Diethyl phthalate	28.0		Rotary kiln incineration
U089—Diethyl stilbestrol		FSUBS; or INCIN		
U090—Dihydrosafrole		FSUBS; or INCIN		
U091—3,3′-Dimethoxybenzidine		INCIN		
U092—Dimethylamine		INCIN		
U093—Dimethylaminoazobenzene	p-Dimethylaminoazobenzene	INCIN		(Treatment method specified
U094—7,12-Dimethylbenz-(a)anthracene		FSUBS; or INCIN		
U095—Dimethylbenzidine,3,3′-		INCIN		
U096—alpha, alpha-Dimethyl-benzylhydroperoxide		FSUBS; CHOXD; CHRED; or INCIN		
U097—Dimethylcarbamoyl chloride		INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U098—Dimethylhydrazine,1,1-		FSUBS; CHOXD; CHRED; or INCIN		
U099—Dimethylhydrazine,1,2-		FSUBS; CHOXD; CHRED; or INCIN		
U101—2,4-Dimethyl phenol	2,4-Dimethyl phenol	14.0		Incineration
U102—Dimethyl phthalate	Dimethyl phthalate	28.0		Rotary kiln incineration
U103—Dimethyl sulfate		FSUBS; CHOXD; CHRED; or INCIN		
U105—2,4-Dinitrotoluene	2,4-Dinitrotoluene	140.0		Incineration
U106—2,6-Dinitrotoluene	2,6-Dinitrotoluene	28.0		Incineration
U107—Di-n-octyl phthalate	Di-n-octyl phthalate	28.0		Rotary kiln incineration
U108—1,4-Dioxane	1,4-Dioxane	170.0		Incineration or fuel substitution
U109—1,2-Diphenylhydrazine		FSUBS; CHOXD; CHRED; or INCIN		
U110—Dipropylamine		INCIN		
U111—Di-n-propylnitrosoamine	Di-n-propylnitrosoamine	14.0		Incineration
U112—Ethyl acetate	Ethyl acetate	33.0		Incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U113—Ethyl acrylate		FSUBS; or INCIN		
U114—Ethylene bis-dithiocarbamic acid		INCIN		
U115—Ethylene oxide		CHOXD; or INCIN		
U116—Ethylene thiourea		INCIN		
U117—Ethyl ether	Ethyl ether	160.0		Incineration
U118—Ethylmethacrylate	Ethyl methacrylate	160.0		Incineration
U119—Ethyl methane sulfonate		INCIN		
U120—Fluoranthene	Fluoranthene	8.2		Incineration
U121—Fluorotrichloromethane	Trichloromonofluoromethane	33.0		Incineration
U122—Formaldehyde		FSUBS; or INCIN		
U123—Formic acid		FSUBS; or INCIN		
U124—Furan		FSUBS; or INCIN		
U125—Furfural		FSUBS; or INCIN		
U126—Glycidylaldehyde		FSUBS; or INCIN		
U127—Hexachlorobenzene	Hexachlorobenzene	37.0		Incineration
U128—Hexachlorobutadiene	Hexachlorobutadiene	28.0		Incineration
U129—Lindane	alpha-BHC	0.66		Incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
	beta-BHC	0.66		
	delta-BHC	0.66		
	gamma-BHC (Lindane)	0.66		
U130—Hexachlorocyclopentadiene	Hexachlorocyclopentadiene	3.6		Incineration
U131—Hexachloroethane	Hexachloroethane	28.0		Incineration
U132—Hexachlorophene		INCIN		
U133—Hydrazine		FSUBS; CHOXD; CHRED; or INCIN		
U134—Hydrogen fluoride	Fluoride	ADGAS fb NEUTR; or NEUTR		(Treatment method specified)
U135—Hydrogen sulfide		CHOXD; CHRED; or INCIN		
U136—Cacodylic acid	Arsenic		5.6	Vitrification
U137—Indeno(1,2,3-c,d)pyrene	Indeno(1,2,3-c,d)pyrene	8.2		Incineration
U138—Iodomethane	Iodomethane	65.0		Incineration
U140—Isobutanol	Isobutyl alcohol	170.0		Incineration
U141—Isosafrole	Isosafrole	2.6		Incineration
U142—Kepone	Kepone	0.13		Incineration
U143—Lasiocarpine		INCIN		
U144—Lead acetate	Lead		0.51	Incineration followed by stabilization

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U145—Lead phosphate	Lead		0.51	Incineration followed by stabilization
U146—Lead subacetate	Lead		0.51	Incineration followed by stabilization
U147—Maleic anhydride		FSUBS; or INCIN		
U148—Maleic hydrazide		INCIN		
U149—Malononitrile		INCIN		
U150—Melphalan		INCIN		
U151—Mercury (Low-mercury subcategory <260 mg/kg)	Mercury		0.20 0.025	Acid leaching, chemical precipitation
U151—Mercury (High-mercury subcategory ≥260 mg/kg)	Mercury	RMERC		(Treatment method specified)
U151—Mercury contaminated with radioactive materials		AMLGM		
U152—Methacrylonitrile	Methacrylonitrile	84.0		Incineration
U153—Methane thiol		INCIN		
U154—Methanol		FSUBS; or INCIN		
U155—Methapyrilene	Methapyrilene	1.5		Incineration
U156—Methyl chlorocarbonate		INCIN		
U157—3-Methylcholanthrene	3-Methylcholanthrene	15.0		Incineration
U158—4,4′-Methylene-bis-(2-chloroaniline)	4,4′-Methylene-bis-(2-chloroaniline)	35.0		Incineration
U159—Methyl ethyl ketone	Methyl ethyl ketone	36.0		Incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U160—Methyl ethyl ketone peroxide		FSUBS; CHOXD; CHRED; or INCIN		
U161—Methyl isobutyl ketone	Methyl isobutyl ketone	33.0		Incineration
U162—Methyl methacrylate	Methyl methacrylate	160.0		Incineration
U163—N-Methyl-N'nitro-N-nitrosoguanidine		INCIN		
U164—Methylthiouracil		INCIN		
U165—Naphthalene	Naphthalene	3.1		Incineration
U166—1,4-Naphthaquinone		FSUBS; or INCIN		
U167—1-Naphthylamine		INCIN		
U168—2-Napthylamine	2-Napthylamine	INCIN		(Treatment method specified)
U169—Nitrobenzene	Nitrobenzene	14.0		Incineration
U170—p-Nitrophenol	4-Nitrophenol	29.0		Incineration
U171—Nitropropane,2-		INCIN		
U172—N-Nitroso-di-n-butylamine	N-Nitroso-di-n-butylamine	17.0		Incineration
U173—N-Nitro-di-N-ethanolamine		INCIN		
U174—N-Nitrosodiethylamine	N-Nitrosodiethylamine	28.0		Incineration
U176—N-Nitroso-N-ethylurea		INCIN		
U177—N-Nitroso-N-methylurea		INCIN		
U178—N-Nitroso-N-methylurethane		INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U179—N-Nitrosopiperidine	N-Nitrosopiperidine	35.0		Incineration
U180—N-Nitrosopyrrolidine	N-Nitrosopyrrolidine	35.0		Incineration
U181—5-Nitro-o-toluidine	5-Nitro-o-toluidine	28.0		Incineration
U182—Paraldehyde		FSUBS; or INCIN		
U183—Pentachlorobenzene	Pentachlorobenzene	37.0		Incineration
U184—Pentachloroethane		INCIN		
U185—Pentachloronitrobenzene	Pentachloronitrobenzene	4.8		Incineration
U186—1,3-Pentadiene		FSUBS; or INCIN		
U187—Phenacetin	Phenacetin	16.0		Incineration
U188—Phenol	Phenol	6.2		Incineration
U189—Phosphorus sulfide		CHOXD; CHRED; or INCIN		
U190—Phthalic anhydride	Phthalic anhydride (measured as phthalic acid)	28.0		Rotary kiln incineration
U191—2-Picoline		INCIN		
U192—Pronamide	Pronamide	1.5		Incineration
U193—1,3-Propane sultone		INCIN		
U194—N-Propylamine		INCIN		
U196—Pyridine	Pyridine	16.0		Incineration
U197—p-Benzoquinone		FSUBS; or INCIN		
U200—Reserpine		INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U201—Resorcinol	Resorcinol	FSUBS; or INCIN		
U202—Saccharin and salts		INCIN		
U203—Safrole	Safrole	22.0		Incineration
U204—Selenious acid	Selenium		5.7	Stabilization
U205—Selenium disulfide	Selenium		5.7	Stabilization
U206—Streptozotocin		INCIN		
U207—1,2,4,5-Tetrachlorobenzene	1,2,4,5-Tetrachlorobenzene	19.0		Incineration
U208—1,1,1,2-Tetrachloroethane	1,1,1,2-Tetrachloroethane	42.0		Incineration
U209—1,1,2,2-Tetrachloroethane	1,1,2,2-Tetrachloroethane	42.0		Incineration
U210—Tetrachloroethylene	Tetrachloroethylene	5.6		Incineration
U211—Carbon tetrachloride	Carbon tetrachloride	5.6		Incineration
U213—Tetrahydrofuran		FSUBS; or INCIN		
U214—Thallium (I) acetate	Thallium	RTHRM; or STABL		(Treatment method specified)
U215—Thallium (I) carbonate	Thallium	RTHRM; or STABL		(Treatment method specified)
U216—Thallium (I) chloride	Thallium	RTHRM; or STABL		(Treatment method specified)
U217—Thallium (I) nitrate	Thallium	RTHRM; or STABL		(Treatment method specified)
U218—Thioacetamide		INCIN		
U219—Thiourea		INCIN		
U220—Toluene	Toluene	28.0		Incineration

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U221—Toluenediamine		FSUBS; or INCIN		
U222—o-Toluidine hydrochloride		INCIN		
U223—Toluene diisocyanate		FSUBS; or INCIN		
U225—Bromoform	Tribromomethane (Bromoform)	15.0		Incineration
U226—1,1,1-Trichloroethane	1,1,1-Trichloroethane	5.6		Incineration
U227—1,1,2-Trichloroethane	1,1,2-Trichloroethane	5.6		Incineration
U228—Trichloroethylene	Trichloroethylene	5.6		Incineration
U234—sym-Trinitrobenzene		INCIN		
U235—tris-(2,3-Dibromopropyl) phosphate	tris-(2,3-Dibromopropyl) phosphate	0.10		Rotary kiln incineration
U236—Trypan blue		INCIN		
U237—Uracil mustard		INCIN		
U238—Ethyl carbamate		INCIN		
U239—Xylenes	Xylenes	28.0		Incineration
U240—2,4-D	2,4-Dichlorophenoxyacetic acid	10.0		Incineration
U240—2,4-D, salts and esters		INCIN		
U243—Hexachloropropene	Hexachloropropene	28.0		Incineration
U244—Thiram		INCIN		
U246—Cyanogen bromide		CHOXD; WETOX; or INCIN		

Hazardous waste description	Constituents of concern	Total composition (mg/kg)	TCLP (mg/L)	BDAT used to derive treatment standards
U247—Methoxychlor	Methoxychlor	0.18		Incineration
U248—Warfarin, when present at concentrations of 0.3% or less		FSUBS; or INCIN		
U249—Zinc phosphide, when present at concentrations of 10% or less		CHOXD; CHRED; or INCIN		
U328—o-Toluidine		INCIN or thermal destruction		
U353—p-Toluidine		INCIN or thermal destruction		
U359—2-ethoxy-ethanol		FSUBS; or INCIN		

[a]Also applies to D001 and D002 wastes prohibited under 40 CFR 268.37.

Appendix B.

TECHNOLOGY CODES USED IN APPENDIX A

Appendix B. TECHNOLOGY CODES AND DESCRIPTION OF TECHNOLOGY-BASED STANDARDS

Technology code	Description of technology-based standards
ADGAS:	Venting of compressed gases into an absorbing or reacting media (i.e., solid or liquid)—venting can be accomplished through physical release utilizing valves/piping, physical penetration of the container, and/or penetration through detonation.
AMLGM:	Amalgamation of liquid, elemental mercury contaminated with radioactive materials utilizing inorganic reagents such as copper, zinc, nickel, gold, and sulfur that result in a nonliquid, semisolid amalgam and thereby reducing potential emissions of elemental mercury vapors to the air.
BIODG:	Biodegradation of organics or nonmetallic inorganics (i.e., degradable inorganics that contain the elements of phosphorus, nitrogen, and sulfur) in units operated under either aerobic or anaerobic conditions such that a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals (e.g., total organic carbon can often be used as an indicator parameter for the biodegradation of many organic constituents that cannot be directly analyzed in wastewater residues).
CARBN:	Carbon adsorption (granulated or powered) of nonmetallic inorganics, organo-metallics, and/or organic constituents, operated such that a surrogate compound or indicator parameter has not undergone breakthrough (e.g., total organic carbon can often be used as an indicator parameter for the adsorption of many organic constituents that cannot be directly analyzed in wastewater residues). Breakthrough occurs when the carbon has become saturated with the constituent (or indicator parameter) and substantial change in adsorption rate associated with that constituent occurs.
CHOXD:	Chemical or electrolytic oxidation utilizing the following oxidation reagents (or waste reagents) or combinations of reagents: (1) hypochlorite (e.g., bleach); (2) chlorine; (3) chlorine dioxide; (4) ozone or uv (ultraviolet light) assisted ozone; (5) peroxides; (6) persulfates; (7) perchlorates; (8) permagantes; and/or (9) other oxidizing reagents of equivalent efficiency, performed in units operated such that a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals (e.g., total organic carbon can often be used as an indicator parameter for the oxidation of many organic constituents that cannot be directly analyzed in wastewater residues). Chemical oxidation specifically includes what is commonly referred to as alkaline chlorination.

Technology code	Description of technology-based standards
CHRED:	Chemical reduction utilizing the following reducing reagents (or waste reagents) or combinations of reagents: (1) sulfur dioxide; (2) sodium, potassium, or alkali salts or sulfites, bisulfites, metabisulfites, and polyethylene glycols (e.g., NaPEG and KPEG); (3) sodium hydrosulfide; (4) ferrous salts; and/or (5) other reducing reagents of equivalent efficiency, performed in units operated such that a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals (e.g., total organic halogens can often be used as an indicator parameter for the reduction of many halogenated organic constituents that cannot be directly analyzed in wastewater residues). Chemical reduction is commonly used for the reduction of hexavalent chromium to the trivalent state.
DEACT:	Deactivation to remove the hazardous characteristics of a waste because of its ignitability, corrosivity, and/or reactivity.
FSUBS:	Fuel substitution in units operated in accordance with applicable technical operating requirement.
HLVIT:	Vitrification of high-level mixed radioactive wastes in units in compliance with all applicable radioactive protection requirements under control of the Nuclear Regulatory Commission.
IMERC:	Incineration of wastes containing organics and mercury in units operated in accordance with the technical operating requirements of 40 CFR Part 264, Subpart O, and Part 265, Subpart O. All wastewater and nonwastewater residues derived from this process must then comply with the corresponding treatment standards per waste code with consideration of any applicable subcategories (e.g., high and low mercury subcategories).
INCIN:	Incineration in units operated in accordance with the technical operating requirements of 40 CFR Part 264, Subpart O, and Part 265, Subpart O.
LLEXT:	Liquid-liquid extraction (often referred to as solvent extraction) of organics from liquid wastes into an immiscible solvent for which the hazardous constituents have a greater solvent affinity, resulting in an extract high in organics that must undergo either incineration, reuse as a fuel, or other recovery/reuse and a raffinate (extracted liquid waste) proportionately low in organics that must undergo further treatment as specified in the standard.
MACRO:	Macroencapsulation with surface coating materials such as polymeric organics (e.g., resins and plastics) or with a jacket of inert inorganic materials to substantially reduce surface exposure to potential leaching media. Macroencapsulation specifically does not include any material that would be classified as a tank or container according to 40 CFR 260.10.

Technology code	Description of technology-based standards
NEUTR:	Neutralization with the following reagents (or waste reagents) or combinations of reagents: (1) acids; (2) bases; or (3) water (including wastewaters) resulting in a pH >2 but <12.5 as measured in the aqueous residuals.
NLDBR:	No land disposal based on recycling.
PRECP:	Chemical precipitation of metals and other inorganics as insoluble precipitates of oxides, hydroxides, carbonates, sulfides, chlorides, fluorides, or phosphates. The following reagents (or waste reagents) are typically used alone or in combination: (1) lime (i.e., containing oxides and/or hydroxides of calcium and/or magnesium); (2) caustic (i.e., sodium and/or potassium hydroxides); (3) soda ash (i.e., sodium carbonate); (4) sodium sulfide; (5) ferric sulfate or ferric chloride; (6) alum; or (7) sodium sulfate. Additional flocculating, coagulation, or similar reagents/processes that enhance sludge dewatering characteristics are not precluded from use.
RBERY:	Thermal recovery of beryllium.
RCGAS:	Recovery/reuse of compressed gases, including techniques such as reprocessing of the gases for reuse/resale; filtering/adsorption of impurities; remixing for direct reuse and resale; and use of the gas as a fuel source.
RCORR:	Recovery of acids or bases utilizing one or more of the following recovery technologies: (1) distillation (i.e., thermal concentration); (2) ion exchange; (3) resin or solid adsorption; (4) reverse osmosis; and/or (5) incineration for the recovery of acid—Note: this does not preclude the use of other physical separation or concentration techniques such as decantation, filtration (including ultrafiltration), and centrifugation, when used in conjunction with the above listed recovery technologies.
RLEAD:	Thermal recovery of lead in secondary lead smelters.
RMERC:	Retorting or roasting in a thermal processing unit capable of volatilizing mercury and subsequently condensing the volatilized mercury for recovery. The retorting or roasting unit (or facility) must be subject to one or more of the following: (a) a National Emissions Standard for Hazardous Air Pollutants (NESHAP) for mercury; (b) a best available control technology (BACT) or a lowest achievable emission rate (LAER) standard for mercury imposed pursuant to a Prevention of Significant Deterioration (PSD) permit; or (c) a state permit that establishes emission limitations (within meaning of Sect. 302 of the Clean Air Act) for mercury. All wastewater and nonwastewater residues derived from this process must then comply with the corresponding treatment standards per waste code with consideration of any applicable subcategories (e.g., high or low mercury subcategories).

Technology code	Description of technology-based standards
RMETL:	Recovery of metals or inorganics utilizing one or more of the following direct physical/removal technologies: (1) ion exchange; (2) resin or solid (i.e., zeolites) adsorption; (3) reverse osmosis; (4) chelation/solvent extraction; (5) freeze crystallization; (6) ultrafiltration and/or (7) simple precipitation (i.e., crystallization)—Note: This does not preclude the use of other physical phase separation or concentration techniques such as decantation, filtration (including ultrafiltration), and centrifugation, when used in conjunction with the above-listed recovery technologies.
RORGS:	Recovery of organics utilizing one or more of the following technologies: (1) distillation; (2) thin-film evaporation; (3) steam stripping; (4) carbon adsorption; (5) critical fluid extraction; (6) liquid-liquid extraction; (7) precipitation/crystallization (including freeze crystallization); or (8) chemical phase separation techniques (i.e., addition of acids, bases, demulsifiers, or similar chemicals)—Note: This does not preclude the use of other physical phase separation techniques such as a decantation, filtration (including ultrafiltration), and centrifugation, when used in conjunction with the above-listed recovery technologies.
RTHRM:	Thermal recovery of metal or inorganics from nonwastewaters in units identified as industrial furnaces according to 40 CFR 260.10 (1), (6), (7), (11), and (12) under the definition of "industrial furnaces."
STABL:	Stabilization with the following reagents (or waste reagents) or combinations of reagents: (1) Portland cement; or (2) lime/pozzolans (e.g., fly ash and cement kiln dust)—this does not preclude the addition of reagents (e.g., iron salts, silicates, and clays) designed to enhance the set/cure time and/or compressive strength or to overall reduce the leachability of the metal or inorganic.
SSTRP:	Steam stripping of organics from liquid wastes utilizing direct application of steam to the wastes operated such that liquid and vapor flow rates, as well as temperature and pressure ranges, have been optimized, monitored, and maintained. These operating parameters are dependent upon the design parameters of the unit such as the number of separation stages and the internal column design. Thus, resulting in a condensed extract high in organics that must undergo either incineration, reuse as a fuel, or other recovery/reuse and an extracted wastewater that must undergo further treatment as specified in the standard.
WETOX:	Wet air oxidation performed in units operated such that a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals (e.g., total organic carbon can often be used as an indictor parameter for the oxidation of many organic constituents that cannot be directly analyzed in wastewater residues).

Technology code	Description of technology-based standards
WTRRX:	Controlled reaction with water for highly reactive inorganic or organic chemicals with precautionary controls for protection of workers form potential violent reactions as well as precautionary controls for potential emissions of toxic/ignitable levels of gases released during the reaction.

Appendix C.

TREATMENT STANDARDS FOR DEBRIS

Appendix C. ALTERNATIVE TREATMENT STANDARDS FOR HAZARDOUS DEBRIS[1]

Technology description	Performance and/or design and operating standard	Contaminant restrictions[2]
A. Extraction Technologies:		
1. Physical Extraction		
a. *Abrasive Blasting:* Removal of contaminated debris surface layers using water and/or air pressure to propel a solid media (e.g., steel shot, aluminum oxide grit, plastic beads).	*Glass, Metal, Plastic, Rubber.* Treatment to a clean debris surface.[3] *Brick, Cloth, Concrete, Paper, Pavement, Rock, Wood:* Removal of at least 0.6 cm of the surface layer; and treatment to a clean debris surface.[3]	*All Debris:* None.
b. *Scarification, Grinding, and Planing:* Process utilizing striking piston heads, saws, or rotating grinding wheels such that contaminated debris surface layers are removed.	Same as above.	Same as above.
c. *Spalling:* Drilling or chipping holes at appropriate locations and depth in the contaminated debris surface and applying a tool that exerts a force on the sides of those holes such that the surface layer is removed. The surface layer removed remains hazardous debris subject to the debris treatment standards.	Same as above.	Same as above.
d. *Vibratory Finishing:* Process utilizing scrubbing media, flushing fluid, and oscillating energy such that hazardous contaminants or contaminated debris surface layers are removed.[4]	Same as above.	Same as above.

Technology description	Performance and/or design and operating standard	Contaminant restrictions[2]
e. *High Pressure Steam and Water Sprays:* Application of water or steam sprays of sufficient temperature, pressure, residence time, agitation, surfactants, and detergents to remove hazardous contaminants from debris surfaces or to remove contaminated debris surface layers.	Same as above.	Same as above.
2. Chemical Extraction		
a. *Water Washing and Spraying:* Application of water sprays or water baths of sufficient temperature, pressure, residence time, agitation, surfactants, acids, bases, and detergents to remove hazardous contaminants from debris surfaces and surface pores or to remove contaminated debris surface layers.	*All Debris:* Treatment to a clean debris surface.[3] *Brick, Cloth, Concrete, Paper, Pavement, Rock, Wood:* Debris must be no more than 1.2 cm (1/2 in.) in one dimension (i.e., thickness limit,[5] except that this thickness limit may be waived under an "Equivalent Technology" approval under §268.42(b);[6] debris surfaces must be in contact with water solution for at least 15 min.	*Brick, Cloth, Concrete, Paper, Pavement, Rock, Wood:* Contaminant must be soluble to at least 5% by weight in water solution or 5% by weight in emulsion; if debris is contaminated with a dioxin-listed waste,[7] an "Equivalent Technology" approval under §268.42(b) must be obtained.[6]
b. *Liquid Phase Solvent Extraction:* Removal of hazardous contaminants from debris surfaces and surface pores by applying a nonaqueous liquid or liquid solution which causes the hazardous contaminants to enter the liquid phase and be flushed away from the debris along with the liquid or liquid solution while using appropriate agitation, temperature, and residence time.[4]	Same as above.	*Brick, Cloth, Concrete, Paper, Pavement, Rock, Wood:* Same as above, except that contaminant must be soluble to at least 5% by weight in the solvent.

Technology description	Performance and/or design and operating standard	Contaminant restrictions[2]
c. *Vapor Phase Solvent Extraction:* Application of an organic vapor using sufficient agitation, residence time, and temperature to cause hazardous contaminants on contaminated debris surfaces and surface pores to enter the vapor phase and be flushed away with the organic vapor.[4]	Same as above, except that brick, cloth, concrete, paper, pavement, rock, and wood surfaces must be in contact with the organic vapor for at least 60 min.	Same as above.
3. Thermal Extraction		
a. *High Temperature Metals Recovery:* Application of sufficient heat, residence time, mixing, fluxing agents, and/or carbon in a smelting, melting, or refining furnace to separate metals from debris.	For refining furnaces, treated debris must be separated from treatment residuals using simple physical or mechanical means,[8] and, prior to further treatment, such residuals must meet the waste-specific treatment standards for organic compounds in the waste contaminating the debris.	*Debris contaminated with a dioxin-listed waste:*[5] Obtain an "Equivalent Technology" approval under §268.42(b).[6]
b. *Thermal Desorption:* Heating in an enclosed chamber under either oxidizing or nonoxidizing atmospheres at sufficient temperature and residence time to vaporize hazardous contaminants from contaminated surfaces and surface pores and to remove the contaminants from the heating chamber in a gaseous exhaust gas.[9]	*All Debris:* Obtain an "Equivalent Technology" approval under §268.42(b);[6] treated debris must be separated from treatment residuals using simple physical or mechanical means,[8] and, prior to further treatment, such residue must meet the waste-specific treatment standards for organic compounds in the waste contaminating the debris. *Brick, Cloth, Concrete, Paper, Pavement, Rock, Wood:* Debris must be no more than 10 cm (4 in.) in one dimension (i.e., thickness limit),[5] except that this thickness limit may be waived under the "Equivalent Technology" approval.	*All Debris:* Metals other than mercury.

Technology description	Performance and/or design and operating standard	Contaminant restrictions[2]
B. Destruction Technologies:		
1. *Biological Destruction (Biodegradation):* Removal of hazardous contaminants from debris surfaces and surface pores in an aqueous solution and biodegration of organic or nonmetallic inorganic compounds (i.e., inorganics that contain phosphorus, nitrogen, or sulfur) in units operated under either aerobic or anaerobic conditions.	*All Debris:* Obtain an "Equivalent Technology" approval under §268.42(b);[6] treated debris must be separated from treatment residuals using simple physical or mechanical means,[8] and, prior to further treatment, such residue must meet the waste-specific treatment standards for organic compounds in the waste contaminating the debris. *Brick, Cloth, Concrete, Paper, Pavement, Rock, Wood:* Debris must be no more than 1.2 cm (1/2 in.) in one dimension (i.e., thickness limit),[5] except that this thickness limit may be waived under the "Equivalent Technology" approval	*All Debris:* Metal contaminants.
2. Chemical Destruction		
a. *Chemical Oxidation:* Chemical or electrolytic oxidation utilizing the following oxidation reagents (or waste reagents) or combination of reagents— (1) hypochlorite (e.g., bleach); (2) chlorine; (3) chlorine dioxide; (4) ozone or uv (ultraviolet light) assisted ozone; (5) peroxides, (6) persulfates; (7) perchlorates; (8) permanganates; and/or (9) other oxidizing reagents of equivalent destruction efficiency.[4] Chemical oxidation specifically includes what is referred to as alkaline chlorination.	*All Debris:* Obtain an "Equivalent Technology" approval under §268.42(b);[6] treated debris must be separated from treatment residuals using simple physical or mechanical means,[8] and, prior to further treatment, such residue must meet the waste-specific treatment standards for organic compounds in the waste contaminating the debris. *Brick, Cloth, Concrete, Paper, Pavement, Rock, Wood:* Debris must be no more than 1.2 cm (1/2 in.) in one dimension (i.e., thickness limit),[5] except that this thickness limit may be waived under the "Equivalent Technology" approval	*All Debris:* Metal contaminants.

Technology description	Performance and/or design and operating standard	Contaminant restrictions[2]
b. *Chemical Reduction:* Chemical reaction utilizing the following reducing reagents (or waste reagents) or combination of reagents: (1) sulfur dioxide; (2) sodium, potassium, or alkali salts of sulfites, bisulfites, and metabisulfites, and polyethylene glycols (e.g., NaPEG and KPEG); (3) sodium hydrosulfide; (4) ferrous salts; and/or (5) other reducing reagents of equivalent efficiency.[4]	Same as above.	Same as above.
3. *Thermal Destruction:* Treatment in an incinerator operating in accordance with Subpart O of Parts 264 or 265 of this chapter; a boiler or industrial furnace operating in accordance with Subpart H of Part 266 of this chapter, or other thermal treatment unit operated in accordance with Subpart X, Part 264, of this chapter, or Subpart P, Part 265, of this chapter, but excluding for purposes of these debris treatment standards Thermal Desorption Units.	Treated debris must be separated from treatment residuals using simple physical or mechanical means,[8] and, prior to further treatment, such residue must meet the waste-specific treatment standards for organic compounds in the waste contaminating the debris.	*Brick, Concrete, Glass, Metal, Pavement, Rock, Metal:* Metals other than mercury, except that there are no metal restrictions for vitrification. *Debris contaminated with a dioxin-listed waste*[7] Obtain an "Equivalent Technology" approval under §268.42(b),[6] except that this requirement does not apply to vitrification.
C. Immobilization Technologies:		
1. *Macroencapsulation:* 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.	Encapsulating material must completely encapsulate debris and be resistant to degradation by the debris and its contaminants and materials into which it may come into contact after placement (leachate, other waste, microbes).	None.

Technology description	Performance and/or design and operating standard	Contaminant restrictions[2]
2. *Microencapsulation:* Stabilization of the debris with the following reagents (or waste reagents) such that the leachability of the hazardous contaminants is reduced: (1) Portland cement, or (2) lime/pozzolans (e.g., fly ash and cement kiln dust). Reagents (e.g., iron salts, silicates, and clays) may be added to enhance the set/cure time and/or compressive strength or to reduce the leachability of the hazardous constituents.[5]	Leachability of the hazardous contaminants must be reduced.	None.
3. *Sealing:* Application of an appropriate material which adheres tightly to the debris surface to avoid exposure of the surface to potential leaching media. When necessary to effectively seal the surface, sealing entails pretreatment of the debris surface to remove foreign matter and to clean and roughen the surface. Sealing materials include epoxy, silicone, and urethane compounds, but paint may not be used as a sealant.	Sealing must avoid exposure of the debris surface to potential leaching media and sealant must be resistant to degradation by the debris and its contaminants and materials into which it may come into contact after placement (leachate, other waste, microbes).	None.

[1]Hazardous debris must be treated by either these standards or the waste-specific treatment standards for the waste contaminating the debris. The treatment standards must be met for each type of debris contained in a mixture of debris types, unless the debris is converted into treatment residue as a result of the treatment process. Debris treatment residuals are subject to the waste-specific treatment standards for the waste contaminating the debris.

[2]Contaminant restriction means that the technology is not BDAT for that contaminant. If debris containing a restricted contaminant is treated by the technology, the contaminant must be subsequently treated by a technology for which it is not restricted in order to be land disposed (and excluded from Subtitle C regulation).

[3]"Clean debris surface" means the surface, when viewed without magnification, shall be free of all visible contaminated soil and hazardous waste except that residual staining from soil and waste consisting of light shadows, slight streaks, or minor discolorations, and soil and waste in cracks, crevices, and pits may be present provided that such staining and waste and soil in cracks, crevices, and pits shall be limited to no more than 5% of each square inch of surface area.

Technology description	Performance and/or design and operating standard	Contaminant restrictions[2]

[4]Acids, solvents, and chemical reagents may react with some debris and contaminants to form hazardous compounds. For example, acid washing of cyanide-contaminated debris could result in the formation of hydrogen cyanide. Some acids may also react violently with some debris and contaminants, depending on the concentration of the acid and the type of debris and contaminants. Debris treaters should refer to the safety precautions specified in Material Safety Data Sheets for various acids to avoid applying an incompatible acid to a particular debris/contaminant combination. For example, concentrated sulfuric acid may react violently with certain organic compounds, such as acrylonitrile.

[5]If reducing the particle size of debris to meet the treatment standards results in material that no longer meets the 60-mm minimum particle size limit for debris, such material is subject to the waste-specific treatment standards for the waste contaminating the material, unless the debris has been cleaned and separated from contaminated soil and waste prior to size reduction. At a minimum, simple physical or mechanical means must be used to provide such cleaning and separation of nondebris materials to ensure that the debris surface is free of caked soil, waste, or other nondebris material.

[6]The demonstration "Equivalent Technology" under §268.42(b) must document that the technology treats contaminants subject to treatment to a level equivalent to that required by the performance and design and operating standards for other technologies in this table such that residual levels of hazardous contaminants will not pose a hazard to human health and the environment without management controls.

[7]Dioxin-listed wastes are EPA Hazardous Waste numbers F020, F021, F022, F023, F026, and F027.

[8]Any soil, waste, and other nondebris material that remains on the debris surface (or remains mixed with the debris) after treatment is considered a treatment residual that must be separated from the debris using, at a minimum, simple physical or mechanical means. Examples of simple physical or mechanical means are vibratory or trommel screening or water washing. The debris surface need not be cleaned to a "clean debris surface" as defined in note 3 when separating treated debris from residue; rather, the surface must be free of caked soil, waste, or other nondebris material. Treatment residuals are subject to the waste-specific treatment standards for the waste contaminating the debris.

[9]Thermal desorption is distinguished from thermal destruction in that the primary purpose of thermal desorption is to volatilize contaminants and to remove them from the treatment chamber for subsequent destruction or other treatment.

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