BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

BACKGROUND DOCUMENT FOR

PHTHALATE WASTES

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This document provides the Agency's technical support for selecting and developing treatment standards for the constituents to be regulated in the phthalate wastes. Sections 2 thru 7 present waste-specific information for the K023, K093, and K094 wastes. Section 8 presents a discussion of the development of treatment standards for those phthalate wastes designed as U wastes (U028, U069, U088, U102, U107,and U190).

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Pursuant to section 3004(m) of the Resource Conservation and Recovery Act (RCRA) as enacted by the Hazardous and Solid Waste Amendments (HSWA) on November 8, 1984, the Environmental Protection Agency (EPA) is promulgating treatment standards based on the best demonstrated available technology (BDAT) for the waste treatability group identified as phthalate wastes. This treatability group includes wastes identified in 40 CFR 261.32 as K023, K093, and K094 and in 40 CFR 261.33 as U028, U069, U088, U102, U107, and U190. Compliance with these BDAT treatment standards is a prerequisite for the placement of these wastes in units designated as land disposal units according to 40 CFR Part 268. The effective date of these treatment standards is June 8, 1989.

This background document provides the Agency's technical support for selecting and developing treatment standards for the constituents to be regulated in the phthalate wastes. Sections 2 through 7 present waste-specific information for the K023, K093, and K094 wastes. Section 2 presents the number and location of facilities affected by the land disposal restrictions, the waste-generating process, and the waste characterization data. Section 3 presents the technologies used to treat the wastes (or similar wastes). Section 4 presents the available performance data, including data on which the treatment standards are based. Section 5 explains EPA's determination of BDAT, while Section 6 discusses the selection of constituents to be regulated. Treatment standards are determined in Section 7. Section 8 presents a discussion

of the development of treatment standards for those phthalate wastes designated as U wastes (U028, U069, U088, U102, U107, and U190).

The BDAT program and promulgated methodology are more thoroughly described in two additional documents: Methodology for Developing Best Demonstrated Available Technology (BDAT) Treatment Standards (USEPA 1989b) and Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") (USEPA 1987). The petition process to be followed in requesting a variance from the BDAT treatment standards is discussed in the methodology document.

It is EPA's understanding that six facilities produce phthalic anhydride. The Agency is proposing to regulate one organic constituent in both nonwastewater and wastewater forms of K023, K093, and K094 wastes. (For the purpose of determining the applicability of the treatment standards, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than 1 percent (weight basis) total organic carbon (TOC). Wastes not meeting this definition must comply with the proposed treatment standards for nonwastewaters.)

BDAT treatment standards for wastewaters and nonwastewaters for K023, K093, and K094 (see Table 1-1) have been directly transferred from the

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*The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, the quantity of total suspended solids is measured by Method 209c (Total Suspended Solids Dried at 103 to 105°C) in Standard Methods for the Examination of Water and Wastewater, 16th Edition (APHA, AWWA, and WPCF 1985).

treatment standards for K024 wastes (covered under the First Third BDAT list of hazardous wastes). Table 1-2 presents BDAT treatment standards for wastewaters and nonwastewaters for U phthalates (U028, U069, U088, U102, U107, and U190), which have also been transferred from the treatment standards for K024 wastes. These treatment standards are based on total concentration analyses of the ash residues and the scrubber water generated during rotary kiln incineration of K024 waste. If the concentrations of the regulated constituents, as generated or as present in the treatment residuals, are lower than or equal to the proposed BDAT treatment standards, then treatment is not necessary as a prerequisite to land disposal.

Table 1-1 BDAT Treatment Standards for K023, K093, K094, and U190 Wastes

Constituent	Maximum for any single grab sample		
	Nonwastewater		Wastewater
	Total concentration (mg/kg)	TCLP leachate concentration (mg/l)	Total concentration (mg/l)
Semivolatile organics			
Phthalic anhydride (measured as phthalic acid)[a]	28	NA	0.54

NA = Not applicable.

[a]This constituent is regulated as an indicator for phthalic anhydride, which cannot be easily analyzed because it rapidly hydrolyzes and converts to phthalic acid by absorbing moisture.

Table 1-2 BDAT Treatment Standards for U Phthalates (U028, U069, U088, U102, and U107)

Waste Code	Constituent	Maximum for any single grab sample		
		Nonwastewater		Wastewater
		Total concentration (mg/kg)	TCLP leachate concentration (mg/l)	Total concentration (mg/l)
U028	Bis-(2-ethylhexyl) phthalate	28	NA	0.54
U069	Di-n-butyl phthalate	28	NA	0.54
U088	Diethyl phthalate	28	NA	0.54
U102	Dimethyl phthalate	28	NA	0.54
U107	Di-n-octyl phthalate	28	NA	0.54

2. INDUSTRIES AFFECTED AND WASTE CHARACTERIZATION

The purpose of this section is to describe the phthalic anhydride industry affected by the land disposal restrictions for K023, K093, and K094 and to present available characterization data for these wastes.

Under 40 CFR 261.32, wastes identified as K023, K093, and K094 are specifically generated in the production of phthalic anhydride and are listed as follows:

K023: Distillation light ends from the production of phthalic anhydride from napthalene.

K093: Distillation light ends from the production of phthalic anhydride from ortho-xylene.

K094: Distillation bottoms from the production of phthalic anhydride from ortho-xylene.

The Agency has determined that these listed wastes (K023, K093, and K094) represent a single waste treatability group based on their similar chemical characteristics. The Agency has examined the source of the wastes, the specific similarities in waste composition, applicable and demonstrated treatment technologies, and attainable treatment performance in order to support the approach that these wastes represent a single treatability group.

2.1 Industry Affected and Process Description

2.1.1 K023 Waste

The listed waste K023 is generated in a distillation column as light ends during the production of phthalic anhydride from napthalene in the organic chemical industry. The Agency estimates that only one facility currently uses this process and may generate K023 waste. This facility,

which is located in the State of Illinois (EPA Region V), generates approximately 300 tons of K023 waste per year.

Phthalic anhydride is manufactured by a process that uses a vaporized napthalene and air mixture fed into a fixed-bed reactor containing a vanadium pentoxide catalyst. The naphthalene is oxidized to phthalic anhydride, carbon dioxide, and water vapor at a temperature of about 350°C. These gases pass through a vapor cooler that reduces the gas temperature to just below the dew point of the gases (126°C). The condensed liquid is then routed into crude phthalic anhydride storage.

The crude phthalic anhydride is subsequently heated at atmospheric pressure in a distillation column to dehydrate traces of phthalic acid and to convert other chemicals to compounds having higher boiling points, which can be separated from the product during distillation. Other chemicals are added to shorten the time required for purification. These chemicals include sodium carbonate, sodium hydroxide, or a material to tie up naphthoquinone in a polymer state so that it can be easily removed from the product. The light ends from the distillation column constitute the waste stream K023. Figure 2-1 is a process schematic of the manufacture of phthalic anhydride and the generation of the listed waste K023.

2.1.2 K093 and K094 Wastes

During the production of phthalic anhydride using ortho-xylene as feed material, the listed waste K093 is generated in a distillation column as light ends and the distillation bottoms are the listed waste

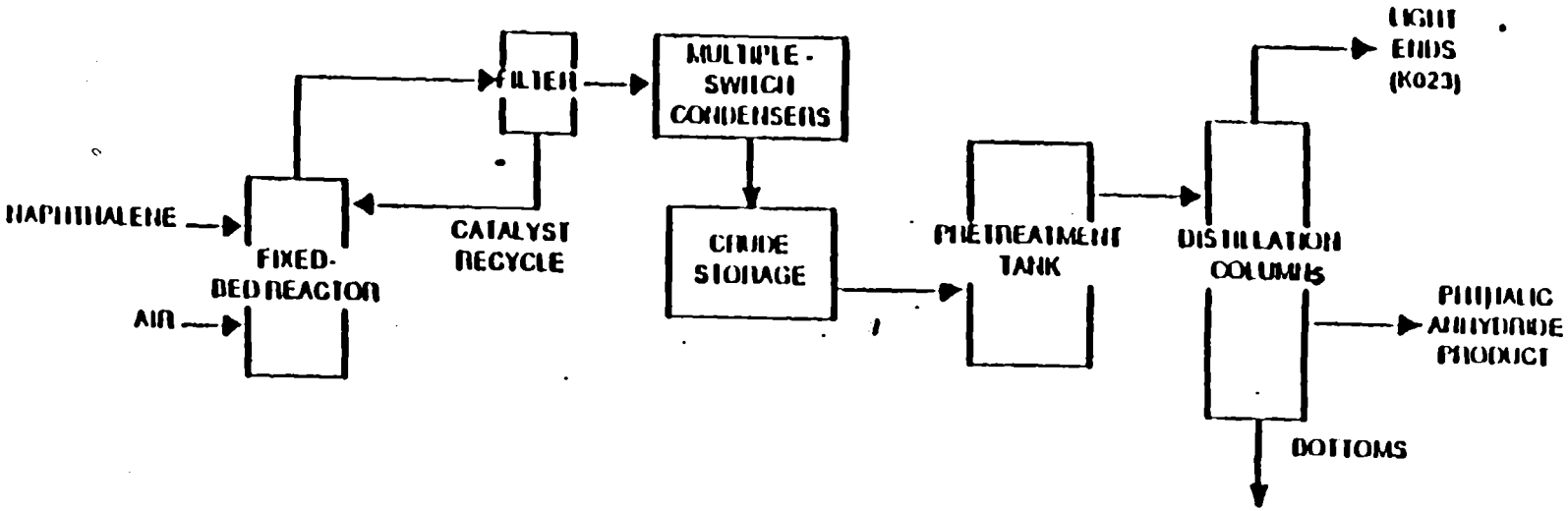

FIGURE 2-1 SCHEMATIC DIAGRAM OF THE GENERATION OF K023.

(PHTHALIC ANHYDRIDE PRODUCTION USING NAPTHALENE AS FEED)

K094. The Agency estimates that six facilities may generate K093 and/or K094. These facilities are listed on Table 2-1. Approximately 1,000 ton/yr of K093 and K094 wastes (combined) are generated by these six facilities (USEPA 1986).

Phthalic anhydride can be manufactured by the vapor phase oxidation of ortho-xylene. Ortho-xylene is mixed with air and fed to a fixed-bed tubular reactor containing vanadium pentoxide catalyst. Phthalic anhydride is formed by the following reaction:

$$C_6H_4(CH_3)_2 + 3O_2 \rightarrow C_6H_4(CO)_2O + 3H_2O.$$

The crude reactor effluent is condensed and sent to a distillation column, where the light ends are removed as K093 waste. The stripped phthalic anhydride is then distilled in a second column, where the heavy ends or bottoms are removed as K094. Figure 2-2 is a process schematic of the manufacture of phthalic anhydride and the generation of the listed wastes K093 and K094.

2.2 Waste Characterization

2.2.1 K023 Waste

All waste characterization data available to the Agency for K023 waste are presented in Table 2-2. The table shows the major constituents in the waste and their approximate concentrations. The percent concentration of each major constituent in the waste was determined from best estimates based on chemical analyses and discussion with the one known generator. At least 87 percent of the waste is composed of the BDAT list constituent phthalic anhydride. Usually, less than 0.5 percent

Table 2-1 Facilities That May Generate K023, K093, and K094 Wastes

Name of facility	Capacity (10^6 lb/yr) of phthalic anhydride product	Raw material	EPA region
BASF Corporation, Kearny, NJ	175	ortho-xylene	II
Exxon Corporation, Baton Rouge, LA	220	ortho-xylene	VI
Koppers Company, Cicero, IL	125[a]	Coal tars--naphthalene	V
	100	ortho-xylene	
Stepan Company, Millsdale, IL	170	ortho-xylene	V
Sterling Chemical Co., Texas City, TX	165	ortho-xylene	VI
Tenn-USS Chemical Co., Pasadena, TX	210	ortho-xylene	VI

[a]This unit can also be operated on ortho-xylene feed.

Reference: SRI 1988.

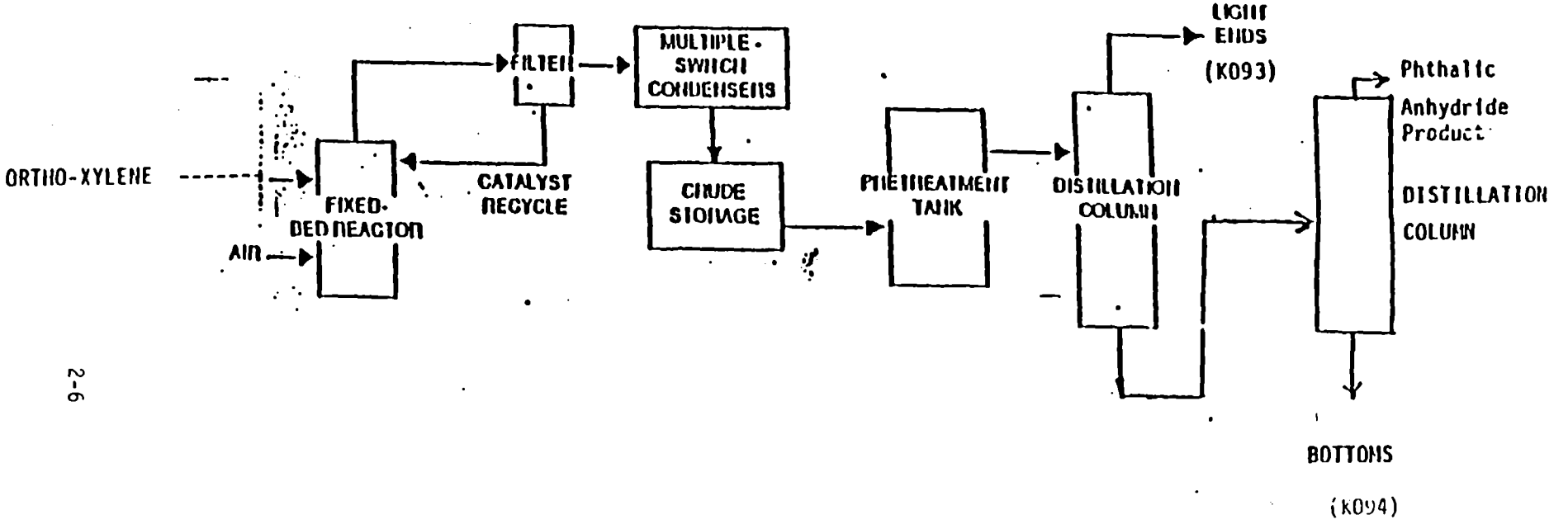

FIGURE 2-2 SCHEMATIC DIAGRAM OF THE GENERATION OF K093 AND K094. (PHTHALIC ANHYDRIDE PRODUCTION USING ORTHO-XYLENE AS FEED)

Table 2-2 K023 - Waste Composition Data

	Plant 1 (%)	Plant 2 (%)
BDAT list constituents		
Phthalic annydride	87-90	92-99
Maleic annydride		<0.5
Other constituents		
Benzoic acid	10-13	1-6

Reference: USEPA 1985

of this waste is maleic anhydride. No other BDAT list constituent (except phthalic anhydride and maleic anhydride) was detected at treatable concentrations in the untreated waste sample.

2.2.2 K093 and K094 Wastes

All waste characterization data available to the Agency for K093 and K094 wastes are presented in Tables 2-3 and 2-4. These tables show the major constituents in the wastes and their approximate concentrations. The percent concentration of each major constituent in the waste was determined from best estimates based on chemical analyses and data from other sources. In K093 and K094, the BDAT list constituent phthalic anhydride is present in the waste at treatable concentrations. In K093, the BDAT list constituent maleic anhydride is also typically present at treatable concentrations. No other BDAT list constituents are expected to be present in the untreated K093 and K094 wastes at treatable concentrations.

2.3 Determination of Waste Treatability Group

In cases where EPA believes that constituents present in wastes represented in different codes can be treated to similar concentrations by using the same technology, the Agency may combine the waste codes into one treatability group.

Based on the methods of generation and waste characterization data available to the Agency for K023, K093, and K094 wastes, the Agency has determined that these three wastes represent a single waste treatability group. These three wastes are generated by the phthalic anhydride manufacturing industry. They are also generated from similar processes,

Table 2-3 K093 - Waste Composition Data

	Plant 1 (%)	Plant 2 (%)
BOAT list constituents		
Phthalic anhydride	10	36
Maleic anhydride	90	23
Other constituents		
Benzoic acid		38
Toluic acid		1.5
Toluic aldehyde		1.5

Reference: USEPA 1985.

Table 2-4 K094 - Waste Composition Data

	Plant 1 (%)	Plant 2 (%)
8047 list constituents		
Phthalic anhydride	44.5	50
Other constituents		
Anthraquinone		6
Quinones	1.0	
Tars	54.5	39
Toluic acid		1.5
Toluic aldehyde		1.5
Trimellitic anhydride		1.5
Na_2CO_3		0.2

Reference: USEPA 1985.

i.e., during the purification step of phthalic anhydride manufacture. Although the concentrations of specific constituents will vary from waste code to waste code, all of the wastes contain similar constituents (i.e., major constituents present are phthalic anhydride and maleic anhydride) and are expected to be treatable to similar levels using the same technology. The Agency has examined the source of these wastes, the specific similarities in waste composition, applicable and demonstrated treatment technologies, and attainable treatment performance in order to support a single regulatory approach proposed for these listed wastes.

3. APPLICABLE AND DEMONSTRATED TREATMENT TECHNOLOGIES

Section 2 established one treatability group for the management of K023, K093, and K094 wastes. This section identifies the treatment technologies that are applicable to this treatability group and determines which, if any, of the applicable technologies can be considered demonstrated for the purposes of establishing BDAT.

To be applicable, a technology must be theoretically usable to treat the waste in question or to treat a waste that is similar in terms of the parameters that affect treatment selection.* To be demonstrated, the technology must be employed in full-scale operation for the treatment of the waste in question or a similar waste. Technologies available only at pilot- and bench-scale operations are not considered demonstrated technologies.

3.1 Applicable Treatment Technologies

Initial data gathering on the treatment of K023, K093, and K094 wastes included review of the technical literature and EPA's National Survey of Hazardous Waste Treatment, Storage, Disposal, and Recycling Facilities (1986).

As shown in Section 2.2, and based on the processes generating K023, K093, and K094 wastes, these wastes are expected to contain some of the BDAT list organic constituents and are not expected to contain treatable levels of BDAT list inorganic constituents. Since K023, K093,

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*For detailed discussions of the technologies that are applicable for these wastes, or for wastes judged to be similar, refer to EPA's Treatment Technology Background Document (USEPA 1989a).

and K094 contain BDAT list organics, the Agency considers that the technologies applicable to the untreated listed wastes should include those that destroy or reduce the total amount of various organic compounds in the waste. Additionally, residuals (wastewaters and nonwastewaters) generated from the treatment of BDAT list organics should also be considered for further treatment, if necessary.

The Agency has identified incineration and fuel substitution as applicable destruction technologies because these technologies have been shown to treat organic wastes with high Btu content, low metals concentrations, and low water content. Incineration and fuel substitution are destruction technologies in which energy, in the form of heat, is transferred to the waste to destabilize chemical bonds and eventually destroy hazardous constituents by converting them to carbon dioxide, water, and other oxidized waste constituents. In general, two residuals are generated by incineration or fuel substitution processes: ash and scrubber water. The scrubber water from incineration and fuel substitution is designated as a wastewater form derived from the treatment of these listed wastes. The scrubber water is not expected to contain BDAT list organics at treatable levels since most of the organics are destroyed in the incinerator, furnace, or boiler.

The Agency believes that solvent extraction may be another applicable technology for K023, K093, and K094 nonwastewaters. The Agency also believes that biological treatment, steam stripping, and carbon adsorption are potentially applicable to wastewater forms of K023, K093, and K094 wastes.

Based on the waste-generating processes, the Agency does not expect BDAT list metals to be present in K023, K093, and K094 wastes (both nonwastewaters and wastewaters); nor is there any reason to believe that they should be present at treatable levels. Therefore, there is no need to investigate technologies applicable for treating BDAT list metals.

3.2 Demonstrated Treatment Technologies

The Agency cannot identify any facilities that currently use incinerators to treat K023 waste. However, incineration is demonstrated on wastes that are similar to K023 (wastes that have a high Btu content and a high percentage of organics). Based on the waste characteristics of K023, the Agency also believes that fuel substitution is demonstrated on wastes similar to K023 wastes. The Agency lacks data on the current waste management practices of these phthalate anhydride wastes.

From the information available to the Agency, at least one of the generators of K093 and K094 uses fuel substitution. Hence, fuel substitution is demonstrated on K093 and K094 wastes. Since K023, K093, and K094 represent a single waste treatability group, fuel substitution and incineration are demonstrated treatment technologies for the K023, K093, and K094 waste group.

4. PERFORMANCE DATA BASE

This section presents the data available to EPA on the performance of demonstrated technologies in treating the listed wastes. These data are used elsewhere in the document for determining which technologies represent BDAT (Section 5), for selecting constituents to be regulated (Section 6), and for developing treatment standards (Section 7). Eligible data, in addition to full-scale demonstration data, may include data developed at research facilities or obtained through other applications at less than full-scale operation, as long as the technology is demonstrated in full-scale operation for a similar waste or wastes as defined in Section 3.

Where data are not available on the treatment of the specific wastes of concern, the Agency may elect to transfer data on the treatment of a similar waste or wastes, using a demonstrated technology. To transfer data from another waste category, EPA must find that the waste treatability group covered by this background document is no more difficult to treat (based on the waste characteristics that affect performance of the demonstrated treatment technology) than the treated wastes from which performance data are being transferred.

No performance data are available to the Agency to characterize treatment for K023, K093, or K094. However, the Agency has a data base for incineration of a similar waste, K024, which, as defined by 40 CFR 261.32, is the distillation bottoms from the production of phthalic anhydride from napthalene. This similarity is based on the production processes, the waste compositions, and the waste characteristics

affecting performance of the demonstrated treatment technology. The waste characteristics affecting performance are located in the Treatment Technology Background Document (USEPA 1989a). The Agency is transferring performance data from the treatment of K024 to the K023, K093, and K094 wastes since the Agency believes that these wastes are no more difficult to treat than the tested K024 waste.

The performance data base for K024 waste includes the untreated and treated waste concentrations for a given constituent, the values of operating parameters that were measured at the time the waste was being treated, the values of relevant design parameters for the treatment technology, and data on waste characteristics that affect the performance of the treatment technology.

Tables 3-1 through 3-6 of the Best Demonstrated Available Technology (BDAT) Background Document for K024 (USEPA 1988a) present the data of total waste concentration analyses for K024 waste samples, as well as the design and operating data for the treatment system. Based on a review of the operating data obtained during collection of the samples, the data sets appear to reflect treatment by a well-operated system. Furthermore, in all cases the BDAT list organics detected in the untreated waste are reduced to nearly nondetectable levels in the treated residuals. No BDAT list metal constituents were detected in the untreated or treated wastes, nor are they expected to be present.

5. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

This section presents the Agency's rationale for the determination of best demonstrated available technology (BDAT) for K023, K093, and K094 nonwastewaters and wastewaters.

To determine BDAT, the Agency examines all available performance data on technologies that are identified as demonstrated to determine (using statistical techniques) whether one or more of the technologies performs significantly better than the others. In addition, all performance data used for determination of best technology must first be adjusted for accuracy, as discussed in EPA's publication Methodology for Developing Best Demonstrated Available Technology (BDAT) Treatment Standards. (An accuracy adjustment assesses the ability of an analytical technique to recover a particular constituent from the waste in a particular test. It is usually done by spiking a sample with a known amount of the target constituents and then comparing the amount recovered with results from unspiked samples.) BDAT must be specifically defined for all streams associated with the management of the listed wastes; this pertains to the original waste as well as to any residual waste streams created by the treatment process.

The technology that performs best on a particular waste or waste treatability group is then evaluated to determine whether it is "available." To be available the technology must (1) be commercially available to any generator and (2) provide "substantial" treatment of the waste, as determined through evaluation of accuracy-adjusted data. In determining whether treatment is substantial, EPA may consider data on

the performance of a waste similar to the waste in question provided that the similar waste is at least as difficult to treat. If the best technology is found to be not available, then the next best technology is evaluated, and so on.

Consistent with EPA's methodology for determining BDAT, the Agency evaluated the incineration performance data for the similar waste, K024, to determine whether this technology would provide statistically significant treatment for BDAT list organic constituents in K023, K093, and K094 wastes. Based on the evaluation of the design and operating parameters of the similar treatment system, the analytical testing, and the quality of the data, EPA determined that statistically significant treatment occurs. This determination is based on the findings that in all data sets, BDAT list organic constituents are reduced to nondetectable levels, or to nearly nondetectable levels, in the treatment residuals. In addition to achieving this substantial reduction, incineration is a widely available commercial technology. EPA concludes that incineration is therefore the best demonstrated available treatment for K023, K093, and K094 wastes.

Some commenters on the proposed rule for phthalates pointed out that phthalic anhydride can be hydrolyzed to phthalic acid. The commenters stated that treatment by hydrolysis significantly reduces the toxicity of the waste (as phthalic acid has significantly lower toxicity than the phthalic anhydride originally present in the waste). Destruction of phthalic anhydride by incineration provides a more complete reduction in

total toxicity than simple hydrolysis (i.e., incineration completely destroys both the phthalic anhydride and the phthalic acid to carbon dioxide and water, while hydrolysis does not provide any significant destruction of the organics, but rather enlarges the phthalic anhydride molecule to the acid form).

As noted in Sections 3 and 4, BDAT list metals are not expected to be present in K023, K093, and K094 wastes. Hence, residuals from incineration will not require any treatment for BDAT list metals.

Since incineration for K023, K093, and K094 will generate two treatment residuals--ash (a nonwastewater form of K023, K093, and K094) and combustion gas scrubber water (a wastewater form of K023, K093, and K094)--BDAT must be identified for both types of waste streams.

5.1 Nonwastewaters

As discussed previously, EPA has identified incineration as the best demonstrated available technology for K023, K093, and K094 wastes as generated. The Agency believes that fuel substitution is the only other equivalent demonstrated technology for the treatment of K023, K093, and K094 nonwastewaters. As noted, incineration/fuel substitution produces one nonwastewater residual, ash. Since, in all cases, organic constituent levels in this residual are at or near nondetectable levels for the tested K024 waste, EPA concludes that no further treatment could improve upon the levels of performance achieved by incineration or fuel substitution alone and that no further treatment of the ash for the organic constituents is necessary. The performance data base for the tested K024 waste is available in Chapter 3 of the BDAT Background

Document for K024. Incineration/fuel substitution is therefore the basis for BDAT for nonwastewater residuals from incineration or fuel substitution of K023, K093, and K094 nonwastewaters.

5.2 Wastewaters

Scrubber water is the other residual likely to be produced by incineration or fuel substitution of K023, K093, and K094 nonwastewaters. From the treatment data for K024, the Agency expects that levels of phthalic acid in this wastewater will be below detection limits. The Agency concludes, therefore, that no further treatment of this residual wastewater stream could improve upon the level of performance achieved by incineration/fuel substitution alone and that no further treatment is required. Consequently, incineration/fuel substitution is the basis for BDAT for wastewater residuals from incineration or fuel substitution of K023, K093, and K094 nonwastewaters.

6. SELECTION OF REGULATED CONSTITUENTS

This section presents the rationale for the selection of regulated constituents for the treatment of K023, K093, and K094 wastes.

Constituents selected for regulation must satisfy the following criteria:

1. They must be on the BDAT list of regulated constituents. (Presence on the BDAT list implies the existence of approved techniques for analyzing the constituent in treated waste matrices.)

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

3. Where performance data are transferred, the selected constituents must be easier to treat than the waste constituent(s) for which performance data are transferred. Factors for assessing ease of treatment will vary according to the technology of concern. For instance, for incineration the factors include bond dissociation energy, thermal conductivity, and boiling point.

From the group of constituents that are eligible to be regulated, EPA may select a subset of constituents as representative of the broader group. For instance, out of a group of constituents that react similarly to treatment, the Agency might name only those that are the most difficult to treat as regulated constituents for the purpose of setting a standard.

6.1 Identification of Major Constituents in the Untreated Waste

The analytical data gathered or generated as part of the BDAT program were reviewed to select major constituents in the untreated waste. As a

general rule, any BDAT list constituent present in the waste at a treatable concentration would be eligible for selection.

Phthalic anhydride* and maleic anhydride** are the only BDAT list constituents detected in the untreated waste. These constituents and their concentrations identified in the untreated K023, K093, and K094 wastes are listed in Tables 2-2, 2-3, and 2-4.

6.2 Constituents Selected for Regulation

Phthalic anhydride is selected as the only regulated constituent for K023, K093, and K094 because this constituent is present in the untreated waste at treatable concentrations. Maleic anhydride may also be present in K023 and K093 wastes at treatable concentrations. Since maleic anhydride is more volatile and has a lower bond dissociation energy than phthalic anhydride, the Agency believes that maleic anhydride will be controlled more easily by incineration than phthalic anhydride. Hence, in the course of achieving any regulatory limit set for phthalic acid (i.e., the indicator compound for phthalic anhydride), maleic anhydride will also be adequately controlled. The Agency is using phthalic acid

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*Phthalic anhydride is a BDAT list constituent that cannot be easily analyzed because it rapidly hydrolyzes to phthalic acid in the presence of moisture. Phthalic acid, although not a BDAT list constituent, is an indicator for phthalic anhydride. All of the wastewater and nonwastewater standards for K023, K093, and K094 are expressed as "phthalic anhydride ... (measured as phthalic acid)." Thus, the Agency is specifically requiring analysis for phthalic acid after hydrolysis of K023, K093, K094, and U190 nonwastewaters.

**Maleic anhydride is being added to the BDAT list of hazardous constituents.

as a surrogate for phthalic anhydride in phthalate wastes. Although methods for the measurement of phthalic anhydride concentration exist, the measurement of phthalic acid concentration as a surrogate for phthalic anhydride provides a more effective means of measuring treatment. This is because phthalic anhydride is unstable due to its hygroscopic nature in the presence of atmospheric moisture. The Agency has based the treatment standards for phthalic anhydride wastes on the direct analysis of phthalic acid. The Agency believes that any phthalic anhydride present in the incinerator ash (if incineration is used for the treatment of phthalic anhydride wastes) will absorb atmospheric moisture and hydrolyze itself to phthalic acid. Therefore, analysis for phthalic acid in incinerator ash is not expected to require a hydrolysis step to convert phthalic anhydride to phthalic acid. Also, incineration, which has been selected as BDAT, is expected to destroy both phthalic anhydride and phthalic acid present in the untreated phthalic anhydride waste. The Agency never intended to analyze solely for phthalic acid in the untreated waste. In cases where phthalic anhydride wastes have not undergone incineration (i.e., treated residuals of phthalic anhydride wastes from treatment technologies other than incineration or the untreated phthalic anhydride wastes themselves) or in cases where treated residuals from incineration contain phthalic anhydride that has not been hydrolyzed to phthalic acid, a hydrolysis step for the measurement of phthalic acid concentration may be warranted. Currently, there is no approved EPA method for hydrolyzing phthalic anhydride wastes for the

measurement of phthalic acid concentration. Until such a method becomes available, the Agency suggests that hydrolysis for the purpose of producing phthalic acid for analysis should include the consideration of the following:

For nonwastewaters containing phthalic anhydride, a representative sample should be hydrolyzed with a sufficient amount of water (not to exceed a 10-fold dilution), mixed for a sufficient time to ensure complete hydrolysis, and then analyzed for phthalic acid. The analytical results obtained for phthalic acid concentration should then be corrected to account for the dilution water used to hydrolyze the waste sample. The Agency reiterates that this hydrolysis procedure is probably not necessary where BDAT (i.e., incineration) has been employed.

There were no other BDAT list organic constituents (other than phthalic anhydride and maleic anhydride) detected or suspected to be present in the untreated K023, K093, and K094 wastes. As noted earlier, the Agency has no data that suggest the presence of BDAT list metals in K023, K093, and K094 wastes. Therefore, EPA has chosen not to regulate BDAT list metals for K023, K093, and K094 at this time.

7. DEVELOPMENT OF BDAT TREATMENT STANDARDS

The Agency bases treatment standards fo regulated constituents on the performance of well-designed and well-operated BDAT treatment systems. These standards must account for analytical limitations in available performance data and must be adjusted for variabilities related to treatment, sampling, and analytical techniques and procedures.

BDAT standards are determined for each constituent by multiplying the arithmetic mean of accuracy-adjusted constituent concentrations detected in treated waste by a "variability factor" specific to each treatment technology defined as BDAT. Accuracy adjustment of performance data has been discussed in Section 5 in relation to defining "substantial treatment." Variability factors correct for normal variations in the performance of a particular technology over time. They are designed to reflect the 99th percentile level of performance that the technology achieves in commercial operation. (For more information on the principles of calculating variability factors, see EPA's publication Methodology for Developing Best Demonstrated Available Technology (BDAT) Treatment Standards (USEPA 1989b). For details on the calculation of variability factors for K024 waste, see the Best Demonstrated Available Technology (BDAT) Background Document for K024 (USEPA 1988a).)

Where EPA has identified BDAT for a particular waste, but because of data limitations or for some other compelling reason cannot define specific treatment standards for that waste, the Agency can require the use of that treatment process as a technology standard. Similarly, where there are no known generators of a waste or where EPA believes that the

waste can be totally recycled or reused as a raw material, the Agency may specify a "no land disposal" standard, which effectively amounts to setting the performance standard at zero for all waste constituents.

As noted earlier, treatment performance data for incineration/fuel substitution of K023, K093, and K094 are not presently available to the Agency. For K023, K093, and K094 wastewaters and nonwastewaters, treatment standards have been transferred from incineration of K024 because the Agency determined that:

1. All of these wastes are generated from the production of phthalic anhydride.

2. Distillation residues generated from production processes using napthalene (corresponding to K023 and K024 wastes) are expected to contain higher concentrations of less volatile constituents than distillation residues generated from production processes using ortho-xylene (corresponding to K093 and K094 wastes). Since these constituents in K023 and K024 have lower volatility, they are more difficult to vaporize and destroy in a rotary kiln. K023 and K024 are thus more difficult to treat than K093 and K094.

3. Distillation bottoms (K024) are expected to contain lower concentrations of volatile constituents than the distillation light ends (K023) and thus would be more difficult to treat than K023.

Based on this analysis, the Agency has determined that K024 represents the most difficult to treat of the four wastes generated from the production of phthalic anhydride. Consequently, the Agency has no reason to believe that incineration of K023, K093, and K094 will not perform as well as incineration of the tested waste, K024. The calculation of treatment standards for K024 is presented in Table 7-1. Table 7-2 presents the treatment standards for K023, K093, and K094 nonwastewaters and wastewaters, which have been transferred from K024. Where treatment

performance data are available, the Agency maintains it should establish concentration-based treatment standards rather than specify a method of treatment. Concentration-based standards allow industry the flexibility to use any treatment technology or combination of technologies to treat the wastes as long as the land disposal residuals produced have concentrations of the regulated constituents less than or equal to the treatment standards.

Additionally, the Agency would like to point out that although methods for the measurement for phthalic anhydride exist, the measurement of phthalic acid as a surrogate provides a more effective means of measuring treatment because phthalic anhydride hydrolyzes to phthalic acid in the presence of atmospheric moisture. All of the wastewater and nonwastewater standards for K023, K093, and K094 are expressed as "phthalic anhydride ... (measured as phthalic acid)." Thus, the Agency is specifically requiring analysis for phthalic acid after hydrolysis of K023, K093, and K094 nonwastewaters.

Table 7-1 Calculation of BDAT Treatment Standards for K024

Constituent	Concentration in treated waste	Analytical accuracy-correction factor	Average accuracy-corrected concentrations[a]	Variability[d] factor	Proposed BDAT treatment standard
Phthalic acid[b] in nonwastewater (ash)	<8.2 mg/kg	1.19	9.8 mg/kg	2.8	28 mg/kg
Phthalic acid[b] in wastewater (scrubber water)	<160 µg/l	1.2	192 µg/l	2.8	0.54 mg/l

[a]Assumes < values are at the detection limit.
[d]Variability factor of 2.8 is used when all samples are below the detection limit for the constituent.
[b]Used as an indicator for phthalic anhydride, which is a constituent of K024.

Reference: USEPA 1988a.

Table 7-2 BDAT Treatment Standards
for K023, K093, and K094

Constituent	Proposed BDAT treatment standard total composition
Phthalic acid[a] in nonwastewater	28 mg/kg
Phthalic acid[a] in wastewater	0.54 mg/l

[a]Used as an indicator for phthalic anhydride.

8. U WASTE CODES

This section addresses the development of treatment standards for those U wastes designated as phthalates. These wastes include U028 (bis-(2-ethylhexyl) pthalate), U069 (di-n-butyl phthalate), U088 (diethyl phthalate), U102 (dimethyl phthalate), U107 (di-n-octyl phthalate), and U190 (phthalic anhydride). The U phthalates have similarities in chemical structure and elemental content of the primary constituent of concern (i.e., phthalate) in each waste. Because of these similarities, these wastes should be treatable to similar concentrations using the same technology; therefore, the Agency combined these codes into one treatability group.

According to 40 CFR 261.33, the above-mentioned materials are hazardous wastes when they are discarded or are intended to be discarded; when they are mixed with waste oil, used oil, or another material; and when they are applied to the land or are contained in products that are applied to the land.

These materials can be present in different forms, which include:

- Any commercial or off-specification commercial chemical product with any of the above generic names;
- Residues remaining in containers that held any of the above-mentioned products; or
- The residue of contaminated soil, water, or other debris that results when there is a cleanup of a commercial or off-specification commercial chemical product or manufacturing chemical intermediate having the generic name of any of the above-listed products that had been spilled onto the land or into the water.

8.1 Development of Treatment Standards

Some of the industries that may generate U code phthalate wastes are industries that manufacture phthalate plasticizers, unsaturated polyester resins, and alkyd resins, as well as other users of phthalate compounds. Table 8-1 presents the number of facilities that may generate U028, U069, U088, U102, U107, and U190 in each EPA Region.

Since these listed compounds are all organics, incineration is applicable and demonstrated for U phthalate nonwastewaters, as it was for the K023, K024, K093, and K094 phthalate wastes.

BDAT standards for all of these U wastes are being promulgated based on the transfer of data from the performance of rotary kiln incineration for K024 nonwastewaters (distillation bottoms from the production of phthalic anhydride from naphthalene). Treatment standards for K024 wastewaters and nonwastewaters were promulgated with the First Third wastes on August 8, 1988. These standards were based on the performance of incineration of K024 nonwastewaters in a rotary kiln and the concentrations of hazardous constituents found in the ash (nonwastewater) and scrubber water (wastewater) residuals. In today's rule, the Agency is setting concentration-based treatment standards for U028, U069, U088, U102, U107, and U190.

Except for U190 (i.e., phthalic anhydride, which forms phthalic acid by a hydrolysis reaction), all of these U wastes are esters of phthalic acid. These esters are commonly referred to as phthalates. The difference between these compounds is the number of methylene ($-CH_2-$) hydrocarbon groups on each ester group (e.g., diethyl phthalate has one

Table 8-1 Number of Facilities That May Generate U028, U069, U088, U102, U107, and U190 in Each EPA Region

EPA Region	Number of facilities
I	5
II	4
III	6
IV	5
V	12
VI	8
VII	0
VIII	1
IX	1
X	1

Reference: USEPA 1986

more methylene on each ester group than dimethyl phthalate). EPA believes that these structural similarities support the transfer of the performance data from phthalic anhydride in K024 to these individual U phthalates. Standards for these wastes are derived from a direct transfer of the numerical values for phthalic acid to each of the individual phthalate esters (i.e., 28 mg/kg for all nonwastewaters and 0.54 mg/l for all wastewaters as measured by each phthalate). Currently, these are the best treatment data on phthalates available to the Agency. Therefore, the Agency intends to transfer the treatment standards from phthalic anhydride in K024 wastes to the phthalate esters and phthalic anhydride U wastes included in the Second Third rule.

Some commenters argued that the Agency has not adequately demonstrated the transferability of the treatment standards for K024 wastes to these phthalate esters. The commenters stated that they had found no support for EPA's statement that all of these compounds are anticipated to be easier to burn than phthalic acid. At the same time, the commenters claimed the following information as support for their position: (1) the K024 phthalic anhydride residue is a solid and the phthalates are typically liquids and (2) the autoignition temperature (a measure of the ease of ignition) for phthalic anhydride is 1083°F, 1032°F for dimethyl phthalate, 950°F for phthalic acid, and 735°F for bis-(2-ethylhexyl) phthalate. (Note: The commenters did not mention an autoignition temperature for diethyl, di-n-butyl, or di-n-octyl phthalate.)

The Agency recognizes that many factors affect how easily a compound can be burned. These factors include boiling point, activation energy, bond dissociation energy, heat of combustion, heat of formation, and general structural class. However, the information provided by the commenters appears to support the Agency's position rather than that of the commenters. In general, solids should be more difficult to burn than liquids. In addition, phthalic anhydride with the highest autoignition temperature appears to be more difficult to burn than phthalic acid or the other identified phthalates.

Moreover, the data support the Agency's belief that these phthalates have the same relative difficulty in burning (within the same order of magnitude). More important, the Agency maintains that the performance data available to the Agency support its belief that the treatment standards for the incineration of K024 are not only transferable to these phthalate wastes but also achievable on a routine basis.

Incineration data for K024 indicate that untreated K024 wastes contained from 1.3 to 22 percent phthalic anhydride, approximately 10 percent ash, and up to 83 percent polymeric materials. Analysis of the incinerator residues for phthalic acid, the surrogate for phthalic anhydride (see previous discussion for K023, K093, and K094 wastes), indicated that there was destruction of phthalic acid to detection limits of 8.2 mg/kg in the ash and 0.16 mg/l in the scrubber water. Thus, if phthalic anhydride is, as the commenters' data indicate, one of the more difficult wastes to burn, then the other phthalates and phthalic acid

should be able to be destroyed to these levels. The Agency points out that the ash and the polymeric materials present in the untreated K024 wastes also contribute to the difficulty of incinerating this waste. Thus, the Agency concluded that the K024 wastes are the most difficult to treat of these wastes.

The commenters expressed concern about several other issues that led them to believe that the standards could not be achieved. These issues include the potential for false positives resulting from cross-contamination from: (1) the co-incineration of nonhazardous materials containing phthalates; (2) plastic materials used during sampling and analysis; (3) nonhazardous materials co-disposed with treatment residuals; (4) liners and covers used in roll-off containers used to transport ash (containing 35 mg/kg of phthalates); and (5) plastic materials used in the scrubber water systems. They also argued that household garbage (containing 22 mg/kg of phthalates) and landfill liners would exceed the treatment standards. Thus, they concluded that the treatment standards were not meaningful, nor could they possibly be met. Several commenters further concluded that since the treatment standards could not be met, the Agency should simply establish incineration as a technology rather than set concentration-based standards. Finally, one commenter also stated that the Agency has an insufficient number of data points upon which to base the standards.

In response to the majority of these comments, the Agency points to test burn data from four vastly different waste types that illustrate several of the Agency's positions. The wastes include those identified

as: (1) K019 (heavy ends from the distillation of ethylene dichloride in ethylene dichloride production); (2) K037 (wastewater treatment sludges from the production of Disulfoton); (3) F024 (various wastes from the production of chlorinated aliphatics such as distillation residues, heavy ends, tars, and reactor cleanout wastes); and (4) K101/K102 (distillation tar residues from the distillation of aniline-based compounds and residue from activated carbon in the production of veterinary pharmaceuticals). These wastes clearly represent a myriad of different hazardous waste types, and these data are from more than one incineration facility.

EPA analyzed for various phthalates in the incineration residues from these test burns as follows: (1) six data sets for di-n-butyl and bis-(2-ethylhexyl) phthalate in K019 ash residues and six data sets for di-n-octyl, di-n-butyl, and bis-(2-ethylhexyl) phthalate in K019 scrubber waters; (2) six data sets for bis-(2-ethylhexyl) phthalate in K037 ash and scrubber wastes; (3) six data sets for diethyl and bis-(2-ethylhexyl) phthalate in F024 ash and scrubber waters; and (4) six data sets for bis-(2-ethylhexyl) phthalate in K101 and K102 ash and scrubber waters.

In general, the majority of the measured values for phthalates were approximately at the detection limit for most of the phthalates analyzed. In kiln ash, the measured values or detection limits ranged from <0.42 to <2.0 mg/kg. This is consistent with the estimated Practical Quantification Limits (PQLs) for these phthalates in ash residues (as calculated by multiplying the detection limits for the individual phthalates as measured by SW-846 Method 8250 by the correction

factor of 670 for low-level contaminated soil) ranging from 1.6 mg/kg for dimethyl phthalate to a maximum of 2.5 mg/kg for di-n-butyl, di-n-octyl, and bis-(2-ethylhexyl) phthalate. The data from these four test burns also indicated that in the scrubber waters the measured values for these phthalates (or their detection limits) ranged from <0.002 to <0.050 mg/l. The concentrations of phthalates in the untreated wastes ranged from 0.05 to 500 mg/kg.

The concentrations of phthalates in the untreated wastes (for the aforementioned data) were relatively low. Accordingly, EPA did not attempt to transfer standards for phthalates from these wastes. However, these data illustrate several important points with regard to cross-contamination and achievability of the standards. For four different test burns on four vastly different waste types, analysis of treatment residuals indicated concentrations or achievable detection limits well below the promulgated treatment standards (typically an order of magnitude less). Thus, the commenters' cross-contamination concerns during incineration, scrubber water processing, sample collection, transport of analytical samples, and laboratory preparation and analysis of the samples are clearly not supported by these data. In addition, the proper use of analytical techniques in accordance with standard quality assurance/quality control (QA/QC) procedures in their laboratories can also reduce the potential for incidental cross-contamination.

With respect to cross-contamination concerns resulting from incineration of nonhazardous wastes, the Agency notes that, in general, a facility operator may need to segregate wastes to meet treatment

standards, and this need is fully consistent with the intent of the land disposal restrictions. However, based on the demonstration of incinerability of the high concentrations of phthalic anhydride in K024 wastes, the demonstration of achievability of low detection limits for ash and scrubber waters, and the basic high efficiency of destruction inherent to hazardous waste incinerators, the Agency believes that segregation of other wastes from these phthalate wastes is unnecessary and that compliance with the treatment standards for phthalate wastes would not be mitigated by co-incineration with other wastes containing phthalates.

With respect to the cross-contamination concerns stemming from co-disposal with nonhazardous wastes, from liners and covers of roll-off containers, or from the landfill liners, the Agency notes that contamination from these materials (as evidenced in the commenters' data referenced above) would be expected to be low compared to the standards. It appears unlikely that an ash residue that typically contains <2.0 mg/kg of phthalates would be significantly contaminated to a level above the treatment standard of 28 mg/kg by wastes containing only 22 mg/kg or 35 mg/kg of phthalates. The fact that these materials contain phthalate levels at or near the treatment standards has no relevance to the achievability of the treatment standards. The fact that incineration can destroy hazardous wastes to a level that may be deemed nonhazardous is exactly the goal of incineration.

One commenter suggested that the Agency set technology-based treatment standards for these wastes instead of concentration-based standards. This commenter felt that setting technology-based standards would

eliminate the concerns over the achievability of the treatment standards because of cross-contamination. Though section 3004(m) specifies that BDAT treatment standards may be expressed as either concentration-based levels or as a method of treatment (treatment-based), the Agency maintains that where treatment performance data are available, concentration-based treatment standards should be established rather than specifying a method of treatment. Concentration-based standards allow industry the flexibility to use any treatment technology or combination of technologies to treat the wastes as long as the land disposal residuals produced have concentrations of the regulated constituents less than or equal to the treatment standards.

Moreover, none of the commenters supported their claims (that the treatment standards could not be achieved) with data on the measurement of phthalates in treatment residuals. Because acceptable treatment performance data were available for treatment of K024 and since the data support the belief that cross-contamination will not affect the achievability of the standards, the Agency is promulgating the concentration-based treatment standards for U028, U069, U088, U102, and U107.

Some commenters on the proposed Second Third rule have also commented on the difficulty of incinerating contaminated soils with U constituents because of the low Btu content of soil. The Agency has not yet determined the transferability of treatment standards to contaminated soils and debris. The Agency will address this issue at a later date.

U190, phthalic anhydride, is not a phthalic ester. Nevertheless, EPA is promulgating the same BDAT treatment standards as those developed for K024 based on treatment of phthalic anhydride wastes because phthalic anhydride, the main hazardous constituent of U190, is the regulated constituent of K024.

While the promulgated treatment standards for nonwastewaters and wastewaters for these U phthalate wastes are based on the performance of incineration of K024 in a rotary kiln, other treatment technologies that can achieve these standards, such as fluidized-bed incineration, fuel substitution, biodegradation, carbon adsorption, and solvent extraction, are not precluded from use by this rule. Since the phthalate compounds consist only of carbon, hydrogen, and oxygen, it is highly likely that fuel substitution could serve as an alternative to incineration for these wastes. The Agency is unaware of any alternative treatment or recycling technologies that have been examined specifically for these wastes.

The U wastes addressed in this treatability group are grouped as "phthalates" in order to solicit specific comments from manufacturers and users of phthalates regarding standards for these wastes. In addition, analyses for these constituents are often complicated by the high probability of cross-contamination by these constituents in the laboratory. Phthalates are common constituents of plastics (such as plastic gloves used during the analyses) because of their use as plasticizers. Proper analytical procedures, however, will eliminate or minimize any cross-contamination.

Tables 8-2 and 8-3 present the treatment standards for the U phthalate wastes, which are derived from a direct transfer of the numerical value for phthalic anhydride in K024 to the respective phthalate compound for the nonwastewater and wastewater residuals. The Agency believes that the relatively high numerical values (compared to the treatment levels of phthalates in F024, K019, K037, and K101/K102 wastes) for each individual phthalate will account for the potential analytical contamination problems (as previously discussed) that are anticipated from handling wastes that contain these phthalates (i.e., the U wastes). All standards are based on analysis of total constituent concentration.

Table 8-2 BDAT Treatment Standards for U Phthalates U028, U069, U088, U102, U107, and U190, Respectively (Nonwastewaters)

Constituent	Maximum for any single grab sample: Total composition (mg/kg)	Maximum for any single grab sample: TCLP (mg/l)
Bis-(2-ethylhexyl) phthalate	28	Not applicable
Di-n-butyl phthalate	28	Not applicable
Diethyl phthalate	28	Not applicable
Dimethyl phthalate	28	Not applicable
Di-n-octyl phthalate	28	Not applicable
Phthalic anhydride (measured as phthalic acid)[a]	28	Not applicable

[a]Used as an indicator for phthalic anhydride.

Table 8-3 BDAT Treatment Standards for U Phthalates U028, U069, U088, U102, U107, and U190, Respectively (Wastewaters)

Constituent	Maximum for any single grab sample: Total composition (mg/kg)	Maximum for any single grab sample: TCLP (mg/l)
Bis-(2-ethylhexyl) phthalate	0.54	Not applicable
Di-n-butyl phthalate	0.54	Not applicable
Diethyl phthalate	0.54	Not applicable
Dimethyl phthalate	0.54	Not applicable
Di-n-octyl phthalate	0.54	Not applicable
Phthalic anhydride (measured as phthalic acid)	0.54	Not applicable

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