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FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

BACKGROUND DOCUMENT

FOR

NEWLY LISTED WASTES

K107, K108, K109, K110,
K111, K112, U328, U353,
K117, K118, K136,
K123, K124, K125, K126,
K131, K132,
U359

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation/Acronym	Definition
AC	Activated Carbon
ACF	Accuracy Correction Factor
AFF	Aerobic Fixed Film
AirS	Air Stripping
AL	Aerobic Lagoons
AnFF	Anaerobic Fixed Film
APCD	Air Pollution Control Devices
API	American Petroleum Institute
ART	Articles not part of WERL database
AS	Activated Sludge Biological Treatment
BDAT	Best Demonstrated Available Technology
BGAC	Biological Granular Activated Carbon
BT	Biological Treatment
CAC	Chemically Assisted Clarification
CFR	Code of Federal Regulations
ChOx	Chemical Oxidation
Chred	Chemical Reduction
CWA	Clean Water Act
DAF	Dissolved Air Flotation
DNT	Dinitrotoluene
EAD	Engineering and Analysis Division
EBDC	Ethylene Bisdithiocarbamic Acid
EDB	Ethylene Dibromide
EPA	Environmental Protection Agency (United States)
FIL	Filtration

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

Abbreviation/Acronym	Definition
FR	Federal Register
FWPCA	Federal Water Pollution Control Act
GAC	Activated Carbon (Granular)
HSWA	Hazardous and Solid Waste Amendments
ITD	Industrial Technology Division
LDR	Land Disposal Restrictions
Leachate	Industry Submitted Leachate Data
LL	Liquid-Liquid Extraction
NPDES	National Pollutant Discharge Elimination System
OCPSF	Organic Chemicals, Plastics, and Synthetic Fibers
OER	On-site Engineering Report
OSW	Office of Solid Waste
PACT®	Powdered Activated Carbon Addition to Activated Sludge
RBC	Rotating Biological Contactor
RCRA	Resource Conservation and Recovery Act
RO	Reverse Osmosis
SCOx	Super Critical Oxidation
SExt	Solvent Extraction
SS	Steam Stripping
TCLP	Toxicity Characteristic Leaching Procedure
TDA	Toluenediamine
TF	Trickling Filter
TOC	Total Organic Carbon

LIST OF ABBREVIATIONS AND ACRONYMS (Continued)

Abbreviation/Acronym	Definition
TSS	Total Suspended Solids
UDMH	Unsymmetrical Dimethylhydrazine (1,1-Dimethylhydrazine)
UF	Ultrafiltration
UV	Ultraviolet Radiation
VF	Variability Factor
WAO	Wet Air Oxidation
WERL	Water Engineering Research Laboratory
WOx	Wet Air Oxidation

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (the Agency or EPA) is establishing best demonstrated available technology (BDAT) treatment standards for the following listed hazardous wastes identified in Title 40, Code of Federal Regulations, Sections 261.32 and 261.33(f) (40 CFR 261.32 and 261.33(f)):

- 1,1-Dimethylhydrazine (UDMH) Production Wastes: K107, K108, K109, and K110;
- Dinitrotoluene (DNT) and Toluenediamine (TDA) Production Wastes: K111, K112, U328, and U353;
- Ethylene Dibromide (EDB) Production Wastes: K117, K118, and K136;
- Ethylenebisdithiocarbamic Acid (EBDC) Production Wastes: K123, K124, K125, and K126;
- Methyl Bromide Production Wastes: K131 and K132; and
- 2-Ethoxyethanol Waste: U359.

These BDAT treatment standards are promulgated in accordance with the amendments to the Resource Conservation and Recovery Act (RCRA) of 1976, enacted by the Hazardous and Solid Waste Amendments (HSWA) of November 8, 1984. The Agency's legal authority and promulgated methodology for establishing treatment standards and the petition process necessary for requesting a variance from the treatment standards are summarized in EPA's Methodology for Developing BDAT Treatment Standards (Reference 1).

This background document provides the Agency's rationale and technical support for developing the BDAT treatment standards for these wastes. These standards include both methods of treatment and concentration-based treatment standards. This background document also presents the following waste-specific information: the number and locations of facilities that may be affected by the land disposal restrictions for these wastes; the processes generating these wastes; waste characterization data; the technologies used to treat these wastes (or similar wastes, if any); and the treatment performance data on which the treatment standards are based. This document also explains how EPA determines BDAT, selects constituents for regulation, and calculates treatment standards.

Under 40 CFR 261.32 and 40 CFR 261.33(f), the wastes identified above are listed as follows:

1,1-Dimethylhydrazine (UDMH) Production Wastes

K107 - Column bottoms from product separation from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides.

K108 - Condensed column overheads from product separation and condensed reactor vent gases from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides.

K109 - Spent filter cartridges from product purification from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides.

K110 - Condensed column overheads from intermediate separation from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides.

Dinitrotoluene (DNT) and Toluenediamine (TDA) Production Wastes and Related U Wastes

K111 - Product washwaters from the production of dinitrotoluene via nitration of toluene.

K112 - Reaction by-product water from the drying column in the production of toluenediamine via hydrogenation of dinitrotoluene.

U328 - o-Toluidine.

U353 - p-Toluidine.

Ethylene Dibromide (EDB) Production Wastes

K117 - Wastewater from the reactor vent gas scrubber in the production of ethylene dibromide via bromination of ethene.

K118 - Spent adsorbent solids from purification of ethylene dibromide in the production of ethylene dibromide via bromination of ethene.

K136 - Still bottoms from the purification of ethylene dibromide in the production of ethylene dibromide via bromination of ethene.

Ethylenebisdithiocarbamic Acid (EBDC) Production Wastes

K123 - Process wastewater (including supernates, filtrates, and washwaters) from the production of ethylenebisdithiocarbamic acid and its salts.

K124 - Reactor vent scrubber water from the production of ethylenebisdithiocarbamic acid and its salts.

K125 - Purification solids (including filtration, evaporation and centrifugation solids) from the production of ethylenebisdithiocarbamic acid and its salts.

K126 - Baghouse dust and floor sweepings in milling and packaging operations from the production or formulation of ethylenebisdithiocarbamic acid and its salts.

Methyl Bromide Production Wastes

K131 - Wastewater from the reactor and spent sulfuric acid from the acid dryer from the production of methyl bromide.

K132 - Spent absorbent and wastewater separator solids from the production of methyl bromide.

2-Ethoxyethanol Wastes

U359 - 2-Ethoxy-ethanol.

Treatment standards for all of the waste streams covered in this background document were developed by transferring performance data used to calculate First, Second, and Third Third BDAT treatment standards.

The Agency is establishing either concentration-based BDAT treatment standards or BDAT treatment standards expressed as a method of treatment for wastewater and nonwastewater forms of each of these wastes. Wastewaters are defined as containing less than 1% (weight basis) total suspended solids[1] (TSS) and less than 1% (weight basis) total organic carbon (TOC). Wastes not meeting this criteria are defined as being "nonwastewater" and must comply with the nonwastewater treatment standards.

The Agency is establishing BDAT treatment standards expressed as a method of treatment for wastewater and nonwastewater forms of UDMH production wastes (K107, K108, K109, and K110), as shown in Table 1-1. The BDAT treatment standards established for U098 ("off-specification, out-dated, or discarded UDMH") in the Final Rule for Third Third wastes (55 FR 22688; June 1, 1990) are the basis of these standards. The Agency believes that methods of treatment are the most appropriate standards for UDMH wastes because the regulated organic constituents of K107-K110

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[1]The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids is measured by Method 209C (total suspended solids dried at 103-105°C) in Standard Methods for the Examination of Water and Wastewater, Sixteenth Edition (Reference 2).

are relatively unstable and consequently are difficult to quantify in treatment residuals. These wastes are discussed in Section 2.0.

The Agency is establishing concentration-based BDAT treatment standards for wastewater and nonwastewater forms of K111 and treatment standards expressed as methods of treatment for wastewater and nonwastewater forms of K112, U328, and U353, as shown in Table 1-2. The promulgated treatment standards for K111 are numerically identical to the BDAT treatment standards for 2,4-dinitrotoluene and 2,6-dinitrotoluene in F039; this decision reflects a modification to the treatment standards proposed for K111. The Agency believes that specified methods of treatment are the most appropriate standards for K112, U328, and U353 because the regulated organic constituents of K112, U328, and U353 are relatively unstable and consequently are difficult to quantify in treatment residuals. These wastes are discussed in Section 3.0.

The Agency is establishing concentration-based BDAT treatment standards for wastewater and nonwastewater forms of EDB production wastes (K117, K118, and K136), as shown in Table 1-3. The promulgated treatment standards are equivalent to the F039 BDAT treatment standards for organobromine wastes (U029, U030, U066, U067, U068, and U225), and are derived from data used to calculate BDAT treatment for chloroform wastes in the Final Rule for Third Third wastes. These wastes are discussed in Section 4.0.

The Agency is establishing BDAT treatment standards expressed as methods of treatment for wastewater and nonwastewater forms of EBDC production wastes (K123, K124, K125, and K126), as shown in Table 1-4. The BDAT treatment standards established for U114 (EBDC) and U116 (ethylene thiourea) in the Final Rule for Third Third wastes are the basis for these standards. The Agency believes that methods of treatment are the most appropriate standards for EBDC production wastes because the organic constituents of concern in K123-K126 are relatively unstable and consequently are difficult to quantify in treatment residuals. These wastes are discussed in Section 5.0.

The Agency is establishing concentration-based BDAT treatment standards for wastewater and nonwastewater forms of methyl bromide production wastes (K131 and K132), as shown in Table 1-5. These treatment standards are based on the BDAT treatment standards established for U029 (methyl bromide) in the Final Rule for Third Third wastes. These wastes are discussed in Section 6.0.

The Agency is establishing BDAT treatment standards expressed as methods of treatment for wastewater and nonwastewater forms of 2-ethoxyethanol wastes (U359), as shown in Table 1-6. The BDAT treatment standards established for U154 (methanol) in the Final Rule for Third Third wastes are the basis of these treatment standards. The Agency believes that methods of treatment are the most appropriate standards for 2-ethoxyethanol production waste because the constituent of concern is relatively unstable and consequently is difficult to quantify in treatment residuals. This waste is discussed in Section 7.0.

The numerical treatment standards for the organic constituents regulated in wastewater and nonwastewater forms of K111, K117, K118, K131, K132, and K136 are based on the total concentrations of each constituent in the waste. The units used for total constituent concentrations of organic constituents in nonwastewaters are mg/kg (parts per million on a weight-by-weight basis). The units used for total constituent concentrations of organic constituents in wastewaters are mg/l (parts per million on a weight-by-volume basis). If the concentrations of the regulated constituents in wastewater and nonwastewater forms of K111, K117, K118, K131, K132, and K136, as generated, are less than or equal to these promulgated BDAT treatment standards, then treatment of the waste would not be required prior to land disposal.

Table 1-1

BDAT Treatment Standards for UDMH Production Wastes: K107, K108, K109, and K110 Nonwastewaters and Wastewaters

Nonwastewaters	
Method of Treatment:	Incineration

Wastewaters	
Methods of Treatment:	Incineration; or Chemical Oxidation followed by Carbon Adsorption; or Biodegradation followed by Carbon Adsorption

Table 1-2

**BDAT Treatment Standards for
DNT and TDA Production Wastes and Related U Wastes:
K111, K112, U328, and U353
Nonwastewaters and Wastewaters**

K111 Nonwastewaters
Maximum for Any Single Grab Sample

BDAT List Constituent	Total Concentration in Nonwastewaters (mg/kg)
2,4-Dinitrotoluene	140
2,6-Dinitrotoluene	28

K111 Wastewaters
Maximum for Any 24-Hour Composite

BDAT List Constituent	Total Concentration in Wastewaters (mg/l)
2,4-Dinitrotoluene	0.32
2,6-Dinitrotoluene	0.55

K112, U328, and U353 Nonwastewaters

Method of Treatment:	Incineration

K112, U328, and U353 Wastewaters

Methods of Treatment:	Incineration; or Chemical Oxidation followed by Carbon Adsorption; or Biodegradation followed by Carbon Adsorption

Table 1-3

BDAT Treatment Standards for EDB Production Wastes: K117, K118, and K136 Nonwastewaters and Wastewaters

K117, K118, and K136 Nonwastewaters Maximum for Any Single Grab Sample	
BDAT List Constituent	**Total Concentration in Nonwastewaters (mg/kg)**
Ethylene dibromide	15
Bromomethane	15
Chloroform	5.6

K117, K118, and K136 Wastewaters Maximum for any 24-Hour Composite Sample	
BDAT List Constituent	**Total Concentration in Wastewaters (mg/l)**
Ethylene dibromide	0.028
Bromomethane	0.11
Chloroform	0.046

Table 1-4

BDAT Treatment Standards for EBDC Production Wastes: K123, K124, K125, and K126 Nonwastewaters and Wastewaters

K123, K124, K125, and K126 Nonwastewaters	
Method of Treatment:	Incineration
K123, K124, K125, and K126 Wastewaters	
Methods of Treatment:	Incineration; or Chemical Oxidation followed by either Biological Treatment or Carbon Adsorption

Table 1-5

BDAT Treatment Standards for Methyl Bromide Production Wastes: K131 and K132 Nonwastewaters and Wastewaters

Nonwastewaters Maximum for Any Single Grab Sample	
BDAT List Constituent	Total Concentration in Nonwastewaters (mg/kg)
Bromomethane (methyl bromide)	15

Wastewaters Maximum for any 24-Hour Composite Sample	
BDAT List Constituent	Total Concentration in Wastewaters (mg/l)
Bromomethane (methyl bromide)	0.11

Table 1-6

BDAT Treatment Standards for U359 Nonwastewaters and Wastewaters

U359 Nonwastewaters	
Methods of Treatment:	Incineration or Fuel Substitution
U359 Wastewaters	
Methods of Treatment:	Incineration; or Chemical Oxidation followed by either Biological Treatment or Carbon Adsorption; or Biodegradation followed by Carbon Adsorption

2.0 UDMH PRODUCTION WASTES (K107, K108, K109, K110)

This section describes the Agency's approach in establishing BDAT treatment standards for K107, K108, K109, and K110. This includes a description of the industry affected by the land disposal restrictions for UDMH production wastes, a presentation of available waste characterization data, and a discussion of the Agency's rationale in determining BDAT treatment standards for these wastes.

In 40 CFR 261.32 (hazardous wastes from specific sources), waste identified as K107 is listed as column bottoms from product separation from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides; K108 is listed as condensed column overheads from product separation and condensed reactor vent gases from the production of UDMH from carboxyl acid hydrazides; K109 is listed as spent filter cartridges from product purification from the production of UDMH from carboxylic acid hydrazides; and K110 is listed as condensed column overheads from intermediate separation from the production of UDMH from carboxylic acid hydrazides.

2.1 Industry Affected and Waste Characterization

2.1.1 Industry Affected and Process Description

To the Agency's knowledge, one domestic facility produces and purifies UDMH and may potentially generate K107, K108, K109, and K110. This facility is Olin Chemicals, located in Lake Charles, LA, of Region VI. This facility was identified using the 1990 SRI Directory of Chemical Producers (3) and data collected during EPA's listing efforts for K107, K108, K109, and K110 (4).

1,1-Dimethylhydrazine, commonly known as unsymmetrical dimethylhydrazine (UDMH), is used as a rocket fuel, as an adsorbent for acid gases in the manufacture of various photographic chemicals, and as a stabilizer for organic peroxide fuel additives. It is also used as an analytical reagent for aldehyde and ketone analysis. A simplified flow diagram illustrating the manufacturing process generating UDMH and its related wastewater is presented in Figure 2-1.

UDMH is made by the reductive catalytic alkylation of a carboxylic acid hydrazide with formaldehyde and hydrogen, followed by basic hydrolysis of carboxylic acid dimethylhydrazide to remove the carboxyl group, as shown in the following equation:

$$RCONHNH_2 \xrightarrow{CH_2O/H_2} RCONHN(CH_3)_2 \xrightarrow{base} (CH_3)_2NNH_2$$

The primary waste generated consists of the column bottoms from the final purification step in the production of commercial UDMH (K107, shown in Figure 2-1 and characterized in Table 2-1). The second listed waste generated consists of the condensed overheads from a combination of reactor vent gases and final product separation vent gases which are co-condensed as a liquid waste (K108, shown in Figure 2-1 and characterized in Table 2-1). The third listed waste generated consists of spent filter cartridges from product purification (K109, shown in Figure 2-1 and characterized in Table 2-1). Finally, the fourth listed waste generated consists of condensed overheads from intermediate separation columns used before the final step in UDMH synthesis (K110, shown in Figure 2-1 and characterized in Table 2-1).

2.1.2 Waste Characterization

Table 2-1 presents a summary of the available characterization data for K107, K108, K109, and K110. None of the BDAT List constituents are expected to be present in these wastes; data are presented for 1,2-dimethylhydrazine, which is believed to be present or has been detected in K107, K108, K109, and K110.

2.2 Applicable and Demonstrated Treatment Technologies

This section identifies the technologies that are applicable for the treatment of nonwastewater and wastewater forms of K107, K108, K109, and K110 and determines which of the applicable technologies can be considered demonstrated for the purpose of establishing BDAT.

To be considered applicable, a technology must theoretically be usable to treat the waste in question or to treat a waste that is similar, in terms of parameters that affect treatment selection. (Detailed descriptions of technologies that are applicable to listed hazardous wastes are provided in EPA's Treatment Technology Background Document (5).) To be considered demonstrated, a technology must be employed in full-scale operation for treatment of the waste in question or of a similar waste. Technologies available only at pilot-scale or bench-scale operations are not considered in identifying demonstrated technologies.

2.2.1 Applicable Treatment Technologies

Nonwastewaters

Since nonwastewater forms of K107, K108, K109, and K110 generally contain hazardous organic constituents at treatable concentrations, applicable treatment technologies include those that destroy or reduce the total amount of various organic compounds in the waste. The Agency has identified the following treatment technologies as applicable for these wastes:

- Chemical oxidation;
- Critical fluid extraction followed by incineration of the contaminated solvents;
- Distillation;

- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- Solvent extraction followed by incineration or recycle of the extract; and
- Wet air oxidation.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and are described in more detail in Appendix A.

<u>Wastewaters</u>

Since wastewater forms of K107, K108, K109, and K110 may contain hazardous organic constituents at treatable concentrations, applicable treatment technologies include those that destroy or reduce the total amount of various organic compounds in the waste. Therefore, the Agency has identified the following treatment technologies as potentially applicable for treatment of these wastes:

- Biological treatment;
- Carbon adsorption;
- Chemical oxidation;
- Distillation;
- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- Solvent extraction followed by incineration or recycle of the extract;
- Steam stripping; and
- Wet air oxidation.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and are described in more detail in Appendix A.

The concentrations and type(s) of constituents present in the waste generally determine which technology is most applicable. Carbon adsorption, for example, is often used as a polishing step following primary treatment by biological treatment, solvent extraction, or wet air oxidation. Typically, carbon adsorption is applicable for treatment of wastewaters containing total organic constituent concentrations of less than 0.1%. Wet air oxidation, biological treatment, and solvent extraction (followed by incineration or recycle or the extract) are applicable for treatment of wastewaters containing organic constituents at concentrations of up to 1%.

2.2.2 Demonstrated Treatment Technologies

This section identifies those applicable treatment technologies that EPA considers to be demonstrated for the purpose of establishing BDAT for K107, K108, K109, and K110.

<u>Nonwastewaters</u>

The Agency believes that incineration is a demonstrated technology for the treatment of nonwastewater forms of K107, K108, K109, and K110. For the land disposal restrictions program, the Agency has tested rotary kiln incineration on a full-scale operational basis for many organic waste constituents including:

<u>Aromatic and other Hydrocarbon Wastes</u>

Toluene

<u>Polynuclear Aromatic Wastes</u>

Benzo(a)pyrene
Chrysene
Indeno(1,2,3-cd)pyrene
Benz(a)anthracene
Fluoranthene
Naphthalene

The Agency believes that because incineration is demonstrated for the treatment of many organic waste constituents, including those which are structurally similar to dimethylhydrazine, it is also demonstrated for these wastes. The Agency is not aware of any facilities that treat K107, K108, K109, and K110 by fuel substitution and the Agency believes that fuel substitution is inappropriate for wastes such as K107, K108, K109, and K110 that contain many constituents with molecular components other than carbon, hydrogen, and oxygen. Therefore, the Agency believes that fuel substitution is not a demonstrated technology for these wastes.

From review of the 1986 TSDR Survey (6) and the USEPA's Water Engineering Research Laboratory (WERL) database (7), the Agency has determined that some facilities also treat nonwastewater forms of aromatic and polynuclear aromatic wastes or wastes judged to be similar to K107, K108, K109, and K110 using wet air oxidation, chemical oxidation, and distillation on a full-scale operational basis. Therefore, EPA considers these technologies to be demonstrated for aromatic and polynuclear aromatic wastes such as K107, K108, K109, and K110.

The Agency is not aware of any facilities that treat nonwastewater forms of these wastes or wastes judged to be similar on a full-scale operational basis using solvent extraction (followed by incineration or recycle of the extract) or critical fluid extraction (followed by incineration of the contaminated solvents); therefore, EPA believes that these technologies are not currently demonstrated for these wastes.

<u>Wastewaters</u>

The following technologies have been identified as demonstrated for treatment of the following types of organic wastes (organized by chemical structure):

Aromatic and Other Hydrocarbon Wastes

Incineration
Biological Treatment
Carbon Adsorption
Wet Air Oxidation
Chemical Oxidation
Steam Stripping

Brominated Organic Wastes

Biological Treatment

Halogenated Aliphatic Wastes

Incineration
Wet Air Oxidation
Chemical Oxidation
Biological Treatment
Carbon Adsorption
Solvent Extraction
Distillation
Steam Stripping

Halogenated Pesticide and Chlorobenzene Wastes

Biological Treatment
Wet Air Oxidation
Steam Stripping
Carbon Adsorption

Oxygenated Hydrocarbon and Heterocyclic Wastes

Biological Treatment
Carbon Adsorption
Steam Stripping
Wet Air Oxidation

Wastes of a Pharmaceutical Nature

Wet Air Oxidation

Phenolic Wastes

- Wet Air Oxidation
- Carbon Adsorption
- Biological Treatment
- Chemical Oxidation
- Solvent Extraction
- Steam Stripping

Polynuclear Aromatic Wastes

- Incineration
- Biological Treatment
- Carbon Adsorption
- Wet Air Oxidation
- Chemical Oxidation
- Steam Stripping

Organo-Nitrogen Compound Wastes

- Biological Treatment
- Carbon Adsorption
- Steam Stripping
- Wet Air Oxidation
- Solvent Extraction

Miscellaneous Halogenated Organic Wastes

- Biological Treatment
- Steam Stripping
- Carbon Adsorption
- Solvent Extraction followed by Steam Stripping followed by Carbon Adsorption
- Chemical Oxidation
- Wet Air Oxidation

For some of the waste groups, the Agency is not aware of any facilities that incinerate wastewater forms of these organic wastes. However, commenters responding to the Second Third proposed rule indicated that they were incinerating many wastewaters and that they did not want to be precluded from doing so. In addition, the Agency has conducted incineration tests which demonstrate that incineration is an effective treatment technology for a wide variety of organic compounds, including halogenated and nonhalogenated organic compounds and pesticides. EPA's evidence that incineration constitutes significant treatment for these compounds is that these compounds were quantified at or near their detection limits in the ash and scrubber water residues from these tests. The chemical structures and physical properties of these compounds are similar to those of the compounds in K107, K108, K109, and K110. Since incineration is demonstrated for treatment of organic waste constituents in nonwastewater forms of K107, K108, K109, and K110 as discussed above, the Agency believes incineration is also demonstrated for these waste constituents in wastewater forms of these wastes. Therefore, the Agency also identifies incineration as a demonstrated technology for wastewater forms of K107, K108, K109, and K110.

Based on engineering judgment, the Agency considers the following technologies to be demonstrated for wastewater forms of K107, K108, K109, and K110:

- Biological treatment;
- Carbon adsorption;
- Chemical oxidation;
- Distillation;
- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- Solvent extraction followed by incineration or recycle of the extract;
- Steam stripping; and
- Wet air oxidation.

2.3 Identification of Best Demonstrated Available Technology (BDAT)

This section presents the Agency's rationale for determining the best demonstrated available technology (BDAT) for nonwastewater and wastewater forms of K107, K108, K109, and K110. The best demonstrated available technology is determined based on a thorough review of all the treatment performance data available on the waste of concern or wastes judged to be similar.

For a treatment technology to be identified as "best," the treatment performance data are screened to determine:

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

Following the identification of "best," the Agency determines whether the technology is "available." An available treatment technology is one that (1) is not a proprietary or patented process that cannot be purchased or licensed from the proprietor (i.e., it must be commercially available), and (2) substantially diminishes the toxicity of the waste or substantially reduces the likelihood of migration of hazardous constituents from the waste.

2.3.1 Nonwastewaters

As discussed previously, incineration is a demonstrated treatment technology for nonwastewater forms of K107, K108, K109, and K110.

The Agency obtained incinerator ash analytical data from the 14 BDAT treatment tests conducted at what EPA considers to be well-designed and well-operated hazardous waste incinerators. Strict quality assurance/quality control measures were employed to ensure the accuracy of the data, and since EPA was collecting these data to identify and characterize BDAT treatment technologies, appropriate performance variables, namely U and P waste constituent concentrations in treated and untreated waste, were measured. The Agency has determined that due to the high temperatures, efficient mixing, and consistent residence times used at commercial hazardous waste incinerators, incineration processes are relatively indiscriminate in the destruction of organics. Therefore, based on the treatment performance data available, the Agency considers incineration to be the "best" technology for the treatment of nonwastewater forms of K107, K108, K109, and K110.

Incineration is a commercially available technology. Additionally, treatment performance data from the 14 BDAT incineration treatment tests indicated substantial treatment by incineration for the waste constituents of concern and other similar constituents in nonwastewater forms of unquantifiable U wastes. Therefore, incineration is considered an "available" treatment technology for K107, K108, K109, and K110 for the purpose of establishing BDAT.

Incineration has been determined to be BDAT for all of the non-wastewater organic constituents that cannot be quantified in hazardous waste matrices using current analytical methods, based on similarities in chemical and physical properties including those contained in nonwastewater forms of K107, K108, K109, and K110.

2.3.2 Wastewaters

As discussed previously, incineration, wet air oxidation, biological treatment, carbon adsorption, solvent extraction followed by incineration or recycle of the extract, chemical oxidation, distillation, and steam stripping are all demonstrated technologies for the treatment of wastewater forms of K107, K108, K109, and K110.

The Agency believes that the best technologies for treating wastewater forms of K107, K108, K109, and K110 are those technologies that destroy the constituents found in these wastes. Steam stripping, solvent extraction followed by incineration or recycle of the extract, and distillation are technologies that remove the constituents from the wastewater stream; however, the waste constituents are not destroyed but are processed into a more concentrated waste stream, i.e., the condensate, extract, or bottom stream (or still bottoms). These waste streams typically require further treatment before disposal. As a result, the Agency does not consider steam stripping, solvent extraction, or distillation to be the best technologies for treating wastewater forms of the wastes covered in this subsection.

Because a technology removes waste constituents from the waste stream to be land disposed, but does not destroy them, does not necessarily preclude it from being considered "best." As discussed below, carbon adsorption is being established as part of the chemical oxidation and biodegradation treatment trains. The purpose of the carbon adsorption step as part of these treatment trains is to remove organic by-products resulting from the oxidation of waste constituents or biologically degraded by-products. Carbon adsorption was selected as the removal step over steam stripping, solvent extraction, and distillation because the Agency believes that carbon adsorption is the most appropriate removal technology for the widest range of organic compounds likely to be present in the oxidation and biological treatment effluent streams.

Chemical oxidation provides treatment by oxidizing the organic constituents found in these wastes. However, to ensure effective treatment of these wastes, chemical oxidation treatment should include a final carbon adsorption step. Since the constituent of concern (1,1-dimethylhydrazine) is not quantifiable, it is not possible to accurately judge the effectiveness of the chemical oxidation step. Therefore, the Agency believes that it is sound engineering judgment to include a final step of carbon adsorption following oxidation. Carbon adsorption will ensure that the oxidation by-products are removed from the wastewater matrix. The Agency believes that chemical oxidation followed by carbon adsorption should be considered a "best" technology train for the treatment of 1,1-dimethylhydrazine in wastewater forms of K107, K108, K109, and K110. (It should be noted that spent carbon from the treatment of these wastewaters would become a nonwastewater form of this waste (54 Federal Register 26630-1, June 23, 1989) and thus would be required to be incinerated to meet the applicable treatment standard.)

The Agency is also including biodegradation followed by carbon adsorption as a "best" technology train for the treatment of 1,1-dimethylhydrazine in wastewater forms of K107, K108, K109, and K110. This determination is based on hydrolysis data indicating that hydrazines break down rapidly in water to simple amines and ammonia, which are known to be amenable to biological treatment.

The definition of biodegradation as a technology-based standard for listed wastewaters calls for operating the unit such that "a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals". EPA believes that this provision will provide permitting and compliance authorities with sufficient control over the biodegradation unit that biodegradation can be designated as BDAT for these wastes.

The Agency believes it is sound engineering judgement to include a final step of carbon adsorption following biodegradation to ensure effective treatment of these wastes. Carbon adsorption will ensure that the biological break-down products are removed from the wastewater matrix. (It should be noted that spent carbon from the treatment of these wastewaters becomes a nonwastewater form of this waste and thus would be required to be incinerated to meet the applicable treatment standard.)

In cases where the Agency has treatment performance data for both wastewater treatment processes and incineration (as measured by total constituent concentration in scrubber water), the Agency prefers to establish treatment standards based on the wastewater treatment processes. However, the Agency has determined that wastewaters are also treated by incineration and does not intend to preclude industry from continuing this practice. Therefore, EPA is also identifying incineration as a best demonstrated technology for the wastewater forms of K107, K108, K109, and K110.

Treatment performance data included in Volume A of the Background Document for Organic U and P Wastes and Multi-Source Leachate (F039) (8) indicated substantial treatment of organic constituents by carbon adsorption, chemical oxidation, and biological treatment. In addition, these technologies are commercially available. Therefore, these technologies are considered to be "available" treatment technologies for the purpose of establishing BDAT. As discussed in Section 2.2.1, incineration is also an "available" treatment technology for treatment of these wastes.

Based on the above discussion, EPA is promulgating the following methods of treatment as treatment standards for organic constituents that are not quantifiable in wastewater forms of K107, K108, K109, and K110: (1) incineration, (2) chemical oxidation followed by carbon adsorption, and (3) biodegradation followed by carbon adsorption. The Agency believes that these standards will ensure effective treatment (removal and destruction) of the constituents of concern.

Table 2-1

Summary of Available Characterization Data for K107, K108, K109, and K110

BDAT List Constituents	Concentration in Untreated Waste (%)			
	K107	K108	K109	K110
None				
Other Constituents				
1,1-Dimethylhydrazine	0.01	1-10	40-50	trace-0.01

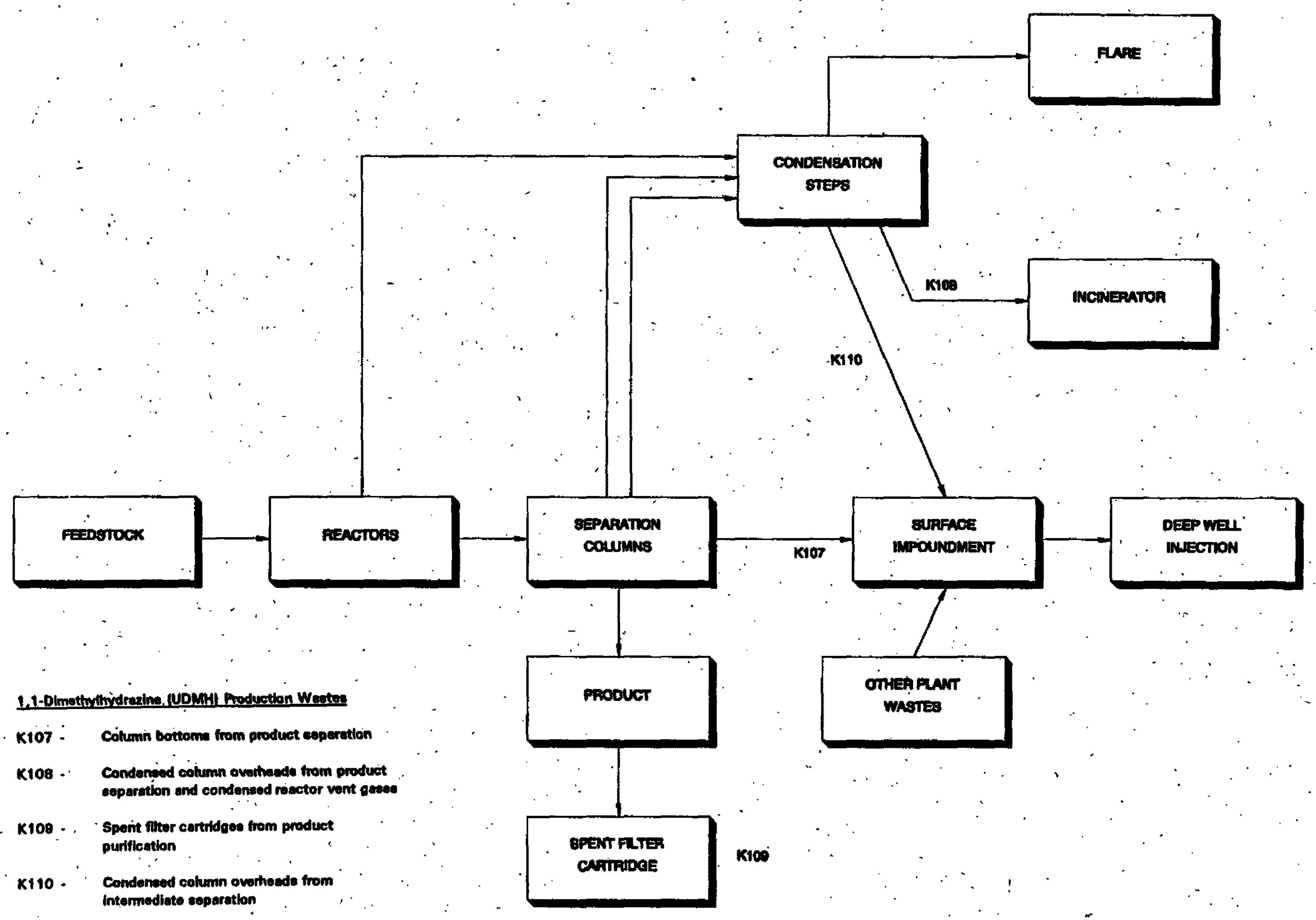


Figure 2-1. UDMH ction Process

3.0 DNT AND TDA PRODUCTION WASTES (K111, K112) AND U328 AND U353

This section describes the Agency's approach in establishing BDAT treatment standards for K111, K112, U328, and U353. This includes a description of the industry that would be affected by land disposal restrictions for dinitrotoluene (DNT) and toluenediamine (TDA) production wastes, a presentation of available waste characterization data, and a discussion of the Agency's rationale in determining BDAT treatment standards for these wastes.

Under 40 CFR 261.32 (hazardous wastes from specific sources), waste identified as K111 is listed as product washwaters from the production of DNT via nitration of toluene, and K112 is listed as reaction by-product water from the drying column in the production of TDA via hydrogenation of DNT. U328 and U353 are listed in 40 CFR 261.33(f) as o-toluidine and p-toluidine, respectively.

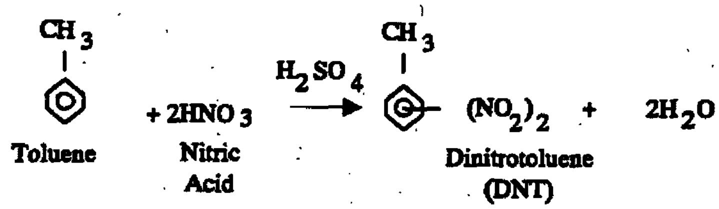
3.1 Industry Affected and Waste Characterization

3.1.1 Industry Affected and Process Description

To the Agency's knowledge, six domestic facilities produce and purify DNT and TDA and may potentially generate K111, K112, U328, and U353. Nonwastewaters generated during the production of TDA and toluene diisocyanate have been addressed in the Second Third final rule (i.e., K113, K114, K115, K116, and K027). Table 3-1 lists these facilities by state and EPA region. These facilities were identified using the 1990 SRI Directory of Chemical Producers (3) and data collected during EPA's listing efforts for K111 and K112 (5).

DNT and TDA are generally produced for use in toluene diisocyanate manufacturing. TDA may also be produced for use in the manufacture of dyes or other chemical products. Toluene diisocyanate is used to manufacture polyurethanes, including polyurethane foam products, coatings, elastomers, and adhesives. A simplified flow diagram illustrating the manufacturing process generating toluene diisocyanate is presented in Figure 3-1.

The dinitration of toluene is represented by the overall reaction:



The manufacture of toluene diisocyanate (TDI) typically involves three steps: (1) nitration of toluene to form DNT, (2) hydrogenation of DNT to form TDA, and (3) phosgenation of TDA to form TDI.

As shown in Figure 3-1, toluene is nitrated with nitric acid in the presence of sulfuric acid, which acts as a solvent and a catalyst. The two-phase product from the nitration reactor is separated into organic and acid layers. Spent acid is then sent to a recovery unit, where the recovered acid solution is recycled to the reactor. Water, a by-product of the nitration reaction, is separated in the acid recovery step and is used in the DNT washing process following acid separation. The organic layer from the acid separation step, which contains the desired product DNT, is purified through a two-stage or three-stage washing process. Washwaters from the washing process form the listed waste K111.

Next, the DNT product is dissolved in a solvent (typically methanol) and is combined with a catalyst (either palladium on carbon or Raney nickel). The mixture is then sent to a pressurized reactor where hydrogen is introduced. The TDA product from the hydrogenation reaction is sent to a catalyst recovery unit. The crude product is then distilled through a series of columns. Solvent is removed from the solvent recovery column and is completely recycled. By-product water resulting from the hydrogenation of dinitrotoluene is removed in the TDA drying column. The by-product water forms the listed waste K112.

Following distillation, the purified TDA is dissolved in a solvent, typically chlorobenzene or o-dichlorobenzene. The resulting mixture is then sent to a series of reactors to form TDI. Phosgene liquid is fed into the bottom of these reactors, which are referred to as phosgenators. The crude TDI product from the phosgenation reaction is then distilled through a series of columns. Phosgene is recovered in the phosgene recovery column and recycled to the phosgenators. Solvent is removed from the solvent recovery column and sent to a separation column. Bottoms from the solvent recovery column are sent to the residue separation column, where TDI residue is separated from the overhead TDI product.

U328 and U353 consist of commercial chemical products or manufacturing intermediates from non-specific sources containing o-toluidine and p-toluidine, respectively, as the sole active ingredients. Commercial chemical products or manufacturing intermediates include all commercially pure grades of the listed chemical, all technical grades, and all formulated products in which the listed chemical is the sole active ingredient. Off-specification products containing either o-toluidine or p-toluidine as the sole active ingredient are also included. Finally, any residue of o-toluidine or p-toluidine that remains in a container or in an inner liner removed from a container and will not be recycled, reclaimed, or reused, and any residue or contaminated soil, water, or debris from a spill of o-toluidine or p-toluidine are included.

U328 and U353 do not include manufacturing process wastes. A product becomes a waste when it is:

- Discarded or intended to be discarded;
- Mixed with another material and applied to the land for dust suppression or road treatment;
- Applied to land in lieu of its original intended use; or
- Distributed or burned as a fuel or fuel additive.

3.1.2 Waste Characterization

Table 3-2 presents a summary of the available characterization data for K111, K112, U328, and U353. Data are presented for BDAT List constituents and other compounds that are believed to be present or were quantified in K111, K112, U328, and U353.

3.2 Applicable and Demonstrated Treatment Technologies

This section identifies the technologies that are applicable for the treatment of nonwastewater and wastewater forms of K111, K112, U328, and U353 and determines which of the applicable technologies can be considered demonstrated for the purpose of establishing BDAT.

To be applicable, a technology must theoretically be usable to treat the waste in question or to treat a waste that is similar in terms of parameters that affect treatment selection. (Detailed descriptions of technologies that are applicable to listed hazardous wastes are provided in EPA's Treatment Technology Background Document (5).) To be demonstrated, a technology must be employed in full-scale operation for treatment of the waste in question or of a similar waste. Technologies available at only pilot-scale or bench-scale operations are not considered in identifying demonstrated technologies.

3.2.1 Applicable Treatment Technologies

Nonwastewaters

Since nonwastewater forms of K111, K112, U328, and U353 generally contain hazardous organic constituents at treatable concentrations, applicable treatment technologies include those that destroy or reduce the total amount of various organic compounds in the waste. The Agency has identified the following treatment technologies as applicable for these wastes:

- Chemical oxidation;
- Critical fluid extraction followed by incineration of the contaminated solvents;
- Distillation;
- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- Solvent extraction followed by incineration or recycle of the extract; and
- Wet air oxidation.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and are described in more detail in Appendix A.

Wastewaters

Since wastewater forms of K111, K112, U328, and U353 may contain hazardous organic constituents at treatable concentrations, applicable treatment technologies include those that destroy or reduce the total amount of various organic compounds in the waste. Therefore, the Agency has identified the following treatment technologies as potentially applicable for treatment of these wastes:

- Biological treatment;
- Carbon adsorption;
- Chemical oxidation;
- Distillation;
- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- PACT® treatment (including powdered activated carbon addition to activated sludge and biological granular carbon technologies);
- Solvent extraction followed by incineration or recycle of the extract;
- Steam stripping; and
- Wet air oxidation.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and have been described in more detail in Appendix A.

The concentrations and type(s) of constituents present in the waste generally determine which technology is most applicable. Carbon adsorption, for example, is often used as a polishing step following primary treatment by biological treatment, solvent extraction, or oxidation. Typically, carbon adsorption is applicable for treatment of wastewaters containing total organic constituent concentrations less than 0.1%. Wet air oxidation, biological treatment, and solvent extraction (followed by incineration or recycle of the extract) are applicable for treatment of wastewaters containing organic constituents at concentrations of up to 1%.

3.2.2 Demonstrated Treatment Technologies

This section identifies those applicable treatment technologies that EPA considers to be demonstrated for the purpose of establishing BDAT for K111, K112, U328, and U353.

<u>Nonwastewaters</u>

The Agency believes that incineration is a demonstrated technology for the treatment of nonwastewater forms of K111, K112, U328, and U353. For the land disposal restrictions program, the Agency has tested rotary kiln incineration on a full-scale operational basis for many organic waste constituents including:

<u>Aromatic and Other Hydrocarbon Wastes</u>

Toluene

<u>Phenolic Wastes</u>

2-sec-Butyl-4,6-dinitrophenol (Dinoseb)
o-Cresol
p-Cresol
Phenol

<u>Polynuclear Aromatic Wastes</u>

Benzo(a)pyrene
Chrysene
Indeno(1,2,3-cd)pyrene
Benz(a)anthracene
Fluoranthene
Naphthalene

Organo-Nitrogen Compound Wastes

Acetonitrile
Acrylonitrile
Aniline
Nitrobenzene
Pyridine

The Agency believes that because incineration is demonstrated for the treatment of many organic waste constituents, including those which are structurally similar to those constituents found in K111, K112, U328, and U353, incineration is also demonstrated for these wastes. The Agency is not aware of any facilities that treat these wastes by fuel substitution and the Agency believes that fuel substitution is inappropriate for wastes such as K111, K112, U328, and U353 that contain many constituents with molecular components other than carbon, hydrogen, and oxygen. Hence, the Agency believes that fuel substitution is not a demonstrated technology for K111, K112, U328, and U353.

From review of the 1986 TSDR Survey (6) and EPA's WERL database (7), the Agency has determined that some facilities also treat nonwastewater forms of aromatic and polynuclear aromatic wastes or wastes judged to be similar to K111, K112, U328, and U353 using wet air oxidation, chemical oxidation, and distillation on a full-scale operational basis; therefore, EPA considers these technologies to be demonstrated for aromatic and polynuclear aromatic wastes such as K111, K112, U328, and U353.

The Agency is not aware of any facilities that treat nonwastewater forms of these wastes or wastes judged to be similar on a full-scale operational basis using solvent extraction (followed by incineration or recycle of the extract) or critical fluid extraction (followed by incineration of the contaminated solvents); therefore, EPA believes that these technologies are not currently demonstrated for these wastes.

Wastewaters

The following technologies have been identified as demonstrated for treatment of the following types of organic wastes (organized by chemical structure): K111, K112, U328, and U353.

Aromatic and Other Hydrocarbon Wastes

Incineration
Biological Treatment
Carbon Adsorption
Wet Air Oxidation
Chemical Oxidation
Steam Stripping

Phenolic Wastes

Wet Air Oxidation
Carbon Adsorption
Biological Treatment
Chemical Oxidation
Solvent Extraction
Steam Stripping

Polynuclear Aromatic Wastes

Incineration
Biological Treatment
Carbon Adsorption
Wet Air Oxidation
Chemical Oxidation
Steam Stripping

Organo-Nitrogen Compound Wastes

Biological Treatment
Carbon Adsorption
Steam Stripping
Wet Air Oxidation
Solvent Extraction

The Agency is not aware of any facilities that incinerate wastewater forms of some of the waste groups. However, commenters responding to the Second Third proposed rule indicated that they were incinerating many wastewaters and that they did not want to be precluded from doing so. In addition, the Agency has conducted incineration tests which demonstrated that incineration is an effective treatment technology for a wide variety of organic compounds, including halogenated and nonhalogenated organic compounds and pesticides. EPA's evidence that incineration constitutes significant treatment for these compounds is based on these compounds being quantified at or near their detection limits in the ash and scrubber water residues from these tests. The chemical structures and physical properties of these compounds are similar to those of the compounds in K111, K112, U328, and U353. Since incineration is demonstrated for treatment of organic waste constituents in nonwastewater forms of K111, K112, U328, and U353 as discussed above, the Agency believes incineration is also demonstrated for these waste constituents in wastewater forms of these wastes. Therefore, the Agency is also identifying incineration as a demonstrated technology for wastewater forms of K111, K112, U328, and U353.

Based on engineering judgment, the Agency considers the following technologies to be demonstrated for wastewater forms of K111, K112, U328, and U353:

- Biological treatment;
- Carbon adsorption;
- Chemical oxidation;
- Distillation;
- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- Solvent extraction followed by incineration or recycle of the extract;
- Steam stripping; and
- Wet air oxidation.

3.3 Treatment Performance Data

The Agency does not have treatment performance data for treatment of nonwastewater and wastewater forms of K111. However, during the comment period, one commenter submitted information indicating that the concentrations of 2,4-dinitrotoluene and 2,6-dinitrotoluene in nonwastewater and wastewater forms of K111 are sufficiently high that if K111 was treated to meet existing F039 treatment standards for dinitrotoluenes, then the other constituents in K111 would be treated to acceptably low concentrations. Therefore, treatment performance data were transferred from other previously tested wastes to develop concentration-based treatment standards for K111.

EPA's methodology for transfer of treatment performance data is provided in EPA's Methodology for Developing BDAT Treatment Standards (1). Transfer of treatment performance data is technically valid in cases where the untested waste is generated from a similar industry or similar processing step, or has similar waste characteristics affecting treatment performance and treatment selection as the tested wastes. Sources of treatment performance data for potential transfer to nonwastewater forms of K111 include wastes previously tested by rotary kiln, fluidized-bed, or liquid injection incineration and are identified in EPA's Final Best Demonstrated Available Technology (BDAT) Background Document for U and P Wastes and Multi-Source Leachate (F039), Volume C: Nonwastewater Forms of Organic U and P Wastes and Multi-Source Leachate (F039) for Which There Are Concentration-Based Treatment Standards (10) (referred to hereafter as Volume C of the F039 Background Document). Sources of treatment performance data for potential transfer to wastewater forms of K111 include those wastes and technologies identified in EPA's Final Best Demonstrated Available Technology (BDAT) Background Document For U and P Wastes and Multi-Source Leachate (F039), Volume A: Wastewater Forms of Organic U and P Wastes and Multi-Source Leachate (F039) For Which There Are Concentration-Based Treatment Standards (8) (referred to hereafter as Volume A of the F039 Background Document).

3.3.1 Treatment of Organic Constituents in K111 Nonwastewaters

Wastes previously tested by the Agency by rotary kiln, fluidized-bed, or liquid injection incineration include: D014, D016, F024, K001, K011, K013, K014, K015, K019, K024, K037, K048, K051, K087, K101, K102, P020, P059, U028, U080, U122, U127, U141, U161, U166, U188, U192, U220, U226, and U239.

Treatment performance data from these previously tested wastes which were used to develop treatment standards for nonwastewater forms of F039 were also used to develop treatment standards for 2,4-dinitrotoluene and 2,6-dinitrotoluene in K111. Treatment performance data for the two BDAT List constituents of concern in K111 from these 14 incineration tests are presented in Table 3-3. A key to the test numbers identified in Table 3-3 is given in Table 3-4.

3.3.2 Treatment of Organic Constituents in K111 Wastewaters

Treatment standards for organic BDAT List Constituents in K111 wastewaters were developed from treatment performance data transferred from EPA's Volume A of the F039 Background Document (8). These data were used for transfer to wastewater forms of K111 because the Agency prefers, whenever possible, to use appropriate treatment performance data from well-designed and well-operated wastewater treatment units, rather than scrubber water concentration data, in setting BDAT treatment standards. These data represent treatment using a specific wastewater treatment technology as opposed to scrubber water from incineration.

Tables 3-5 and 3-6 present all of the available wastewater treatment performance data for 2,4-dinitrotoluene and 2,6-dinitrotoluene, respectively. The data used to determine the BDAT treatment standards are shown with an asterisk. Presented below are short descriptions of the data sources for wastewater treatment performance data on 2,4-dinitrotoluene and 2,6-dinitrotoluene and the Agency's rationale for determining which data sets were used in the development of each treatment standard.

Sources of Treatment Performance Data

This section describes each of the sources of wastewater treatment performance data used to compile data for the determination of treatment standards.

WAO/PACT® Data. For specific Third Third U and P waste codes, a wastewater treatment performance test was conducted using Wet Air Oxidation (WAO) and PACT® treatment technologies. The treatment performance data from this test were incorporated into the tables of this section.

WERL Database. U.S. EPA's Risk Reduction Engineering Laboratory, which now includes the former Water Engineering Research Laboratory (WERL), has developed and is continuing to expand a database on the treatability of chemicals in various types of waters and wastewaters. This WERL database has been compiled from wastewater treatment performance data available in literature. The treatment performance data for BDAT List constituents in this database have been included in the tables of this section.

Treatment Performance Data

2,4-Dinitrotoluene. The data available for 2,4-dinitrotoluene were compiled from the WERL database and literature WAO data and are presented in Table 3-5. Technologies for which data are available include AS, PACT®, and WOX. The treatment performance data represent bench-scale and full-scale studies. The resulting effluent concentrations ranged from 58 ppb to 26,000 ppb.

The Agency is establishing PACT® as BDAT for 2,4-dinitrotoluene. PACT® was selected as BDAT because it represents full-scale data with a high influent concentration and the lowest effluent concentration of the technologies represented in Table 3-5. The BDAT treatment standard for 2,4-dinitrotoluene was calculated using the effluent concentration of 58 ppb and the appropriate variability factor. The calculation of the resulting BDAT treatment standard for 2,4-dinitrotoluene (0.32 ppm) is described in Section 3.6 and is shown in Table 3-7.

2,6-Dinitrotoluene. The data available for 2,6-dinitrotoluene were compiled from the WERL database and are presented in Table 3-6. Technologies for which data are available include AL, AS, and PACT®. The treatment performance data represent bench-scale, pilot-scale, and full-scale studies. The resulting effluent concentrations ranged from 18 ppb to 260 ppb.

The Agency is establishing PACT® as BDAT for 2,6-dinitrotoluene. PACT® was selected as BDAT because it represents full-scale data with a high influent concentration and the lowest average effluent concentration of those full-scale data which show substantial treatment. The BDAT treatment standard for 2,6-dinitrotoluene was calculated using the effluent concentration of 100 ppb and the appropriate variability factor. The calculation of the resulting BDAT treatment standard for 2,6-dinitrotoluene (0.55 ppm) is described in Section 3.6 and is shown in Table 3-7.

3.4 Identification of Best Demonstrated Available Technology (BDAT)

This section presents the Agency's rationale for determining the best demonstrated available technology (BDAT) for nonwastewater and wastewater forms of K111, K112, U328, and U353.

EPA determines the best demonstrated available technology based on a thorough review of all of the treatment performance data available for the waste of concern or wastes judged to be similar. Following the identification of "best," the Agency determines whether the technology is "available." An available treatment technology is one that (1) is not a proprietary or patented process that cannot be purchased or licensed from the proprietor (i.e., it must be commercially available), and (2) substantially diminishes the toxicity of the waste or substantially reduces the likelihood of migration of hazardous constituents from the waste.

3.4.1 Nonwastewaters

The determination of BDAT for nonwastewater forms of K111, K112, U328, and U353 is discussed below.

K111

The treatment performance data that were evaluated to determine BDAT treatment standards for nonwastewater forms of K111 are presented in Section 3.3. The treatment performance data were screened to determine:

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

EPA has identified incineration as demonstrated for the treatment of organic constituents in nonwastewater forms of K111. EPA has treatment performance data from the incineration of 2,4-dinitrotoluene and 2,6-dinitrotoluene in wastes considered to be similar to K111.

All of the incineration data included in Section 3.3 represent BDAT for wastes included in previous rulemakings and therefore have already met the above conditions. Thus, incineration is the "best" technology for treating organic nonwastewater forms of K111.

K112, U328, and U353

As discussed previously, incineration is also a demonstrated treatment technology for nonwastewater forms of K112, U328, and U353.

The Agency obtained incinerator ash analytical data from the 14 BDAT treatment tests conducted at what EPA considers to be well-designed and well-operated hazardous waste incinerators. Strict quality assurance/quality control measures were employed to ensure the accuracy of the data, and since EPA was collecting these data to identify and characterize BDAT treatment technologies, appropriate performance variables, namely waste constituent concentrations in treated and untreated waste, were measured. The Agency has determined that due to the high temperatures, efficient mixing, and consistent residence times used at commercial hazardous waste incinerators, incineration processes are relatively indiscriminate in the destruction of organics. Therefore, based on the treatment performance data available, the Agency considers incineration to be the "best" technology for the treatment of nonwastewater forms of K112, U328, and U353.

Incineration is a commercially available technology. Additionally, treatment performance data from the 14 BDAT incineration treatment tests show substantial treatment by incineration for the waste constituents of concern and other similar constituents in nonwastewater forms of unquantifiable U wastes. Therefore, incineration is an "available" treatment technology for K111, K112, U328, and U353 for the purpose of establishing BDAT.

3.4.2 Wastewaters

The determination of BDAT for wastewater forms of K111, K112, U328, and U353 is discussed below.

K111

The treatment performance data that were evaluated to determine BDAT treatment standards for wastewater forms of K111 are presented in Section 3.3. As discussed in Section 3.3, the Agency believes that the data from PACT® treatment of 2,4-dinitrotoluene and 2,6-dinitrotoluene represent the best treatment performance for these constituents.

K112, U328, and U353

As discussed previously, incineration, wet air oxidation, biological treatment, carbon adsorption, solvent extraction followed by incineration or recycle of the extract, chemical oxidation, distillation, and steam stripping are all demonstrated technologies for the treatment of wastewater forms of K112, U328, and U353.

The Agency believes that the best technologies for treating K112, U328, and U353 are those technologies that destroy the constituents found in these wastes. Steam stripping, solvent extraction followed by incineration or recycle of the extract, and distillation are technologies that remove the constituents from the wastewater stream; however, the waste constituents are not destroyed but are processed into a more concentrated waste stream, i.e., the condensate, extract, or bottom stream (or still bottoms). These waste streams typically require further treatment before disposal. As a result, the Agency does not consider steam stripping, solvent extraction, or distillation to be the best technologies for treating wastewater forms of the wastes covered in this subsection.

Because a technology removes waste constituents from the waste stream to be land disposed, but does not destroy them, does not necessarily preclude it from being considered "best." As discussed below, carbon adsorption is being established as part of the chemical oxidation and biodegradation treatment trains. The purpose of the carbon adsorption step as part of these treatment trains is to remove organic by-products resulting from the oxidation of waste constituents or biologically degradated by-products. Carbon adsorption was selected as the removal step over steam stripping, solvent extraction, and distillation because the Agency believes that carbon adsorption is the most appropriate removal technology for the widest range of organic compounds likely to be present in the oxidation and biological treatment effluent streams.

Chemical oxidation provides treatment by oxidizing the BDAT List constituents found in these wastes. However, to ensure effective treatment of these wastes, chemical oxidation treatment should include a final carbon adsorption step. Carbon adsorption will ensure that the oxidation by-products are removed from the wastewater matrix. The Agency believes that chemical oxidation followed by carbon adsorption should be considered a "best" technology train for the treatment of organic constituents in wastewater forms of K112, U328, and U353. (It should be noted that spent carbon from the treatment of these wastewaters would become a nonwastewater form of the waste (54 Federal Register 26630-1, June 23, 1989) and thus would be required to be incinerated to meet the applicable treatment standard.)

The Agency is also including biodegradation followed by carbon adsorption as a "best" technology train for the treatment of organic constituents in wastewater forms of K112, U328, and U353. Recently submitted data indicated that biological treatment can achieve significant reductions in the concentrations of 2,4-dinitrotoluene and 2,6-dinitrotoluene in wastewater forms of K112. Based on these data, EPA is establishing biodegradation as a method of treatment for wastewater forms of K112.

The Agency also believes that o-toluidine and p-toluidine, the listed components of U328 and U353, are chemically similar to DNT, and that the treatment standards for wastewater forms of K112 should apply to wastewater forms of these wastes as well. Therefore, EPA is establishing biodegradation as a method of treatment for wastewater forms of U328 and U353.

The definition of biodegradation as a treatment standard for wastewaters calls for operating the unit such that, "a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals." The Agency believes that this provision will provide permitting and compliance authorities with sufficient control over the biodegradation unit that it can be designated as BDAT for wastewater forms of K112, U328, and U359.

The Agency believes it is sound engineering judgement to include a final step of carbon adsorption following biodegradation to ensure effective treatment of these wastes. This step will ensure that the biological break-down products are removed from the wastewater matrix. (It should be noted that spent carbon from the treatment of these wastewaters becomes a nonwastewater form of the waste and thus would be required to be incinerated to meet the applicable treatment standard.)

In cases where the Agency has treatment performance data for both wastewater treatment processes and incineration (as measured by total constituent concentration in scrubber water), the Agency prefers to establish treatment standards based on the wastewater treatment processes. However, the Agency has determined that wastewaters are also treated by incineration and does not intend to preclude industry from continuing this practice. Therefore, EPA is also identifying incineration as a best demonstrated technology for these wastewater forms of K112, U328, and U353.

Treatment performance data included in Volume A of the F039 Background Document (8) indicated substantial treatment of organic constituents by

PACT®, carbon adsorption, chemical oxidation, and biological treatment. In addition, these technologies are commercially available. Therefore, these technologies are considered to be "available" treatment technologies for the purpose of establishing BDAT. As discussed in Section 3.2.1, incineration is also an "available" treatment technology for treatment of K112, U328, and U353.

Based on the above discussion, EPA is promulgating the following methods of treatment as treatment standards for organic constituents that are not quantifiable in wastewater forms of K112, U328, and U353: (1) incineration, (2) chemical oxidation followed by carbon adsorption, and (3) biodegradation followed by carbon adsorption. The Agency believes that each standard will ensure effective treatment (removal and destruction) of the constituents of concern.

3.5 Selection of Regulated Constituents in K111

The Agency has developed a list of hazardous constituents (the BDAT Constituent List, presented in EPA's Methodology for Developing BDAT Treatment Standards (1)) from which constituents are selected for regulation. EPA may revise this list as additional data and information become available. The list is divided into the following categories: volatile organics, semivolatile organics, metals, inorganics other than metals, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorus insecticides, polychlorinated biphenyls (PCBs), and dioxins and furans. This section presents EPA's methodology and rationale for selection of constituents for regulation in nonwastewater and wastewater forms of K111.

Generally, constituents selected for regulation must satisfy the following criteria:

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

2. The constituent must be present in, or be suspected of being present in, the untreated waste. For example, analytical difficulties 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.

From a group of constituents that may be selected for regulation because they meet the above criteria, EPA may select a subset of constituents that represents the broader group. For example, from a group of constituents that react similarly to treatment, the Agency may select for regulation those constituents that (1) are the most difficult to treat, based on waste characteristics affecting treatment performance; (2) are representative of other constituents in the waste, based on structural similarities; or (3) are present in the untreated waste in the highest concentrations. Selecting a subset of constituents for regulation is done to facilitate implementation of industry compliance and of EPA's enforcement program.

The Agency initially considered all constituents on the BDAT List for regulation in K111. Table 3-2 summarizes available waste characterization data for constituents in K111 and presents ranges of concentrations for constituents detected in the waste. Constituents for which analyses were not performed are identified by "NA" (not analyzed).

Two BDAT List constituents have been identified in K111, 2,4-dinitrotoluene and 2,6-dinitrotoluene. The Agency has selected both BDAT List constituents for regulation in nonwastewater and wastewater forms of K111.

3.6 Calculation of BDAT Treatment Standards for K111

The Agency bases concentration-based treatment standards on the performance of well-designed and well-operated treatment systems. These standards account for analytical limitations in available treatment performance data and for variabilities related to treatment, sampling, and analytical techniques and procedures. This section presents the calculation of treatment standards for the constituents selected for regulation in Section 3.5 using the available treatment performance data discussed in Section 3.3.

3.6.1 Nonwastewaters

Treatment standards for regulated constituents in nonwastewater forms of K111 were calculated based on data compiled from the BDAT incineration database for incinerator ash. Treatment performance data from eleven (11) incinerator tests were used to calculate the BDAT treatment standards for 2,4-dinitrotoluene and 2,6-dinitrotoluene in nonwastewater forms of K111.

The Agency considered the detection limits from each of these tests and determined which were the most representative for each waste constituent. The Agency selected the highest detection limit for each regulated constituent from the incineration tests to account for the anticipated variability in untreated wastes.

Concentration-based treatment standards for regulated waste constituents were calculated by multiplying the constituent detection limit in ash by an accuracy correction factor and a variability factor. The following subsections discuss these three components of the treatment standard calculation. The calculation of treatment standards for regulated constituents in nonwastewater forms of K111 are summarized in Table 3-7.

<u>**Detection Limits**</u>

The detection limits for 2,4-dinitrotoluene and 2,6-dinitrotoluene in ash were used to calculate the treatment standards for nonwastewater forms of K111. The highest detection limit for each of these constituents from the 11 incineration tests was used.

Accuracy Correction Factors

The detection limits used to calculate treatment standards were corrected using matrix spike recovery data from the same test from which the detection limits were taken to account for analytical interferences associated with the chemical matrices of the samples. Detection limits were corrected for accuracy as follows:

- A matrix spike recovery was determined for each regulated constituent. In cases where a matrix spike was not performed for a regulated constituent in the treatment test from which the detection limit was taken, the matrix spike recovery from a similar constituent from that treatment test was transferred to the constituent.
- An accuracy correction factor was determined for each of the above constituents by dividing 100 by the matrix spike recovery (expressed as a percentage) for that constituent.
- Detection limits for each of the regulated constituents were corrected by multiplying the detection limit for each constituent by its corresponding accuracy correction factor. The detection limit and accuracy correction factor for each constituent are shown on Table 3-7.

Matrix spike recoveries used to adjust detection limits for the regulated constituents in nonwastewater forms of K111 are included in Appendix B. Duplicate matrix spikes were performed for some waste constituents. If a duplicate matrix spike was performed for a constituent, the matrix spike recovery used for that constituent was the lower of the two values between the first matrix spike and the duplicate spike. Matrix spike recoveries of less than 20% are not acceptable and were not used to correct detection limits. Matrix spike recoveries greater than 100% were considered to be 100% for the purpose of this calculation so that the data were not adjusted to concentrations below the detection limits. In cases where the detection limit came from more than one test, the lowest matrix spike recovery among the tests was used.

Variability Factors

The variability factor accounts for the variability inherent in treatment system performance, treatment residual collection, and analysis of the treated waste samples. Variability factors could not be calculated for regulated constituents that were not detected in the incinerator ash residuals. Therefore, a variability factor of 2.8 was used to account for this inherent variability, as discussed in the Methodology for Developing BDAT Treatment Standards (1).

3.6.2 Wastewaters

Treatment standards for wastewater forms of K111 were calculated based on data compiled from EPA's wastewater treatment performance database. Specifically, treatment performance data from PACT® treatment were used.

Concentration-based treatment standards for regulated waste constituents were calculated by multiplying the constituent effluent concentration (as presented in Section 3.3) by an accuracy correction factor and a variability factor. The following subsections discuss these three components of the treatment standard calculation. The calculation of treatment standards for regulated constituents in wastewater forms of K111 are summarized in Table 3-7.

Constituent Effluent Concentration

The effluent concentration obtained using the BDAT for each regulated constituent in K111 was determined as discussed in Section 3.3.2. The treatment performance data for each regulated constituent are presented in Tables 3-5 and 3-6 at the end of this section.

Accuracy Correction Factors

Accuracy correction factors account for analytical interferences associated with the chemical matrices of the samples. EAD variability factors were used or transferred for use in the calculations of treatment standards for regulated constituents in wastewater forms of K111. Based on the fact that EAD variability factors were originally calculated to represent performance, analytical, and matrix variations, an additional accuracy correction factor was not used.

Variability Factors

A variability factor (VF) accounts for the variability inherent in the treatment system performance, treatment residual collection, and analysis of the treated waste samples. Variability factors are generally calculated as described in EPA's Methodology for Developing BDAT Treatment Standards (1). However, original effluent data points were not available for the regulated constituents in K111 since WERL effluent data were used to determine treatment standards and those data were presented as averages in the WERL database. Therefore, it was not possible to calculate an individual variability factor for these constituents; instead, an average variability factor was used. The average variability factors were generated from the EAD variability factors and are specific to the type of constituent under consideration (i.e., volatile organic, acid extractable semivolatile organic, etc.). The calculation of average variability factors is discussed in Appendix C.

Table 3-1

Facilities that May Generate K111 and K112, by State and EPA Region

Facility	Location	EPA Region
Air Products and Chemicals	Pasadena, TX	VI
BASF Corporation	Geismar, LA	VI
Mobay Corporation	Baytown, TX	VI
Mobay Corporation	New Martinsville, WV	III
Olin Chemicals	Lake Charles, LA	VI
Rubicon	Geismar, LA	VI

Facilities that May Generate U328 and U353, by State and EPA Region

Facility	Location	EPA Region
Archem Company	Houston, TX	VI
DuPont	Deepwater, NJ	II
First Chemical Company	Pascagoula, MS	IV
Olin Chemicals	Lake Charles, LA	VI
G. Frederick Smith Chemicals Company	Columbus, OH	V

Table 3-2

Summary of Available Characterization Data for K111, K112, U328, and U353

BDAT List Constituents	Concentration in Untreated Waste (%)			
	K111	K112	U328	U353
2,4-Dinitrotoluene	0.08	NA	NA	NA
2,6-Dinitrotoluene	0.02	NA	NA	NA
Other Constituents				
Sulfuric Acid	1-4	NA	NA	NA
Nitric acid	1-4	NA	NA	NA
2,6-Dinitro-p-cresol	0.06	NA	NA	NA
Mononitrotoluenes	0.005	NA	NA	NA
Mononitrophenols	0.007*	NA	NA	NA
Dinitrophenols	0.007*	NA	NA	NA
Nitrobenzoic acids	0.007*	NA	NA	NA
Mononitrocresols	0.007*	NA	NA	NA
2,4-Toluenediamine	NA	0.05-0.3	NA	NA
2,6-Toluenediamine	NA	0.05-0.3	NA	NA
3,4-Toluenediamine	NA	0.05-0.3	NA	NA
o-Toluidine	NA	0-0.06	NA	NA
p-Toluidine	NA	0-0.04	NA	NA

NA - Not analyzed.

*Total combined concentration.

Table 3-3

Treatment Performance Data Collected by EPA from Incineration of 2,4-Dinitrotoluene and 2,6-Dinitrotoluene

Constituent	Test No.	Detection Limit (ppm)												
		1	2	3	4	5	6	7	8	9	10	11	13	14
2,4-Dinitrotoluene		0.5	0.38	0.01	50	0.5	0.4	5	1	0.42	1	0.351	0.36	0.36
2,6-Dinitrotoluene		0.5	0.13	0.01	10	0.5	0.4	1	1	0.42	1	0.351	0.36	0.36

MLM/027
[illegible]01.mlm

Table 3-4

Wastes Tested by Incineration

Test Number	Waste Code(s) Tested	Technology Used	Background Document Reference Numbers	On-Site Engineering Report Reference Numbers
1	K001-Pentachlorophenol	Rotary Kiln	18	28
2	K001-Creosote	Rotary Kiln	18	29
3	K011, K013, K014	Rotary Kiln	17	30
4	K019	Rotary Kiln	19	31
5	K024	Rotary Kiln	20	32
6	K037	Rotary Kiln	21	33
7	K048, K051	Fluidized Bed	22	34, 35
8	K087	Rotary Kiln	23	36
9	K101	Rotary Kiln	24	37
10	K102	Rotary Kiln	25	38
11	F024	Rotary Kiln	26	39
12	K015	Liquid Injection	27	40
13	D014, D016, P059[a], U127[a], U192[a]	Rotary Kiln	NA	41
14	U141[a], U028[a], P020[a], U122[a], U226[a], U239[a], U080[a], U220[a], U166[a], U161[a], U188[a]	Rotary Kiln	NA	42

NA - Not applicable.

[a]Commercial chemical products were used in these incineration tests as surrogates for these wastes.

Table 3-5

Wastewater Treatment Performance Data for 2,4-Dinitrotoluene

Technology	Technology Size	Facility	Range of Influent Concentrations (ppb)	No. of Data Points	Average Effluent Concentration (ppb)	Removal (%)	Reference
AS	Full	6B	10,000-100,000	3	110	99.15	WERL
PACT*	Full	6B	1,000-10,000	4	58	96.4	WERL*
WOX	Bench	Zimpro	10,000,000	1	26,000	99.74	WAO
WOX [B]	Bench	236A	>1,000,000	1	12,000	99.88	WERL

AS - Activated Sludge
PACT - Powdered Activated Carbon Addition to Activated Sludge
WOX - Wet Air Oxidation
WERL - Water Engineering Research Laboratory Database
WAO - Wet Air Oxidation Database
*Data used to develop treatment standard.

Table 3-6

Wastewater Treatment Performance Data for 2,6-Dinitrotoluene

Technology	Technology Size	Facility	Range Influent Concentration (ppb)	No. of Data Points	Average Effluent Concentration (ppb)	Removal (%)	Reference
AL	Bench	371D	100-1,000		27	97.3	WERL
AS	Full	6B	1,000-10,000	3	260	92.4	WERL
AS	Pilot	241B	100-1,000	10	124	70	WERL
AS	Full	1B	0-100	2	18	18	WERL
PACT*	Full	6B	100-1,000	3	100	70	WERL*

AL - Aerobic Lagoons
AS - Activated Sludge
PACT - Powdered Activated Carbon Addition to Activated Sludge
WERL - Water Engineering Research Laboratory Database
*Data used to develop treatment standard.

Table 3-7

Calculation of Nonwastewater and Wastewater Treatment Standards for K111

Regulated Constituent	Effluent Concentration (or Detection Limit)	Accuracy Correction Factor	Variability Factor	Treatment Standard
K111 Nonwastewaters				
2,4-Dinitrotoluene	50 mg/kg	1.0	2.8	140 mg/kg
2,6-Dinitrotoluene	10 mg/kg	1.0	2.8	28 mg/kg
K111 Wastewaters				
2,4-Dinitrotoluene	0.058 mg/L	*	5.5	0.32 mg/L
2,6-Dinitrotoluene	0.10 mg/L	*	5.5	0.55 mg/L

*An accuracy correction factor was not used since an EAD variability factor was used.

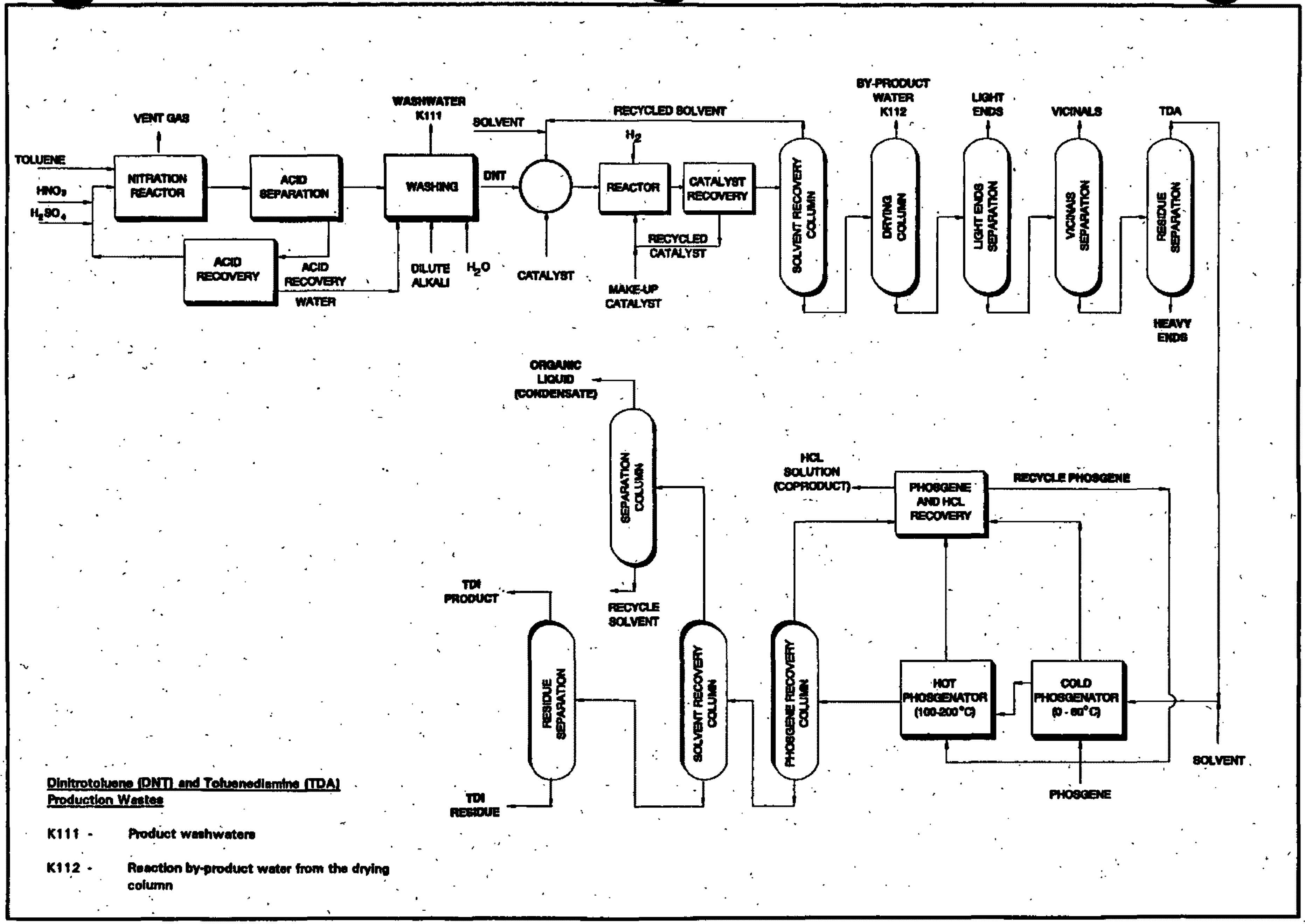


Figure 3-1 DNT & TDA Production Process

4.0 EDB PRODUCTION WASTES (K117, K118, K136)

This section describes the Agency's approach in establishing BDAT treatment standards for K117, K118, and K136. This includes a description of the industry that would be affected by the land disposal restrictions for ethylene dibromide (EDB) production wastes, a presentation of available waste characterization data, and a discussion of the Agency's rationale in determining BDAT treatment standards for these wastes.

Under 40 CFR 261.32 (hazardous wastes from specific sources), waste identified as K117 is listed as wastewater from the reactor vent gas scrubber in the production of EDB via bromination of ethene; K118 is listed as spent adsorbent solids from purification of EDB via bromination of ethene, and K136 is listed as still bottoms from the purification of EDB in the production of EDB via bromination of ethene.

4.1 Industry Affected and Waste Characterization

4.1.1 Industry Affected and Process Description

To the Agency's knowledge, two domestic facilities produce EDB from the bromination of ethene and may potentially generate K117, K118, and K136. The facilities are Ethyl Corporation located in Magnolia, AR, and Great Lakes Chemical located in El Dorado, AR. Both facilities are located in EPA Region VI. These facilities were identified using the 1990 SRI Directory of Chemical Producers (3) and data collected during EPA's listing efforts for K117, K118, and K136 (11).

Ethylene dibromide is used as a component of tetra-alkyl lead anti-knock gasoline additives. It is also used as an intermediate in chemical synthesis (e.g., vinyl bromide) and as a nonflammable solvent for resins, gums, and waxes. EDB has also been used as a soil fumigant for the agricultural industry, but was banned by EPA for this use. A simplified flow diagram illustrating the manufacturing process generating ethylene dibromide is presented in Figure 4-1.

Ethylene dibromide is produced by the following reaction sequence:

$$C_2H_4 + Br_2 \text{ ----------> } BrCH_2CH_2Br$$

The reaction of bromine with ethylene is highly exothermic; thus, various methods are used to bring these two feedstocks together so as to dissipate the heat of reaction and minimize the formation of by-products (12). These various methods are not expected to affect the generation and composition of the waste streams.

A gaseous vent stream leaves the reactor and is passed through a condenser to condense unreacted ethene, bromine, and EDB which are recycled to the reactor. The noncondensable gases, which consist of low boiling paraffinic hydrocarbons and unreacted ethene and bromine, are then scrubbed with water to remove traces of EDB and organics prior to being vented to the atmosphere. The scrubber produces an aqueous effluent (K117, as shown in Figure 4-1).

Purification of crude liquid can involve either filtration or drying over an activated adsorbent packing or similar solid, to remove inorganic solids or reduce color. This purification process produces spent adsorbent solids (K118, as shown in Figure 4-1). The wastes are solids containing adsorbed EDB. The purified product meets the commercial specification of 99.5% minimum EDB.

The product can also be purified by distillation. Distillation produces an organic still bottom that combines EDB and any high-boiling materials produced by side reactions (K136, as shown in Figure 4-1).

4.1.2 Waste Characterization

Table 4-1 presents a summary of the available characterization data for K117, K118, and K136. Data are presented for BDAT List constituents and other compounds that are believed to be present in or were quantified in K117, K118, and K136.

4.2 Applicable and Demonstrated Treatment Technologies

This section identifies the technologies that are applicable for the treatment of nonwastewater and wastewater forms of K117, K118, and K136 and discusses which of the applicable technologies can be considered demonstrated for the purpose of establishing BDAT.

To be applicable, a technology must theoretically be usable to treat the waste in question or to treat a waste that is similar in terms of parameters that affect treatment selection. (Detailed descriptions of technologies that are applicable to listed hazardous wastes are provided in EPA's Treatment Technology Background Document (5).) To be demonstrated, a technology must be employed in full-scale operation for treatment of the waste in question or of a similar waste. Technologies available only at pilot-scale or bench-scale operations are not considered in identifying demonstrated technologies.

4.2.1 Applicable Treatment Technologies

Nonwastewaters

Since nonwastewater forms of K117, K118, and K136 generally contain hazardous organic constituents at treatable concentrations, applicable treatment technologies include those that destroy or reduce the total amount of various organic compounds in the waste. The Agency has identified the following treatment technologies as applicable for these wastes:

- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- Solvent extraction followed by incineration or recycle of the extract; and
- Critical fluid extraction followed by incineration of the contaminated solvents.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and are described in more detail in Appendix A.

<u>Wastewaters</u>

Since wastewater forms of K117, K118, and K136 may contain hazardous organic constituents at treatable concentrations, applicable technologies include those that destroy or reduce the total amount of various organic compounds in the waste. Therefore, the Agency has identified the following treatment technologies as potentially applicable for treatment of these wastes:

- Biological treatment;
- Carbon adsorption;
- Chemical oxidation;
- Chemically assisted clarification;
- PACT® treatment (including powdered activated carbon addition to activated sludge and biological granular activated carbon technologies);
- Reverse osmosis;
- Solvent extraction;

- Stripping treatment (including steam stripping and air stripping technologies); and
- Wet air oxidation.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and are described in more detail in Appendix A.

The concentrations and type(s) of constituents present in the waste generally determine which technology is most applicable. Carbon adsorption, for example, is often used as a polishing step following primary treatment by biological treatment, solvent extraction, or oxidation. Typically, carbon adsorption is applicable for treatment of wastewaters containing total organic constituent concentrations less than 0.1%. Wet air oxidation, PACT® treatment, biological treatment, and solvent extraction are applicable for treatment of wastewaters containing organic constituents at concentrations of up to 1%.

4.2.2 Demonstrated Treatment Technologies

This section identifies those applicable treatment technologies that EPA considers to be demonstrated for the purpose of establishing BDAT for K111, K112, U328, and U353.

Nonwastewaters

The Agency believes that incineration is a demonstrated technology for the treatment of nonwastewater forms of K117, K118, and K136. For the land disposal restrictions program, the Agency conducted an ethylene dibromide incineration test on a full-scale operational basis. The Agency believes that since incineration is demonstrated for treatment of EDB, treatment is therefore demonstrated for similar brominated organic waste constituents. Analytical data and complete discussions of the test methods used are available in the corresponding on-site engineering report (OER) for the EDB incineration test (13).

The Agency is not aware of any facilities that treat the nonwastewater forms of brominated organic wastes, or wastes judged to be similar, by fuel substitution and the Agency believes that fuel substitution is inappropriate for wastes such as K117, K118, and K136 that contain many constituents with molecular components other than carbon, hydrogen, and oxygen. Therefore, the Agency believes that fuel substitution is not currently demonstrated for these wastes. In addition, the Agency is not aware of any facilities that treat nonwastewater forms of the brominated organic wastes, or wastes judged to be similar, using solvent extraction or critical fluid extraction on a full-scale operational basis; therefore, EPA believes that these technologies are not currently demonstrated for these wastes.

Wastewaters

The Agency has identified biological treatment, air/steam stripping, reverse osmosis, chemically assisted clarification, and carbon adsorption as demonstrated technologies for the treatment of organic constituents in wastewater forms of K117, K118, and K136. These technologies have been identified as providing treatment on a full-scale operational basis for the BDAT List constituents in K117, K118, and K136, including ethylene dibromide, bromomethane, and chloroform.

Analytical data and additional discussions of the constituents expected to be found in K117, K118, and K136 are presented in Section 4.3.

The Agency is not aware of any facilities that treat wastewater forms of brominated organic wastes by PACT®, solvent extraction, chemical oxidation, or wet air oxidation; therefore, the Agency believes that these technologies are not currently demonstrated for these wastes.

4.3 Treatment Performance Data

The Agency does not have treatment performance data for treatment of nonwastewater and wastewater forms of K117, K118, and K136. Therefore, treatment performance data were transferred from other previously tested wastes to develop concentration-based treatment standards for these wastes.

EPA's methodology for transfer of treatment performance data is provided in EPA's Methodology for Developing BDAT Treatment Standards (1). Transfer of treatment performance data is technically valid in cases where the untested waste is generated from a similar industry or similar processing step, or has similar waste characteristics affecting treatment performance and treatment selection as the tested wastes. Sources of treatment performance data for potential transfer to nonwastewater forms of K117, K118, and K136 include wastes previously tested by rotary kiln, fluidized-bed, or liquid injection incineration and identified in EPA's Volume C of the F039 Background Document (10). Sources of treatment performance data for potential transfer to wastewater forms of K117, K118, and K136 include those wastes and technologies identified in EPA's Volume A of the F039 Background Document (8).

4.3.1 Treatment of Organic Constituents in Nonwastewaters

Wastes previously tested by the Agency by rotary kiln, fluidized-bed, or liquid injection incineration include: D014, D016, F024, K001, K011, K013, K014, K015, K019, K024, K037, K048, K051, K087, K101, K102, P020, P059, U028, U080, U122, U127, U141, U161, U166, U188, U192, U220, U226, and U239.

In addition, the Agency is aware of several facilities that currently incinerate bromine-containing wastes. At Rollins Environmental Services, Deer Park, Texas, the Agency has previously incinerated ethylene dibromide wastes that were cancelled pesticides under FIFRA provisions. Excess oxygen conditions were carefully controlled to reduce the amount of bromine gas and to increase the amount of hydrogen bromine gas generated by incineration. Hydrogen bromide is readily absorbed by the air pollution control devices (APCDs), while bromide is difficult to remove by APCDs. The Agency believes that control of the undesirable conversion of the bromine-containing waste to bromine gas significantly affects the design and operation of the incineration systems. For these reasons, the Agency does not believe that transfer of treatment performance data from incineration of the non-brominated wastes listed in previous sections of this document is technically valid for the purpose of developing concentration-based treatment standards for brominated constituents in organic wastes.

Therefore, treatment performance data from the EDB incineration test were used to develop treatment standards for EDB and bromomethane in K117, K118, and K136. EDB treatment performance data from the EDB incineration test for the untreated waste feed and the incinerator ash treatment residual are included in Table 4-2. Design data for the treatment systems used for the EDB incineration test are included in Table 4-3.

Since the waste characterization data presented in Section 4.1.2 also identify chloroform as a constituent in K117, incineration treatment performance data on chloroform were transferred to K117, K118, and K136. Specifically, the Agency considered treatment performance data from the 14 EPA-conducted incineration tests listed in Table 4-4. Chloroform was detected in the untreated or treated wastes from treatment tests 3 and 4; accordingly, data from these two tests were used in the development of treatment standards for chloroform. Table 4-5 presents the highest detection limits available for chloroform in the incinerator ash in all 14 incineration tests.

4.3.2 Treatment of Organic Constituents in Wastewaters

Treatment standards for organic BDAT List Constituents in these wastewaters were developed from treatment performance data transferred from EPA's Volume A of the F039 Background Document (8). These data were used for transfer to wastewater forms of K117, K118, and K136 because the Agency prefers, whenever possible, to use appropriate treatment performance data from well-designed and well-operated wastewater treatment units, rather than scrubber water concentration data, in setting BDAT treatment standards. These data represent treatment using a specific wastewater treatment technology as opposed to scrubber water.

Tables 4-6, 4-7, and 4-8 at the end of this section present the available treatment performance data for ethylene dibromide, bromomethane, and chloroform. The data used to determine the BDAT treatment standards are shown with an asterisk.

Presented below are short descriptions of the data sources for wastewater treatment performance data on ethylene dibromide, bromomethane and chloroform and the Agency's rationale for determining which data sets were used in the development of each treatment standard.

Sources of Treatment Performance Data

This section describes each of the sources of wastewater treatment performance data sources to compile data for determination of treatment standards.

WAO/PACT® Data. For specific Third Third U and P waste codes, a wastewater treatment performance test was conducted using Wet Air Oxidation (WAO) and PACT® treatment technologies. The treatment performance data from this test were incorporated into the tables of this section.

ITD Database--Effluent Guidelines. In response to the Federal Water Pollution Control Act (FWPCA) of 1972 and the Clean Water Act (CWA) of 1977, EPA promulgated regulations to reduce the level of pollutants in wastewater discharged from industrial point sources using the "Best Available Technology Economically Achievable." The program of developing and promulgating effluent guidelines was assigned to the Industrial Technology Division (ITD) (now titled Engineering and Analysis Division (EAD)) within EPA's Office of Water Regulations and Standards. To date, EAD has promulgated effluent guidelines for 27 industrial categories.

The treatment performance data used for EAD's promulgation efforts have been summarized by category in specific effluent limitations guidelines and standards development documents. The treatment performance data from the Development Document for Effluent Limitations Guidelines, New Source Performance Standards, and Pretreatment Standards for the Organic Chemicals and the Plastics and Synthetic Fibers Point Source Category (14) for BDAT List organic constituents for which EAD effluent limitations exist were incorporated into the tables of this section.

NPDES Database. Under the Clean Water Act, the discharge of pollutants into the waters of the United States is prohibited unless a permit is issued by EPA or a state under the National Pollutant Discharge Elimination System (NPDES). An NPDES permit provides effluent limitations for specific pollutants that a facility can discharge. The permit also provides for monitoring and reporting requirements by a facility to check whether the effluent limitations are being met. The monitoring data submitted by facilities to EPA or the state as part of the NPDES permit program is summarized in a database.

The NPDES database was searched for 90 BDAT List constituents to identify facilities that have monitoring data for any of those constituents. Constituent data from this search, representing concentrations of constituents in wastewater effluents, have been incorporated into the tables of this section. EPA was unable to evaluate whether substantial treatment occurred since corresponding influent concentrations of the constituents were unavailable. The treatment technologies or treatment trains represented by the NPDES data were identified in some, but not all cases. Where available, the treatment technology has been specified in the tables of this section.

WERL Database. U.S. EPA's Risk Reduction Engineering Laboratory, which now includes the former Water Engineering Research Laboratory (WERL), has developed and is continuing to expand a database on the treatability of chemicals in various types of waters and wastewaters. This WERL database has been compiled from wastewater treatment performance data available in literature. The treatment performance data for BDAT List constituents in this database have been included in the tables of this section.

Treatment Performance Data

Ethylene Dibromide (1,2-dibromoethane). The data available for ethylene dibromide were compiled from the WERL database and are presented in Table 4-6. Technologies for which data are available include AirS and RO. The treatment performance data represent pilot-scale studies only. The resulting effluent concentrations ranged from 0.06 ppb to 7.0 ppb with a detection limit for ethylene dibromide established at 4.8 ppb.

The Agency is establishing air stripping (AirS) as BDAT for EDB. Air stripping was selected as BDAT because of its high removal efficiency and ability to treat wastewater to a level below the detection limit. The BDAT treatment standard for EDB was calculated using a detection limit of 4.8 ppb and the appropriate variability factor. The calculation of the resulting BDAT treatment standard for EDB (0.028 ppm) is described in Section 4.6 and is shown in Table 4-10.

<u>Bromomethane</u>. The data for bromomethane were compiled from the WERL and NPDES databases and are presented in Table 4-7. Technologies for which data are available include AS and BT. The treatment performance data represent full-scale technologies and show an effluent concentration range of 1 ppb to 20 ppb.

The Agency is establishing activated sludge biological treatment as BDAT for bromomethane. Activated sludge was selected as BDAT because the available data show high influent concentrations and a high removal efficiency. The BDAT treatment standard for bromomethane was calculated using the effluent concentration of 20 ppb and the appropriate variability factor. The calculation of the resulting BDAT treatment standard for bromomethane (0.11 ppm) is described in Section 4.6 and is shown in Table 4-10.

<u>Chloroform</u>. Several sources of wastewater treatment performance data were available for chloroform including data from the EAD, WERL, and WAO databases. These data are presented in Table 4-8. Technologies for which data are available include AL, AS, AS+Fil, AirS, CAC, CAC+AirS, chemical oxidation (ChOx), GAC, PACT®, RO, SCOx, SS, TF, and WOX. The treatment performance data represent bench-scale, pilot-scale, and full-scale data. The resulting effluent concentrations ranged from 0.13 ppb to 16,000 ppb.

The treatment performance data available from the EAD database were used in determining the BDAT treatment standard for this constituent for the following reasons:

(1) The EAD data represent treatment performance data from the OCPSF sampling episodes. The data collected by EAD include long-term sampling of several industries. These data are therefore a good reflection of the total organic chemical industry and adequately represent a wastewater containing chloroform.

(2) The EAD data were carefully screened prior to inclusion in the OCPSF database. These data were used in determining a promulgated EAD effluent limitation.

(3) A promulgated EAD limitation represents data that have undergone both EPA and industry review and acceptance.

The Agency is establishing steam stripping (SS) as BDAT for chloroform. The BDAT treatment standard was calculated using the EAD median long-term average of 12.2 ppb and the EAD Option 1 variability factor. The calculation of the resulting BDAT treatment standard for chloroform (0.046 ppm) is described in Section 4.6 and is shown in Table 4-10.

4.4 Identification of Best Demonstrated Available Technology (BDAT)

This section presents the Agency's rationale for determining the best demonstrated available technology (BDAT) for nonwastewater and wastewater forms of K117, K118, and K136.

EPA determines the best demonstrated available technology based on a thorough review of all of the treatment performance data available for the waste of concern or wastes judged to be similar. Following the identification of "best," the Agency determines whether the technology is "available." An available treatment technology is one that (1) is not a proprietary or patented process that cannot be purchased or licensed from the proprietor (i.e., it must be commercially available), and (2) substantially diminishes the toxicity of the waste or substantially reduces the likelihood of migration of hazardous constituents from the waste.

4.4.1 Nonwastewaters

The treatment performance data that were evaluated to determine BDAT treatment standards for the nonwastewater forms of K117, K118, and K136 are presented in Section 4.3. The treatment performance data were screened to determine:

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

EPA has identified incineration as demonstrated for the treatment of organic constituents in nonwastewater forms of K117, K118, and K136. EPA has treatment performance data from the incineration of constituents included in each of these wastes.

All of the incineration data included in Section 4.3 represent BDAT for wastes included in previous rulemakings and therefore have already met the above conditions. Thus, incineration is the "best" technology for treating organic nonwastewater forms of these wastes in each group of wastes.

Incineration, identified as the "best" technology for these organic wastes, is commercially available. Treatment performance data included in Section 4.3 show substantial treatment by incineration for waste constituents of concern and other similar constituents. Because incineration is applicable, demonstrated, and "available," it is therefore being established as BDAT for treatment of the organic constituents in nonwastewater forms of K117, K118, and K136.

4.4.2 Wastewaters

The treatment performance data that were evaluated to determine BDAT treatment standards for wastewater forms of K117, K118, and K136 are presented in Section 4.3. The Agency believes that data from the EAD and BDAT programs should be used preferentially over data from other sources whenever possible. The EAD database represents a comprehensive source of wastewater treatment performance data and usually represents longer term sampling with a greater number of sample sets than data in other wastewater treatment performance databases. Data generated as part of the BDAT program represent controlled tests and follow EPA protocols for sampling and analysis procedures.

The following is an outline of the hierarchy used to determine the best demonstrated technology for wastewater constituents included in this document. All data used in determining BDAT for a constituent came from the highest level in the hierarchy in which they were available for a particular constituent.

(1) EAD treatment performance data that were used to promulgate an EAD effluent limitation standard. The data representing EAD Option I were used in all cases (43).

(2) Agency-sponsored BDAT wastewater treatment test data.

(3) Industry-submitted multi-source leachate treatment performance data, where the data showed substantial treatment.

(4) Other available treatment performance data. Evaluation of these data was based on:

   (a) The treatment technology for which data were available;
   (b) Whether the data represented full-, pilot-, or bench-scale treatment;
   (c) The concentration of the constituent of interest in the influent to treatment;
   (d) The average concentration of the constituent of interest in the effluent from treatment; and
   (e) The removal efficiency of the treatment technology.

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

The demonstrated technologies identified in Section 4.2.2 and determined to be best for each constituent as identified in Section 4.3 are all commercially available. In addition, treatment performance data included in Section 4.3 show substantial treatment of the constituent for which the technology was selected as BDAT. Therefore, the technologies selected as best and demonstrated for each constituent are also considered to be available and are being promulgated as BDAT.

4.5 Selection of Regulated Constituents

The Agency has developed a list of hazardous constituents (the BDAT Constituent List, presented in EPA's Methodology for Developing BDAT Treatment Standards (1)) from which constituents are selected for regulation. EPA may revise this list as additional data and information become available. The list is divided into the following categories: volatile organics, semivolatile organics, metals, inorganics other than metals, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorus insecticides, polychlorinated biphenyls (PCBs), and dioxins and furans. This section presents EPA's methodology and rationale for selection of constituents for regulation in nonwastewater and wastewater forms of K117, K118, and K136.

Generally, constituents selected for regulation must satisfy the following criteria:

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

2. The constituent must be present in, or be suspected of being present in, the untreated waste. For example, analytical difficulties 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.

From a group of constituents that may be selected for regulation because they meet the above criteria, EPA may select a subset of constituents that represents the broader group. For example, from a group of constituents that react similarly to treatment, the Agency may select for regulation those constituents that (1) are the most difficult to treat, based on waste characteristics affecting treatment performance; (2) are representative of other constituents in the waste, based on structural similarities; or (3) are present in the untreated waste in the highest concentrations. Selecting a subset of constituents for regulation facilitates implementation of industry compliance and of EPA's enforcement program.

The Agency initially considered all constituents on the BDAT List for regulation in K117, K118, and K136. Table 4-1 summarizes available waste characterization data for constituents in K117, K118, and K136 and presents ranges of concentrations for constituents detected in the waste. Constituents for which analyses were not performed are identified by "NA" (not analyzed).

Three BDAT List constituents have been identified in K117, K118, and K136; namely, ethylene dibromide, bromomethane, and chloroform. The Agency has selected these three BDAT List constituents for regulation in nonwastewater and wastewater forms of K117, K118, and K136.

4.6 Calculation of BDAT Treatment Standards

The Agency bases concentration-based treatment standards on the performance of well-designed and well-operated treatment systems. These standards account for analytical limitations in available treatment performance data and for variabilities related to treatment, sampling, and analytical techniques and procedures. This section presents the treatment standards calculated for the constituents selected for regulation in Section 4.5 using the available treatment performance data discussed in Section 4.3.

4.6.1 Nonwastewaters

Treatment standards for regulated constituents in nonwastewater forms of K117, K118, and K136 were calculated based on data compiled from the BDAT incineration database for incinerator ash. Specifically, treatment performance data from the Agency's ethylene dibromide incineration test were used to calculate BDAT treatment standards for ethylene dibromide and bromomethane in nonwastewater forms of K117, K118, and K136. The treatment standard for bromomethane was based on a transfer of treatment performance data from ethylene dibromide. Treatment performance data from two incinerator tests were used to calculate the BDAT treatment standard for chloroform in nonwastewater forms of K117, K118, and K136.

The Agency considered the detection limits from each of these tests and determined which were the most representative for each waste constituent. The Agency selected the highest detection limit for each regulated constituent from the incineration tests to account for the anticipated variability in untreated wastes.

Concentration-based treatment standards for regulated waste constituents were calculated by multiplying the constituent detection limit in ash by an accuracy correction factor and a variability factor. The following subsections discuss these three components of the treatment standard calculation. The calculations of treatment standards for regulated constituents in nonwastewater forms of K117, K118, and K136 are summarized in Table 4-9.

Detection Limits

The detection limits for ethylene dibromide, bromomethane, and chloroform in ash were used to calculate the treatment standards for nonwastewater forms of K117, K118, and K136. The highest detection limit for each of these constituents from the 11 incineration tests was used.

Accuracy Correction Factors

The detection limits used to calculate treatment standards were corrected using matrix spike recovery data from the same test from which the detection limits were taken to account for analytical interferences associated with the chemical matrices of the samples. Detection limits were corrected for accuracy as follows:

- A matrix spike recovery was determined for each regulated constituent. In cases where a matrix spike was not performed for a regulated constituent in the treatment test from which the detection limit was taken, the matrix spike recovery from a similar constituent from that treatment test was transferred to the constituent.
- An accuracy correction factor was determined for each of the above constituents by dividing 100 by the matrix spike recovery (expressed as a percentage) for that constituent.

- Detection limits for each of the regulated constituents were corrected by multiplying the detection limit for each constituent by its corresponding accuracy correction factor. The accuracy corrected detection limit for each regulated constituent is shown on Table 4-9.

Matrix spike recoveries used to adjust detection limits for the regulated constituents in nonwastewater forms of K117, K118, and K136 are included in Appendix B. Duplicate matrix spikes were performed for some waste constituents. If a duplicate matrix spike was performed for a constituent, the matrix spike recovery used for that constituent was the lower of the two values between the first matrix spike and the duplicate spike. Matrix spike recoveries of less than 20% are not acceptable and were not used to correct detection limits. Matrix spike recoveries greater than 100% were considered to be 100% for the purpose of this calculation so that the data were not adjusted to concentrations below the detection limits. In cases where the detection limit came from more than one test, the lowest matrix spike recovery among the tests was used.

<u>Variability Factors</u>

The variability factor accounts for the variability inherent in treatment system performance, treatment residual collection, and analysis of the treated waste samples. Variability factors could not be calculated for regulated constituents that were not detected in the incinerator ash residuals. Therefore, a variability factor of 2.8 was used to account for this inherent variability, as discussed in the <u>Methodology for Developing BDAT Treatment Standards</u> (1).

4.6.2 Wastewaters

Treatment standards for wastewater forms of K117, K118 and K136 were calculated based on data compiled from EPA's wastewater treatment performance database. Specifically, treatment performance data from air and steam stripping and biological treatment were used.

Concentration-based treatment standards regulated for waste constituents were calculated by multiplying the constituent effluent concentration (as presented in Section 4.3) by an accuracy correction factor and a variability factor. The following subsections discuss these three components of the treatment standard calculation. The calculation of treatment standards for regulated constituents in wastewater forms of K117, K118, and K136 are summarized in Table 4-10.

<u>Constituent Effluent Concentration</u>

The effluent concentration obtained using the BDAT for each regulated constituent was determined as discussed in Section 4.3.2. The treatment performance data for each regulated constituent are presented in Tables 4-6, 4-7, and 4-8 at the end of this section.

<u>Accuracy Correction Factors</u>

Accuracy correction factors account for analytical interferences associated with the chemical matrices of the samples. EAD variability factors were used (or transferred for use) in the calculations of treatment standards for regulated constituents in wastewater forms of K117, K118, and K136. Based on the fact that EAD variability factors were originally calculated to represent performance, analytical, and matrix variations, accuracy correction factors were not used.

<u>Variability Factors</u>

A variability factor (VF) accounts for the variability inherent in the treatment system performance, treatment residual collection, and analysis of the treated waste samples. Variability factors are calculated as described in EPA's Methodology for Developing BDAT Treatment Standards (1). However, original effluent data points were not available for ethylene dibromide and bromomethane in K117, K118, and K136 since WERL effluent data were used to determine treatment standards and these data were used to determine treatment standards and these data were presented as averages in the WERL database. Therefore, it was not possible to calculate an individual variability factor for these constituents; instead, an average variability factor was used. The average variability factors were generated from the EAD variability factors and are specific to the type of constituent under consideration (i.e., volatile organic, acid extractable semivolatile organic, etc.). The calculation of average variability factors is discussed in Appendix C.

Table 4-1

Summary of Available Characterization Data for K117, K118, K136

BDAT List Constituents	Concentration in Untreated Waste (%)		
	K117	K118	K136
Ethylene dibromide	0.01-0.22	1-75	CBI
Chloroform	0-0.0001	NA	CBI
Bromomethane	NA	0-0.0004	CBI
Other Constituents			
1,1,2-Tribromomethane	NA	0-0.02	CBI
Bromoethane	0-0.007	NA	CBI
Bromochloroethane	0.002-0.0002	0-0.01	CBI
Bis(2-bromo)ethyl ether	NA	0-0.06	CBI

CBI = Confidential Business Information.

NA = Not analyzed.

Table 4-2

Treatment Performance Data Collected by EPA from Incineration of Ethylene Dibromide (EDB) at Rollins Environmental Services, Inc. (Texas) - Incineration

BDAT List Constituent	Sample Set No.	Untreated Waste		Incineration Ash	
		Detection Limit (mg/kg)	Concentration of EDB (mg/kg)	Detection Limit (mg/kg)	EDB Concentration in Solids Discharge Stream (mg/kg)
1,2-Dibromoethane (Ethylene dibromide)	1	25,000	119,000	5	<5
	2	25,000	92,000	5	<5
	3	25,000	102,000	5	<5

Source: EDB Test Burn Progress Emissions Test Results (13).

Table 4-3

Design Parameters for the Incineration System at Rollins Environmental Services, Inc. (Texas)

Physical Design Parameter	Value or Description
ROTARY KILN:	
Manufacturer	*
Height	NR
Inside diameter	9.5 feet
Length	32.8 feet
Volume	2,324 cubic feet
Width	NR
Materials of construction:	
Outer shell	1.18-inch steel plate with 9-inch refractory lining.
Front wall	0.59-inch steel plate with castable refractory and refractory brick lining.
LODDBY FURNACE:	
Manufacturer	*
Height	NR
Inside diameter	6.25 feet
Length	14 feet
Volume	429 cubic feet
Width	NR
AFTERBURNER:	
Manufacturer	*
Height	13.5 feet
Inside diameter	NR
Length	49 feet
Volume	8,300 cubic feet
Width	12.5 feet
Materials of construction:	
Outer shell	13-inch refractory bricks supported by stainless steel clips attached to steel beams.
Ceiling	6-inch bricks

NR - Not Reported.

*This equipment was designed for RES(TX), Inc., and therefore does not carry a model number.

Source: EDB Test Burn Progress Emissions Test Results (13)

Table 4-4

Wastes Tested by Incineration

Test Number	Waste Code(s) Tested	Technology Used	Background Document Reference Numbers	On-Site Engineering Report Reference Numbers
1	K001-Pentachlorophenol	Rotary Kiln	18	28
2	K001-Creosote	Rotary Kiln	18	29
3	K011, K013, K014	Rotary Kiln	17	30
4	K019	Rotary Kiln	19	31
5	K024	Rotary Kiln	20	32
6	K037	Rotary Kiln	21	33
7	K048, K051	Fluidized-Bed	22	34, 35
8	K087	Rotary Kiln	23	36
9	K101	Rotary Kiln	24	37
10	K102	Rotary Kiln	25	38
11	F024	Rotary Kiln	26	39
12	K015	Liquid Injection	27	40
13	D014, D016, P059[a], U127[a], U192[a]	Rotary Kiln	NA	41
14	U141[a], U028[a], P020[a], U122[a], U226[a], U239[a], U080[a], U220[a], U166[a], U161[a], U188[a]	Rotary Kiln	NA	42

NA - Not applicable.

[a]Commercial chemical products were used in these incineration tests as surrogates for these wastes.

Table 4-5

Summary of Detection Limits for Chloroform in Ash Samples from the Fourteen EPA Incineration Tests*

Test No.**	Detection Limit (ppm)
1	2
2	10
3	2[a]
4	2[b]
5	2
6	2
7	2
8	0.025
9	0.005
10	1.5
11	0.005
13	0.01
14	0.01

[a]Chloroform detected in scrubber water.
[b]Chloroform detected in untreated waste.

*Incinerator ash samples were not collected for Test 12.
**Corresponding waste codes are indicated in Table 4-4.

Table 4-6

Wastewater Treatment Performance Data for Ethylene Dibromide

Technology	Technology Size	Facility	Range Influent Concentration (ppb)	No. of Data Points	Average Effluent Concentration (ppb)	Removal (%)	Reference
AirS*	Pilot	218B	0-100	1	0.060	96.5	WERL*
RO	Pilot	323B	0-100	1	7	15	WERL

AirS - Air Stripping
RO - Reverse Osmosis
WERL - Water Engineering Research Laboratory Database
*The method detection limit for ethylene dibromide (4.8 ppb) was used in developing the BDAT treatment standard.

Table 4-7

Wastewater Treatment Performance Data for Bromomethane

Technology	Technology Size	Facility	Range Influent Concentration (ppb)	No. of Data Points	Average Effluent Concentration (ppb)	Removal (%)	Reference
		LA0066435		12	5.6		NPDES
		LA0066214		15	11.786		NPDES
		PA0011371		9	1.0		NPDES
		LA0065501		6	10.0		NPDES
		NJ0028291		2	1.0		NPDES
AS*	Full	1B	100-1,000	5	20	82	WERL*
AS*	Full	1B	100-1,000	2	20	82	WERL*
BT	Full	LA0038245		38	9.868		NPDES

AS - Activated Sludge
BT - Biological Treatment
NPDES - National Pollutant Discharge Elimination System Database
WERL - Water Engineering Research Laboratory Database
*Data used in developing treatment standard.

Table 4-8

Wastewater Treatment Performance Data for Chloroform

Technology	Technology Size	Facility	Range Influent Concentration (ppb)	No. of Data Points	Average Effluent Concentration (ppb)	Removal (%)	Reference
AL	Full	1607B	0-100	3	9.000	90.1	WERL
AL	Full	1B	100-1,000	6	26.000	96.8	WERL
AL	Pilot	203A	100-1,000	14	53.000	61	WERL
AL	Full	141A	100-1,000		16.000	92.3	WERL
AL	Full	1607B	100-1,000	2	10.000	97.4	WERL
AL	Full	1607B	100-1,000	3	130.000	86	WERL
AL	Pilot	203A	100-1,000	14	31.000	77	WERL
AS	Full	1B	0-100	3	20.000	80	WERL
AS	Full	6B	100-1,000	7	30.000	77	WERL
AS	Full	1B	0-100	5	6.000	86	WERL
AS	Full	6B	100-1,000	3	10.000	97.7	WERL
AS	Bench	202D	10,000-100,000		200.000	99.43	WERL
AS	Full	234A	0-100		1.2000	61	WERL
AS	Full	1B	0-100	6	21.000	62	WERL
AS	Full	375E	0-100	7	1.000	75	WERL
AS	Full	1B	100-1,000	6	59.000	51	WERL
AS	Full	975B	0-100		2.000	93.8	WERL
AS	Full	234A	0-100		2.300	72	WERL
AS	Full	234A	0-100		0.500	98.4	WERL
AS	Full	6B	100-1,000	3	10.000	98.2	WERL
AS	Full	238A	0-100	3	2.400	46	WERL

27
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Table 4-8

(Continued)

Technology	Technology Size	Facility	Range Influent Concentration (ppb)	No. of Data Points	Average Effluent Concentration (ppb)	Removal (%)	Reference
AS	Full	1607B	100-1,000	3	50.000	86	WERL
AS	Full	1607B	1,000-10,000	2	40.000	96.9	WERL
AS	Pilot	206B	100-1,000	20	3.600	97.4	WERL
AS	Full	375E	0-100	7	20.000	78	WERL
AS	Full	1587E	0-100		1.600	65	WERL
AS	Pilot	241B	100-1,000	5	44.000	85	WERL
AS	Full	234A	0-100		1.300	84	WERL
AS	Pilot	203A	100-1,000	14	18.000	87	WERL
AS	Full	6B	1,000-10,000	27	19.000	98.7	WERL
AS	Full	201B	0-100	29	38.000	53	WERL
AS	Full	234A	0-100		1.300	65	WERL
AS	Pilot	240A	0-100	14	2.000	98	WERL
AS+Fil	Full	6B	1,000-10,000	3	10.000	99.41	WERL
AS+Fil	Full	6B	100-1,000	14	10.000	95.8	WERL
AirS	Bench	1328E	100,000-1,000,000	5	16,000.000	93.1	WERL
AirS	Pilot	369A	0-100		1.400	98.2	WERL
AirS	Pilot	213B	0-100	1	13.000	77	WERL
AirS	Bench	1328E	10,000-100,000	5	4,400.000	83	WERL
AirS	Pilot	225B	0-100	1	0.130	98.9	WERL
AirS	Bench	17A	0-100		2.600	96.9	WERL
AirS	Bench	17A	1,000-10,000		110.000	91.7	WERL
AirS	Bench	17A	0-100		3.900	88	WERL

Table 4-8

(Continued)

Technology	Technology Size	Facility	Range Influent Concentration (ppb)	No. of Data Points	Average Effluent Concentration (ppb)	Removal (%)	Reference
AirS	Bench	17A	100-1,000		4.200	98.6	WERL
AirS	Pilot	210B	100-1,000	1	1.000	99.2	WERL
AirS	Bench	17A	100-1,000		3.700	98.6	WERL
AirS	Bench	1328E	100-1,000	5	34.000	84	WERL
AirS	Pilot	434B	1,000-10,000	4	41.000	98	WERL
CAC	Pilot	203A	100-1,000	14	106.000	22	WERL
CAC+AirS	Full	1833D	0-100	25	0.200	89	WERL
ChOx	Bench	640E	100-1,000	2	7.000	96	WERL
ChOx	Bench	640E	100-1,000	1	3.000	99	WERL
ChOx (Oz)	Pilot	331D	0-100		46.000	37	WERL
ChOx (Oz)	Pilot	331D	0-100		2.800	35	WERL
GAC	Full	1264B	0-100		1.000	87	WERL
GAC	Pilot	331D	0-100		1.000	98.6	WERL
GAC	Full	245B	100-1,000	1	10.000	97.6	WERL
GAC	Full	237A	100-1,000	1	10.000	98.1	WERL
GAC	Full	245B	100-1,000	1	10.000	96.2	WERL
PACT	Bench	242E	0-100		20.000	47	WERL
PACT	Bench	Zimpro	1,470	1	4.000	99.9	WAO
PACT	Bench	Zimpro	38	1	20.000	47	WAO
RO	Pilot	180A	0-100		0.890	71	WERL
RO	Full	250B	1,000-10,000		110.000	94.5	WERL
RO	Full	250B	100-1,000		53.000	87	WERL

27
1.mlm

Table 4-8

(Continued)

Technology	Technology Size	Facility	Range Influent Concentration (ppb)	No. of Data Points	Average Effluent Concentration (ppb)	Removal (%)	Reference
SCOx	Pilot	65D	100-1,000		1.700	99.83	WERL
SS[a]	Full	415T	7,330-1,088,000	15	10.500		EAD-L[b]
SS[a]	Full	913	28,700-200,000	14	129.200		EAD-L[b]
SS	Full	6B	100,000-1,000,000	15	10.000	99.99	WERL
SS	Full	6B	10,000-100,000	2	120.000	99.88	WERL
SS	Full	251B	1,000,000	10	6,000.000	99.99	WERL
SS	Full	251B	100,000-1,000,000	10	9,600.000	96.4	WERL
TF	Pilot	240A	0-100	14	11.000	89	WERL
TF	Full	1B	0-100	4	14.000	86	WERL
TF	Pilot	203A	100-1,000	14	102.000	24	WERL
WOx	Bench	Zimpro	4,450,000	1	3,000.000	99.9	WAO
WOx	Bench	Zimpro	270,000	1	1,000.000	99	WAO

[a]Detection limit = 10 ppb.
[b]Data used in developing BDAT treatment standard.
AL - Aerobic Lagoons
AS - Activated Sludge
Fil - Filtration
AirS - Air Stripping
CAC - Chemically Assisted Clarification
ChOx - Chemical Oxidation
Oz - Ozone
GAC - Activated Carbon (granular)
PACT® - Powdered Activated Carbon Addition to Activated Sludge
RO - Reverse Osmosis
SCOx - Super Critical Oxidation
SS - Steam Stripping
TF - Trickling Filter
WOx - Wet Air Oxidation
WERL - Water Engineering Research Laboratory Database
EAD-L - Engineering and Analysis Division Database
WAO - Wet Air Oxidation Database

Table 4-9

Calculation of Nonwastewater Treatment Standards for K117, K118, and K136

Regulated Constituent	Constituent from Which Treatment Performance Data Were Transferred	Arithmetic Average of Corrected Detection Limit Values (ppm)	Variability Factor (VF)	Treatment Standard (Average x VF) (ppm)
Brominated Organic Constituents				
Ethylene dibromide	N/A	5.41	2.8	15
Bromomethane	Ethylene dibromide (EDB Test Burn)	5.41	2.8	15
Other Organic Constituents				
Chloroform	N/A	2.0	2.8	5.6

N/A = Not applicable; treatment performance data were not transferred from another constituent.

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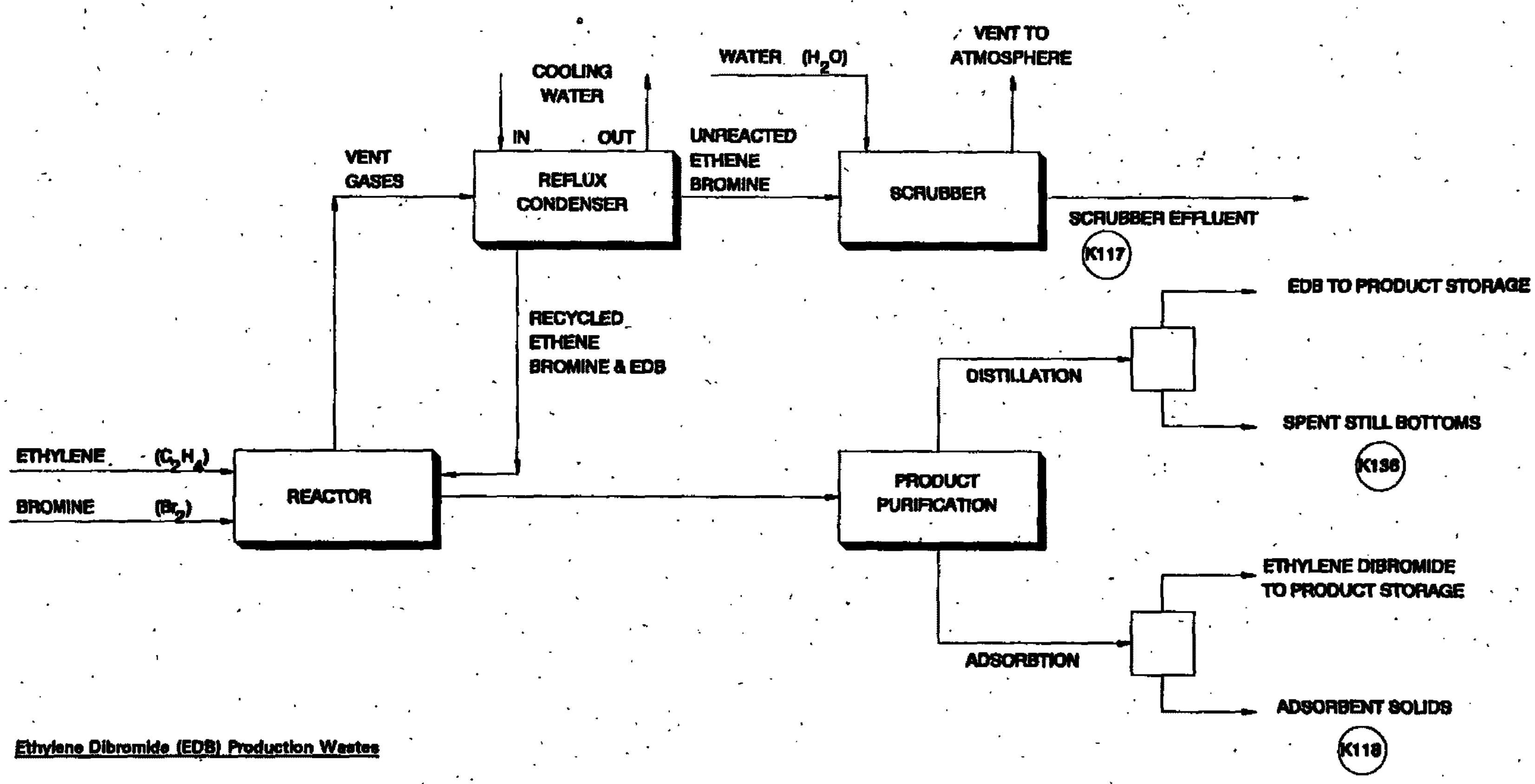
Table 4-10

Calculation of Wastewater Treatment Standards for K117, K118, and K136

Regulated Constituent	Effluent Concentration (mg/l)	Variability Factor*	Treatment Standard (mg/l)
Brominated Organic Constituents			
Ethylene dibromide	0.0048	5.7	0.028
Bromomethane	0.020	5.7	0.11
Other Organic Constituents			
Chloroform	0.012	3.7	0.046

*The variability factor (VF) represents an EAD VF and therefore, accounts for both variability and accuracy correction.



Ethylene Dibromide (EDB) Production Wastes

K117 - Wastewater from the reactor vent gas scrubber

K118 - Spent adsorbent solids from purification of ethylene dibromide

K136 - Still bottoms from the purification of ethylene dibromide

Figure 4-1. Ethylene Dibr Production Process

5.0 EBDC PRODUCTION WASTES (K123, K124, K125, K126)

This section describes the Agency's approach in establishing BDAT treatment standards for K123, K124, K125, and K126. This includes a description of the industry that would be affected by the land disposal restrictions for ethylenebisdithiocarbamic acid (EBDC) production wastes, a presentation of available waste characterization data, and a discussion of the Agency's rationale in determining BDAT treatment standards for these wastes.

Under 40 CFR 261.32 (hazardous wastes from specific sources), waste identified as K123 is listed as process wastewater (including supernates, filtrates, and washwaters) from the production of EBDC and its salts; K124 is listed as reactor vent scrubber water from the production of EBDC and its salts; K125 is listed as purification solids (including filtration, evaporation, and centrifugation solids) from the production of EBDC and its salts; and K126 is listed as baghouse dust and floor sweepings in milling and packaging operations from the production of EBDC and its salts.

5.1 Industry Affected and Waste Characterization

5.1.1 Industry Affected and Process Description

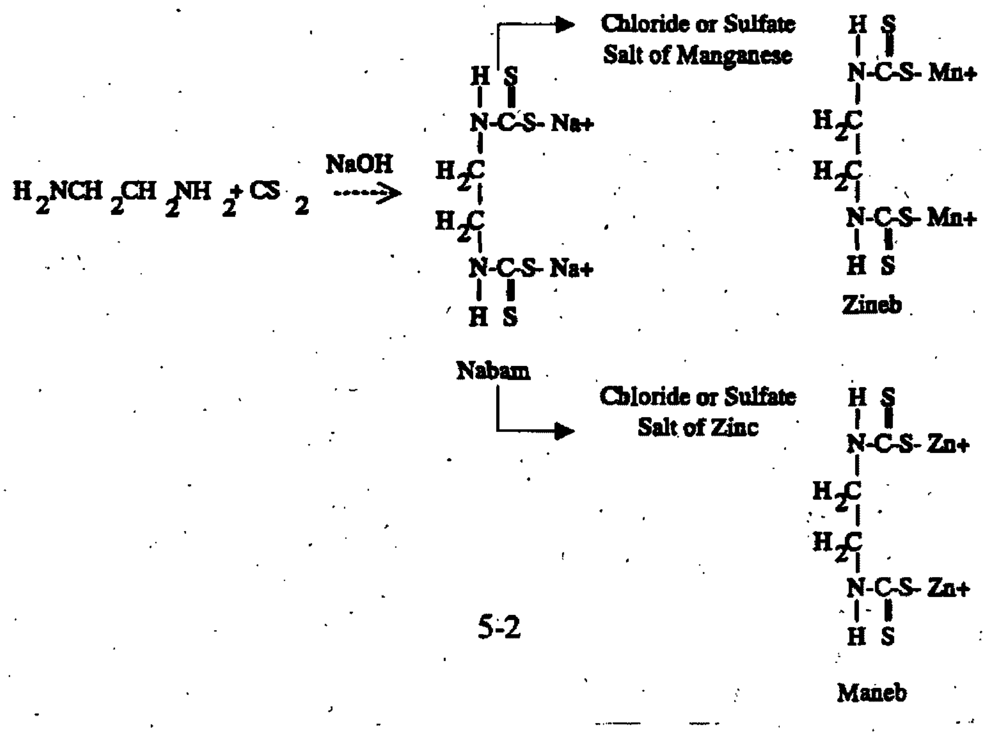
To the Agency's knowledge, two domestic facilities produce and purify EBDC and its salts and may potentially generate K123, K124, K125, and K126. These facilities are Alco Chemicals in Chattanooga, TN, and Vinings Industries in Marietta, GA. Both facilities are located in EPA Region IV. These facilities were identified using the 1990 SRI Directory of Chemical Producers (3) and data collected during EPA's listing efforts for K123, K124, K125, and K126 (15).

EBDC is used mainly as a fungicide. Nabam, the sodium salt of EBDC, is primarily used as an algicide in rice; it is also used as an intermediate in the synthesis of other products. Zineb, the zinc salt of EBDC, is used against downy mildews, rusts, and scabs; it is one of the most widely used fungicides of this group. Maneb, the manganese salt of EBDC, is widely used as a foliar fungicide for control of downy mildews on hops and vine, against downy mildews, rust, and scabs on fruit, vegetables, maize, rice, cereals, tobacco, and as a seed dressing and soil treatment. Mancozeb, a combination of maneb and zineb, is used as a foliar fungicide with additional acaricidal action and as a seed treatment. Polyram (a zineb-ammonia adduct) has the additional property of having a relatively long residue effect. A simplified flow diagram illustrating the manufacturing process generating EBDC is presented in Figure 5-1.

Nabam is typically produced by reacting ethylenediamine with carbon disulfide in the presence of sodium hydroxide. Nabam is soluble in water and may be sold as an aqueous solution or used as an intermediate in the production of other products.

Maneb is produced by adding the chloride or sulfate salt of manganese to a solution of nabam or to a solution of the ammonium salt of EBDC (formed by the addition of ammonium hydroxide to ethylene diamine and carbon disulfide). Likewise, zineb is produced by reacting the chloride or sulfate salt of zinc with nabam or with the ammonium salt of EBDC.

The reaction for these processes is as follows:



Both maneb and zineb are insoluble and may be recovered from the aqueous solution by filtration or centrifugation. An insoluble metal precipitate may also be formed by using hydrogen peroxide as an oxidant to produce insoluble thiuramsulfides from the soluble sodium or ammonium EBDC salts. Polyram, for example, is produced by blending zineb with ethylene thiuramonosulfide. These solid precipitates (e.g., maneb, polyram) are typically dried and formulated with clay and/or surfactants to produce the final product.

The production of EBDC generates both aqueous and solid wastes. K123 includes a collection of aqueous wastes which are formed from any of the following operations: (1) separation of the aqueous supernatant generated after precipitation of the insoluble EBDC product (formed as either a transition metal salt and/or thiuramsulfide); (2) concentration of this aqueous supernatant in the evaporator, resulting in the formation of an aqueous waste; and (3) washing of the product, also producing process wastewater. K124 is formed from the passage of reactor vent gases through a scrubber, typically generating a caustic aqueous waste. K125 consists of the purification solids formed from the evaporation of water from the mother liquor or from the filtration and centrifugation of the EBDC salt during wastewater treatment. K126 consists of dust and floor sweepings from milling and packaging operations.

5.1.2 Waste Characterization

Table 5-1 presents a summary of the available characterization data for K123, K124, K125, and K126. Data are presented for BDAT List constituents and other compounds that are believed to be present or have been detected in K123, K124, K125, and K126.

5.2 Applicable and Demonstrated Treatment Technologies

This section identifies the technologies that are applicable for the treatment of nonwastewater and wastewater forms of K123, K124, K125, and K126 and determines which of the applicable technologies can be considered demonstrated for the purpose of establishing BDAT.

To be applicable, a technology must theoretically be usable to treat the waste in question or to treat a waste that is similar, in terms of parameters that affect treatment selection. (Detailed descriptions of technologies that are applicable to listed hazardous wastes are provided in EPA's Treatment Technology Background Document (5).) To be demonstrated, a technology must be employed in full-scale operation for treatment of the waste in question or of a similar waste. Technologies available only at pilot-scale or bench-scale operations are not considered in identifying demonstrated technologies.

5.2.1 Applicable Treatment Technologies

Nonwastewaters

Since nonwastewater forms of K123, K124, K125, and K126 generally contain hazardous organic constituents at treatable concentrations, applicable treatment technologies include those that destroy or reduce the total amount of various organic compounds in the waste. The Agency has identified the following treatment technologies as applicable for these wastes:

- Chemical oxidation;
- Critical fluid extraction followed by incineration of the contaminated solvents;
- Distillation;
- Incineration (fluidized-bed, rotary kiln, and liquid injection);

- Solvent extraction followed by incineration or recycle of the extract; and
- Wet air oxidation.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and are described in more detail in Appendix A.

Wastewaters

Since wastewater forms of K123, K124, K125, and K126 may contain hazardous organic constituents at treatable concentrations, applicable treatment technologies include those that destroy or reduce the total amount of various organic compounds in the waste. Therefore, the Agency has identified the following treatment technologies as potentially applicable for treatment of these wastes:

- Biological treatment;
- Carbon adsorption;
- Chemical oxidation;
- Distillation;
- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- Solvent extraction followed by incineration or recycle of the extract;
- Steam stripping; and
- Wet air oxidation.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and have been described in more detail in Appendix A.

The concentrations and type(s) of constituents present in the waste generally determine which technology is most applicable. Carbon adsorption, for example, is often used as a polishing step following primary treatment by biological treatment, solvent extraction, or wet air oxidation. Typically, carbon adsorption is applicable for treatment of wastewaters containing total organic constituent concentrations of less than 0.1%. Wet air oxidation, biological treatment, and solvent extraction (followed by incineration or recycle of the extract) are applicable for treatment of wastewaters containing organic constituents at concentrations of up to 1%.

5.2.2 Demonstrated Treatment Technologies

This section identifies those applicable treatment technologies that EPA considers to be demonstrated for the purpose of establishing BDAT for K123, K124, K125, and K126.

Nonwastewaters

The Agency believes that incineration is a demonstrated technology for the treatment of nonwastewater forms of K123, K124, K125, and K126. For the land disposal restrictions program, the Agency has tested rotary kiln incineration on a full-scale operational basis for many organic waste constituents including:

Aromatic and other Hydrocarbon Wastes

Toluene

Brominated Organic Wastes

1,2-Dibromoethane (ethylene dibromide)

Halogenated Aliphatic Wastes

Bis(2-chloroethyl)ether
1,1-Dichloroethane

1,1,1-Trichloroethane
1,2,4-Trichlorobenzene

Halogenated Pesticide and Chlorobenzene Wastes

Hexachlorocyclopentadiene
Chlordane
Heptachlor
Chlorobenzene
1,2-Dichlorobenzene
1,4-Dichlorobenzene
Hexachlorobenzene
Pentachlorobenzene
Pentachloronitrobenzene
1,2,4,5-Tetrachlorobenzene
2,4-Dichlorophenoxyacetic acid
Methoxychlor
Hexachlorobutadiene

Oxygenated Hydrocarbon and Heterocyclic U and P Wastes

Acetone
Ethyl acetate
Methyl ethyl ketone
Methyl isobutyl ketone
1,4-Naphthoquinone

Wastes of a Pharmaceutical Nature

Isosafrole

Phenolic Wastes

2-sec-Butyl-4,6-dinitrophenol (Dinoseb)
o-Cresol
p-Cresol
Phenol

Polynuclear Aromatic Wastes

Benzo(a)pyrene
Chrysene
Indeno(1,2,3-cd)pyrene
Benz(a)anthracene

Fluoranthene
Naphthalene

Organo-Nitrogen Compound Wastes

Acetonitrile
Acrylonitrile
Aniline
Nitrobenzene
Pyridine

Miscellaneous Halogenated Organic Wastes

Chloromethane
Dichlorodifluoromethane
Vinyl chloride
Bis(2-chloroethyl)ether
3,3'-Dichlorobenzidine
Pronamide

The Agency believes that because incineration is demonstrated for the treatment of many organic waste constituents, including those which are structurally similar to the constituents found in K123, K124, K125, and K126, it is also demonstrated for these wastes. The Agency is not aware of any facilities that treat these wastes by fuel substitution and the Agency believes that fuel substitution is in appropriate for wastes such as K123, K124, K125, and K126 that contain many constituents with molecular components other than carbon, hydrogen, and oxygen. Thus, the Agency believes that fuel substitution is not a demonstrated technology for these wastes.

From review of the 1986 TSDR Survey (6) and the USEPA's Water Engineering Research Laboratory (WERL) database (7), the Agency has determined that some facilities also treat nonwastewater forms of aromatic and polynuclear aromatic wastes or wastes judged to be similar to K123, K124, K125, and K126 using wet air oxidation, chemical oxidation, and distillation on a full-scale operational basis. Therefore, EPA considers these technologies to be demonstrated for aromatic and polynuclear aromatic wastes such as K123, K124, K125, and K126.

The Agency is not aware of any facilities that treat nonwastewater forms of these wastes or wastes judged to be similar on a full-scale operational basis using solvent extraction (followed by incineration or recycle of the extract) or critical fluid extraction (followed by incineration of the contaminated solvents); therefore, EPA believes that these technologies are not currently demonstrated for these wastes.

<u>Wastewaters</u>

The following technologies have been identified as demonstrated for treatment of the following types of organic wastes (organized by chemical structure):

<u>Aromatic and Other Hydrocarbon Wastes</u>

Incineration
Biological Treatment
Carbon Adsorption
Wet Air Oxidation
Chemical Oxidation
Steam Stripping

<u>Brominated Organic Wastes</u>

Biological Treatment

<u>Halogenated Aliphatic Wastes</u>

Incineration
Wet Air Oxidation
Chemical Oxidation
Biological Treatment
Carbon Adsorption
Solvent Extraction
Distillation
Steam Stripping

Halogenated Pesticide and Chlorobenzene Wastes

Biological Treatment
Wet Air Oxidation
Steam Stripping
Carbon Adsorption

Oxygenated Hydrocarbon and Heterocyclic Wastes

Biological Treatment
Carbon Adsorption
Steam Stripping
Wet Air Oxidation

Wastes of a Pharmaceutical Nature

Wet Air Oxidation

Phenolic Wastes

Wet Air Oxidation
Carbon Adsorption
Biological Treatment
Chemical Oxidation
Solvent Extraction
Steam Stripping

Polynuclear Aromatic Wastes

Incineration
Biological Treatment
Carbon Adsorption
Wet Air Oxidation
Chemical Oxidation
Steam Stripping

Organo-Nitrogen Compound Wastes

Biological Treatment
Carbon Adsorption
Steam Stripping
Wet Air Oxidation
Solvent Extraction

Miscellaneous Halogenated Organic Wastes

Biological Treatment
Steam Stripping
Carbon Adsorption
Solvent Extraction followed by Steam Stripping followed by Carbon Adsorption
Chemical Oxidation
Wet Air Oxidation

The Agency is not aware of any facilities that incinerate wastewater forms of some of the waste groups. However, commenters responding to the Second Third proposed rule indicated that they were incinerating many wastewaters and that they did not want to be precluded from doing so. In addition, the Agency has conducted incineration tests which demonstrate that incineration is an effective treatment technology for a wide variety of organic compounds, including halogenated and nonhalogenated organic compounds and pesticides. EPA's evidence that incineration constitutes significant treatment for these compounds is based on these compounds being quantified at or near their detection limits in the ash and scrubber water from these tests. The chemical structures and physical properties of these compounds are similar to those of the compounds in K123, K124, K125, and K126. Since incineration is demonstrated for treatment of organic waste constituents in nonwastewater forms of K123, K124, K125, and K126 as discussed above, the Agency believes incineration is also demonstrated for these waste constituents in wastewater forms of these wastes. Therefore, the Agency also identifies incineration as a demonstrated technology for wastewater forms of K123, K124, K125, and K126.

Based on engineering judgment, the Agency considers the following technologies to be demonstrated for wastewater forms of K123, K124, K125, and K126:

- Biological treatment;
- Carbon adsorption;

- Chemical oxidation;
- Distillation;
- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- Solvent extraction followed by incineration or recycle of the extract;
- Steam stripping; and
- Wet air oxidation.

5.3 Identification of Best Demonstrated Available Technology (BDAT)

This section presents the Agency's rationale for determining the best demonstrated available technology (BDAT) for nonwastewater and wastewater forms of K123, K124, K125, and K126. The best demonstrated available technology is determined based on a thorough review of all the treatment data available on the waste of concern or wastes judged to be similar.

For a treatment technology to be identified as "best," the treatment performance data are screened to determine:

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

Following the identification of "best," the Agency determines whether the technology is "available." An available treatment technology is one that (1) is not a proprietary or patented process that cannot be purchased or licensed from the proprietor (i.e., it must be commercially available), and (2) substantially diminishes the toxicity of the waste or substantially reduces the likelihood of migration of hazardous constituents from the waste.

5.3.1 Nonwastewaters

As discussed previously, incineration is a demonstrated treatment technology for nonwastewater forms of K123, K124, K125, and K126.

The Agency obtained incinerator ash analytical data from the 14 BDAT treatment tests conducted at what EPA considers to be well-designed and well-operated hazardous waste incinerators. Strict quality assurance/quality control measures were employed to ensure the accuracy of the data, and since EPA was collecting these data to identify and characterize BDAT treatment technologies, appropriate performance variables, namely, U and P waste constituent concentrations in treated and untreated waste, were measured. The Agency has determined that due to the high temperatures, efficient mixing, and consistent residence times used at commercial hazardous waste incinerators, incineration processes are relatively indiscriminate in the destruction of organics. Therefore, based on the treatment performance data available, the Agency considers incineration to be the "best" technology for the treatment of nonwastewater forms of K123, K124, K125, and K126.

Incineration is a commercially available technology. Additionally, treatment performance data from the 14 BDAT incineration treatment tests show substantial treatment by incineration for organic waste constituents in nonwastewater forms of unquantifiable U wastes; therefore, incineration is considered an "available" treatment technology for K123, K124, K125, and K126 for the purpose of establishing BDAT.

Incineration has been determined to be BDAT for all of the nonwastewater organic constituents that cannot be quantified in hazardous waste matrices using current analytical methods, including those contained in nonwastewater forms of K123, K124, K125, and K126, based on similarities in chemical and physical properties.

5.3.2 Wastewaters

As discussed previously, incineration, wet air oxidation, biological treatment, carbon adsorption, solvent extraction followed by incineration or recycle of the extract, chemical oxidation, distillation, and steam stripping are all demonstrated technologies for the treatment of wastewater forms of K123, K124, K125, and K126.

The Agency believes that the best technologies for treating wastewater forms of K123, K124, K125, and K126 are those technologies that destroy the constituents found in these wastes. Steam stripping, solvent extraction followed by incineration or recycle of the extract, and distillation are technologies that remove the constituents from the wastewater stream; however, the waste constituents are not destroyed but are processed into a more concentrated waste stream, i.e., the condensate, extract, or bottom stream (or still bottoms). These waste streams typically require further treatment before disposal. As a result, the Agency does not consider steam stripping, solvent extraction, or distillation to be the best technologies for treating wastewater forms of the wastes covered in this subsection. The Agency realizes that biodegradation may provide effective treatment for these wastes. Nevertheless, since EPA has negligible data for the performance of biological treatment with similar wastes, EPA is not designating biological treatment as an acceptable treatment method for these wastes.

Because a technology removes waste constituents from the waste stream to be land disposed, but does not destroy them, does not necessarily preclude it from being considered "best". As discussed below, carbon adsorption is being established as part of the chemical oxidation treatment train. The purpose of the carbon adsorption step as part of this treatment train is to remove organic by-products resulting from the oxidation of waste constituents. Carbon adsorption was selected for this removal step over steam stripping, solvent extraction, and distillation because the Agency believes that carbon adsorption is the most appropriate removal technology for the widest range of organic compounds likely to be present in the oxidation effluent stream.

Chemical oxidation provides treatment by oxidizing the organic constituents found in these wastes. However, to ensure effective treatment of these wastes, chemical oxidation treatment should include a final carbon adsorption or biological treatment step. Since these constituents are not quantifiable, it is not possible to accurately judge the effectiveness of the chemical oxidation step. Therefore, the Agency believes that it is sound engineering judgement to include a final step of carbon adsorption or biological treatment following oxidation. This step will ensure that these organic constituents and the oxidation by-products are removed from the wastewater matrix. (It should be noted that spent carbon from the treatment of these wastewaters would become a nonwastewater form of this waste (54 Federal Register 26630-1, June 23, 1989) and thus would be required to be incinerated to meet the applicable treatment standard.)

In cases where the Agency has treatment performance data for both wastewater treatment processes and incineration (as measured by total constituent concentration in scrubber water), the Agency prefers to establish treatment standards based on the wastewater treatment processes. However, the Agency has determined that wastewaters are also treated by incineration and does not intend to preclude industry from continuing this practice. Therefore, EPA is also identifying incineration as a best demonstrated technology for wastewater forms of these wastes.

Treatment performance data included in Volume A of the F039 Background Document (16) indicated substantial treatment of organic constituents by chemical oxidation, carbon adsorption, and biological treatment. In addition, these technologies are commercially available. Therefore, these technologies are considered to be "available" treatment technologies for the purpose of establishing BDAT. As discussed in Section 5.3.1, incineration is also an "available" treatment technology for treatment of these wastes.

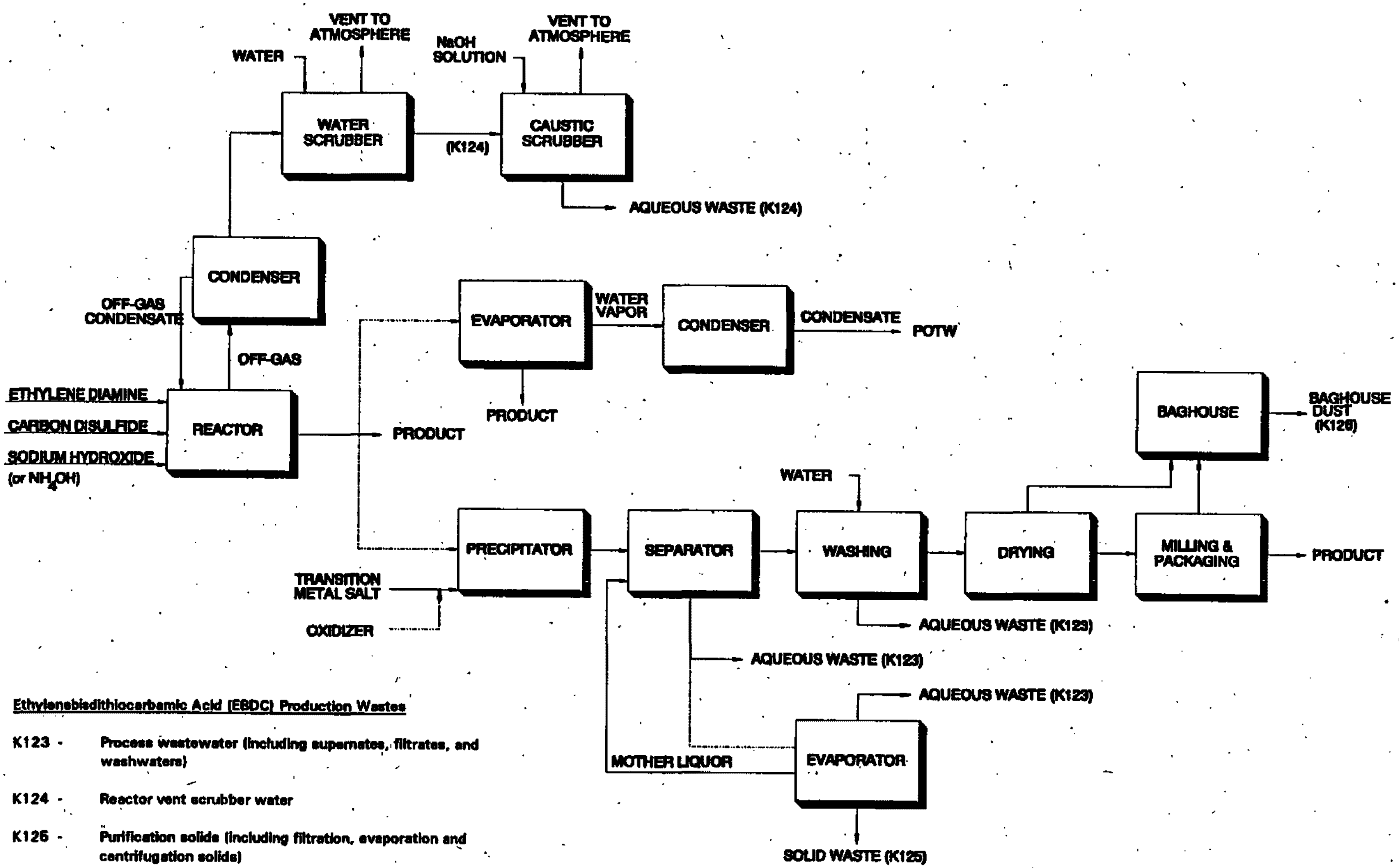
Based on the above discussion, EPA is promulgating the following methods of treatment as treatment standards for organic constituents that are not quantifiable in wastewater forms of K123, K124, K125, and K126: (1) incineration, (2) chemical oxidation followed by carbon adsorption, and (3) chemical oxidation followed by biological treatment. The Agency believes that these standards will ensure effective treatment (removal and destruction) of the constituents of concern.

Table 5-1

Summary of Available Characterization Data for K123, K124, K125, and K126

BDAT List Constituents	Concentration in Untreated Waste (%)			
	K123	K124	K125	K126
Zinc	NA	NA	CBI	NA
Other Constituents				
Ethylene thiourea	CBI	CBI	CBI	CBI
Ethylenebisisothiocyanate	CBI	NA	NA	CBI
Sodium hydroxide	NA	<50	NA	NA
Ethylenebisdithiocarbamate	NA	NA	CBI	NA

CBI - Confidential Business Information
NA - Not analyzed



Ethylenebisdithiocarbamic Acid (EBDC) Production Wastes

K123 - Process wastewater (including supernates, filtrates, and washwaters)

K124 - Reactor vent scrubber water

K125 - Purification solids (including filtration, evaporation and centrifugation solids)

K126 - Baghouse dust and floor sweepings in milling and packaging operations

Figure 5-1. EBDC ction Process

6.0 METHYL BROMIDE PRODUCTION WASTES (K131, K132)

This section describes the Agency's approach in establishing BDAT treatment standards for K131 and K132. This includes a description of the industry affected by the land disposal restrictions for methyl bromide production wastes, a presentation of available waste characterization data, and a discussion of the Agency's rationale in determining BDAT treatment standards for these wastes.

Under 40 CFR 261.32 (hazardous wastes from specific sources), wastes identified as K131 are listed as wastewater from the reactor and spent sulfuric acid from the acid dryer from the production of methyl bromide. K132 wastes are listed as spent absorbent and wastewater separator solids from the production of methyl bromide.

6.1 Industry Affected and Waste Characterization

This section describes the industry affected by the land disposal restrictions for K131 and K132 and presents available characterization data for these wastes.

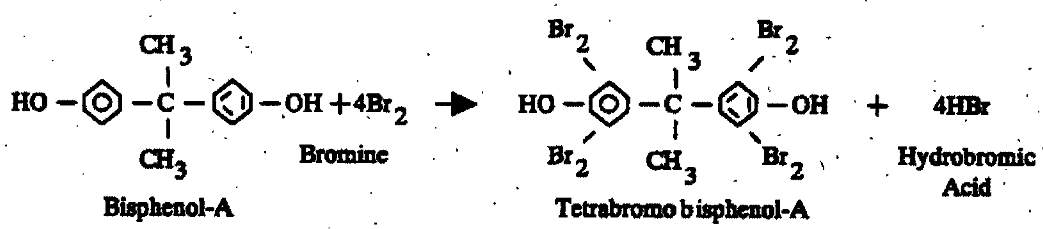
6.1.1 Industry Affected and Process Description

To the Agency's knowledge, two domestic facilities produce and purify methyl bromide and may potentially generate K131 and K132. The facilities are Ethyl Corporation, located in Magnolia, AR, and Great Lakes Chemical, located in El Dorado, AR. Both facilities are located in EPA Region VI. These facilities were identified using the 1990 SRI Directory of Chemical Producers (3) and data collected during EPA's listing efforts for K131 and K132 (16).

Methyl bromide is used mainly as a soil and space fumigant. Other uses for methyl bromide are as a methylating agent in organic synthesis, as a fire extinguisher for airplane engines, in ionization chambers, as a wool degreaser, and for extracting oils from nuts, seeds, and flowers.

Methyl bromide (CH_3Br) can be produced by two reaction sequences. In the first sequence, bisphenol-A (BPA) is dissolved in methanol (CH_3OH) and bromine (Br_2) is added to the solution. Stoichiometry requires that four moles of bromine be used per each mole of bisphenol-A reacted. A slight excess of bromine is generally used to ensure complete bromination. The reaction results in the production of tetrabromobisphenol-A (TBBPA) and hydrobromic acid. Hydrobromic acid then is methylated to produce methyl bromide. Methyl bromide is volatile, distills out of the reactor, and is then purified as discussed below. The reactions are as follows:

Reaction 1:



Reaction 2:

$$4HBr + HCH_3OH \longrightarrow 4CH_3Br + 4H_2O$$

Hydrobromic Acid | Methanol | Methyl Bromide | Water

A typical process flow diagram for production of methyl bromide by this process is shown in Figure 6-1. The feedstocks, bisphenol-A, methanol, and bromine are added to the reactor. Water is added to the reactor to precipitate TBBPA, which is removed by centrifugation. The gaseous methyl bromide product is vented from the reactor and may be condensed or scrubbed with an alkali solution, such as sodium hydroxide (NaOH) or sodium carbonate (Na_2CO_3) to neutralize residual hydrobromic acid. The unreacted methanol and brine, which contains bromine, are recycled to the reactor.

The crude product is then washed with sulfuric acid to dry the methyl bromide and then may be condensed (12). The acid dryer generates a corrosive spent sulfuric acid effluent (K131). To further purify the product, the methyl bromide may be passed over an absorbent solid to remove impurities. A spent solid absorbent is generated (K132) if this additional purification process is used.

The second methyl bromide production sequence utilized industrially produces only methyl bromide. As in the first sequence, methyl bromide is produced by reacting liquid methanol with liquid hydrobromic acid. Hydrobromic acid is commonly produced <u>in-situ</u> by reacting either sulfur (S) or sulfur dioxide (SO_2) with bromine and water (H_2O) (12). Sulfuric acid (H_2SO_4) is produced as a by-product of these reactions as follows:

$$S + 3Br_2 + 4H_2O \longrightarrow 6HBr + H_2SO_4$$
$$SO_2 + Br_2 + 2H_2O \longrightarrow 2HBr + H_2SO_4$$

Hydrobromic acid then reacts with methanol to form methyl bromide and water:

$$CH_3OH + HBr \longrightarrow CH_3Br + H_2O$$

The overall reactions are:

$$S + 3Br_2 + 6CH_3OH \longrightarrow 6CH_3Br + H_2SO_4 + 2H_2O$$
$$SO_2 + Br_2 + 2CH_3OH \longrightarrow 2CH_3Br + H_2SO_4$$

The yield of methyl bromide by this sequence is approximately 90-95%.

In both the reactor and the acid dryer, sulfuric acid can react with methanol in two side reactions to produce methyl hydrogen sulfate (CH_3SO_4H) and dimethyl sulfate ($CH_3SO_4CH_3$), as follows:

$$CH_3OH + H_2SO_4 \text{ -------> } CH_3SO_4H + H_2O$$

$$CH_3OH + CH_3SO_4H \text{ ------> } CH_3SO_4CH_3 + H_2O$$

If the sulfur is used as a feedstock and the co-product TBBPA is not produced, the wastewater from the reactor is K131 and is discharged. The crude product is then contacted with sulfuric acid to dry the methyl bromide by absorbing water. The acid dryer will also generate a corrosive spent sulfuric acid effluent identified as K131.

6.1.2 Waste Characterization

Table 6-1 presents a summary of the available characterization data for K131 and K132. Data are presented for BDAT List constituents and other compounds that are believed to be present in or were quantified in K131 and K132.

6.2 Applicable and Demonstrated Treatment Technologies

This section identifies the technologies that are applicable for the treatment of nonwastewater and wastewater forms of K131 and K132 and determines which of the applicable technologies can be considered demonstrated for the purpose of establishing BDAT.

To be applicable, a technology must theoretically be usable to treat the waste in question or to treat a waste that is similar in terms of parameters that affect treatment selection. (Detailed descriptions of technologies that are applicable to listed hazardous wastes are provided in EPA's Treatment Technology Background Document (5).) To be demonstrated, a technology must be employed in full-scale operation for treatment of the waste in question or of a similar waste. Technologies available only at pilot-scale or bench-scale operations are not considered in identifying demonstrated technologies.

6.2.1 Applicable Treatment Technologies

Nonwastewaters

Since nonwastewater forms of K131 and K132 may contain hazardous organic constituents at treatable concentrations, applicable treatment technologies include those that destroy or reduce the total amount of various organic compounds in the waste. The Agency has identified the following treatment technologies as applicable for these wastes:

- Critical fluid extraction followed by incineration of the contaminated solvents;
- Incineration (fluidized-bed, rotary kiln, and liquid injection); and
- Solvent extraction followed by incineration or recycle of the extract.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and are described in more detail in Appendix A.

Wastewaters

Since wastewater forms of K131 and K132 may contain hazardous organic constituents at treatable concentrations, applicable technologies include those that destroy or reduce the total amount of various organic compounds in the wastewater. Therefore, the Agency has identified the following treatment technologies as potentially applicable for treatment of these wastes:

- Biological treatment;
- Carbon adsorption;
- Chemical oxidation;

- Chemically assisted clarification;

- PACT® treatment (including powdered activated carbon addition to activated sludge and biological granular activated carbon technologies);

- Reverse osmosis;

- Solvent extraction;

- Stripping treatment (including steam stripping and air stripping technologies); and

- Wet air oxidation.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and are described in more detail in Appendix A.

The concentrations and type(s) of constituents present in the waste generally determine which technology is most applicable. Carbon adsorption, for example, is often used as a polishing step following primary treatment by biological treatment, solvent extraction, or oxidation. Typically, carbon adsorption is applicable for treatment of wastewaters containing total organic constituent concentrations less than 0.1%. Wet air oxidation, PACT® treatment, biological treatment, and solvent extraction are applicable for treatment of wastewaters containing organic constituents at concentrations of up to 1%.

6.2.2 Demonstrated Treatment Technologies

This section identifies those applicable treatment technologies that EPA considers to be demonstrated for the purpose of establishing BDAT for K131 and K132.

Nonwastewaters

The Agency believes that incineration is a demonstrated technology for the treatment of nonwastewater forms of K131 and K132. This is based on the belief that nonwastewater and wastewater forms of K131 and K132 are chemically similar to ethylene dibromide (EDB). For the land disposal restrictions program, the Agency conducted an EDB incineration test on a full-scale operational basis. The Agency believes that since incineration is demonstrated for treatment of EDB, treatment is therefore demonstrated for similar brominated organic waste constituents. Analytical data and complete discussions of the test methods used are available in the corresponding on-site engineering report (OER) for the EDB incineration test (13).

The Agency is not aware of any facilities that treat the nonwastewater forms of brominated organic wastes or wastes judged to be similar by fuel substitution; therefore, the Agency believes that fuel substitution is not currently demonstrated for these wastes. The Agency is also not aware of any facilities that treat nonwastewater forms of the brominated organic wastes or wastes judged to be similar using solvent extraction or critical fluid extraction on a full-scale operational basis; therefore, EPA believes that these technologies are not currently demonstrated for these wastes.

Wastewaters

The Agency has identified biological treatment, air/steam stripping, reverse osmosis, chemically assisted clarification and carbon adsorption as demonstrated technologies for the treatment of organic constituents in wastewater forms of K131 and K132. These technologies have been identified as providing treatment on a full-scale operational basis for methyl bromide and other brominated compounds.

Analytical data and additional discussions of the constituents expected to be found in K131 and K132 are presented in Section 6.3.

The Agency is not aware of any facilities that treat wastewater forms of brominated organic wastes by PACT®, solvent extraction, chemical oxidation, or wet air oxidation; therefore, the Agency believes that these technologies are not currently demonstrated for these wastes.

6.3 Treatment Performance Data

The Agency does not have treatment performance data for treatment of nonwastewater and wastewater forms of K131 and K132. Therefore, treatment performance data were transferred from other previously tested wastes to develop concentration-based treatment standards for these wastes.

EPA's methodology for transfer of treatment performance data is provided in EPA's Methodology for Developing BDAT Treatment Standards (1). Transfer of treatment performance data is technically valid in cases where the untested waste is generated from a similar industry or similar processing step, or has similar waste characteristics affecting treatment performance and treatment selection as the tested wastes. Sources of treatment performance data for potential transfer to nonwastewater forms of K131 and K132 include wastes previously tested by rotary kiln, fluidized-bed, or liquid injection incineration and identified in EPA's Volume C of the F039 Background Document (10). Sources of treatment performance data for potential transfer to wastewater forms of K131 and K132 include those wastes and technologies identified in EPA's Volume A of the F039 Background Document (8).

6.3.1 Treatment of Organic Constituents in Nonwastewaters

Wastes previously tested by the Agency by rotary kiln, fluidized-bed, or liquid injection incineration include: D014, D016, K001, K011, K013, K014, K015, K019, K024, K037, K048, K051, K087, K101, K102, P020, P059, U028, U080, U122, U127, U141, U161, U166, U188, U192, U220, U226, and U239.

In addition, the Agency is aware of several facilities that currently incinerate bromine-containing wastes. At Rollins Environmental Services, Deer Park, Texas, the Agency has previously incinerated ethylene dibromide wastes that were cancelled pesticides under FIFRA provisions. Excess oxygen conditions were carefully controlled to reduce the amount of bromide gas and to increase the amount of hydrogen bromine gas generated by incineration. Hydrogen bromine is readily absorbed by the air pollution control devices (APCDs), while bromine is difficult to remove by APCDs. The Agency believes that control of the undesirable conversion of the bromine-containing waste to bromine gas significantly affects the design and operation of the incineration systems. For these reasons, the Agency does not believe that transfer of treatment performance data from incineration of the non-brominated wastes listed in previous sections of this document is technically valid for the purpose of developing concentration-based treatment standards for brominated constituents in organic wastes.

Therefore, treatment performance data from the EDB incineration test were used to develop treatment standards for methyl bromide in K131 and K132. Treatment performance data from the EDB incineration test for the untreated waste feed and incinerator ash treatment residual are included in Table 6-2. Design data for the treatment systems used for the ethylene dibromide incineration test are included in Table 6-3.

6.3.2 Treatment of Organic Constituents in Wastewaters

Treatment standards for organic BDAT List constituents in these wastewaters were developed from treatment performance data transferred from EPA's Volume A of the F039 Background Document (8). These data were used for transfer to wastewater forms of K131 and K132 because the Agency prefers, whenever possible, to use appropriate treatment performance data from well-designed and well-operated wastewater treatment units, rather than scrubber water concentration data, in setting

BDAT treatment standards. These data represent treatment using a specific wastewater treatment technology as opposed to scrubber water.

Table 6-4 presents the available treatment performance data for methyl bromide. The data used to determine the BDAT treatment standard are shown with an asterisk.

Presented below are short descriptions of the data sources for wastewater treatment performance data on methyl bromide and the Agency's rationale for determining which data set was used in the development of the treatment standard.

<u>**Sources of Treatment Performance Data**</u>

This section describes each of the sources of wastewater treatment performance data used to compile data for the determination of treatment standards.

NPDES Database. Under the Clean Water Act, the discharge of pollutants into the waters of the United States is prohibited unless a permit is issued by EPA or a state under the National Pollutant Discharge Elimination System (NPDES). An NPDES permit provides effluent limitations for specific pollutants that a facility can discharge. The permit also provides for monitoring and reporting requirements by a facility to check whether the effluent limitations are being met. The monitoring data submitted by facilities to EPA or the state as part of the NPDES permit program is summarized in a database.

The NPDES database was searched for 90 BDAT List constituents to identify facilities that have monitoring data for any of those constituents. Constituent data from this search, representing concentrations of constituents in wastewater effluents, have been incorporated into the tables of this section. EPA was unable to evaluate whether substantial treatment occurred since corresponding influent concentrations of the constituents were unavailable. The treatment technologies or treatment trains represented by the NPDES data were identified in some, but not all cases. Where available, the treatment technology has been specified in the tables of this section.

WERL Database. U.S. EPA's Risk Reduction Engineering Laboratory, which now includes the former Water Engineering Research Laboratory (WERL), has developed and is continuing to expand a database on the treatability of chemicals in various types of waters and wastewaters. This WERL database has been compiled from wastewater treatment performance data available in literature. The treatment performance data for BDAT List constituents in this database have been included in the tables of this section.

Treatment Performance Data

Methyl Bromide. The data for methyl bromide were compiled from the WERL and NPDES databases and are presented in Table 6-4. Technologies for which data are available include AS and BT. The treatment performance data represent full-scale technologies and result in an effluent concentration range of 1 ppb to 20 ppb.

The Agency is establishing activated sludge biological treatment (AS) as BDAT for methyl bromide. Activated sludge was selected as BDAT because the available data show high influent concentrations and a high removal efficiency. The BDAT treatment standard for methyl bromide was calculated using the effluent concentration of 20 ppb and the appropriate variability factor. The calculation of the resulting BDAT treatment standard for methyl bromide (0.11 ppm) is described in Section 6.6 and is shown in Table 6-5.

6.4 Identification of Best Demonstrated Available Technology (BDAT)

This section presents the Agency's rationale for determining the best demonstrated available technology (BDAT) for nonwastewater and wastewater forms of K131 and K132.

EPA determines the best demonstrated available technology based on a thorough review of all of the treatment performance data available for the waste of concern or wastes judged to be similar. Following the identification of "best," the Agency determines whether the technology is "available." An available treatment technology is one that (1) is not a proprietary or patented process that cannot be purchased or licensed from the proprietor (i.e., it must be commercially available), and (2) substantially diminishes the toxicity of the waste or substantially reduces the likelihood of migration of hazardous constituents from the waste.

6.4.1 Nonwastewaters

The treatment performance data that were evaluated to determine BDAT treatment standards for the nonwastewater forms of K131 and K132 are presented in Section 6.3 The treatment performance data were screened to determine:

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

EPA has identified incineration as demonstrated for the treatment of organic constituents in nonwastewater forms of K131 and K132. EPA has treatment performance data from the incineration of constituents included in each group of wastes.

All of the incineration data included in Section 4.3 represent BDAT for wastes included in previous rulemakings and therefore have already met the above conditions. Thus, incineration is the "best" technology for treating organic nonwastewater forms of these wastes in each group of wastes.

Incineration, identified as the "best" technology for these organic wastes, is commercially available. Treatment performance data included in Section 6.3 show substantial treatment by incineration for waste constituents of concern and other similar constituents. Because incineration is applicable, demonstrated, and "available," it is therefore being established as BDAT for treatment of the organic constituents in nonwastewater forms of K131 and K132.

6.4.2 Wastewaters

The treatment performance data that were evaluated to determine BDAT treatment standards for wastewater forms of K131 and K132 were presented in Section 6.3. The methodology used in determining the "best" technology for treatment of wastewater constituents that are included in K131 and K132 was that for any constituent without EAD data, BDAT wastewater treatment test data, or industry-submitted leachate treatment performance data showing substantial treatment, and other available treatment performance data were evaluated to determine BDAT and were used to calculate the BDAT concentration-based treatment standard. Considered in this evaluation were the treatment technology for which data were available, whether the data represented a full-scale, pilot-scale, or bench-scale technology, the concentration of the constituent of concern in the influent to treatment, the average concentration of the constituent of concern in the effluent from treatment, and the removal efficiency of the treatment technology. Full-scale treatment data with an influent concentration range greater than 100 ppb were preferred over pilot-scale or bench-scale data and preferred over data with a low (i.e., 0-100 ppb) influent concentration range. If several sets of data met these criteria (i.e., full-scale available technologies with high influent concentrations), they were compared by examination of their average effluent values and percent removals.

EPA has identified biological treatment as the "best" demonstrated technology for wastewater forms of K131 and K132. Biological treatment is commercially available and the treatment performance data included in Section 6.3 show substantial treatment of methyl bromide by this technology. Therefore, biological treatment is also considered to be available and is being promulgated as BDAT.

6.5 Selection of Regulated Constituents

The Agency has developed a list of hazardous constituents (the BDAT Constituent List, presented in EPA's Methodology for Developing BDAT Treatment Standards (1)) from which constituents are selected for regulation. EPA may revise this list as additional data and information become available. The list is divided into the following categories: volatile organics, semivolatile organics, metals, inorganics other than metals, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorus insecticides, polychlorinated biphenyls (PCBs), and dioxins and furans. This section presents EPA's methodology and rationale for selection of constituents for regulation in nonwastewater and forms of K131 and K132.

Generally, constituents selected for regulation must satisfy the following criteria:

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

2. <u>The constituent must be present in, or be suspected of being present in, the untreated waste.</u> For example, analytical difficulties may prevent a constituent from being identified in the untreated waste, but its identification residual may lead the Agency to conclude that it is present in the untreated waste.

From a group of constituents that may be selected for regulation because they meet the above criteria, EPA may select a subset of constituents that represents the broader group. For example, from a group of constituents that react similarly to treatment, the Agency may select for regulation those constituents that (1) are the most difficult to treat, based on waste characteristics affecting treatment performance; (2) are representative of other constituents in the waste, based on structural similarities; or (3) are present in the untreated waste in the highest concentrations. Selecting a subset of constituents for regulation facilitates implementation of industry compliance and of EPA's enforcement program.

The Agency initially considered all constituents on the BDAT List for regulation in K131 and K132. Table 6-1 summarizes the constituents believed to be present in these wastes. Two BDAT List constituents have been identified in K131 and K132, methyl bromide and methanol. The Agency has selected methyl bromide for regulation in nonwastewater and wastewater forms of K131 and K132. The Agency has not selected methanol for regulation due to concerns regarding the accurate quantitation of this constituent.

6.6 Calculation of BDAT Treatment Standards

The Agency bases concentration-based treatment standards on the performance of well-designed and well-operated treatment systems. These standards account for analytical limitations in available treatment performance data and for variabilities related to treatment, sampling, and analytical techniques and procedures.

This section presents the treatment standards calculated for methyl bromide using the available treatment performance data discussed in Section 6.3.

6.6.1 Nonwastewaters

Treatment standards for regulated constituents in nonwastewater forms of K131 and K132 were calculated based on data compiled from the BDAT incineration database for incinerator ash. Specifically, detection limit data from the Agency's ethylene dibromide incineration test were transferred for use in calculating the BDAT treatment standards for methyl bromide in nonwastewater forms of K131 and K132. This transfer is justified by the Agency's belief that methyl bromide is structurally similar to EDB.

The concentration-based treatment standard for methyl bromide was calculated by multiplying the detection limit for ethylene dibromide in ash by an accuracy correction factor and a variability factor. The following subsections discuss these three components of the treatment standard calculation. This calculation is summarized in Table 6-5.

<u>Detection Limits</u>

The detection limit for ethylene dibromide in ash was transferred to methyl bromide to calculate the treatment standard for nonwastewater forms of K131 and K132.

<u>Accuracy Correction Factors</u>

The detection limit used to calculate the treatment standard for methyl bromide was corrected using matrix spike recovery data from the same test from which the detection limit was taken to account for analytical interferences associated with the chemical matrices of the samples. The detection limit was corrected for accuracy as follows:

- A matrix spike recovery was determined for the regulated constituent. In cases where a matrix spike was not performed for a regulated constituent in the treatment test from which the detection limit was taken, the matrix spike recovery from a similar constituent from that treatment test was transferred to the constituent.

- An accuracy correction factor was determined for the constituent by dividing 100 by the matrix spike recovery (expressed as a percentage) for that constituent.

- The detection limit was then corrected by multiplying by the corresponding accuracy correction factor. The accuracy corrected detection limit for ethylene dibromide (and transferred to methyl bromide) is shown on Table 6-5.

The matrix spike recovery used to adjust the detection limit for methyl bromide in nonwastewater forms of K131 and K132 is included in Appendix B. Duplicate matrix spikes were performed for some waste constituents. If a duplicate matrix spike was performed for a constituent, the matrix spike recovery used for that constituent was the lower of the two values between the first matrix spike and the duplicate spike. Matrix spike recoveries of less than 20% are not acceptable and were not used to correct detection limits. Matrix spike recoveries greater than 100% were considered to be 100% for the purpose of this calculation so that the data were not adjusted to concentrations below the detection limits.

Variability Factors

The variability factor accounts for the variability inherent in treatment system performance, treatment residual collection, and analysis of the treated waste samples. Variability factors could not be calculated for waste constituents that were not detected in the incinerator ash residuals. In these cases, a variability factor of 2.8 was used to account for this inherent variability, as discussed in the Methodology for Developing BDAT Treatment Standards (1).

6.6.2 Wastewaters

Treatment standards for wastewater forms of K131 and K132 were calculated based on data compiled from EPA's wastewater treatment performance database. Specifically, treatment performance data from biological treatment were used to calculate the BDAT treatment standard for methyl bromide in wastewater forms of K131 and K132.

The concentration-based treatment standard for methyl bromide was calculated by multiplying the constituent effluent concentration (as presented in Section 6.3) by an accuracy correction factor and a variability factor. The following subsections discuss these three components of the treatment standard calculation. The calculation for methyl bromide in wastewater forms of K131 and K132 is summarized in Table 6-5.

Constituent Effluent Concentration

The effluent concentration obtained using the BDAT for methyl bromide in K131 and K132 was determined as discussed in Section 6.3.2. The treatment performance data for methyl bromide are presented in Table 6-4.

Accuracy Correction Factors

Accuracy factors account for analytical interferences associated with the chemical matrices of the samples. An EAD variability factor was transferred for use in the calculation of the methyl bromide treatment standard. Based on the fact that EAD variability factors were originally calculated to represent performance, analytical, and matrix variations, an additional accuracy correction factor was not used.

Variability Factors

A variability factor (VF) accounts for the variability inherent in the treatment system performance, treatment residual collection, and analysis of the treated waste samples. Variability factors are calculated as described in EPA's Methodology for Developing BDAT Treatment Standards (1). However, original effluent data points were not available for methyl bromide in K131 and K132 since WERL effluent data were used to determine treatment standards and these data were presented as averages in the WERL database. Therefore, it was not possible to calculate an individual variability factor for this constituent; instead, an average variability factor was used. The average variability factors were generated from the EAD variability factors and are specific to the type of constituent under consideration (i.e., volatile organic, acid extractable semivolatile organic, etc.). The calculation of average variability factors is discussed in Appendix C.

Table 6-1

Summary of Available Characterization Data for K131 and K132

Constituents Believed to be Present in K131 and K132*
BDAT List Constituents
Methanol
Methyl Bromide
Other Constituents
Dimethyl Sulfate
Sulfuric Acid
Methyl Hydrogen Sulfate
Methyl Ether
Ethanol
Hydrobromic Acid

*All data for constituents believed to be present in K131 and K132 is classified as Confidential Business Information.

Table 6-2

Treatment Performance Data Collected by EPA from Incineration of Ethylene Dibromide (EDB) at Rollins Environmental Services, Inc. (Texas) - Incineration

BDAT List Constituent	Sample Set No.	Untreated Waste		Incineration Ash	
		Detection Limit (mg/kg)	Concentration of EDB (mg/kg)	Detection Limit (mg/kg)	EDB Concentration in Solids Discharge Stream (mg/kg)
1,2-Dibromoethane (Ethylene dibromide)	1	25,000	119,000	5	<5
	2	25,000	92,000	5	<5
	3	25,000	102,000	5	<5

Source: EDB Test Burn Progress Emissions Test Results (13).

Table 6-3

Design Parameters for the Incinerator System at Rollins Environmental Services, Inc. (Texas)

Physical Design Parameter	Value or Description
ROTARY KILN:	
Manufacturer	*
Height	NR
Inside diameter	9.5 feet
Length	32.8 feet
Volume	2,324 cubic feet
Width	NR
Materials of construction:	
Outer shell	1.18-inch steel plate with 9-inch refractory lining.
Front wall	0.59-inch steel plate with castable refractory and refractory brick lining.
LODDBY FURNACE:	
Manufacturer	*
Height	NR
Inside diameter	6.25 feet
Length	14 feet
Volume	429 cubic feet
Width	NR
AFTERBURNER:	
Manufacturer	*
Height	13.5 feet
Inside diameter	NR
Length	49 feet
Volume	8,300 cubic feet
Width	12.5 feet
Materials of construction:	
Outer shell	13-inch refractory bricks support by stainless steel clips attached to steel beams.
Ceiling	6-inc bricks.

NR - Not Reported
*This equipment was designed for RES(TX), Inc., and therefore does not carry a model number.

Source: EDB Test Burn Progress Emissions Test Results (13)

Table 6-4

Wastewater Treatment Performance Data for Methyl Bromide

Technology	Technology Size	Facility	Range Influent Concentration (ppb)	No. of Data Points	Average Effluent Concentration (ppb)	Removal (%)	Reference
		LA0066435		12	5.6		NPDES
		LA0066214		15	11.786		NPDES
		PA0011371		9	1.0		NPDES
		LA0065501		6	10.0		NPDES
		NJ0028291		2	1.0		NPDES
AS*	Full	1B	100-1,000	5	20.0	82	WERL*
AS*	Full	1B	100-1,000	2	20.0	82	WERL*
BT	Full	LA0038245		38	9.868		NPDES

AS - Activated Sludge
BT - Biological Treatment
NPDES - National Pollutant Discharge Elimination System Database
WERL - Water Engineering Research Laboratory Database
*Data used to develop treatment standard.

Table 6-5

Calculation of Nonwastewater and Wastewater Treatment Standards for K131 and K132

Regulated Constituent	Constituent From Which Treatment Performance Data Were Transferred	Detection Limit Effluent Concentration Accuracy Corrected	Variability Factor	Treatment Standard
Nonwastewaters				
Methyl Bromide	Ethylene Dibromide	5.41 mg/kg	2.8	15 mg/kg
Wastewaters				
Methyl Bromide	Methyl Bromide	0.020 mg/L	5.7*	0.11 mg/L

*The variability factor represents an EAD VF and, therefore, accounts for both variability and accuracy correction.

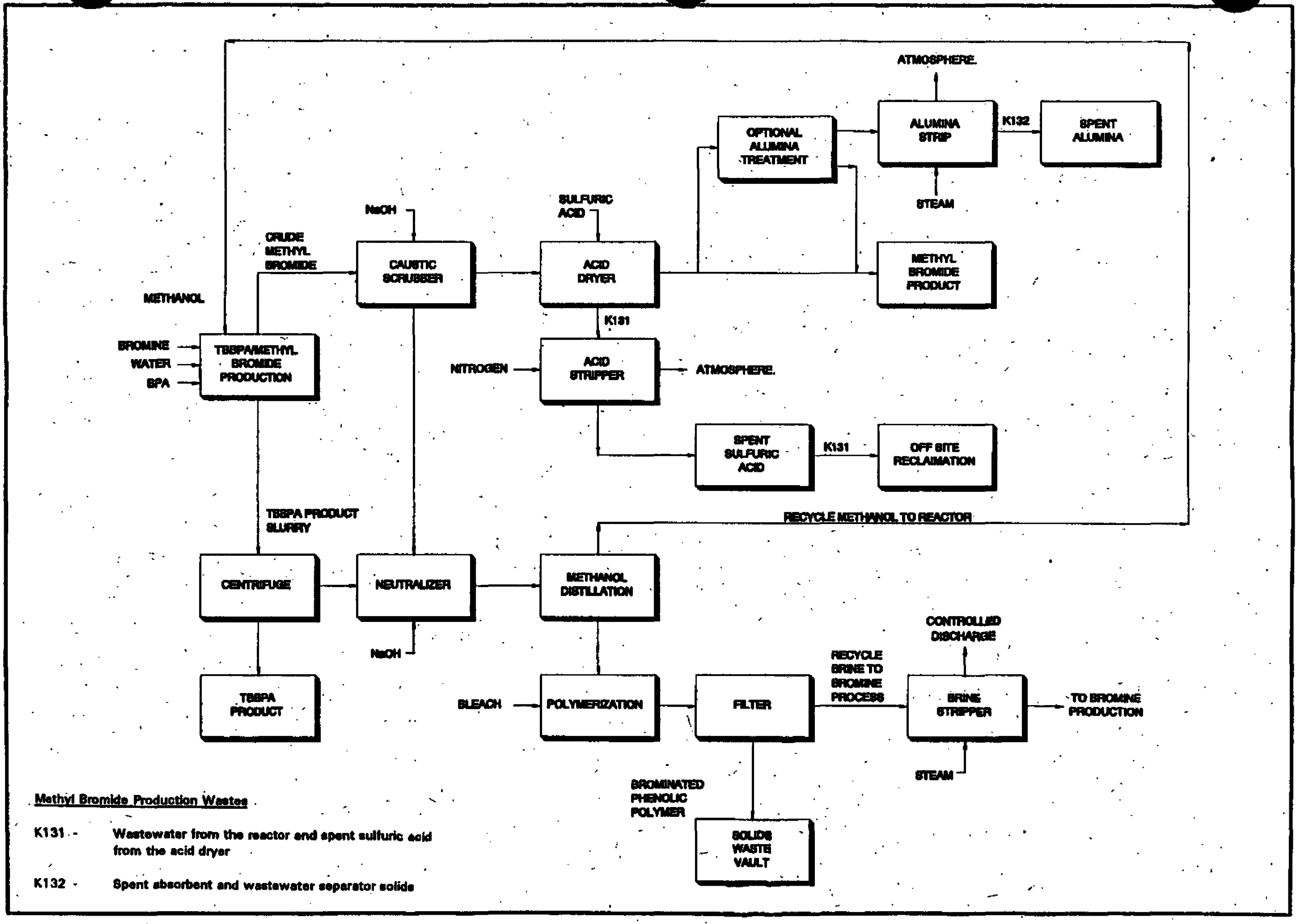


Figure 6-1. Methyl Bromide Production Process

7.0 2-ETHOXYETHANOL WASTE (U359)

This section describes the Agency's approach in establishing BDAT treatment standards for U359. This includes a description of the industry affected by the land disposal restrictions for 2-ethoxyethanol wastes, a presentation of available waste characterization data, and a discussion of the Agency's rationale in determining BDAT treatment standards for this waste.

7.1 Industry Affected and Waste Characterization

7.1.1 Industry Affected and Process Description

To the Agency's knowledge, three domestic facilities manufacture 2-ethoxyethanol and may potentially generate U359. Table 7-1 lists these facilities by state and EPA region. These facilities were identified using the 1990 SRI Directory of Chemical Producers (3) and data collected during EPA's listing efforts for U359 (17).

U359 consists of a commercial chemical product or manufacturing intermediate from a non-specific source containing 2-ethoxyethanol as the sole active ingredient. Commercial chemical products or manufacturing intermediates include all commercially pure grades of the listed chemical, all technical grades, and all formulated products in which the listed chemical is the sole active ingredient. Off-specification product containing 2-ethoxyethanol as the sole active ingredient is also included. Finally, any residue that remains in a container that contained 2-ethoxyethanol or inner liner removed from a container that contained 2-ethoxyethanol and that will not be recycled, reclaimed, or reused; or any residue or contaminated soil, water, or debris from a spill of 2-ethoxyethanol is also considered U359. U359 does not include manufacturing process wastes. A process waste occurs when a product is:

- Discarded or intended to be discarded;

- Mixed with another material and applied to the land for dust suppression or road treatment;
- Applied to land in lieu of its original intended use; or
- Distributed or burned as a fuel or fuel additive.

7.1.2 Waste Characterization

Table 7-2 presents a summary of the available characterization data for U359.

7.2 Applicable and Demonstrated Treatment Technologies

This section identifies the technologies that are applicable for the treatment of nonwastewater and wastewater forms of U359 and determines which of the applicable technologies can be considered demonstrated for the purpose of establishing BDAT.

To be applicable, a technology must theoretically be usable to treat the waste in question or to treat a waste that is similar, in terms of parameters that affect treatment selection. (Detailed descriptions of technologies that are applicable to listed hazardous wastes are provided in EPA's Treatment Technology Background Document (5).) To be demonstrated, a technology must be employed in full-scale operation for treatment of the waste in question or of a similar waste. Technologies available only at pilot-scale or bench-scale operations are not considered in identifying demonstrated technologies.

7.2.1 Applicable Treatment Technologies

<u>Nonwastewaters</u>

Since nonwastewater forms of U359 may contain hazardous organic constituents at treatable concentrations, applicable treatment technologies include those that destroy or reduce the total amount of various organic compounds in the waste. The Agency has identified the following treatment technologies as applicable for these wastes:

- Chemical oxidation;
- Critical fluid extraction followed by incineration of the contaminated solvents;
- Distillation;
- Fuel substitution;
- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- Solvent extraction followed by incineration or recycle of the extract; and
- Wet air oxidation.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and are described in more detail in Appendix A.

<u>Wastewaters</u>

Since wastewater forms of U359 may contain hazardous organic constituents at treatable concentrations, applicable technologies include those that destroy or reduce the total amount of various organic compounds in the waste.

Therefore, the Agency has identified the following treatment technologies as potentially applicable for treatment of these wastes:

- Biological treatment;
- Carbon adsorption;
- Chemical oxidation;
- Distillation;
- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- Solvent extraction followed by incineration or recycle of the extract;
- Steam stripping; and
- Wet air oxidation.

These treatment technologies were identified based on current waste treatment practices and engineering judgment and are described in more detail in Appendix A.

The concentrations and type(s) of constituents present in the waste generally determine which technology is most applicable. Carbon adsorption, for example, is often used as a polishing step following primary treatment by biological treatment, solvent extraction, or oxidation. Typically, carbon adsorption is applicable for treatment of wastewaters containing organic constituents at concentrations of less than 0.1%. Wet air oxidation, biological treatment, and solvent extraction (followed by incineration or recycle of the extract) are applicable for treatment of wastewaters containing organic constituents at concentrations of up to 1%.

7.2.2 Demonstrated Treatment Technologies

This section identifies those applicable treatment technologies that EPA considers to be demonstrated for the purpose of establishing BDAT for U359.

Nonwastewaters

The Agency believes that incineration is a demonstrated technology for the treatment of nonwastewater forms of U359. For the land disposal restrictions program, the Agency has tested rotary kiln incineration on a full-scale operational basis for many organic waste constituents including:

Aromatic and other Hydrocarbon Wastes

Toluene

Brominated Organic Wastes

Ethylene Dibromide

Halogenated Aliphatic Wastes

Bis(2-chloroethyl)ether
1,1-Dichloroethane
1,1,1-Trichloroethane
1,2,4-Trichlorobenzene

Halogenated Pesticide and Chlorobenzene Wastes

Hexachlorocyclopentadiene
Chlordane
Heptachlor
Chlorobenzene
1,2-Dichlorobenzene
1,4-Dichlorobenzene
Hexachlorobenzene
Pentachlorobenzene
Pentachloronitrobenzene
1,2,4,5-Tetrachlorobenzene
2,4-Dichlorophenoxyacetic acid
Methoxychlor
Hexachlorobutadiene

Oxygenated Hydrocarbon and Heterocyclic U and P Wastes

- Acetone
- Ethyl acetate
- Methyl ethyl ketone
- Methyl isobutyl ketone
- 1,4-Naphthoquinone

Wastes of a Pharmaceutical Nature

- Isosafrole

Phenolic Wastes

- 2-sec-Butyl-4,6-dinitrophenol (Dinoseb)
- o-Cresol
- p-Cresol
- Phenol

Polynuclear Aromatic Wastes

- Benzo(a)pyrene
- Chrysene
- Indeno(1,2,3-cd)pyrene
- Benz(a)anthracene
- Fluoranthene
- Naphthalene

Organo-Nitrogen Compound Wastes

- Acetonitrile
- Acrylonitrile
- Aniline
- Nitrobenzene
- Pyridine

Miscellaneous Halogenated Organic Wastes

- Chloromethane
- Dichlorodifluoromethane
- Vinyl chloride
- Bis(2-chloroethyl)ether
- 3,3'-Dichlorobenzidine
- Pronamide

In addition, current management practices for nonwastewater forms of U359 include incineration. One generator of U359 indicated that this waste was incinerated off site and another generator indicated that biological treatment sludges from the treatment of wastewater forms of U359 are also incinerated.

The Agency believes that because incineration is demonstrated for the treatment of many organic waste constituents, including those which are structurally similar to those constituents found in U359, that incineration is also demonstrated for U359. The Agency is not aware of any facilities that treat these wastes by fuel substitution. However, the Agency believes that fuel substitution is an appropriate technology for these wastes, particularly considering that 2-ethoxyethanol contains only carbon hydrogen, and oxygen in its molecular structure.

From review of the 1986 TSDR Survey (6) and the USEPA's Water Engineering Research Laboratory (WERL) database (7), the Agency has determined that some facilities also treat nonwastewater forms of aromatic and polynuclear aromatic wastes or wastes judged to be similar to U359 using wet air oxidation, chemical oxidation, and distillation on a full-scale operational basis. Therefore, EPA considers these technologies to be demonstrated for aromatic and polynuclear aromatic wastes such as U359.

The Agency is not aware of any facilities that treat nonwastewater forms of these wastes or wastes judged to be similar on a full-scale operational basis using solvent extraction (followed by incineration or recycle of the extract) or critical fluid extraction (followed by incineration of the contaminated solvents); therefore, EPA believes that these technologies are not currently demonstrated for these wastes.

Wastewaters

The following technologies have been identified as demonstrated for treatment of the following types of organic wastes (organized by chemical structure):

Aromatic and Other Hydrocarbon Wastes

Incineration
Biological Treatment
Carbon Adsorption
Wet Air Oxidation
Chemical Oxidation
Steam Stripping

Brominated Organic Wastes

Biological Treatment

Halogenated Aliphatic Wastes

Incineration
Wet Air Oxidation
Chemical Oxidation
Biological Treatment
Carbon Adsorption
Solvent Extraction
Distillation
Steam Stripping

Halogenated Pesticide and Chlorobenzene Wastes

Biological Treatment
Wet Air Oxidation
Steam Stripping
Carbon Adsorption

Oxygenated Hydrocarbon and Heterocyclic Wastes

Biological Treatment
Carbon Adsorption
Steam Stripping
Wet Air Oxidation

Wastes of a Pharmaceutical Nature

Wet Air Oxidation

Phenolic Wastes

Wet Air Oxidation
Carbon Adsorption
Biological Treatment
Chemical Oxidation
Solvent Extraction
Steam Stripping

Polynuclear Aromatic Wastes

Incineration
Biological Treatment
Carbon Adsorption
Wet Air Oxidation
Chemical Oxidation
Steam Stripping

Organo-Nitrogen Compound Wastes

Biological Treatment
Carbon Adsorption
Steam Stripping
Wet Air Oxidation
Solvent Extraction

Miscellaneous Halogenated Organic Wastes

Biological Treatment
Steam Stripping
Carbon Adsorption
Solvent Extraction followed by Steam Stripping followed by Carbon Adsorption
Chemical Oxidation
Wet Air Oxidation

The Agency is not aware of any facilities that incinerate wastewater forms of some of the waste groups. However, commenters responding to the Second Third proposed rule indicated that they were incinerating many wastewaters and that they did not want to be precluded from doing so. In addition, the Agency has conducted incineration tests which demonstrate that incineration is an effective treatment technology for a wide variety of organic compounds, including halogenated and nonhalogenated organic compounds and pesticides. EPA's evidence that incineration constitutes significant treatment for these compounds is that these compounds were quantified at or near their detection limits in the ash and scrubber water residues from these tests. The chemical structures and physical properties of these compounds are similar to those of 2-ethoxyethanol. Since incineration is demonstrated for treatment of waste constituents in nonwastewater forms of U359 as discussed in above, the Agency believes incineration is also demonstrated for these waste constituents in wastewater forms of these wastes. Therefore, the Agency also identifies incineration as a demonstrated technology for wastewater forms of U359.

Based on engineering judgment, the Agency considers the following technologies to be demonstrated for wastewater forms of U359:

- Biological treatment;
- Carbon adsorption;
- Chemical oxidation;
- Distillation;
- Incineration (fluidized-bed, rotary kiln, and liquid injection);
- Solvent extraction followed by incineration or recycle of the extract;
- Steam stripping; and
- Wet air oxidation.

7.3 Identification of Best Demonstrated Available Technology (BDAT)

This section presents the Agency's rationale for determining the best demonstrated available technology (BDAT) for nonwastewater and wastewater forms of U359. The best demonstrated available technology is determined based on a thorough review of all the treatment data available on the waste of concern or wastes judged to be similar.

For a treatment technology to be identified as "best," the treatment performance data are screened to determine:

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

Following the identification of "best," the Agency determines whether the technology is "available." An available treatment technology is one that (1) is not a proprietary or patented process that cannot be purchased or licensed from the proprietor (i.e., it must be commercially available), and (2) substantially diminishes the toxicity of the waste or substantially reduces the likelihood of migration of hazardous constituents from the waste.

7.3.1 Nonwastewaters

As discussed previously, incineration is a demonstrated treatment technology for nonwastewater forms of U359.

The Agency obtained incinerator ash analytical data from the 14 BDAT treatment tests, conducted at well-designed and well-operated hazardous waste incinerators. Strict quality assurance/quality control measures were employed to ensure the accuracy of the data, and since EPA was collecting these data to identify and characterize BDAT treatment technologies, appropriate performance variables, namely U and P waste constituent concentrations in treated and untreated waste, were measured. The Agency has determined that due to the high temperatures, efficient mixing, and consistent residence times used at commercial hazardous waste incinerators, incineration processes are relatively indiscriminate in the destruction of organics. Based on the treatment performance data available, the Agency considers incineration to be the "best" technology for the treatment of nonwastewater forms of U359.

Incineration is a commercially available technology. Additionally, treatment performance data from the 14 BDAT incineration treatment tests show substantial treatment by incineration for the waste constituents in nonwastewater forms of unquantifiable U wastes. Therefore, incineration is considered an "available" treatment technology for U359 for the purpose of establishing BDAT.

Incineration has been determined to be BDAT for all of the nonwastewater organic constituents that cannot be quantified in hazardous waste matrices using current analytical methods, including those contained in nonwastewater forms of U359, based on their similarities in chemical and physical properties.

The Agency is promulgating fuel substitution as an alternative to incineration for nonwastewater forms of U359. The basis of this decision is that 2-ethoxyethanol is a readily oxidizable carbon, hydrogen, and oxygen compound that will not release undesirable products (such as halogenic acids, nitrogen, or sulfur dioxide) upon combustion.

7.3.2 Wastewaters

As discussed previously, incineration, wet air oxidation, biological treatment, carbon adsorption, solvent extraction followed by incineration or recycle of the extract, chemical oxidation, distillation, and steam stripping are all demonstrated technologies for the treatment of wastewater forms of U359.

The Agency believes that the best technologies for treating wastewater forms of U359 are those technologies that destroy the constituents found in these wastes. Steam stripping, solvent extraction followed by incineration or recycle of the extract, and distillation are technologies that remove the constituents from the wastewater stream; however, the waste constituents are not destroyed but are processed into a more concentrated waste stream, i.e., the condensate, extract, or bottom stream (or still bottoms). These waste streams typically require further treatment before disposal. As a result, the Agency does not consider steam stripping, solvent extraction, or distillation to be the best technologies for treating wastewater forms of the wastes covered in this subsection.

Because a technology removes waste constituents from the waste stream to be land disposed, but does not destroy them, does not necessarily preclude it from being considered "best". As discussed below, carbon adsorption is being established as part of the chemical oxidation and biodegradation treatment trains. The purpose of the carbon adsorption step as part of these treatment trains is to remove organic by-products resulting from the oxidation of waste constituents or biologically degraded by-products. Carbon adsorption was selected as the removal step over steam stripping, solvent extraction, and distillation because the Agency believes that carbon adsorption is the most appropriate removal technology for the widest range of organic compounds likely to be present in the oxidation and biological treatment effluent streams.

Chemical oxidation provides treatment by oxidizing (or destroying) the organic constituent in U359. However, to ensure effective treatment of this waste, chemical oxidation treatment should include a final carbon adsorption or biological treatment step. Since 2-ethoxyethanol is not quantifiable, it is not possible to accurately judge the effectiveness of the chemical oxidation step. Therefore, the Agency believes that it is sound engineering judgement to include a final step of carbon adsorption or biological treatment following oxidation. Carbon adsorption or biological treatment will ensure that the oxidation by-products are removed from the wastewater matrix. The Agency believes that chemical oxidation followed by carbon adsorption or biological treatment should be considered a "best" technology train for the treatment of 2-ethoxyethanol in wastewater forms of U359. (It should be noted that spent carbon from the treatment of these wastewaters would become a nonwastewater form of this waste (54 Federal Register. 26630-1, June 23, 1989) and thus would be required to be incinerated to meet the applicable treatment standard.)

The Agency is also including biodegradation followed by carbon adsorption as a "best" technology train for the treatment of 2-ethoxyethanol in wastewater forms of U359. This is based on the determination that 2-ethoxyethanol is known to hydrolyze rapidly to ethanol, which is known to be amenable to biological treatment.

The definition of biodegradation as a technology-based standard for listed wastewaters calls for operating the unit such that "a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals." EPA believes that this provision will provide permitting and compliance authorities with sufficient control over the biodegradation unit that biodegradation can be designated as BDAT for U359.

The Agency believes it is sound engineering judgement to include a final step of carbon adsorption following biodegradation to ensure effective treatment of U359. This step will ensure that the biological breakdown products are removed from the wastewater matrix. (It should be noted that spent carbon from the treatment of these wastewaters becomes a nonwastewater form of this waste (54 Federal Register. 26630-1, June 23, 1989) and thus would be required to be incinerated to meet the applicable treatment standard.)

In cases where the Agency has treatment performance data for both wastewater treatment processes and incineration (as measured by total constituent concentration in scrubber water), the Agency prefers to establish treatment standards based on the wastewater treatment processes. However, the Agency has determined that wastewaters are also treated by incineration and does not intend to preclude industry from continuing this practice. Therefore, EPA is also identifying incineration as a best demonstrated technology for these wastes.

Treatment performance data included in Volume A of the Background Document for Organic U and P Wastes and Multi-Source Leachate (F039) (8) show substantial treatment of organic constituents by carbon adsorption, chemical oxidation, and biological treatment. In addition, these technologies are commercially available. Therefore, these technologies are considered to be "available" treatment technologies for the purpose of establishing BDAT. As discussed in Section 7.3.1, incineration is also an "available" treatment technology for treatment of these wastes.

Based on the above discussion, EPA is promulgating the following methods of treatment as treatment standards for organic constituents that are not quantifiable in wastewater forms of U359: (1) incineration, (2) chemical oxidation followed by carbon adsorption, (3) chemical oxidation followed by biological treatment, and (4) biodegradation followed by carbon adsorption. The Agency believes these standards will ensure effective treatment (removal and destruction) of the constituent of concern.

Table 7-1

Facilities that May Generate U359 by State and EPA Region

Facility	Location	EPA Region
Oxy Petrochemicals, Inc.	Bayport, TX	VI
Texas Eastman Co.	Longview, TX	VI
Union Carbide Chemicals and Plastics	Seadrift, TX	VI

Table 7-2

Summary of Available Characterization Data for U359

Matrix	Characterization Data
Laboratory Liquid Samples[a]	100% 2-Ethoxyethanol
Unknown[b]	2-Ethoxyethanol (concentration NA) Benzene (concentrations NA) Cellosolve Acetate (concentrations NA)
U359 Organic Liquid[c]	4% 2-Ethoxyethanol
U359 Untreated Water[c]	<0.1% 2-Ethoxyethanol
U359 Contaminated Soil[c]	NA

NA - Not available
[a]Questionnaire response from Oxy Petrochemicals, Inc.
[b]Questionnaire response from Union Carbide Chemicals & Plastics.
[c]Questionnaire response from Texas Eastman Company.

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Appendix A

TREATMENT TECHNOLOGY DISCUSSION

Biological Treatment

Biological treatment (or Biodegradation) is a destruction technology in which hazardous organic constituents in wastewaters are biodegraded. Types of biological treatment include aerobic fixed film, aerobic lagoons, activated sludge, anaerobic fixed film, rotating biological contactors, sequential batch reactors, and trickling filter technologies. This technology generates two treatment residuals: a treated effluent and a waste biosludge. Waste biosludge may be land disposed without further treatment if it meets the applicable BDAT nonwastewater treatment standards for regulated constituents.

Carbon Adsorption

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

Chemical Oxidation

Chemical oxidation is a treatment technology that may be used to treat wastes containing organics and, in some cases, to treat sulfide and cyanide wastes. The basic principle of chemical oxidation is that some dissolved organic compounds, inorganic cyanides, and sulfides are chemically oxidized to yield carbon dioxide, water, salts, simple organic acids, and, in the case of sulfides, sulfates. The principal chemical oxidants used are hypochlorite, chlorine gas, chlorine dioxide, hydrogen peroxide, ozone, and potassium permanganate. Chemical oxidation generates an aqueous waste stream which is either discharged or transferred to another process for further treatment.

Chemically Assisted Clarification

Chemically assisted clarification, including chemical precipitation, is a separation technology in which the addition of chemicals during treatment results in the formation of insoluble solid precipitates from the wastewater by settling, clarification, and/or polishing filtration. This technology generates two treatment residuals: treated wastewater effluent and separated solid precipitate. The solid precipitate would then require additional treatment as specified by the nonwastewater BDAT treatment standards.

Critical Fluid Extraction

Critical fluid extraction is a solvent extraction technology in which the solvent is brought to its critical state (liquified gas) to aid in the extraction of hazardous organic constituents from the wastes. After the extraction step, the solvent is returned to its normal gaseous state, generating a small volume of extract that is concentrated in hazardous organic constituents. This technology generates two residuals: a treated waste residual from which most of the contaminants are removed and an extract. The extract may be recycled or may be treated by incineration.

Distillation

Distillation is the separation of a liquid mixture into various components by a process of vaporization and condensation. As a treatment technology, distillation is applicable to the treatment of wastes containing organics that are volatile enough to be removed by the application of heat. This technology generates an organic stream that may be reusable, and a bottom stream that is often incinerated.

Fuel Substitution

Fuel substitution is a destruction technology in which energy, as heat, is transferred to the waste to destabilize chemical bonds and destroy organic constituents. Fuel substitution differs from incineration in that the waste is used as a fuel in industrial furnaces or boilers. Two residuals may be generated by the fuel substitution process: ash and scrubber water. The Agency limits the use of fuel substitution as a method of treatment to waste streams whose regulated constituents contain only carbon, hydrogen, and oxygen in their molecular structure.

Incineration

Incineration is a destruction technology in which energy, as heat, is transferred to the waste to destabilize chemical bonds and destroy organic constituents. There are different types of incinerators designed to accommodate different forms of wastes. In a fluidized-bed incinerator, waste is injected into the fluidized-bed material (generally sand and/or incinerator ash), where it is heated to its ignition temperature. Heat energy from the combustion reactions is then transferred back to the fluidized bed. Ash is removed periodically during operation and during bed change-outs.

In a rotary kiln incinerator, wastes are fed into the elevated end of the kiln, and the rotation of the kiln mixes the waste with hot gases to heat the waste to its ignition temperature. Ash is removed from the lower end of the kiln. Combustion gases from the kiln enter the afterburner for complete destruction of organic waste constituents. Other wastes may also be injected into the afterburner.

In a liquid injection incinerator, liquid wastes are atomized and injected into the incinerator. In general, only wastes with low or negligible ash contents are amenable to liquid injection incineration. Therefore, this technology generally does not generate an ash residual.

Combustion gases from the incinerator are then fed to a scrubber system for cooling and removal of entrained particulates and acid gases, if present. In general, with the exception of liquid injection incineration, two residuals are generated by incineration processes: ash and scrubber water.

PACT® Treatment

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

Reverse Osmosis

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

Solvent Extraction

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

Stripping Treatment

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

Wet Air Oxidation

Wet air oxidation, including supercritical oxidation, is a destruction technology in which organic constituents in wastes are oxidized and destroyed under pressure at elevated temperatures in the presence of dissolved oxygen. This technology is applicable for wastes comprised primarily of water and up to 10% total organic constituents. Wet air oxidation generates one treatment residual: treated effluent. The treated effluent may require further treatment for hazardous organic constituents by carbon adsorption. Air emissions from wet air oxidation may require further treatment by incineration.

Appendix B
ACCURACY CORRECTION OF DATA

The treatment performance data and detection limit data used to determine treatment standards were adjusted to account for analytical interferences associated with the chemical matrices of the samples. Generally, treatment performance data were corrected for accuracy as follows: (1) a matrix spike recovery was determined for each BDAT List constituent; (2) an accuracy correction factor was determined for each of the above constituents by dividing 100 by the matrix spike recovery (percent) for that constituent; and (3) treatment performance data or detection limit data for each BDAT List constituent were corrected by multiplying the data for each constituent by its corresponding accuracy correction factor. The procedure for accuracy correction of the data is described in further detail below.

Matrix spike recoveries are developed by analyzing a sample of a treated waste for a constituent and then re-analyzing the sample after the addition of a known amount of the same constituent (i.e., spike) to the sample. The matrix spike recovery represents the total amount of constituent recovered after spiking, minus the initial concentration of the constituent. Duplicate matrix spikes were performed for some BDAT List constituents. If a duplicate matrix spike was performed for a constituent, the matrix spike recovery used for that constituent was the lower of the two values between the first matrix spike and the duplicate spike.

In cases where a matrix spike was not performed for a waste constituent in the treatment test from which the detection limit was taken, the matrix spike recovery from a similar constituent from the treatment test was transferred to the constituent. Matrix spike data for chloroform was transferred from the matrix spike recoveries for trichloroethylene in the same incineration test. The matrix spike for trichloroethylene was 100%, resulting in an accuracy correction factor of 1.

For some constituents, treatment performance data were transferred from F, D, or K wastes. In these cases, when a matrix spike was not performed for a particular constituent, the matrix spike recovery for each constituent was derived from the average matrix spike recoveries of the appropriate analytical fraction (e.g., volatile or semivolatile organics) for which recovery data were available. First, the matrix spike recoveries for all volatile or semivolatile organic constituents from the first matrix spike were averaged. An average matrix spike recovery was then calculated for the duplicate matrix spike recoveries. The lower of the two average matrix spike recoveries was used to calculate the accuracy correction factor for the constituent.

An accuracy correction factor was determined for each constituent by dividing 100 by the matrix spike recovery (percent) for that constituent. An accuracy correction factor of 1.00 was used when both the matrix spike and duplicate matrix spike recoveries exceeded 100 % to ensure the data were not adjusted to concentrations below the detection limits. Matrix spike values of less than 20% are not acceptable and were not used to correct detection limits, nor included in calculating average matrix spike recoveries.

Table B-1 presents the accuracy correction of data from the ethylene dibromide (EDB) incineration test. Accuracy correction factors used for each waste code are presented in Sections 4 and 6.

Table B-1

Accuracy Correction of Ethylene Dibromide Incineration Treatment Performance Data

BDAT List Constituent	Uncorrected Data (ppm)			Matrix Spike	Accuracy Correction Factor	Accuracy-Corrected Data (ppm)			Average Accuracy-Corrected Data (ppm)
	Sample Set					Sample Set			
	#1	#2	#3			#1	#2	#3	
Ethylene Dibromide	5	5	5	92.5%	1.08[a]	5.41	5.41	5.41	5.41

[a]The accuracy correction factor data for EDB was transferred to bromomethane.

Source: EDB Test Burn Program Emissions Test Results (13).

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Appendix C

VARIABILITY FACTOR CALCULATIONS

A variability factor (VF) accounts for the variability inherent in the treatment system performance, treatment residual collection, and analysis of the treated waste samples. Variability factors are calculated as described in EPA's Methodology for Developing BDAT Treatment Standards (1).

Original effluent data points were not always available; therefore, variability factors for some constituents were not calculated as described in Reference 1. For example, WERL effluent data were presented as averages in the WERL database, and therefore, it was not possible to calculate an individual variability factor for these constituents since actual effluent data points were unavailable. For volatile and semivolatile organic constituents where a variability factor was unknown or could not be calculated, an average variability factor was used. The average variability factors were generated from the EAD variability factors and are specific to the type of constituent under consideration (i.e., volatile organic, base neutral extractable semivolatile organic, etc.). The average volatile organic variability factor is an average of the sum of volatile variability factors from EAD data as shown in Table C-1. The average base neutral extractable semivolatile organic variability factor is an average of the sum of base neutral semivolatile variability factors from EAD data as shown in Table C-1. Determination of this average variability factor is similar to the procedure used by EPA in the BDAT land disposal rule in the past to determine average accuracy correction factors.

Table C-1

Variability Factor Calculation for Volatile Organics

Volatile Organics	EAD Variability Factor
Acrylonitrile	4.83045
Benzene	13.5252
Chloroethane	5.34808
Chloroform	3.71334
Chloromethane	3.79125
1,1-Dichloroethane	5.88383
1,2-Dichloroethane	8.22387
1,1-Dichloroethene	2.4723
trans-1,2-Dichloroethene	5.34808
Methylene chloride	3.86915
Tetrachloroethylene	5.34808
Toluene	7.9506
1,1,1-Trichloroethane	5.34808
1,1,2-Trichloroethane	5.34808
Trichloroethylene	5.34808
Vinyl chloride	5.34808
Average	5.7310
Average VF for Volatile Organic	5.7

Table C-2

Variability Factor Calculation for Base Neutral Extractable Semivolatile Organics

Base Neutral Extractable Semivolatile Organics	EAD Variability Factor
Acenaphthalene	5.89125
Acenaphthene	5.89125
Benzo(a)anthracene	5.89125
Benzo(a)pyrene	5.89125
Benzo(k)fluoranthene	5.89125
Bis(2-ethylhexyl)phthalate	5.89125
Chrysene	5.91768
Diethyl phthalate	5.89125
Dimethyl phthalate	4.75961
Di-n-butyl phthalate	4.63833
Fluoranthene	3.23768
Fluoranthene	5.89125
Fluorene	5.89125
Naphthalene	5.89125
Nitrobenzene	4.83045
Phenanthrene	5.89125
Pyrene	5.89125
Average	5.5340
Average VF for Base Neutral Extractable Semivolatile Organics	5.5