FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

BACKGROUND DOCUMENT

FOR

DISTILLATION BOTTOMS FROM THE PRODUCTION OF NITROBENZENE BY THE NITRATION OF BENZENE

K025

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May 1990

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1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA or Agency) is establishing best demonstrated available technology (BDAT) treatment standards for the listed hazardous waste identified in Title 40, Code of Federal Regulations, Section 261.32 (40 CFR 261.32) as K025, distillation bottoms from the production of nitrobenzene by the nitration of benzene. These BDAT treatment standards are being established in accordance with the amendments to the Resource Conservation and Recovery Act (RCRA) of 1976, enacted by the Hazardous and Solid Waste Amendments (HSWA) of November 8, 1984. BDAT treatment standards will be effective no later than May 8, 1990, and on or after the effective date, compliance with these BDAT treatment standards will be a prerequisite under 40 CFR Part 268 for placement of the waste in land disposal units.

This background document provides the Agency's rationale and technical support for developing treatment standards for K025. The document also provides waste characterization data that serve as a basis for determining whether a variance from the treatment standard may be warranted for a particular type of K025 that is more difficult to treat than the wastes on which the K025 treatment standards are based.

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).

Under 40 CFR 261.32, wastes identified as K025 are listed as distillation bottoms from the production of nitrobenzene by the nitration of benzene. The four-digit Standard Industrial Classification (SIC) code associated with the production of nitrobenzene is 2865 (Industrial Organic Chemicals: cyclic organic crudes and intermediates, and organic dyes and pigments). The Agency estimates that there is one domestic facility that may generate K025.

The Agency is establishing treatment standards for nonwastewater and wastewater forms of K025. To determine the applicability of the treatment standards, wastewaters are defined as wastes containing less than 1% (weight basis) total suspended solids[1] (TSS) and less than 4% (weight basis) total organic carbon (TOC). Wastes not meeting this definition are classified as nonwastewaters and must comply with nonwastewater treatment standards.

The Agency is revising the "No Land Disposal Based on No Generation" treatment standard that was promulgated for nonwastewater forms of K025, and is establishing treatment standards for wastewater forms of K025, which have been subject to the "soft hammer" provisions of Section 3004(g)(6) of RCRA. The "No Land Disposal" standard for K025 nonwastewaters was based on the premise that K025 is no longer generated. The Agency believes that this standard should be revised for several reasons: (1) a facility intending to manufacture nitrobenzene in the future by the nitration of benzene, and generating distillation bottoms as a result, would be forced to apply for a variance from the treatment standard (40 CFR 268.44); (2) a facility disposing of K025 from past nitrobenzene manufacturing operations as part of a corrective action would also be forced to apply for a variance from the treatment standard; and (3) a facility changing its treatment process from one that originally did not generate treatment residuals to one that may generate residuals would be forced to apply for a variance from the treatment standard.

EPA is establishing a method of treatment as the treatment standard for nonwastewater and wastewater forms of K025. The Agency is establishing this treatment standard because it is uncertain as to what constituents are present in K025, due to insufficient characterization data for K025. This uncertainty precludes the selection of appropriate BDAT List constituents for regulation, as explained in Section 6.0 of this document. The treatment

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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).

standards for nonwastewater and wastewater forms of K025 are shown in Table 1-1.

This background document presents waste-specific information on the number and locations of facilities that may be affected by the land disposal restrictions for K025, the processes generating this waste, the waste characterization data, the technologies used to treat the waste (or similar wastes, if any), and the treatment performance data which support the establishment of treatment standards (Sections 2.0 - 4.0). This document also explains how EPA determined BDAT and treatment standards for K025 (Sections 5.0 - 6.0).

Table 1-1

BDAT TREATMENT STANDARDS FOR K025

NONWASTEWATERS

INCINERATION[1] AS A METHOD OF TREATMENT

WASTEWATERS

INCINERATION[1] AS A METHOD OF TREATMENT OR LIQUID-LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING FOLLOWED BY INCINERATION OF SPENT CARBON AS A METHOD OF TREATMENT

[1]Incineration must be conducted in accordance with the technical requirements of 40 CFR Part 264 or Part 265 Support O.

2.0 INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

This section describes the industries that may be affected by the land disposal restrictions for K025, the processes generating the waste, and the available waste characterization data.

2.1 Industry Affected and Process Description

K025 is generated as distillation bottoms from the production of nitrobenzene by the nitration of benzene. The primary use of nitrobenzene is in the manufacture of aniline dyes. Nitrobenzene is also used as a solvent in the manufacture of pharmaceuticals. The Agency has identified one potential generator of K025: Rubicon, Inc., located in Geismar, Louisiana in EPA Region VI (Reference 4).

A flow diagram illustrating a typical nitrobenzene production process is presented in Figure 2-1. Nitrobenzene is produced by the direct nitration of benzene using a sulfuric acid-nitric acid mixture. After a two- to four-hour reaction residence time, the mixture is sent to a decanter and is allowed to settle. The mixed acids are recovered and reused. The crude nitrobenzene taken from the top of the decanter can be used directly for aniline production or can be sent on for further refinement. For refinement, the crude product is sent to a washer, where it is neutralized with a dilute sodium carbonate solution and then distilled. Bottoms from this final distillation comprise the listed waste K025.

2.2 Waste Characterization

K025, as generated, meets the definition of a BDAT nonwastewater. However, wastewater forms of K025 may be generated during the treatment, handling, or storage of nonwastewater forms of K025.

As discussed above, one facility was identified as a potential generator of K025. However, K025 is not currently generated at this facility. Therefore, a sample of K025 for full characterization was unavailable.

Previously collected K025 characterization data for constituents on the BDAT list are presented in Table 2-1.

Available data sources (References 5 and 6) indicate the following general composition for K025:

Constituent	Concentration (%)
2,4-Dinitrotoluene	18.6
Nitrobenzenes	71.5
Nitrophenols	3.1
Other polymers containing nitrogen	3.7
Polycarboxylic acids	3.1
Total:	100%

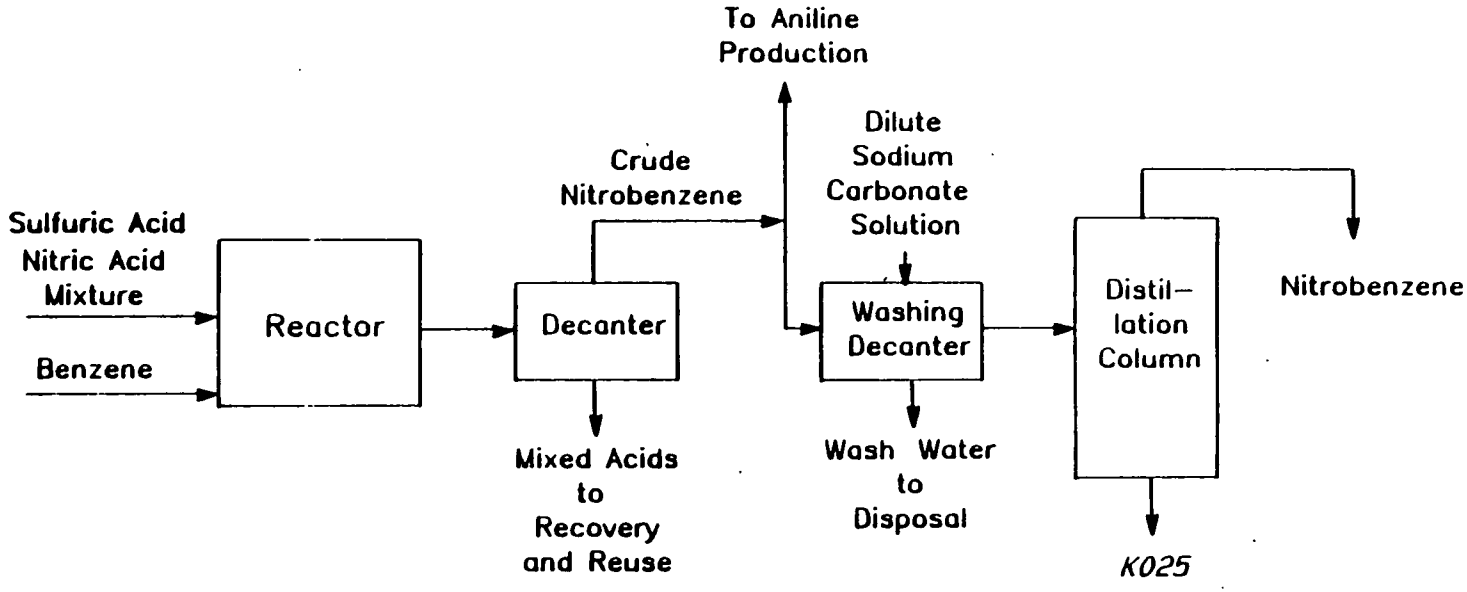

Figure 2-1. Flow Diagram for the Production of Nitrobenzene by the Nitration of Benzene

Table 2-1

K025 CHARACTERIZATION DATA

BDAT List Constituent	Concentration in Untreated Waste (ppm)
102. 2,4-Dinitrotoluene	186,000
126. Nitrobenzene	404,000
127. 4-Nitrophenol	31,000

3.0 APPLICABLE AND DEMONSTRATED TREATMENT TECHNOLOGIES

This section discusses the technologies that are applicable for treatment of K025 nonwastewaters and wastewaters and determines which, if any, 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 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 (Reference 7).) To be demonstrated, a technology must be employed in full-scale operation for treatment of the waste in question or a similar waste. Technologies available only at pilot- or bench-scale operations are not considered in identifying demonstrated technologies.

3.1 Applicable Treatment Technologies

The following subsections present applicable treatment technologies for nonwastewater and wastewater forms of K025.

3.1.1 Nonwastewaters

Since nonwastewater forms of K025 consist primarily of organic compounds (as shown in Section 2.0 of this document), 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 potentially applicable for these wastes: (1) incineration (fluidized-bed and rotary kiln); (2) solvent extraction followed by incineration or recycle of the extract; and (3) critical fluid extraction followed by recycle or incineration of the contaminated solvents. These treatment technologies were identified based on engineering judgment and current waste management practices for organic wastes.

Incineration. Incineration is a destruction technology in which energy, in the form of heat, is transferred to the waste to destabilize chemical bonds and destroy organic constituents. 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.

Combustion gases from the fluidized-bed or kiln afterburner are then fed to a scrubber system for cooling and removal of entrained particulates and acid gases, if present. In general, two residuals are generated by these incineration processes: ash and scrubber water.

Solvent Extraction. Solvent extraction (or 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 results in the generation of two treatment residuals: a treated waste residual and an extract. The extract may be recycled or may be further treated by incineration.

Critical Fluid Extraction. Critical fluid extraction is a solvent extraction technology in which the solvent is brought to its critical state to aid in the extraction of organic constituents from the wastes. After the extraction step, the solvent (liquified gas at its critical state) is brought to its normal condition in the gaseous state and generates a small volume of extract that is concentrated in hazardous organic constituents. This technology results in the generation of two treatment residuals: a treated waste

residual and an extract. The extract may be recycled or may be further treated by incineration.

3.1.2 Wastewaters

Since wastewater forms of K025 may contain organic constituents at treatable concentrations, applicable 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 potentially applicable for treatment of K025 wastewaters: (1) incineration; (2) steam stripping; (3) biological treatment (including PACT^{R} treatment); (4) carbon adsorption; (5) solvent extraction; and (6) wet air oxidation.

Incineration. Incineration of wastewaters in a rotary kiln or fluidized-bed is identical to that for nonwastewaters described previously in this section. In addition, liquid injection incineration may also be applicable to K025 wastewaters. In a liquid injection incinerator, liquid wastes are atomized and injected into the incinerator. 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, only wastes with low or negligible ash contents are amenable to liquid injection incineration. Therefore, this technology generally does not result in the generation of an ash residual.

Steam Stripping. Steam stripping is a separation technology in which organics are removed from the waste by volatilization through the application of heat. This technology results in the formation of two treatment residuals: a treated waste extract and a treated effluent. The treated waste extract and the treated effluent may require further treatment by incineration, and carbon adsorption or biological treatment, respectively.

Biological Treatment. Biological treatment is a destruction technology in which organic constituents in wastewaters are biodegraded. This technology results in the formation of two treatment residuals: a treated effluent and a waste biosludge. The treated effluent and the waste biosludge

may require further treatment for metals by chemical precipitation and stabilization, respectively.

PACT® treatment is the addition of powdered activated carbon to a biological treatment process. This technology results in the formation of two treatment residuals: a treated effluent and a waste biosludge. The treated effluent and the waste biosludge may require further treatment for metals by chemical precipitation and stabilization, respectively. In addition, the waste biosludge may require further treatment by incineration.

Carbon Adsorption. Carbon adsorption is a separation technology in which organic constituents in wastewaters are selectively adsorbed onto activated carbon. This technology results in the formation of two treatment residuals: a treated effluent and spent carbon. The treated effluent may require further treatment for metals by chemical precipitation. The spent carbon may require further treatment by incineration.

Solvent Extraction. Solvent extraction of wastewaters is identical to that for nonwastewaters described previously in this subsection.

Wet Air Oxidation. Wet air oxidation is a destruction technology in which organic constituents in wastes are oxidized and destroyed under pressure at elevated temperatures in the presence of dissolved oxygen. This technology is applicable for wastes comprised primarily of water and up to 10% total organic concentration. Wet air oxidation results in the formation of one treatment residual: treated effluent. The treated effluent may require further treatment for organic constituents by carbon adsorption or PACT® treatment, as described in this subsection. Emissions from wet air oxidation may require further treatment by incineration.

3.2 Demonstrated Treatment Technologies

The Agency is not aware of any facilities that treat K025 nonwastewaters and wastewaters. Therefore, the Agency is not aware of any technologies that are specifically demonstrated for treatment of K025. However, incineration is demonstrated for nonwastewater and wastewater forms of similar wastes, as discussed in Section 4.0 of this document. Additionally, liquid-liquid extraction followed by steam stripping followed by activated carbon adsorption is demonstrated for similar wastewaters. The Agency tested liquid-liquid extraction followed by steam stripping followed by activated carbon adsorption for similar wastes, as discussed in Section 4.0 of this document.

4.0 TREATMENT PERFORMANCE DATA

This section presents the treatment performance data that were used to support the establishment of treatment standards for nonwastewater and wastewater forms of K025.

The Agency does not have treatment performance data for treatment of K025 nonwastewaters or wastewaters. However, the Agency does have performance data for similar wastes previously tested by incineration (rotary kiln or fluidized-bed incineration) for nonwastewaters, and by liquid-liquid extraction followed by steam stripping and activated carbon adsorption for wastewaters. These technologies were identified as applicable and demonstrated for treatment of these wastes, as discussed in Section 3.0 of this document.

4.1 Nonwastewaters

Previous incineration tests conducted by the Agency are listed in Table 4-1 at the end of this section. EPA examined the wastes incinerated in these tests to determine their similarity to K025 nonwastewaters. Specifically, EPA examined (1) whether the untested K025 is generated from a similar industry or processing step, and (2) whether the waste has similar waste characteristics affecting treatment performance as do the previously tested wastes.

Wastes included in Tests 3, 4, 5, 11, 12, 13, and 14 are generated by the organic chemicals industry, as is K025. Several of these wastes are distillation bottoms from the production of an organic chemical. However, since K025 is generated in the production of nitrobenzene as distillation bottoms, it contains nitrogenated organic compounds. Of the wastes generated by a process similar to that generating K025, those incinerated in Tests 3, 4, and 14 contain nitrogenated compounds and are therefore most structurally similar to K025. The mixture of U and P wastes incinerated in Test 14 (Reference 3) was most similar to K025 in that it was also an organic, nitrogen-containing waste with low water content.

Wastes incinerated in Test 14 are expected to have similar thermal conductivities to K025. Although the constituents of concern in K025 were not incinerated in Test 14, several of the U and P wastes incinerated were similar to these constituents with respect to structure: both the constituents in K025 and the wastes represented in Test 14 included aromatic and organonitrogen compounds and alcohols. In addition, the wastes incinerated in Test 14 were similar to K025 with respect to physical properties that affect the treatment performance of incineration, such as their boiling points. Because of these similarities, it is believed that treatment performance similar to that achieved for the surrogate U and P wastes incinerated in Test 14 could be achieved for K025 nonwastewaters.

4.2 Wastewaters

The Agency examined all of the available wastewater treatment performance data. Performance data for treatment of various industrial wastewaters were developed by EPA's Office of Water. Additionally, performance data from treatment of K103/K104 by liquid-liquid extraction followed by steam stripping and activated carbon adsorption were the sole source of data specifically for organonitrogen constituents. EPA examined waste characterization data to evaluate the similarity between these wastes and K025 wastewaters. Specifically, EPA examined (1) whether the untested K025 is generated from a similar industry or processing step, and (2) whether the waste has similar waste characteristics affecting treatment performance as do the previously tested wastes.

Waste characterization data for the wastes tested by the Agency's Office of Water were insufficient to compare these wastes to K025 in terms of waste generation and waste characterization.

K103 is generated during aniline production, and both K025 and K104 are generated during nitrobenzene production. K025 is generated as distillation bottoms from the production of nitrobenzene, K103 is generated as process residues from the production of aniline, and K104 is the combined wastewater streams generated during nitrobenzene and aniline production. The industries

generating these wastes were judged to be similar based on the organonitrogen nature of the chemicals produced by these industries.

After determining that the wastes were generated by similar industries, EPA examined the relative treatability of K025 wastewaters and K103/K104 wastewaters. As discussed in the Treatment Technology Background Document (Reference 7), waste characteristics that affect treatment performance of liquid-liquid extraction followed by steam stripping and carbon adsorption include the boiling points of the waste constituents and the concentrations of total organic carbon, total suspended solids, oil and grease, and volatile organic compounds in the wastes.

K025 and K103/K104 are expected to contain the same, or similar, constituents of concern and therefore would be expected to have similar boiling points. The wastes are expected to have similar concentrations of volatile organic compounds, total organic carbon, total suspended solids, and oil and grease. Because of these similarities, the wastes are believed to be similar and are expected to be treated to similar concentrations by liquid-liquid extraction followed by steam stripping and activated carbon adsorption.

Additionally, the Agency believes that treatment performance similar to that achieved for the surrogate U and P wastes incinerated in Test 14 could be achieved for K025 wastewaters, for the same reasons discussed in Section 4.1 for K025 nonwastewaters.

Table 4-1

WASTES TESTED BY INCINERATION AND SAMPLED BY EPA

Test Number	Waste Code(s)	Treatment Technology Used
1	K001 - Pentachlorophenol	Rotary kiln incineration
2	K001 - Creosote	Rotary kiln incineration
3	K011, K013, K014	Rotary kiln incineration
4	K019	Rotary kiln incineration
5	K024	Rotary kiln incineration
6	K037	Rotary kiln incineration
7	K048, K051	Fluidized-bed incineration
8	K087	Rotary kiln incineration
9	K101	Rotary kiln incineration
10	K102	Rotary kiln incineration
11	F024	Rotary kiln incineration
12	K015	Liquid injection incineration
13	D014, D016[a], P059[a], U127[a], and U192[a]	Rotary kiln incineration
14	U141[a], U028[a], P020[a], U112[a], U226[a], U239[a], U080[a], U220[a], U166[a], U161[a], and U188[a]	Rotary kiln incineration

[a]Commercial chemical products were used in these test burns as surrogates for these wastes.

5.0 IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

This section presents the Agency's rationale for determining the best demonstrated available technology (BDAT) for K025 nonwastewaters and wastewaters.

To determine BDAT, the Agency examines all available treatment performance data on technologies that are identified as demonstrated for the waste of concern, or for a waste similar to the waste of concern, to evaluate whether one or more of the technologies performs significantly better than the others. If data are available for only one technology for treating a waste, then that technology is "best." When data are available for more than one treatment technology, the "best" performing treatment technology is determined by an analysis of variance (ANOVA) test. (The ANOVA test is discussed in EPA's Methodology for Developing BDAT Treatment Standards (Reference 1).)

The treatment technology that is found to perform best on a particular waste stream is then evaluated to determine whether it is "available." To be available, the technology must (1) be commercially available, and (2) provide "substantial" treatment of the waste, as determined through evaluation of treatment performance data that have been corrected for accuracy. In determining whether treatment is substantial, EPA may consider data on a treatment technology's performance on a waste similar to the waste in question, provided that the similar waste is at least as difficult to treat. If it is determined that the best performing treatment technology is not available, then the next best technology is evaluated to determine whether it is "available."

5.1 Review of Treatment Performance Data

The treatment performance data (presented in Section 4.0) for wastes determined to be similar to K025 nonwastewaters and wastewaters were reviewed and assessed to determine whether they 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 measures of performance were used to assess the performance of the particular treatment technology.

The treatment performance data and the design and operating data collected during the test of rotary kiln incineration in Test 14 (Reference 3) and of liquid-liquid extraction followed by steam stripping and activated carbon adsorption (Reference 8) were reviewed for the points described above. For both of these tests, the appropriate measure of performance (total constituent concentration) was used to assess the treatment system. Additionally, the Agency had no reason to believe that these treatment systems were not well-designed and well-operated, or that insufficient analytical quality assurance/ quality control measures were employed in generating treatment performance data.

5.2 Available Treatment Technologies

The demonstrated technologies for treatment of K025, (1) incineration, and (2) liquid-liquid extraction followed by steam stripping followed by carbon adsorption followed by incineration of spent carbon (wastewaters only), are considered to be commercially available. These technologies provide substantial treatment of the U and P wastes incinerated in Test 14 and K103/K104. Since these U and P wastes and K103/K104 are considered to be at least as difficult to treat as K025, the Agency believes that incineration and liquid-liquid extraction followed by steam stripping and activated carbon adsorption will also provide substantial treatment of K025. Consequently, these technologies are considered available for treatment of K025.

5.3 BDAT for K025

As discussed above, (1) incineration and (2) liquid-liquid extraction followed by steam stripping followed by carbon adsorption followed by incineration of spent carbon (wastewaters only) have been determined to be demonstrated and available for treatment of K025. Because the Agency does not have treatment performance data for any other demonstrated and available

technologies for treating nonwastewater forms of K025 or similar wastes, incineration is considered to be the best for nonwastewater forms of K025. Therefore, the best demonstrated available technology (BDAT) for nonwastewater forms of K025 has been determined to be incineration.

For wastewaters, in cases where the Agency has treatment performance data for demonstrated and available 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, the best demonstrated available technologies (BDAT) for wastewater forms of K025 have been determined to be (1) incineration, or (2) liquid-liquid extraction followed by steam stripping followed by carbon adsorption followed by incineration of spent carbon. Scrubber waters generated from the incineration of K025 nonwastewaters are considered to meet the treatment standard for K025 wastewaters and do not require further treatment (see 54 Federal Register 26630 (June 23, 1989)). In addition, these BDAT technologies do not preclude a facility from utilizing recycle or reuse operations in accordance with 40 CFR Part 261.

6.0 DETERMINATION OF BDAT TREATMENT STANDARDS

The Agency prefers, whenever possible, to set concentration-based treatment standards for listed wastes so as not to limit the selection of those treatment technologies that may be used to achieve the BDAT treatment standards. In cases where concentration-based standards cannot be determined, EPA may choose to establish a method of treatment as the treatment standard.

Inherent in the establishment of concentration-based treatment standards is the selection of constituents for regulation. EPA considers several points in its selection of regulated constituents:

- How difficult a constituent is to treat, based on waste characteristics affecting treatment performance;
- How representative a constituent is of others in the waste, based on structural similarities; and
- How much of the constituent is present in the waste, based on concentration levels.

The Agency has limited characterization data for K025 and does not believe that, using the above criteria, these data are sufficient for evaluating which constituents should be regulated in K025. EPA is uncertain whether other constituents, which may not be controlled by regulation of the BDAT List constituents quantified in K025, are present in K025. This uncertainty precludes the selection of appropriate BDAT List constituents for regulation. Accordingly, the Agency is establishing a method of treatment as the treatment standard for nonwastewater and wastewater forms of K025, as discussed below.

6.1 Nonwastewaters

Incineration was determined to be BDAT for nonwastewater forms of K025, as discussed in Section 5.0. Because incineration is a technology that is applicable to treatment of most organic constituents, it is particularly appropriate for treatment of K025, since the identities and physical properties of the waste constituents have not been fully identified.

Accordingly, the Agency is establishing incineration as a method of treatment for nonwastewater forms of K025.

6.2 Wastewaters

Incineration and liquid-liquid extraction followed by steam stripping followed by activated carbon adsorption were determined to be BDAT for wastewater forms of K025, as discussed in Section 5.0. The particular appropriateness of incineration as treatment for K025 nonwastewaters, as noted in Section 6.1, applies equally to K025 wastewaters. Accordingly, the Agency is establishing (1) incineration, or (2) liquid-liquid extraction and steam stripping followed by activated carbon adsorption as a method of treatment for wastewater forms of K025.

7.0 ACKNOWLEDGEMENTS

This background document was prepared for the U.S. Environmental Protection Agency, Office of Solid Waste, by Radian Corporation under Contract No. 68-W9-0072. This document was prepared under the direction of Richard Kinch, Acting Chief, Waste Treatment Branch; Larry Rosengrant, Section Head, Treatment Technology Section; Jerry Vorbach, Project Officer; and Jose Labiosa, Project Manager. Steve Silverman served as EPA legal advisor.

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