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Best Demonstrated Available Technology (BDAT) Background Document for K037

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BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) BACKGROUND DOCUMENT FOR K037

U.S. Environmental Protection Agency
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EXECUTIVE SUMMARY

BDAT Treatment Performance Standards for K037

Pursuant to the Hazardous and Solid Waste Amendments (HSWA) enacted on November 8, 1984, and in accordance with the procedures for establishing treatment standards under Section 3004(m) of the Resource Conservation Act Recovery and (RCRA), treatment standards have been proposed based on the treatment performance of the Best Demonstrated Available Technology (BDAT) for the listed waste identified in 40 CFR part 261.32 (the Code of Federal Regulations) as K037 (wastewater treatment sludge from the production of disulfoton). Wastes designated as K037 must meet the standards prior to disposal in units designated as land disposal units according to 40 CFR Part 268.

Standards have been established for disulfoton and toluene based on performance data using a rotary kiln incinerator. When treating K037 wastes with incineration, scrubber water and an ash residual are generated, so standards for both wastewaters and nonwastewaters have been developed. For the purpose of this proposed land disposal restrictions rule, wastewaters are defined as wastes containing less than 1 percent (weight basis) filterable solids and less than 1 percent (weight basis) total organic carbon (TOC). Nonwastewaters are waste forms containing greater than 1 weight percent filterable solids or greater than one weight percent total organic carbon.

The standards are established based on analyses conducted on the total constituent concentrations found in the treated waste residuals (i.e., ash and scrubber water). These standards become effective as of August 8, 1988, as per the schedule set forth in 40 CFR 268.10.

The following table lists the specific BDAT standards for K037 wastes that have undergone treatment using a rotary kiln incinerator. The units for the total waste concentration are mg/kg (parts per million on a weight-by-weight basis). Testing procedures are specifically identified in Appendix B (QA/QC Section) of this background document.

BDAT Treatment Performance Standards
K037

Organic constituents	Total waste concentration	
	Nonwastewater (mg/kg)	Wastewater (mg/l)
Toluene	28	0.028
Disulfoton	0.10	0.003

1. INTRODUCTION

This section of the background document presents a summary of the legal authority pursuant to which the BDAT treatment standards were developed, a summary of EPA's promulgated methodology for developing BDAT, and finally a discussion of the petition process that should be followed to request a variance from the BDAT treatment standards.

1.1 Legal Background

1.1.1 Requirements Under HSWA

The Hazardous and Solid Waste Amendments of 1984 (HSWA), enacted on November 8, 1984, and which amended the Resource Conservation and Recovery Act of 1976 (RCRA), impose substantial new responsibilities on those who handle hazardous waste. In particular, the amendments require the Agency to promulgate regulations that restrict the land disposal of untreated hazardous wastes. In its enactment of HSWA, Congress stated explicitly that "reliance on land disposal should be minimized or eliminated, and land disposal, particularly landfill and surface impoundment, should be the least favored method for managing hazardous wastes" (RCRA section 1002(b)(7), 42 U.S.C. 6901(b)(7)).

One part of the amendments specifies dates on which particular groups of untreated hazardous wastes will be prohibited from land disposal unless "it has been demonstrated to the Administrator, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous" (RCRA section 3004(d)(1), (e)(1), (g)(5), 42 U.S.C. 6924 (d)(1), (e)(1), (g)(5)).

For the purpose of the restrictions, HSWA defines land disposal "to include, but not be limited to, any placement of . . . hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave" (RCRA section 3004(k), 42 U.S.C. 6924(k)). Although HSWA defines land disposal to include injection wells, such disposal of solvents, dioxins, and certain other wastes, known as the California List wastes, is covered on a separate schedule (RCRA section 3004(f)(2), 42 U.S.C. 6924 (f)(2)). This schedule requires that EPA develop land disposal restrictions for deep well injection by August 8, 1988.

The amendments also require the Agency to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (RCRA section 3004(m)(1), 42 U.S.C. 6924 (m)(1)). Wastes that meet treatment standards established by EPA are not prohibited and may be land disposed. In setting treatment standards for listed or characteristic wastes, EPA may establish different standards for particular wastes within a single waste code with differing treatability characteristics. One such characteristic is the physical form of the waste. This frequently leads to different standards for wastewaters and nonwastewaters.

alternatively, EPA can establish a treatment standard that is applicable to more than one waste code when, in EPA's judgment, all the waste can be treated to the same concentration. In those instances where a generator can demonstrate that the standard promulgated for the generator's waste cannot be achieved, the Agency also can grant a variance from a treatment standard by revising the treatment standard for that particular waste through rulemaking procedures. (A further discussion of treatment variances is provided in Section 1.3.)

The land disposal restrictions are effective when promulgated unless the Administrator grants a national variance and establishes a different date (not to exceed 2 years beyond the statutory deadline) based on "the earliest date on which adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment will be available" (RCRA section 3004(h)(2), 42 U.S.C. 6924 (h)(2)).

If EPA fails to set a treatment standard by the statutory deadline for any hazardous waste in the First Third or Second Third of the schedule (see section 1.1.2), the waste may not be disposed in a landfill or surface impoundment unless the facility is in compliance with the minimum technological requirements specified in section 3004(o) of RCRA. In addition, prior to disposal, the generator must certify to the Administrator that the availability of treatment capacity has been investigated and it has been determined that disposal in a landfill or surface impoundment is the only practical alternative to treatment currently available to the generator. This restriction on the use of

landfills and surface impoundments applies until EPA sets a treatment standard for the waste or until May 8, 1990, whichever is sooner. If the Agency fails to set a treatment standard for any ranked hazardous waste by May 8, 1990, the waste is automatically prohibited from land disposal unless the waste is placed in a land disposal unit that is the subject of a successful "no migration" demonstration (RCRA section 3004(g), 42 U.S.C. 6924(g)). "No migration" demonstrations are based on case-specific petitions that show there will be no migration of hazardous constituents from the unit for as long as the waste remains hazardous.

1.1.2 Schedule for Developing Restrictions

Under Section 3004(g) of RCRA, EPA was required to establish a schedule for developing treatment standards for all wastes that the Agency had listed as hazardous by November 8, 1984. Section 3004(g) required that this schedule consider the intrinsic hazards and volumes associated with each of these wastes. The statute required EPA to set treatment standards according to the following schedule:

(a) Solvents and dioxins standards must be promulgated by November 8, 1986;

(b) The "California List" must be promulgated by July 8, 1987;

(c) At least one-third of all listed hazardous wastes must be promulgated by August 8, 1988 (First Third);

(d) At least two-thirds of all listed hazardous wastes must be promulgated by June 8, 1989 (Second Third); and

(e) All remaining listed hazardous wastes and all hazardous wastes identified as of November 8, 1984, by one or more of the characteristics defined in 40 CFR Part 261 must be promulgated by May 8, 1990 (Third Third).

The statute specifically identified the solvent wastes as those covered under waste codes F001, F002, F003, F004, and F005; it identified the dioxin-containing hazardous wastes as those covered under waste codes F020, F021, F022, and F023.

Wastes collectively known as the California List wastes, defined under Section 3004(d) of HSWA, are liquid hazardous wastes containing metals, free cyanides, PCBs, corrosives (i.e., a pH less than or equal to 2.0), and any liquid or nonliquid hazardous waste containing halogenated organic compounds (HOCs) above 0.1 percent by weight. Rules for the California List were proposed on December 11, 1986, and final rules for PCBs, corrosives, and HOC-containing wastes were established August 12, 1987. In that rule, EPA elected not to establish standards for metals. Therefore, the statutory limits became effective.

On May 28, 1986, EPA published a final rule (51 FR 19300) that delineated the specific waste codes that would be addressed by the First Third, Second Third, and Third Third. This schedule is incorporated into 40 CFR 268.10, .11, and .12.

1.2 Summary of Promulgated BDAT Methodology

In a November 7, 1986, rulemaking, EPA promulgated a technology-based approach to establishing treatment standards under section 3004(m). Section 3004(m) also specifies that treatment standards must "minimize" long- and short-term threats to human health and the environment arising from land disposal of hazardous wastes.

Congress indicated in the legislative history accompanying the HSWA that "[t]he requisite levels of [sic] methods of treatment established by the Agency should be the best that has been demonstrated to be achievable," noting that the intent is "to require utilization of available technology" and not a "process which contemplates technology-forcing standards" (Vol. 130 Cong. Rec. S9178 (daily ed., July 25, 1984)). EPA has interpreted this legislative history as suggesting that Congress considered the requirement under 3004(m) to be met by application of the best demonstrated and achievable (i.e., available) technology prior to land disposal of wastes or treatment residuals. Accordingly, EPA's treatment standards are generally based on the performance of the best demonstrated available technology (BDAT) identified for treatment of the hazardous constituents. This approach involves the identification of potential treatment systems, the determination of whether they are demonstrated and available, and the collection of treatment data from well-designed and well-operated systems.

The treatment standards, according to the statute, can represent levels or methods of treatment, if any, that substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents. Wherever possible, the Agency prefers to establish BDAT treatment standards as "levels" of treatment (i.e., performance standards) rather than adopting an approach that would require the use of specific treatment "methods." EPA believes that concentration-based treatment levels offer the regulated community greater

flexibility to develop and implement compliance strategies as well as an incentive to develop innovative technologies.

1.2.1 Waste Treatability Group

In developing the treatment standards, EPA first characterizes the waste(s). As necessary, EPA may establish treatability groups for wastes having similar physical and chemical properties. That is, if EPA believes that wastes represented by different waste codes could be treated to similar concentrations using identical technologies, the Agency combines the codes into one treatability group. EPA generally considers wastes to be similar when they are both generated from the same industry and from similar processing stages. In addition, EPA may combine two or more separate wastes into the same treatability group when data are available showing that the waste characteristics affecting performance are similar or that one waste would be expected to be less difficult to treat.

Once the treatability groups have been established, EPA collects and analyzes data on identified technologies used to treat the wastes in each treatability group. The technologies evaluated must be demonstrated on the waste or a similar waste and must be available for use.

1.2.2 Demonstrated and Available Treatment Technologies

Consistent with legislative history, EPA considers demonstrated technologies to be those that are used to treat the waste of interest or a similar waste with regard to parameters that affect treatment selection (see November 7, 1986, 51 FR 40588). EPA also will consider as treatment those technologies used to separate or otherwise process chemicals and

other materials. Some of these technologies clearly are applicable to waste treatment, since the wastes are similar to raw materials processed in industrial applications.

For most of the waste treatability groups for which EPA will promulgate treatment standards, EPA will identify demonstrated technologies either through review of literature related to current waste treatment practices or on the basis of information provided by specific facilities currently treating the waste or similar wastes.

In cases where the Agency does not identify any facilities treating wastes represented by a particular waste treatability group, EPA may transfer a finding of demonstrated treatment. To do this, EPA will compare the parameters affecting treatment selection for the waste treatability group of interest to other wastes for which demonstrated technologies already have been determined. The parameters affecting treatment selection and their use for this waste are described in Section 3.2 of this document. If the parameters affecting treatment selection are similar, then the Agency will consider the treatment technology also to be demonstrated for the waste of interest. For example, EPA considers rotary kiln incineration a demonstrated technology for many waste codes containing hazardous organic constituents, high total organic content, and high filterable solids content, regardless of whether any facility is currently treating these wastes. The basis for this determination is data found in literature and data generated by EPA confirming the use of rotary kiln incineration on wastes having the above characteristics.

If no commercial treatment or recovery operations are identified for a waste or wastes with similar physical or chemical characteristics that affect treatment selection, the Agency will be unable to identify any demonstrated treatment technologies for the waste, and, accordingly, the waste will be prohibited from land disposal (unless handled in accordance with the exemption and variance provisions of the rule). The Agency is, however, committed to establishing treatment standards as soon as new or improved treatment processes are demonstrated (and available).

Operations only available at research facilities, pilot- and bench-scale operations will not be considered in identifying demonstrated treatment technologies for a waste because these technologies would not necessarily be "demonstrated." Nevertheless, EPA may use data generated at research facilities in assessing the performance of demonstrated technologies.

As discussed earlier, Congress intended that technologies used to establish treatment standards under Section 3004(m) be not only "demonstrated," but also available. To decide whether demonstrated technologies may be considered "available," the Agency determines whether they (1) are commercially available and (2) substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste.

EPA will only set treatment standards based on a technology that meets the above criteria. Thus, the decision to classify a technology as "unavailable" will have a direct impact on the treatment standard. If

the best technology is unavailable, the treatment standard will be based on the next best treatment technology determined to be available. To the extent that the resulting treatment standards are less stringent, greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal units.

There also may be circumstances in which EPA concludes that for a given waste none of the demonstrated treatment technologies are "available" for purposes of establishing the 3004(m) treatment performance standards. Subsequently, these wastes will be prohibited from continued placement in or on the land unless managed in accordance with applicable exemptions and variance provisions. The Agency is, however, committed to establishing new treatment standards as soon as new or improved treatment processes become "available."

(1) Proprietary or Patented Processes. If the demonstrated treatment technology is a proprietary or patented process that is not generally available, EPA will not consider the technology in its determination of the treatment standards. EPA will consider proprietary or patented processes available if it determines that the treatment method can be purchased or licensed from the proprietor or is commercially available treatment. The services of the commercial facility offering this technology often can be purchased even if the technology itself cannot be purchased.

(2) Substantial Treatment. To be considered "available," a demonstrated treatment technology must "substantially diminish the

toxicity" of the waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste in accordance with section 3004(m). By requiring that substantial treatment be achieved in order to set a treatment standard, the statute ensures that all wastes are adequately treated before being placed in or on the land and ensures that the Agency does not require a treatment method that provides little or no environmental benefit. Treatment will always be deemed substantial if it results in nondetectable levels of the hazardous constituents of concern. If nondetectable levels are not achieved, then a determination of substantial treatment will be made on a case-by-case basis. This approach is necessary because of the difficulty of establishing a meaningful guideline that can be applied broadly to the many wastes and technologies to be considered. EPA will consider the following factors in an effort to evaluate whether a technology provides substantial treatment on a case-by-case basis:

(a) Number and types of constituents treated;

(b) Performance (concentration of the constituents in the treatment residuals); and

(c) Percent of constituents removed.

If none of the demonstrated treatment technologies achieve substantial treatment of a waste, the Agency cannot establish treatment standards for the constituents of concern in that waste.

1.2.3 Collection of Performance Data

Performance data on the demonstrated available technologies are evaluated by the Agency to determine whether the data are representative

of well-designed and well-operated treatment systems. Only data from well-designed and well-operated systems are included in determining BDAT. The data evaluation includes data already collected directly by EPA and/or data provided by industry. In those instances where additional data are needed to supplement existing information, EPA collects additional data through a sampling and analysis program. The principal elements of this data collection program are: (a) identification of facilities for site visits, (b) engineering site visit, (c) Sampling and Analysis Plan, (d) sampling visit, and (e) Onsite Engineering Report.

(1) Identification of Facilities for Site Visits. To identify facilities that generate and/or treat the waste of concern, EPA uses a number of information sources. These include Stanford Research Institute's Directory of Chemical Producers, EPA's Hazardous Waste Data Management System (HWDMS), the 1986 Treatment, Storage, Disposal Facility (TSDF) National Screening Survey, and EPA's Industry Studies Data Base. In addition, EPA contacts trade associations to inform them that the Agency is considering visits to facilities in their industry and to solicit assistance in identifying facilities for EPA to consider in its treatment sampling program.

After identifying facilities that treat the waste, EPA uses this hierarchy to select sites for engineering visits: (1) generators treating single wastes on site; (2) generators treating multiple wastes together on site; (3) commercial treatment, storage, and disposal facilities

(TSDFs); and (4) EPA in-house treatment. This hierarchy is based on two concepts: (1) to the extent possible, EPA should develop treatment standards from data produced by treatment facilities handling only a single waste, and (2) facilities that routinely treat a specific waste have had the best opportunity to optimize design parameters. Although excellent treatment can occur at many facilities that are not high in this hierarchy, EPA has adopted this approach to avoid, when possible, ambiguities related to the mixing of wastes before and during treatment.

When possible, the Agency will evaluate treatment technologies using commercially operated systems. If performance data from properly designed and operated commercial treatment methods for a particular waste or a waste judged to be similar are not available, EPA may use data from research facilities operations. Whenever research facility data are used, EPA will explain why such data were used in the preamble and background document and will request comments on the use of such data.

Although EPA's data bases provide information on treatment for individual wastes, the data bases rarely provide data that support the selection of one facility for sampling over another. In cases where several treatment sites appear to fall into the same level of the hierarchy, EPA selects sites for visits strictly on the basis of which facility could most expeditiously be visited and later sampled if justified by the engineering visit.

(2) Engineering Site Visit. Once a treatment facility has been selected, an engineering site visit is made to confirm that a candidate for sampling meets EPA's criteria for a well-designed facility and to ensure that the necessary sampling points can be accessed to determine operating parameters and treatment effectiveness. During the visit, EPA also confirms that the facility appears to be well operated, although the actual operation of the treatment system during sampling is the basis for EPA's decisions regarding proper operation of the treatment unit. In general, the Agency considers a well-designed facility to be one that contains the unit operations necessary to treat the various hazardous constituents of the waste as well as to control other nonhazardous materials in the waste that may affect treatment performance.

In addition to ensuring that a system is reasonably well designed, the engineering visit examines whether the facility has a way to measure the operating parameters that affect performance of the treatment system during the waste treatment period. For example, EPA may choose not to sample a treatment system that operates in a continuous mode, for which an important operating parameter cannot be continuously recorded. In such systems, instrumentation is important in determining whether the treatment system is operating at design values during the waste treatment period.

(3) Sampling and Analysis Plan. If after the engineering site visit the Agency decides to sample a particular plant, the Agency will then develop a site-specific Sampling and Analysis Plan (SAP) according to the Generic Quality Assurance Project Plan for the Land Disposal Restriction

Program ("BDAT"), EPA/530-SW-87-011. In brief, the SAP discusses where the Agency plans to sample, how the samples will be taken, the frequency of sampling, the constituents to be analyzed and the method of analysis, operational parameters to be obtained, and specific laboratory quality control checks on the analytical results.

The Agency will generally produce a draft of the site-specific Sampling and Analysis Plan within 2 to 3 weeks of the engineering visit. The draft of the SAP is then sent to the plant for review and comment. With few exceptions, the draft SAP should be a confirmation of data collection activities discussed with the plant personnel during the engineering site visit. EPA encourages plant personnel to recommend any modifications to the SAP that they believe will improve the quality of the data.

It is important to note that sampling of a plant by EPA does not mean that the data will be used in the development of treatment standards for BDAT. EPA's final decision on whether to use data from a sampled plant depends on the actual analysis of the waste being treated and on the operating conditions at the time of sampling. Although EPA would not plan to sample a facility that was not ostensibly well-designed and well-operated, there is no way to ensure that at the time of the sampling the facility will not experience operating problems. Additionally, EPA statistically compares its test data to suitable industry-provided data, where available, in its determination of what data to use in developing treatment standards. The methodology for comparing data is presented later in this section.

(Note: Facilities wishing to submit data for consideration in the development of BDAT standards should, to the extent possible, provide sampling information similar to that acquired by EPA. Such facilities should review the Generic Quality Assurance Project Plan for the Land Disposal Restriction Program ("BDAT"), which delineates all of the quality control and quality assurance measures associated with sampling and analysis. Quality assurance and quality control procedures are summarized in Section 1.2.6 of this document.)

(4) Sampling Visit. The purpose of the sampling visit is to collect samples that characterize the performance of the treatment system and to document the operating conditions that existed during the waste treatment period. At a minimum, the Agency attempts to collect sufficient samples of the untreated waste and solid and liquid treatment residuals so that variability in the treatment process can be accounted for in the development of the treatment standards. To the extent practicable, and within safety constraints, EPA or its contractors collect all samples and ensure that chain-of-custody procedures are conducted so that the integrity of the data is maintained.

In general, the samples collected during the sampling visit will have already been specified in the SAP. In some instances, however, EPA will not be able to collect all planned samples because of changes in the facility operation or plant upsets; EPA will explain any such deviations from the SAP in its follow-up Onsite Engineering Report.

(5) Onsite Engineering Report. EPA summarizes all its data collection activities and associated analytical results for testing at a facility in a report referred to as the Onsite Engineering Report (OER). This report characterizes the waste(s) treated, the treated residual concentrations, the design and operating data, and all analytical results including methods used and accuracy results. This report also describes any deviations from EPA's suggested analytical methods for hazardous wastes (Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986).

After the Onsite Engineering Report is completed, the report is submitted to the plant for review. This review provides the plant with a final opportunity to claim any information contained in the report as confidential. Following the review and incorporation of comments, as appropriate, the report is made available to the public with the exception of any material claimed as confidential by the plant.

1.2.4 Hazardous Constituents Considered and Selected for Regulation

(1) Development of BDAT List. The list of hazardous constituents within the waste codes that are targeted for treatment is referred to by the Agency as the BDAT constituent list. This list, provided as Table 1-1, is derived from the constituents presented in 40 CFR Part 261, Appendix VII and Appendix VIII, as well as several ignitable constituents used as the basis of listing wastes as F003 and F005. These sources provide a comprehensive list of hazardous constituents specifically regulated under RCRA. The BDAT list consists of those constituents that can be analyzed using methods published in SW-846, Third Edition.

Table 1-1 BDAT Constituent List

BDAT reference no	Parameter	Cas no.
	Volatiles	
222	Acetone	67-64-1
1.	Acetonitrile	75-05-8
2.	Acrolein	107-02-8
3.	Acrylonitrile	107-13-1
4.	Benzene	71-43-2
5.	Bromodichloromethane	75-27-4
6.	Bromomethane	74-83-9
223.	n-Butyl alcohol	71-36-3
7	Carbon tetrachloride	56-23-5
8.	Carbon disulfide	75-15-0
9.	Chlorobenzene	108-90-7
10.	2-Chloro-1,3-butadiene	126-99-8
11.	Chlorodibromomethane	124-48-1
12.	Chloroethane	75-00-3
13	2-Chloroethyl vinyl ether	110-75-8
14	Chloroform	67-66-3
15.	Chloromethane	74-87-3
16.	3-Chloropropene	107-05-1
17	1,2-Dibromo-3-chloropropane	96-12-8
18	1,2-Dibromoethane	106-93-4
19	Dibromomethane	74-95-3
20	Trans-1,4-Dichloro-2-butene	110-57-6
21.	Dichlorodifluoromethane	75-71-8
22	1,1-Dichloroethane	75-34-3
23	1,2-Dichloroethane	107-06-2
24	1,1-Dichloroethylene	75-35-4
25	Trans-1,2-Dichloroethene	156-60-5
26	1,2-Dichloropropane	78-87-5
27	Trans-1,3-Dichloropropene	10061-02-6
28	cis-1,3-Dichloropropene	10061-01-5
29	1,4-Dioxane	123-91-1
224	2-Ethoxyethanol	110-80-5
225	Ethyl acetate	141-78-6
226	Ethyl benzene	100-41-4
30	Ethyl cyanide	107-12-0
227	Ethyl ether	60-29-7
31	Ethyl methacrylate	97-63-2
214	Ethylene oxide	75-21-8
32	Iodomethane	74-88-4

Table 1-1 (continued)

BDAT reference no.	Parameter	Cas no.
	Volatiles (continued)	
33.	Isobutyl alcohol	78-83-1
228.	Methanol	67-56-1
34.	Methyl ethyl ketone	78-93-3
229.	Methyl isobutyl ketone	108-10-1
35.	Methyl methacrylate	80-62-6
37.	Methacrylonitrile	126-98-7
38.	Methylene chloride	75-09-2
230.	2-Nitropropane	79-46-9
39.	Pyridine	110-86-1
40.	1,1,1,2-Tetrachloroethane	630-20-6
41.	1,1,2,2-Tetrachloroethane	79-34-6
42.	Tetrachloroethene	127-18-4
43.	Toluene	108-88-3
44.	Tribromomethane	75-25-2
45	1,1,1-Trichloroethane	71-55-6
46.	1,1,2-Trichloroethane	79-00-5
47.	Trichloroethene	79-01-6
48.	Trichloromonofluoromethane	75-69-4
49.	1,2,3-Trichloropropane	96-18-4
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
50.	Vinyl chloride	75-01-4
215.	1,2-Xylene	97-47-6
216.	1,3-Xylene	108-38-3
217.	1,4-Xylene	106-44-5
	Semivolatiles	
51.	Acenaphthalene	208-96-8
52.	Acenaphthene	83-32-9
53	Acetophenone	96-86-2
54.	2-Acetylaminofluorene	53-96-3
55.	4-Aminobiphenyl	92-67-1
56.	Aniline	62-53-3
57	Anthracene	120-12-7
58.	Aramite	140-57-8
59.	Benz(a)anthracene	56-55-3
218.	Benzal chloride	98-87-3
60.	Benzenethiol	108-98-5
61	Deleted	
62.	Benzo(a)pyrene	50-32-8

Table 1-1 (continued)

BDAT reference no.	Parameter	CAS no.
	Semivolatiles (continued)	
63.	Benzo(b)fluoranthene	205-99-2
64	Benzo(ghi)perylene	191-24-2
65.	Benzo(k)fluoranthene	207-08-9
66.	p-Benzoquinone	106-51-4
67.	Bis(2-chloroethoxy)methane	111-91-1
68.	Bis(2-chloroethyl)ether	111-44-4
69.	Bis(2-chloroisopropyl)ether	39638-32-9
70.	Bis(2-ethylhexyl)phthalate	117-81-7
71.	4-Bromophenyl phenyl ether	101-55-3
72.	Butyl benzyl phthalate	85-68-7
73.	2-sec-Butyl-4,6-dinitrophenol	88-85-7
74.	p-Chloroaniline	106-47-8
75	Chlorobenzilate	510-15-6
76.	p-Chloro-m-cresol	59-50-7
77.	2-Chloronaphthalene	91-58-7
78.	2-Chlorophenol	95-57-8
79.	3-Chloropropionitrile	542-76-7
80.	Chrysene	218-01-9
81.	ortho-Cresol	95-48-7
82.	para-Cresol	106-44-5
232.	Cyclohexanone	108-94-1
83	Dibenz(a,h)anthracene	53-70-3
84.	Dibenzo(a,e)pyrene	192-65-4
85.	Dibenzo(a,i)pyrene	189-55-9
86.	m-Dichlorobenzene	541-73-1
87.	o-Dichlorobenzene	95-50-1
88.	p-Dichlorobenzene	106-46-7
89.	3,3'-Dichlorobenzidine	91-94-1
90.	2,4-Dichlorophenol	120-83-2
91.	2,6-Dichlorophenol	87-65-0
92.	Diethyl phthalate	84-66-2
93.	3,3'-Dimethoxybenzidine	119-90-4
94	p-Dimethylaminoazobenzene	60-11-7
95	3,3'-Dimethylbenzidine	119-93-7
96.	2,4-Dimethylphenol	105-67-9
97.	Dimethyl phthalate	131-11-3
98	Di-n-butyl phthalate	84-74-2
99	1,4-Dinitrobenzene	100-25-4
100.	4,6-Dinitro-o-cresol	534-52-1
101.	2,4-Dinitrophenol	51-28-5

Table 1-1 (continued)

BDAT reference no.	Parameter	CAS no.
	Semivolatiles (continued)	
102.	2,4-Dinitrotoluene	121-14-2
103.	2,6-Dinitrotoluene	606-20-2
104.	Di-n-octyl phthalate	117-84-0
105.	Di-n-propylnitrosamine	621-64-7
106.	Diphenylamine	122-39-4
219.	Diphenylnitrosamine	86-30-6
107.	1,2-Diphenylhydrazine	122-66-7
108.	Fluoranthene	206-44-0
109.	Fluorene	86-73-7
110.	Hexachlorobenzene	118-74-1
111.	Hexachlorobutadiene	87-68-3
112.	Hexachlorocyclopentadiene	77-47-4
113.	Hexachloroethane	67-72-1
114.	Hexachlorophene	70-30-4
115.	Hexachloropropene	1888-71-7
116.	Indeno(1,2,3-cd)pyrene	193-39-5
117.	Isosafrole	120-58-1
118.	Methapyrilene	91-80-5
119.	3-Methylcholanthrene	56-49-5
120.	4,4'-Methylenebis (2-chloroaniline)	101-14-4
36.	Methyl methanesulfonate	66-27-3
121.	Naphthalene	91-20-3
122.	1,4-Naphthoquinone	130-15-4
123.	1-Naphthylamine	134-32-7
124.	2-Naphthylamine	91-59-8
125.	p-Nitroaniline	100-01-6
126.	Nitrobenzene	98-95-3
127.	4-Nitrophenol	100-02-7
128.	N-Nitrosodi-n-butylamine	924-16-3
129.	N-Nitrosodiethylamine	55-18-5
130.	N-Nitrosodimethylamine	62-75-9
131.	N-Nitrosomethylethylamine	10595-95-6
132.	N-Nitrosomorpholine	59-89-2
133.	N-Nitrosopiperidine	100-75-4
134.	n-Nitrosopyrrolidine	930-55-2
135.	5-Nitro-o-toluidine	99-65-8
136.	Pentachlorobenzene	608-93-5
137.	Pentachloroethane	76-01-7
138	Pentachloronitrobenzene	82-68-8

Table 1-1 (continued)

BDAT reference no.	Parameter	CAS no.
	Semivolatiles (continued)	
139.	Pentachlorophenol	87-86-5
140.	Phenacetin	62-44-2
141.	Phenanthrene	85-01-8
142.	Phenol	108-95-2
220.	Phthalic anhydride	85-44-9
143.	2-Picoline	109-06-8
144.	Pronamide	23950-58-5
145.	Pyrene	129-00-0
146.	Resorcinol	108-46-3
147.	Safrole	94-59-7
148.	1,2,4,5-Tetrachlorobenzene	95-94-3
149.	2,3,4,6-Tetrachlorophenol	58-90-2
150.	1,2,4-Trichlorobenzene	120-82-1
151.	2,4,5-Trichlorophenol	95-95-4
152.	2,4,6-Trichlorophenol	88-06-2
153.	Tris(2,3-dibromopropyl) phosphate	126-72-7
	Metals	
154.	Antimony	7440-36-0
155.	Arsenic	7440-38-2
156.	Barium	7440-39-3
157.	Beryllium	7440-41-7
158.	Cadmium	7440-43-9
159.	Chromium (total)	7440-47-32
221.	Chromium (hexavalent)	-
160.	Copper	7440-50-8
161.	Lead	7439-92-1
162.	Mercury	7439-97-6
163.	Nickel	7440-02-0
164.	Selenium	7782-49-2
165.	Silver	7440-22-4
166.	Thallium	7440-28-0
167.	Vanadium	7440-62-2
168.	Zinc	7440-66-6
	Inorganics	
169	Cyanide	57-12-5
170.	Fluoride	16964-48-8
171.	Sulfide	8496-25-8

Table 1-1 (continued)

BDAT reference no.	Parameter	CAS no.
	Organochlorine pesticides	
172.	Aldrin	309-00-2
173.	alpha-BHC	319-84-6
174.	beta-BHC	319-85-7
175.	delta-BHC	319-86-8
176.	gamma-BHC	58-89-9
177.	Chlordane	57-74-9
178.	DDD	72-54-8
179.	DDE	72-55-9
180.	DDT	50-29-3
181.	Dieldrin	60-57-1
182.	Endosulfan I	939-98-8
183.	Endosulfan II	33213-6-5
184.	Endrin	72-20-8
185.	Endrin aldehyde	7421-93-4
186.	Heptachlor	76-44-8
187.	Heptachlor epoxide	1024-57-3
188.	Isodrin	465-73-6
189.	Kepone	143-50-0
190.	Methoxyclor	72-43-5
191.	Toxaphene	8001-35-2
	Phenoxyacetic acid herbicides	
192.	2,4-Dichlorophenoxyacetic acid	94-75-7
193.	Silvex	93-72-1
194.	2,4,5-T	93-76-5
	Organophosphorous insecticides	
195.	Disulfoton	298-04-4
196.	Famphur	52-85-7
197.	Methyl parathion	298-00-0
198.	Parathion	56-38-2
199.	Phorate	298-02-2
	PCBs	
200.	Aroclor 1016	12674-11-2
201.	Aroclor 1221	11104-28-2
202	Aroclor 1232	11141-16-5

Table 1-1 (continued)

BDAT reference no.	Parameter	CAS no.
	PCBs (continued)	
203.	Aroclor 1242	53469-21-9
204.	Aroclor 1248	12672-29-6
205.	Aroclor 1254	11097-69-1
206.	Aroclor 1260	11096-82-5
	Dioxins and furans	
207.	Hexachlorodibenzo-p-dioxins	-
208.	Hexachlorodibenzofurans	-
209.	Pentachlorodibenzo-p-dioxins	-
210.	Pentachlorodibenzofurans	-
211.	Tetrachlorodibenzo-p-dioxins	-
212.	Tetrachlorodibenzofurans	-
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6

The initial BDAT constituent list was published in EPA's Generic Quality Assurance Project Plan, March 1987 (EPA/530-SW-87-011). Additional constituents will be added to the BDAT constituent list as additional key constituents are identified for specific waste codes or as new analytical methods are developed for hazardous constituents. For example, since the list was published in March 1987, eighteen additional constituents (hexavalent chromium, xylene (all three isomers), benzal chloride, phthalic anhydride, ethylene oxide, acetone, n-butyl alcohol, 2-ethoxyethanol, ethyl acetate, ethyl benzene, ethyl ether, methanol, methyl isobutyl ketone, 2-nitropropane, 1,1,2-trichloro-1,2,2-trifluoroethane, and cyclohexanone) have been added to the list.

Chemicals are listed in Appendix VIII if they are shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life-forms, and they include such substances as those identified by the Agency's Carcinogen Assessment Group as being carcinogenic. Including a constituent in Appendix VIII means that the constituent can be cited as a basis for listing toxic wastes.

Although Appendix VII, Appendix VIII, and the F003 and F005 ignitables provide a comprehensive list of RCRA-regulated hazardous constituents, not all of the constituents can be analyzed in a complex waste matrix. Therefore, constituents that could not be readily analyzed in an unknown waste matrix were not included on the initial BDAT list. As mentioned above, however, the BDAT constituent list is a continuously growing list that does not preclude the addition of new constituents when analytical methods are developed.

There are 5 major reasons that constituents were not included on the BDAT constituent list:

(a) Constituents are unstable. Based on their chemical structure, some constituents will either decompose in water or will ionize. For example, maleic anhydride will form maleic acid when it comes in contact with water and copper cyanide will ionize to form copper and cyanide ions. However, EPA may choose to regulate the decomposition or ionization products.

(b) EPA-approved or verified analytical methods are not available. Many constituents, such as 1,3,5-trinitrobenzene, are not measured adequately or even detected using any of EPA's analytical methods published in SW-846 Third Edition.

(c) The constituent is a member of a chemical group designated in Appendix VIII as not otherwise specified (N.O.S.). Constituents listed as N.O.S., such as chlorinated phenols, are a generic group of some types of chemicals for which a single analytical procedure is not available. The individual members of each such group need to be listed to determine whether the constituents can be analyzed. For each N.O.S. group, all those constituents that can be readily analyzed are included in the BDAT constituents list.

(d) Available analytical procedures are not appropriate for a complex waste matrix. Some compounds, such as auramine, can be analyzed as a pure constituent. However, in the presence of other constituents, the recommended analytical method does not positively identify the constituent. The use of high pressure liquid chromotography (HPLC) presupposes a high expectation of finding the specific constituents of interest. In using this procedure to screen samples, protocols would have to be developed on a case-specific basis to verify the identity of constituents present in the samples. Therefore, HPLC is not an appropriate analytical procedure for complex samples containing unkown constituents.

(e) Standards for analytical instrument calibration are not commercially available. For several constituents, such as benz(c)acridine, commercially available standards of a "reasonably" pure grade are not available. The unavailability of a standard was determined by a review of catalogs from specialty chemical manufacturers.

Two constituents (fluoride and sulfide) are not specifically included in Appendices VII and VIII; however, these compounds are included on the BDAT list as indicator constituents for compounds from Appendices VII and VIII such as hydrogen fluoride and hydrogen sulfide, which ionize in water.

The BDAT constituent list presented in Table 1-1 is divided into the following nine groups:

- Volatile organics
- Semivolatile organics
- Metals
- Other inorganics
- Organochlorine pesticides
- Phenoxyacetic acid herbicides
- Organophosphorous insecticides
- PCBs
- Dioxins and furans

The constituents were placed in these categories based on their chemical properties. The constituents in each group are expected to behave similarily during treatment and are also analyzed, with the exception of the metals and inorganics, by using the same analytical methods.

(2) Constituent Selection Analysis. The constituents that the Agency selects for regulation in each treatability group are, in general, those found in the untreated wastes at treatable concentrations. For certain waste codes, the target list for the untreated waste may have been shortened (relative to analyses performed to test treatment technologies) because of the extreme unlikelihood of the constituent being present.

In selecting constituents for regulation, the first step is to summarize all the constituents that were found in the untreated waste at treatable concentrations. This process involves the use of the statistical analysis of variance (ANOVA) test, described in Section 1.2.6, to determine if constituent reductions were significant. The Agency interprets a significant reduction in concentration as evidence that the technology actually "treats" the waste.

There are some instances where EPA may regulate constituents that are not found in the untreated waste but are detected in the treated residual. This is generally the case where presence of the constituents in the untreated waste interferes with the quantification of the constituent of concern. In such instances, the detection levels of the constituent are relatively high, resulting in a finding of "not detected" when, in fact, the constituent is present in the waste.

After determining which of the constituents in the untreated waste are present at treatable concentrations, EPA develops a list of potential constituents for regulation. The Agency then reviews this list to determine if any of these constituents can be excluded from regulation because they would be controlled by regulation of other constituents in the list.

EPA performs this indicator analysis for two reasons: (1) it reduces the analytical cost burdens on the treater and (2) it facilitates implementation of the compliance and enforcement program. EPA's rationale for selection of regulated constituents for this waste code is presented in Section 5 of this background document.

(3) Calculation of Standards. The final step in the calculation of the BDAT treatment standard is the multiplication of the average treatment value by a factor referred to by the Agency as the variability factor. This calculation takes into account that even well-designed and well-operated treatment systems will experience some fluctuations in performance. EPA expects that fluctuations will result from inherent mechanical limitations in treatment control systems, collection of treated samples, and analysis of these samples. All of the above fluctuations can be expected to occur at well-designed and well-operated treatment facilities. Therefore, setting treatment standards utilizing a variability factor should be viewed not as a relaxing of 3004(m) requirements, but rather as a function of the normal variability of the treatment processes. A treatment facility will have to be designed to meet the mean achievable treatment performance level to ensure that the performance levels remain within the limits of the treatment standard.

The Agency calculates a variability factor for each constituent of concern within a waste treatability group using the statistical calculation presented in Appendix A. The equation for calculating the variability factor is the same as that used by EPA for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act. The variability factor establishes the instantaneous maximum based on the 99th percentile value.

There is an additional step in the calculation of the treatment standards in those instances where the ANOVA analysis shows that more

than one technology achieves a level of performance that represents BDAT. In such instances, the BDAT treatment standard is calculated by first averaging the mean performance value for each technology for each constituent of concern and then multiplying that value by the highest variability factor among the technologies considered. This procedure ensures that all the BDAT technologies used as the basis for the standards will achieve full compliance.

1.2.5 Compliance with Performance Standards

All the treatment standards reflect performance achieved by the Best Demonstrated Available Technology (BDAT). As such, compliance with these standards only requires that the treatment level be achieved prior to land disposal. It does not require the use of any particular treatment technology. While dilution of the waste as a means to comply with the standard is prohibited, wastes that are generated in such a way as to naturally meet the standard can be land disposed without treatment. With the exception of treatment standards that prohibit land disposal, all treatment standards proposed are expressed as a concentration level.

EPA has used both total constituent concentration and TCLP analyses of the treated waste as a measure of technology performance. EPA's rationale for when each of these analytical tests is used is explained in the following discussion.

For all organic constituents, EPA is basing the treatment standards on the total constituent concentration found in the treated waste. EPA based its decision on the fact that technologies exist to destroy the

various organics compounds. Accordingly, the best measure of performance would be the extent to which the various organic compounds have been destroyed or the total amount of constituent remaining after treatment. (NOTE: EPA's land disposal restrictions for solvent waste codes F001-F005 (51 FR 40572) uses the TCLP value as a measure of performance. At the time that EPA promulgated the treatment standards for F001-F005, useful data were not available on total constituent concentrations in treated residuals and, as a result, the TCLP data were considered to be the best measure of performance.)

For all metal constituents, EPA is using both total constituent concentration and/or the TCLP as the basis for treatment standards. The total constituent concentration is being used when the technology basis includes a metal recovery operation. The underlying principle of metal recovery is the reduction of the amount of metal in a waste by separating the metal for recovery; therefore, total constituent concentration in the treated residual is an important measure of performance for this technology. Additionally, EPA also believes that it is important that any remaining metal in a treated residual waste not be in a state that is easily leachable; accordingly, EPA is also using the TCLP as a measure of performance. It is important to note that for wastes for which treatment standards are based on a metal recovery process, the facility has to comply with both the total constituent concentration and the TCLP prior to land disposal.

In cases where treatment standards for metals are not based on recovery techniques but rather on stabilization, EPA is using only the TCLP as a measure of performance. The Agency's rationale is that stabilization is not meant to reduce the concentration of metal in a waste but only to chemically minimize the ability of the metal to leach.

1.2.6 Identification of BDAT

(1) Screening of Treatment Data. This section explains how the Agency determines which of the treatment technologies represent treatment by BDAT. The first activity is to screen the treatment performance data from each of the demonstrated and available technologies according to the following criteria:

(a) Design and operating data associated with the treatment data must reflect a well-designed, well-operated system for each treatment data point. (The specific design and operating parameters for each demonstrated technology for this waste code are discussed in Section 3.2 of this document.)

(b) Sufficient QA/QC data must be available to determine the true values of the data from the treated waste. This screening criterion involves adjustment of treated data to take into account that the type value may be different from the measured value. This discrepancy generally is caused by other constituents in the waste that can mask results or otherwise interfere with the analysis of the constituent of concern.

(c) The measure of performance must be consistent with EPA's approach to evaluating treatment by type of constituents (e.g., total concentration data for organics, and total concentration and TCLP for metals in the leachate from the residual).

In the absence of data needed to perform the screening analysis, EPA will make decisions on a case-by-case basis of whether to include the data. The factors included in this case-by-case analysis will be the

actual treatment levels achieved, the availability of the treatment data and their completeness (with respect to the above criteria), and EPA's assessment of whether the untreated waste represents the waste code of concern. EPA's application of these screening criteria for this waste code are provided in Section 4 of this background document.

(2) Comparison of Treatment Data. In cases in which EPA has treatment data from more than one technology following the screening activity, EPA uses the statistical method known as analysis of variance (ANOVA) to determine if one technology performs significantly better. This statistical method (summarized in Appendix A) provides a measure of the differences between two data sets. If EPA finds that one technology performs significantly better (i.e., the data sets are not homogeneous), BDAT treatment standards are the level of performance achieved by the best technology multiplied by the corresponding variability factor for each regulated constituent.

If the differences in the data sets are not statistically significant, the data sets are said to be homogeneous. Specifically, EPA uses the analysis of variance to determine whether BDAT represents a level of performance achieved by only one technology or represents a level of performance achieved by more than one (or all) of the technologies. If the Agency finds that the levels of performance for one or more technologies are not statistically different, EPA averages the performance values achieved by each technology and then multiplies this value by the largest variability factor associated with any of the

acceptable technologies. A detailed discussion of the treatment selection method and an example of how EPA chooses BDAT from multiple treatment systems is provided in Section A-1.

(3) Quality Assurance/Quality Control. This section presents the principal quality assurance/quality control (QA/QC) procedures employed in screening and adjusting the data to be used in the calculation of treatment standards. Additional QA/QC procedures used in collecting and screening data for the BDAT program are presented in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") (EPA/530-SW-87-001, March 1987).

To calculate the treatment standards for the Land Disposal Restriction Rules, it is first necessary to determine the recovery value for each constituent (the amount of constituent recovered after spiking, which is the addition of a known amount of the constituent, minus the initial concentration in the samples divided by the amount added) for a spike of the treated residual. Once the recovery value is determined, the following procedures are used to select the appropriate percent recovery value to adjust the analytical data:

(a) If duplicate spike recovery values are available for the constituent of interest, the data are adjusted by the lowest available percent recovery value (i.e., the value that will yield the most conservative estimate of treatment achieved). However, if a spike recovery value of less than 20 percent is reported for a specific constituent, the data are not used to set treatment standards because the Agency does not have sufficient confidence in the reported value to set a national standard.

(b) If data are not available for a specific constituent but are available for an isomer, then the spike recovery data are transferred from the isomer and the data are adjusted using the percent recovery selected according to the procedure described in (a) above.

(c) If data are not available for a specific constituent but are available for a similar class of constituents (e.g., volatile organics, acid-extractable semivolatiles), then spike recovery data available for this class of constituents are transferred. All spike recovery values greater than or equal to 20 percent for a spiked sample are averaged and the constituent concentration is adjusted by the average recovery value. If spiked recovery data are available for more than one sample, the average is calculated for each sample and the data are adjusted by the lowest average value.

(d) If matrix spike recovery data are not available for a set of data to be used to calculate treatment standards, then matrix spike recovery data are transferred from a waste that the Agency believes is a similar matrix (e.g., if the data are for an ash from incineration, then data from other incinerator ashes could be used). While EPA recognizes that transfer of matrix spike recovery data from a similar waste is not an exact analysis, this is considered the best approach for adjusting the data to account for the fact that most analyses do not result in extraction of 100 percent of the constituent. In assessing the recovery data to be transferred, the procedures outlined in (a), (b), and (c) above are followed.

The analytical procedures employed to generate the data used to calculate the treatment standards are listed in Appendix B of this document. In cases where alternatives or equivalent procedures and/or equipment are allowed in EPA's SW-846, Third Edition (November 1986) methods, the specific procedures and equipment used are also documented in this Appendix. In addition, any deviations from the SW-846, Third Edition, methods used to analyze the specific waste matrices are documented. It is important to note that the Agency will use the methods and procedures delineated in Appendix B to enforce the treatment

standards presented in Section 6 of this document. Accordingly, facilities should use these procedures in assessing the performance of their treatment systems.

1.2.7 BDAT Treatment Standards for "Derived-From" and "Mixed" Wastes

(1) Wastes from Treatment Trains Generating Multiple Residues. In a number of instances, the proposed BDAT consists of a series of operations each of which generates a waste residue. For example, the proposed BDAT for a certain waste code is based on solvent extraction, steam stripping, and activated carbon adsorption. Each of these treatment steps generates a waste requiring treatment -- a solvent-containing stream from solvent extraction, a stripper overhead, and spent activated carbon. Treatment of these wastes may generate further residues; for instance, spent activated carbon (if not regenerated) could be incinerated, generating an ash and possibly a scrubber water waste. Ultimately, additional wastes are generated that may require land disposal. With respect to these wastes, the Agency wishes to emphasize the following points:

(a) All of the residues from treating the original listed wastes are likewise considered to be the listed waste by virtue of the derived-from rule contained in 40 CFR Part 261.3(c)(2). (This point is discussed more fully in (2) below.) Consequently, all of the wastes generated in the course of treatment would be prohibited from land disposal unless they satisfy the treatment standard or meet one of the exceptions to the prohibition.

(b) The Agency's proposed treatment standards generally contain a concentration level for wastewaters and a concentration level for nonwastewaters. The treatment standards apply to all of the wastes generated in treating the original prohibited waste. Thus, all solids generated from treating these wastes would have

to meet the treatment standard for nonwastewaters. All derived-from wastes meeting the Agency definition of wastewater (less than 1 percent TOC and less than 1 percent total filterable solids) would have to meet the treatment standard for wastewaters. EPA wishes to make clear that this approach is not meant to allow partial treatment in order to comply with the applicable standard.

(c) The Agency has not performed tests, in all cases, on every waste that can result from every part of the treatment train. However, the Agency's treatment standards are based on treatment of the most concentrated form of the waste. Consequently, the Agency believes that the less concentrated wastes generated in the course of treatment will also be able to be treated to meet this value.

(2) Mixtures and Other Derived-From Residues. There is a further question as to the applicability of the BDAT treatment standards to residues generated not from treating the waste (as discussed above), but from other types of management. Examples are contaminated soil or leachate that is derived from managing the waste. In these cases, the mixture is still deemed to be the listed waste, either because of the derived-from rule (40 CFR Part 261.3(c)(2)(i)) or the mixture rule (40 CFR Part 261.3(a)(2)(iii) and (iv) or because the listed waste is contained in the matrix (see, for example, 40 CFR Part 261.33(d)). The prohibition for the particular listed waste consequently applies to this type of waste.

The Agency believes that the majority of these types of residues can meet the treatment standards for the underlying listed wastes (with the possible exception of contaminated soil and debris for which the Agency is currently investigating whether it is appropriate to establish a separate treatability subcategorization). For the most part, these

residues will be less concentrated than the original listed waste. The Agency's treatment standards also make a generous allowance for process variability by assuming that all treatability values used to establish the standard are lognormally distributed. The waste also might be amenable to a relatively nonvariable form of treatment technology such as incineration. Finally, and perhaps most important, the rules contain a treatability variance that allows a petitioner to demonstrate that its waste cannot be treated to the level specified in the rule (40 CFR Part 268.44(a). This provision provides a safety valve that allows persons with unusual waste matrices to demonstrate the appropriateness of a different standard. The Agency, to date, has not received any petitions under this provision (for example, for residues contaminated with a prohibited solvent waste), indicating, in the Agency's view, that the existing standards are generally achievable.

(3) Residues from Managing Listed Wastes or that Contain Listed Wastes. The Agency has been asked if and when residues from managing hazardous wastes, such as leachate and contaminated ground water, become subject to the land disposal prohibitions. Although the Agency believes this question to be settled by existing rules and interpretative statements, to avoid any possible confusion the Agency will address the question again.

Residues from managing First Third wastes, listed California List wastes, and spent solvent and dioxin wastes are all considered to be subject to the prohibitions for the underlying hazardous waste. Residues

from managing California List wastes likewise are subject to the California List prohibitions when the residues themselves exhibit a characteristic of hazardous waste. This determination stems directly from the derived-from rule in 40 CFR Part 261.3(c)(2) or in some cases from the fact that the waste is mixed with or otherwise contains the listed waste. The underlying principle stated in all of these provisions is that listed wastes remain listed until delisted.

The Agency's historic practice in processing delisting petitions addressing mixing residuals has been to consider them to be the listed waste and to require that delisting petitioners address all constituents for which the derived-from waste (or other mixed waste) was listed. The language in 40 CFR Part 260.22(b) states that mixtures or derived-from residues can be delisted provided a delisting petitioner makes a demonstration identical to that which a delisting petitioner would make for the underlying waste. These residues consequently are treated as the underlying listed waste for delisting purposes. The statute likewise takes this position, indicating that soil and debris that are contaminated with listed spent solvents or dioxin wastes are subject to the prohibition for these wastes even though these wastes are not the originally generated waste, but rather are a residual from management (RCRA section 3004(e)(3)). It is EPA's view that all such residues are covered by the existing prohibitions and treatment standards for the listed hazardous waste that these residues contain and from which they are derived.

1.2.8 Transfer of Treatment Standards

EPA is proposing some treatment standards that are not based on testing of the treatment technology of the specific waste subject to the treatment standard. Instead, the Agency has determined that the constituents present in the subject waste can be treated to the same performance levels as those observed in other wastes for which EPA has previously developed treatment data. EPA believes that transferring treatment performance for use in establishing treatment standards for untested wastes is valid technically in cases where the untested wastes are generated from similar industries, similar processing steps, or have similar waste characteristics affecting performance and treatment selection. Transfer of treatment standards to similar wastes or wastes from similar processing steps requires little formal analysis. However, in the case where only the industry is similar, EPA more closely examines the waste characteristics prior to concluding that the untested waste constituents can be treated to levels associated with tested wastes.

EPA undertakes a two-step analysis when determining whether wastes generated by different processes within a single industry can be treated to the same level of performance. First, EPA reviews the available waste characteristic data to identify those parameters that are expected to affect treatment selection. EPA has identified some of the most important constituents and other parameters needed to select the treatment technology appropriate for a given waste. A detailed discussion of each analysis, including how each parameter was selected for each waste, can be found in the background document for each waste.

Second, when an individual analysis suggests that an untested waste can be treated with the same technology as a waste for which treatment performance data are already available, EPA analyzes a more detailed list of constituents that represent some of the most important waste characteristics that the Agency believes will affect the performance of the technology. By examining and comparing these characteristics, the Agency determines whether the untested wastes will achieve the same level of treatment as the tested waste. Where the Agency determines that the untested waste is easier to treat than the tested waste, the treatment standards can be transferred. A detailed discussion of this transfer process for each waste can be found in later sections of this document.

1.3 Variance from the BDAT Treatment Standard

The Agency recognizes that there may exist unique wastes that cannot be treated to the level specified as the treatment standard. In such a case, a generator or owner/operator may submit a petition to the Administrator requesting a variance from the treatment standard. A particular waste may be significantly different from the wastes considered in establishing treatability groups because the waste contains a more complex matrix that makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard.

Variance petitions must demonstrate that the treatment standard established for a given waste cannot be met. This demonstration can be

made by showing that attempts to treat the waste by available technologies were not successful or by performing appropriate analyses of the waste, including waste characteristics affecting performance, which demonstrate that the waste cannot be treated to the specified levels. Variances will not be granted based solely on a showing that adequate BDAT treatment capacity is unavailable. (Such demonstrations can be made according to the provisions in Part 268.5 of RCRA for case-by-case extensions of the effective date.) The Agency will consider granting generic petitions provided that representative data are submitted to support a variance for each facility covered by the petition.

Petitioners should submit at least one copy to:

The Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

An additional copy marked "Treatability Variance" should be submitted to:

Chief, Waste Treatment Branch
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Petitions containing confidential information should be sent with only the inner envelope marked "Treatability Variance" and "Confidential Business Information" and with the contents marked in accordance with the requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, amended by 43 FR 4000).

The petition should contain the following information:

(1) The petitioner's name and address.

(2) A statement of the petitioner's interest in the proposed action.

(3) The name, address, and EPA identification number of the facility generating the waste, and the name and telephone number of the plant contact.

(4) The process(es) and feed materials generating the waste and an assessment of whether such process(es) or feed materials may produce a waste that is not covered by the demonstration.

(5) A description of the waste sufficient for comparison with the waste considered by the Agency in developing BDAT, and an estimate of the average and maximum monthly and annual quantities of waste covered by the demonstration. (Note: The petitioner should consult the appropriate BDAT background document for determining the characteristics of the wastes considered in developing treatment standards.)

(6) If the waste has been treated, a description of the system used for treating the waste, including the process design and operating conditions. The petition should include the reasons the treatment standards are not achievable and/or why the petitioner believes the standards are based on inappropriate technology for treating the waste. (Note: The petitioner should refer to the BDAT background document as guidance for determining the design and operating parameters that the Agency used in developing treatment standards.)

(7) A description of the alternative treatment systems examined by the petitioner (if any); a description of the treatment system deemed appropriate by the petitioner for the waste in question; and, as appropriate, the concentrations in the treatment residual or extract of the treatment residual (i.e., using the TCLP where appropriate for stabilized metals) that can be achieved by applying such treatment to the waste.

(8) A description of those parameters affecting treatment selection and waste characteristics that affect performance, including results of all analyses. (See Section 3.0 for a discussion of waste characteristics affecting performance that the Agency has identified for the technology representing BDAT.)

(9) The dates of the sampling and testing.

(10) A description of the methodologies and equipment used to obtain representative samples.

(11) A description of the sample handling and preparation techniques, including techniques used for extraction, containerization, and preservation of the samples.

(12) A description of analytical procedures used including QA/QC methods.

After receiving a petition for a variance, the Administrator may request any additional information or waste samples that may be required to evaluate and process the petition. Additionally, all petitioners must certify that the information provided to the Agency is accurate under 40 CFR Part 268.4(b).

In determining whether a variance will be granted, the Agency will first look at the design and operation of the treatment system being used. If EPA determines that the technology and operation are consistent with BDAT, the Agency will evaluate the waste to determine if the waste matrix and/or physical parameters are such that the BDAT treatment standards reflect treatment of this waste. Essentially, this latter analysis will concern the parameters affecting treatment selection and waste characteristics affecting performance parameters.

In cases where BDAT is based on more than one technology, the petitioner will need to demonstrate that the treatment standard cannot be met using any of the technologies, or that none of the technologies are appropriate for treatment of the waste. After the Agency has made a determination on the petition, the Agency's findings will be published in the Federal Register, followed by a 30-day period for public comment.

After review of the public comments, EPA will publish its final determination in the Federal Register as an amendment to the treatment standards in 40 CFR Part 268, Subpart D.

2. INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

The previous section presented the generic methodology for developing BDAT standards. The purpose of this section is to provide a complete characterization of the K037 listed waste by describing the industry that generates the waste, the process generating the waste and the data characterizing the waste. According to 40 CFR Part 261.32 (hazardous wastes from specific sources), the waste identified as K037 is specifically generated by the manufacturers of disulfoton and is listed as follows:

K037 - Wastewater treatment sludge from the production of disulfoton.

2.1 Industry Affected and Process Description

Only one facility in the United States is known to produce disulfoton. It is located in EPA Region VII, in the State of Missouri.

The disulfoton production process consists of three basic steps: (1) the formation of diethyl salt (DES), (2) the formation of chlorothio alcohol (CTA), and (3) the reaction of DES and CTA to form disulfoton. A flow diagram for the disulfoton production process is presented in Figure 2-1.

In the first step of the process, diethyl phosphorodithioic acid is formed in the DES unit from the reaction of P_2S_5 and ethanol in toluene. The major side product of this reaction is the 0,0,0-triethylester of the phosphorodithioic acid. The diethyl phosphorodithioic acid is next reacted in the same vessel with caustic

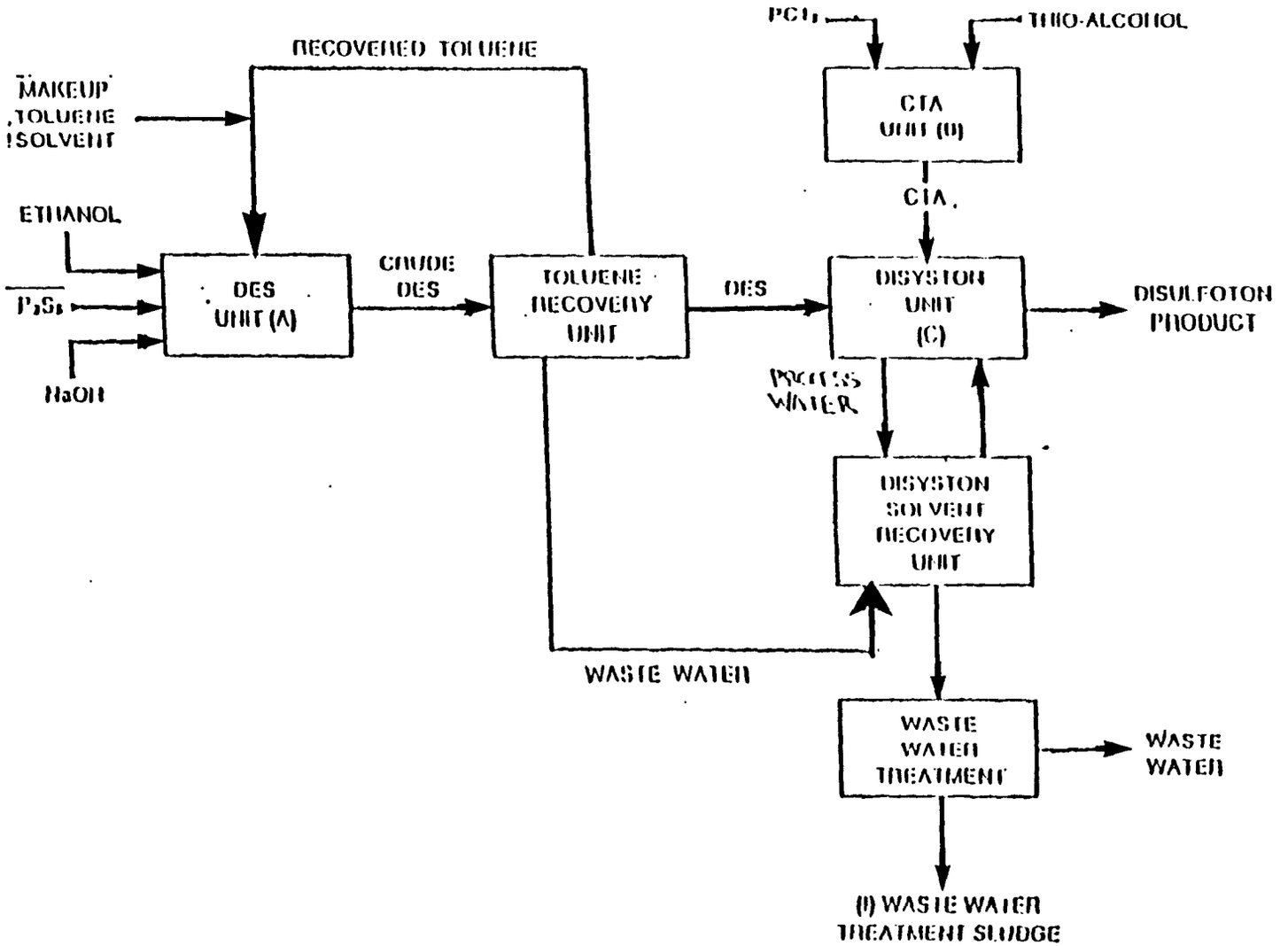


Figure 2-1 PRODUCTION AND WASTE SCHEMATIC FOR DISULFOTON

soda to form DES. The overall reaction for both subreactions is as follows:

$$P_2S_5 + 4C_2H_5OH + 2NaOH \xrightarrow{\text{Toluene}} 2(C_2H_5O)_2P(S)SNa + H_2S + 2H_2O.$$

Ethanol — DES

The DES is then separated from the reaction mix, which is sent to a toluene recovery unit. The recovered toluene is recycled back to the DES unit.

The second step of the disulfoton production process takes place in the CTA unit, where PCl_3 and thio-alcohol are reacted to form CTA as follows:

$$PC_3 + 3HOC_2H_4\text{-}S\text{-}C_2H_5 \longrightarrow 3ClC_2H_4\text{-}S\text{-}C_2H_5 + H_3PO_3.$$

In the final step of the process DES and CTA are reacted in the disyston unit to form disulfoton and sodium chloride:

$$(C_2H_5O)_2P(S)SNa + ClC_2H_4\text{-}S\text{-}C_2H_5 \longrightarrow (C_2H_5O)_2P(S)\text{-}S\text{-}C_2H_4\text{-}S\text{-}C_2H_5 + NaCl$$

Process water from the disyston unit is sent, along with wastewater from the toluene recovery unit, to the disyston solvent recovery unit, where disulfoton is recovered and recycled to the disyston unit. Wastewater from the disyston solvent recovery unit is circulated to wastewater treatment. The sludges generated from wastewater treatment are the waste stream K037.

2.2 Waste Characterization

This section includes all waste characterization data available to the Agency for K037 waste. The approximate percent concentrations of

the major constituents composing K037 waste are listed in Table 2-1. The percent concentration in the waste was determined from engineering judgment based on analytical analyses and plant information. The ranges of BDAT list constituents present in the waste and all other available parameters affecting treatment selection data are presented in Table 2-2. The data show a waste with high concentrations of solids (75 percent), low concentrations of water (less than 5 percent), approximately 20 percent disulfoton, 0.2 percent toluene, and less than 0.1 percent other BDAT list constituents. According to the data, no BDAT list inorganics other than metals, BDAT list organochlorine pesticides, BDAT list phenoxyacetic acid herbicides, PCBs, or dioxins and furans should be present in K037 wastes.

Table 2-1 Constituent Analysis of Untreated K037 Waste

Constituent	Concentration (wt. %)
Disulfoton	20
Toluene	0.2
Water	4.7
Solids (filter paper and diatomaceous earth filter aid)	75
Other BDAT list constituents	<0.1
Total	100 %

References:

1 USEPA 1987a Onsite Engineering Report for K037
2 Personal Communication.

Table 2-2 BDAT List Constituent Concentration and Other Data

BDAT Reference No	BDAT list constituent	Untreated K037 waste concentration (mg/kg) (a)	(b)
	Volatile Organics		
43	Toluene	201-2,000	<25,000
	Semivolatile Organics		
70	bis(2-ethylhexyl) phthalate	<250-500	-
	Metals		
155	Arsenic	<2.0-3.1	-
156	Barium	18-39	-
158	Cadmium	3.3-10	-
159	Chromium	43-93	-
160	Copper	7.0-24	-
161	Lead	5.6-28	-
163	Nickel	46-130	-
167	Vanadium	7-10	-
168	Zinc	89-190	-
	Organophosphorous Insecticides		
195	Disulfoton	104,000-246,000	0-100,000
	Other Parameters		
	Solids (filter paper and diatomaceous earth filter aid)	-	<750,000
	Water	-	125,000-225,000

References.

a USEPA 1987a Onsite Engineering Report for K037
b Personal Communication

3. APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES

This section describes the applicable treatment technologies, demonstrated treatment technologies, and performance data for the treatment of K037. Since the waste characterization data in Section 2 reveals untreated K037 wastes containing high BDAT list organic concentrations and high filterable solids, the technologies considered to be applicable are those that destroy or remove the various organic compounds in wastes with high filterable solids.

3.1 Applicable Treatment Technologies

The Agency has identified the following treatment technologies as being applicable for K037: batch distillation, incineration, and solvent extraction. Batch distillation can be used to separate components having widely different boiling points. Incineration technologies destroy the organic components in the waste feed. Solvent extraction removes organic constituents from a waste by exploiting the relatively high solubilities of the waste constituents in a particular solvent.

As stated previously, the Agency has identified these treatment technologies as applicable for treatment of K037 because the technologies are designed to destroy or remove the toxic organics present in untreated wastes with high filterable solids. The selection of the treatment technologies applicable for treating BDAT list organics in K037 waste is based on data submitted by industry, current literature sources, and field testing.

3.2 Demonstrated Treatment Technologies

The technologies demonstrated on this waste or on waste with similar parameters affecting treatment selection (i.e., high organic content, low water content, and high filterable solids content) are batch distillation and incineration including rotary kiln incineration and fluidized bed incineration. The Agency believes that solvent extraction is potentially applicable to the treatment of K037 waste; however, EPA does not have data on the characteristics of K037 waste that would allow the Agency to conclude that solvent extraction is "demonstrated" on similar wastes. The Agency does not believe that other technologies are applicable because various physical and chemical characteristics of this waste would not allow treatment to occur.

EPA believes batch distillation and fluidized bed incineration to be demonstrated treatment technologies for K037 because both have been used to treat wastes with similar characteristics. The Agency knows of at least one facility using batch distillation and one facility using fluidized bed incineration for treatment of wastes similar to K037. However, EPA is not aware of any generator or TSD facility currently using either technology for treatment of wastes containing a large percentage of K037; nor are there performance data that demonstrate their effectiveness in treating the BDAT list constituents in K037 waste.

The Agency believes rotary kiln incineration is demonstrated to treat K037 since it is being used to treat wastes similar to K037 with regard to parameters affecting treatment selection, including low water content,

high organic content, and high solids concentration. To help develop treatment standards, EPA tested rotary kiln incineration to demonstrate the actual performance achievability. Since the Agency is not aware of any generator or TSD facilities currently using rotary kiln incineration for treatment of wastes containing a large percentage of K037, the K037 was incinerated in EPA's own in-house rotary kiln. Performance data collected by EPA for incineration of K037 using a rotary kiln incinerator are shown in Tables 3-1 through 3-6. A detailed discussion of incineration is presented in Section 3.2.1.

3.2.1. Incineration

This section addresses the commonly used incineration technologies: Liquid injection, rotary kiln, fluidized bed incineration, and fixed hearth. A discussion is provided regarding the applicability of these technologies, the underlying principles of operation, a technology description, waste characteristics that affect performance, and finally important design and operating parameters. As appropriate the subsections are divided by type of incineration unit.

(1) Applicability and Use of This Technology

(a) Liquid Injection

Liquid injection is applicable to wastes that have viscosity values sufficiently low so that the waste can be atomized in the combustion chamber. A range of literature maximum viscosity values are reported with the low being 100 SSU and the high being 10,000 SSU. It is important to note that viscosity is temperature dependent so that while

liquid injection may not be applicable to a waste at ambient conditions, it may be applicable when the waste is heated. Other factors that affect the use of liquid injection are particle size and the presence of suspended solids. Both of these waste parameters can cause plugging of the burner nozzle.

(b) Rotary Kiln/Fluidized Bed/Fixed Hearth

These incineration technologies are applicable to a wide range of hazardous wastes. They can be used on wastes that contain high or low total organic content, high or low filterable solids, various viscosity ranges, and a range of other waste parameters. EPA has not found these technologies to be demonstrated on wastes that are comprised essentially of metals with low organic concentrations. In addition, the Agency expects that some of the high metal content wastes may not be compatible with existing and future air emission limits without emission controls far more extensive than currently practiced.

(2) Underlying Principles of Operation

(a) Liquid Injection

The basic operating principle of this incineration technology is that incoming liquid wastes are volatilized and then additional heat is supplied to the waste to destabilize the chemical bonds. Once the chemical bonds are broken, these constituents react with oxygen to form carbon dioxide and water vapor. The energy needed to destabilize the bonds is referred to as the energy of activation.

(b) Rotary Kiln and Fixed Hearth

There are two distinct principles of operation for these incineration technologies, one for each of the chambers involved. In the primary chamber, energy, in the form of heat, is transferred to the waste to achieve volatilization of the various organic waste constituents. During this volatilization process some of the organic constituents will oxidize to CO_2 and water vapor. In the secondary chamber, additional heat is supplied to overcome the energy requirements needed to destabilize the chemical bonds and allow the constituents to react with excess oxygen to form carbon dioxide and water vapor. The principle of operation for the secondary chamber is similar to liquid injection.

(c) Fluidized Bed

The principle of operation for this incinerator technology is somewhat different than for rotary kiln and fixed hearth incineration, in that there is only one chamber that contains the fluidizing sand and a freeboard section above the sand. The purpose of the fluidized bed is to both volatilize the waste and combust the waste. Destruction of the waste organics can be accomplished to a better degree in the primary chamber of this technology than for rotary kiln and fixed hearth because of 1) improved heat transfer from fluidization of the waste using forced air and 2) the fact that the fluidization process provides sufficient oxygen and turbulence to convert the organics to carbon dioxide and water vapor. The freeboard generally does not have an afterburner; however,

additional time is provided for conversion of the organic constituents to carbon dioxide, water vapor, and hydrochloric acid if chlorine is present in the waste.

(3) Description of Incineration Technologies

(a) Liquid Injection

The liquid injection system is capable of incinerating a wide range of gases and liquids. The combustion system has a simple design with virtually no moving parts. A burner or nozzle atomizes the liquid waste and injects it into the combustion chamber where it burns in the presence of air or oxygen. A forced draft system supplies the combustion chamber with air to provide oxygen for combustion and turbulence for mixing. The combustion chamber is usually a cylinder lined with refractory (i.e., heat resistant) brick and can be fired horizontally, vertically upward, or vertically downward. Figure 3-1 illustrates a liquid injection incineration system.

(b) Rotary Kiln

A rotary kiln is a slowly rotating, refractory-lined cylinder that is mounted at a slight incline from the horizontal (see Figure 3-2). Solid wastes enter at the high end of the kiln, and liquid or gaseous wastes enter through atomizing nozzles in the kiln or afterburner section. Rotation of the kiln exposes the solids to the heat, vaporizes them, and allows them to combust by mixing with air. The rotation also causes the ash to move to the lower end of the kiln where it can be removed. Rotary

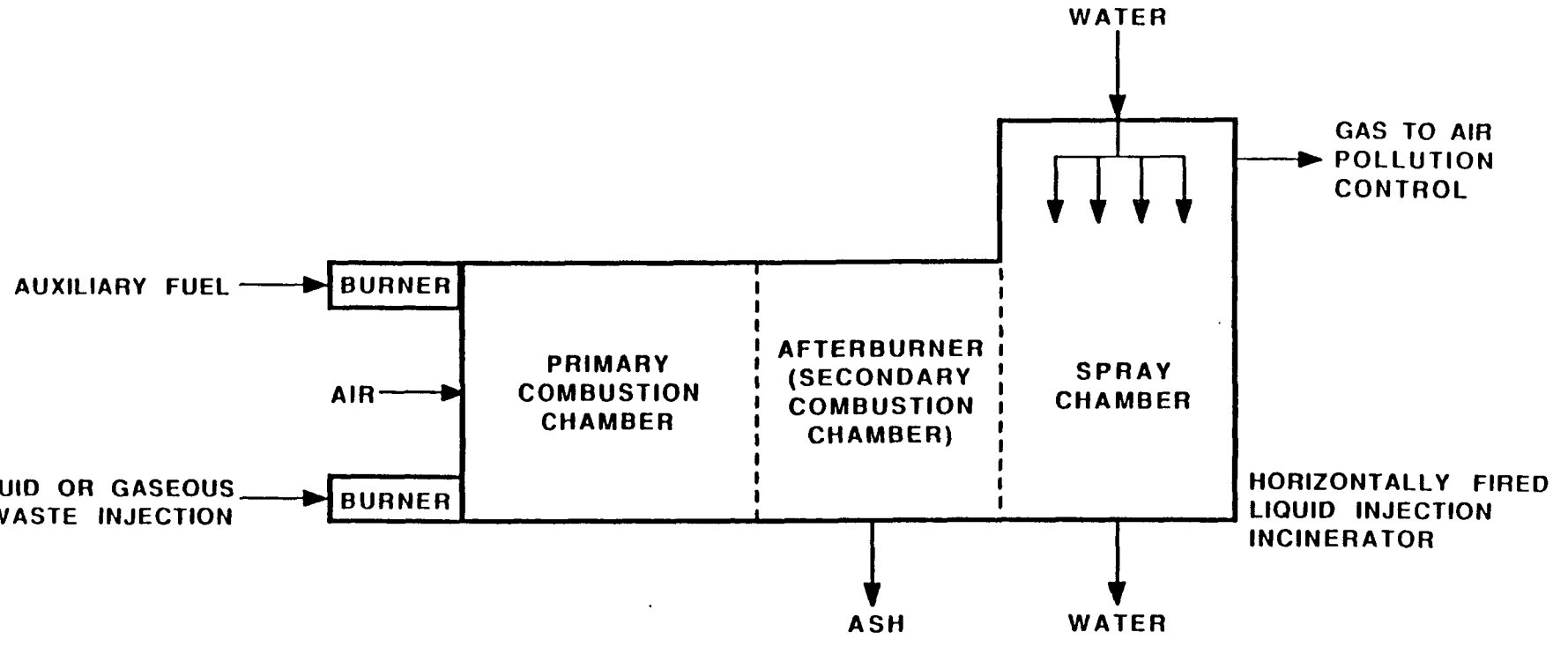


FIGURE 3-1

LIQUID INJECTION INCINERATOR

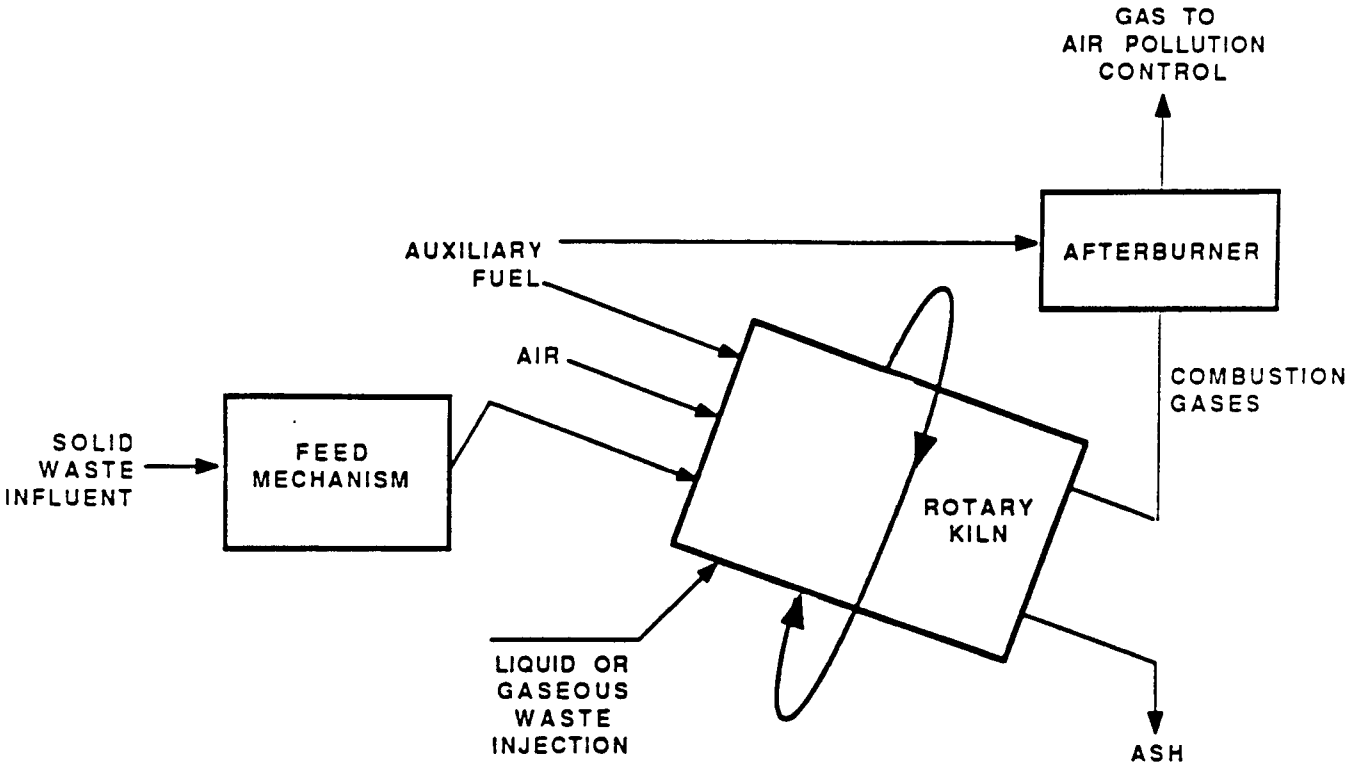


FIGURE 3-2

ROTARY KILN INCINERATOR

kiln systems usually have a secondary combustion chamber or afterburner following the kiln for further combustion of the volatilized components of solid wastes.

(c) Fluidized Bed

A fluidized bed incinerator consists of a column containing inert particles such as sand which is referred to as the bed. Air, driven by a blower, enters the bottom of the bed to fluidize the sand. Air passage through the bed promotes rapid and uniform mixing of the injected waste material within the fluidized bed. The fluidized bed has an extremely high heat capacity (approximately three times that of flue gas at the same temperature), thereby providing a large heat reservoir. The injected waste reaches ignition temperature quickly and transfers the heat of combustion back to the bed. Continued bed agitation by the fluidizing air allows larger particles to remain suspended in the combustion zone. (See Figure 3-3)

(d) Fixed Hearth Incineration

Fixed hearth incinerators, also called controlled air or starved air incinerators, are another major technology used for hazardous waste incineration. Fixed hearth incineration is a two-stage combustion process (see Figure 3-4). Waste is ram-fed into the first stage, or primary chamber, and burned at less than stoichiometric conditions. The resultant smoke and pyrolysis products, consisting primarily of volatile hydrocarbons and carbon monoxide, along with the normal products of combustion, pass to the secondary chamber. Here, additional air is injected to complete the combustion. This two-stage process generally

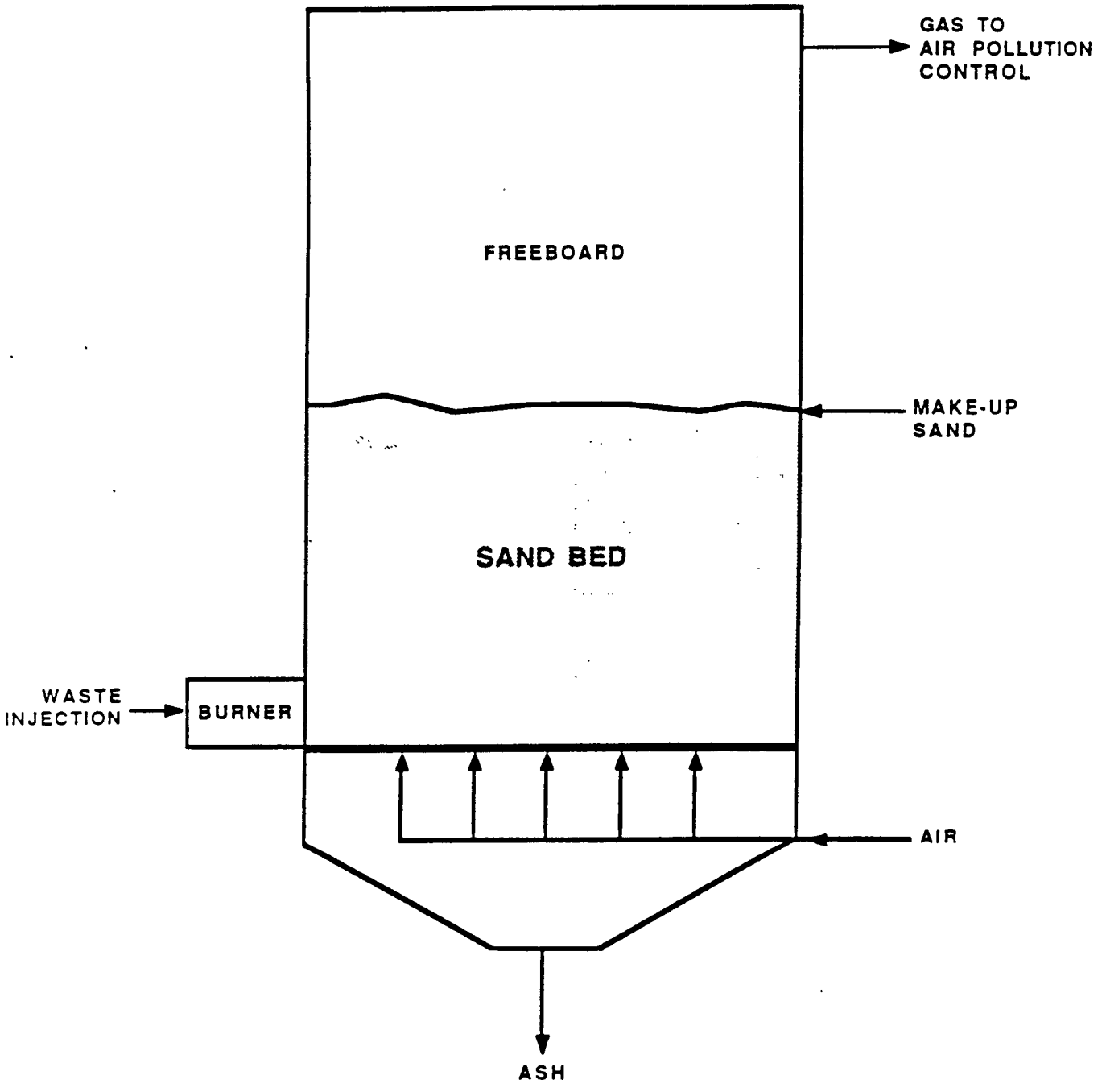


FIGURE 3-3

FLUIDIZED BED INCINERATOR

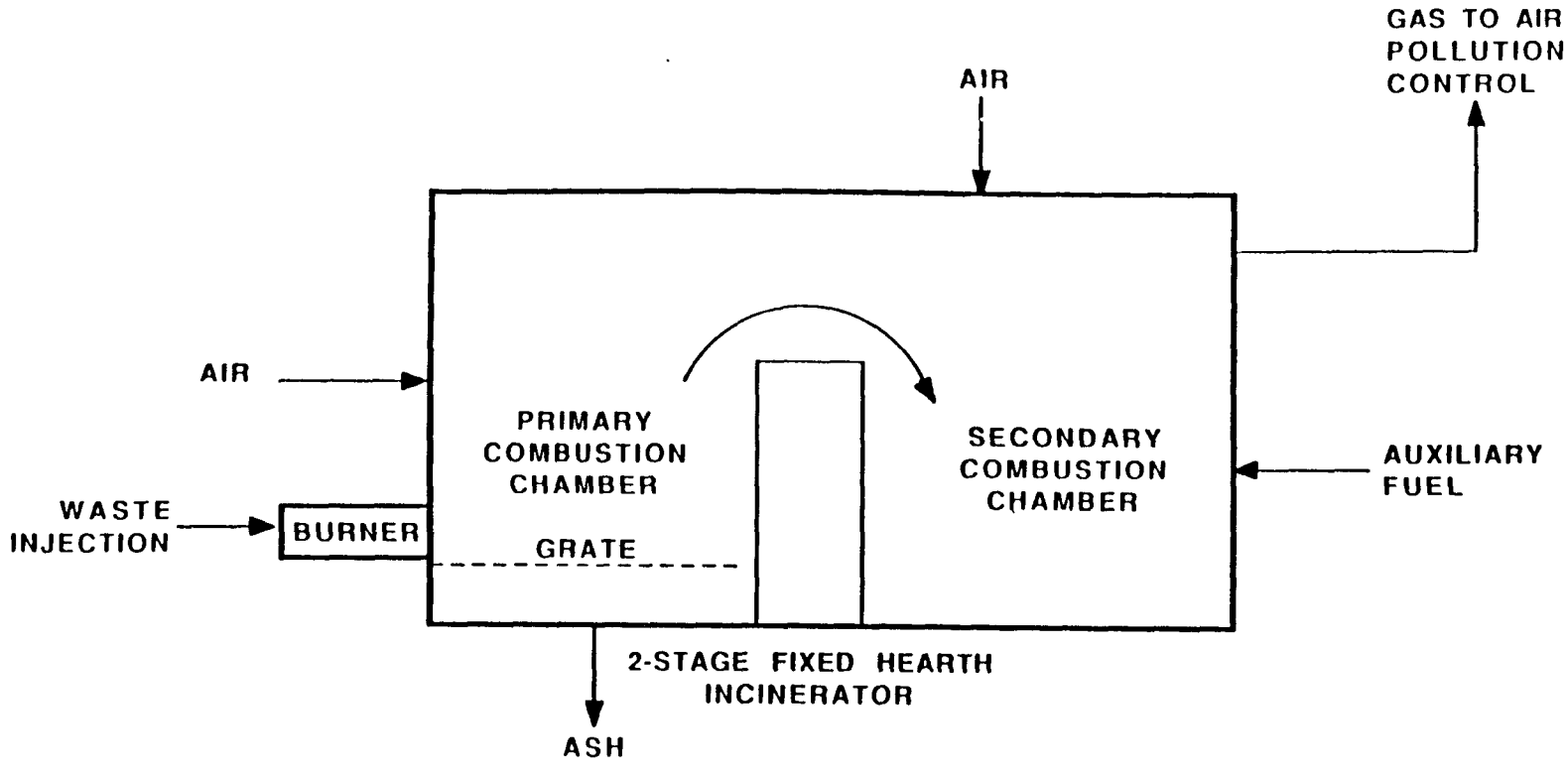


FIGURE 3-4.

FIXED HEARTH INCINERATOR

yields low stack particulate and carbon monoxide (CO) emissions. The primary chamber combustion reactions and combustion gas are maintained at low levels by the starved air conditions so that particulate entrainment and carryover are minimized.

(e) Air Pollution Controls

Following incineration of hazardous wastes, combustion gases are generally further treated in an air pollution control system. The presence of chlorine or other halogens in the waste requires a scrubbing or absorption step to remover HCl and other halo-acids from the combustion gases. Ash in the waste is not destroyed in the combustion process. Depending on its composition, ash will either exit as bottom ash, at the discharge end of a kiln or hearth for example, or as particulate matter (fly ash) suspended in the combustion gas stream. Particulate emissions from most hazardous waste combustion systems generally have particle diameters less than one micron and require high efficiency collection devices to minimize air emissions. In addition, scrubber systems provide additional buffer against accidental releases of incompletely destroyed waste products due to poor combustion efficiency or combustion upsets, such as flame outs.

(4) Waste Characteristics Affecting Performance (WCAP)

(a) Liquid Injection

In determining whether liquid injection is likely to achieve the same level of performance on an untested waste as a previously tested waste, the Agency will compare dissociation bond energies of the constituents in

the untested and tested waste. This parameter is being used as a surrogate indicator of activation energy which, as discussed previously, destabilizes molecular bonds. In theory, the bond dissociation energy would be equal to the activation energy; however, in practice this is not always the case. Other energy effects (e.g., vibrational, the formation of intermediates, and interactions between different molecular bonds) may have a significant influence on activation energy.

Because of the shortcomings of bond energies in estimating activation energy, EPA analyzed other waste characteristic parameters to determine if these parameters would provide a better basis for transferring treatment standards from an untested waste to a tested waste. These parameters include heat of combustion, heat of formation, use of available kinetic data to predict activation energies, and general structural class. All of these were rejected for reasons provided below.

The heat of combustion only measures the difference in energy of the products and reactants; it does not provide information on the transition state (i.e., the energy input needed to initiate the reaction). Heat of formation is used as a predictive tool for whether reactions are likely to proceed; however, there are a significant number of hazardous constituents for which these data are not available. Use of kinetic data were rejected because these data are limited and could not be used to calculate free energy values (ΔG) for the wide range of hazardous constituents to be addressed by this rule. Finally, EPA decided not to

use structural classes because the Agency believes that evaluation of bond dissociation energies allows for a more direct determination of whether a constituent will be destabilized.

(b) Rotary Kiln/Fluidized Bed/Fixed Hearth

Unlike liquid injection, these incineration technologies also generate a residual ash. Accordingly, in determining whether these technologies are likely to achieve the same level of performance on an untested waste as a previously tested waste, EPA would need to examine the waste characteristics that affect volatilization of organics from the waste, as well as, destruction of the organics, once volatilized. Relative to volatilization, EPA will examine thermal conductivity of the entire waste and boiling point of the various constituents. As with liquid injection, EPA will examine bond energies in determining whether treatment standards for scrubber water residuals can be transferred from a tested waste to an untested waste. Below is a discussion of how EPA arrived at thermal conductivity and boiling point as the best method to assess volatilization of organics from the waste; the discussion relative to bond energies is the same for these technologies as for liquid injection and will not be repeated here.

Thermal Conductivity. Consistent with the underlying principles of incineration, a major factor with regard to whether a particular constituent will volatilize is the transfer of heat through the waste. In the case of rotary kiln, fluidized bed, and fixed hearth incineration, heat is transferred through the waste by three mechanisms: radiation, convection, and conduction. For a given incinerator, heat transferred

through various wastes by radiation is more a function of the design and type of incinerator than the waste being treated. Accordingly, the type of waste treated will have a minimal impact on the amount of heat transferred by radiation. With regard to convection, EPA also believes that the type of heat transfer will generally be more a function of the type and design of incinerator than the waste itself. However, EPA is examining particle size as a waste characteristic that may significantly impact the amount of heat transferred to a waste by convection and thus impact volatilization of the various organic compounds. The final type of heat transfer, conduction, is the one that EPA believes will have the greatest impact on volatilization of organic constituents. To measure this characteristic, EPA will use thermal conductivity; an explanation of this parameter, as well as, how it can be measured is provided below.

Heat flow by conduction is proportional to the temperature gradient across the material. The proportionality constant is a property of the material and referred to as the thermal conductivity. (Note: The analytical method that EPA has identified for measurement of thermal conductivity is named "Guarded, Comparative, Longitudinal Heat Flow Technique"; it is described Appendix D). In theory, thermal conductivity would always provide a good indication of whether a constituent in an untested waste would be treated to the same extent in the primary incinerator chamber as the same constituent in a previously tested waste.

In practice, thermal conductivity has some limitations in assessing the transferability of treatment standards; however, EPA has not identified a parameter that can provide a better indication of heat transfer characteristics of a waste. Below is a discussion of both the limitations associated with thermal conductivity, as well as other parameters considered.

Thermal conductivity measurements, as part of a treatability comparison for two different wastes through a single incinerator, are most meaningful when applied to wastes that are homogeneous (i.e., major constituents are essentially the same). As wastes exhibit greater degrees of non-homogeneity (e.g., significant concentration of metals in soil), then thermal conductivity becomes less accurate in predicting treatability because the measurement essentially reflects heat flow through regions having the greatest conductivity (i.e., the path of least resistance) and not heat flow through all parts of the waste.

Btu value, specific heat, and ash content were also considered for predicting heat transfer characteristics. These parameters can no better account for non-homogeneity than thermal conductivity; additionally, they are not directly related to heat transfer characteristics. Therefore, these parameters do not provide a better indication of heat transfer that will occur in any specific waste.

Boiling Point. Once heat is transferred to a constituent within a waste, then removal of this constituent from the waste will depend on its volatility. As a surrogate of volatility, EPA is using boiling point

of the constituent. Compounds with lower boiling points have higher vapor pressures and, therefore, would be more likely to vaporize. The Agency recognizes that this parameter does not take into consideration the impact of other compounds in the waste on the boiling point of a constituent in a mixture; however, the Agency is not aware of a better measure of volatility that can easily be determined.

(5) Incineration Design and Operating Parameters

(a) Liquid Injection

For a liquid injection unit, EPA's analysis of whether the unit is well designed will focus on (1) the likelihood that sufficient energy is provided to the waste to overcome the activation level for breaking molecular bonds and (2) whether sufficient oxygen is present to convert the waste constituents to carbon dioxide and water vapor. The specific design parameters that the Agency will evaluate to assess whether these conditions are met are: temperature, excess oxygen, and residence time. Below is a discussion of why EPA believes these parameters to be important, as well as a discussion of how these parameters will be monitored during operation.

It is important to point out that, relative to the development of land disposed restriction standards, EPA is only concerned with these design parameters when a quench water or scrubber water residual is generated from treatment of a particular waste. If treatment of a particular waste in a liquid injection unit would not generate a wastewater stream, then the Agency, for purposes of land disposal

treatment standards, would only be concerned with the waste characteristics that affect selection of the unit, not the above-mentioned design parameters.

Temperature. Temperature is important in that it provides an indirect measure of the energy available (i.e., Btus/hr) to overcome the activation energy of waste constituents. As the design temperature increases, the more likely it is that the molecular bonds will be destabilized and the reaction completed.

The temperature is normally controlled automatically through the use of instrumentation which senses the temperature and automatically adjusts the amount of fuel and/or waste being fed. The temperature signal transmitted to the controller can be simultaneously transmitted to a recording device, referred to as a strip chart, and thereby continuously recorded. To fully assess the operation of the unit, it is important to know not only the exact location in the incinerator that the temperature is being monitored but also the location of the design temperature.

Excess Oxygen. It is important that the incinerator contain oxygen in excess of the stiochiometric amount necessary to convert the organic compounds to carbon dioxide and water vapor. If insufficient oxygen is present, then destabilized waste constituents could recombine to the same or other BDAT list organic compounds and potentially cause the scrubber water to contain higher concentrations of BDAT list constituents than would be the case for a well operated unit.

In practice, the amount of oxygen fed to the incinerator is controlled by continuous sampling and analysis of the stack gas. If the amount of oxygen drops below the design value, then the analyzer transmits a signal to the valve controlling the air supply and thereby increases the flow of oxygen to the afterburner. The analyzer simultaneously transmits a signal to a recording device so that the amount of excess oxygen can be continuously recorded. Again, as with temperature, it is important to know the location from which the combustion gas is being sampled.

Carbon Monoxide. Carbon monoxide is an important operating parameter because it provides an indication of the extent to which the waste organic constituents are being converted to CO_2 and water vapor. As the carbon monoxide level increases, it indicates that greater amounts of organic waste constituents are unreacted or partially reacted. Increased carbon monoxide levels can result from insufficient excess oxygen, insufficient turbulence in the combustion zone, or insufficient residence time.

Waste Feed Rate. The waste feed rate is important to monitor because it is correlated to the residence time. The residence time is associated with a specific Btu energy value of the feed and a specific volume of combustion gas generated. Prior to incineration, the Btu value of the waste is determined through the use of a laboratory device known as a bomb calorimeter. The volume of combustion gas generated from the waste to be incinerated is determined from an analysis referred to as an

ultimate analysis. This analysis determines the amount of elemental constituents present which include carbon, hydrogen, sulfur, oxygen, nitrogen, and halogens. Using this analysis plus the total amount of air added, the volume of combustion gas can be calculated. Having determined both the Btu content and the expected combustion gas volume, the feed rate can be fixed at the desired residence time. Continuous monitoring of the feed rate will determine whether the unit was operated at a rate corresponding to the designed residence time.

(b) Rotary Kiln

For this incineration, EPA will examine both the primary and secondary chamber in evaluating the design of a particular incinerator. Relative to the primary chamber, EPA's assessment of design will focus on whether it is likely that sufficient energy will be provided to the waste in order to volatilize the waste constituents. For the secondary chamber, analogous to the sole liquid injection incineration chamber, EPA will examine the same parameters discussed previously under liquid injection incineration. These parameters will not be discussed again here.

The particular design parameters to be evaluated for the primary chamber are: kiln temperature, residence time, and revolutions per minute. Below is a discussion of why EPA believes these parameters to be important, as well as a discussion of how these parameters will be monitored during operation.

Temperature. The primary chamber temperature is important, in that it provides an indirect measure of the energy input (i.e., BTUs/hr) that is available for heating the waste. The higher the temperature is

designed to be in a given kiln, the more likely it is that the constituents will volatilize. As discussed earlier under "Liquid Injection", temperature should be continuously monitored and recorded. Additionally, it is important to know the location of the temperature sensing device in the kiln.

Residence Time. This parameter is important in that it affects whether sufficient heat is transferred to a particular constituent in order for volatilization to occur. As the time that the waste is in the kiln is increased, a greater quantity of heat is transferred to the hazardous waste constituents. The residence time will be a function of the specific configuration of the rotary kiln including the length and diameter of the kiln, the waste feed rate, and the rate of rotation. .

Revolutions Per Minute (RPM). This parameter provides an indication of the turbulence that occurs in the primary chamber of a rotary kiln. As the turbulence increases, the quantity of heat transferred to the waste would also be expected to increase. However, as the RPM value increases, the residence time decreases resulting in a reduction of the quantity of heat transferred to the waste. This parameter needs to be carefully evaluated because it provides a balance between turbulence and residence time.

(c) Fluidized Bed

As discussed previously, in the section on "Underlying Principles of Operation", the primary chamber accounts for almost all of the conversion of organic wastes to carbon dioxide, water vapor, and acid gas if

halogens are present. The secondary chamber will generally provide additional residence time for thermal oxidation of the waste constituents. Relative to the primary chamber, the parameters that the Agency will examine in assessing the effectiveness of the design are temperature, residence time, and bed pressure differential. The first two were discussed under rotary kiln and will not be discussed here. The latter, bed pressure differential, is important in that it provides an indication of the amount of turbulence and, therefore, indirectly the amount of heat supplied to the waste. In general, as the pressure drop increases, both the turbulence and heat supplied increase. The pressure drop through the bed should be continuously monitored and recorded to ensure that the designed valued is achieved.

(d) Fixed Hearth

The design considerations for this incineration unit are similar to a rotary kiln with the exception that rate of rotation (i.e., RPMs) is not an applicable design parameter. For the primary chamber of this unit, the parameters that the Agency will examine in assessing how well the unit is designed are the same as discussed under rotary kiln; for the secondary chamber (i.e., afterburner), the design and operating parameters of concern are the same as previously discussed under "Liquid Injection".

3.3 Performance Data

The Agency collected the six data sets of data for untreated and treated wastes to characterize treatment of K037 using a rotary kiln

treatment system. Treatment of K037 resulted in two treatment residuals: ash and scrubber water. Tables 3-1 through 3-6 present the six data sets of total waste concentration analyses for K037 waste samples, and the design and operating data for the treatment system. As shown by the operating data taken during collection of the samples, all six data sets reflect treatment by a well-operated system. Furthermore, all the data sets show treatment of the organic BDAT list constituents detected in the untreated wastes to non-detected levels in the treatment residuals.

Table 3-1 Rotary Kiln Incineration
EPA Collected Data
Sample Set #1

ANALYTICAL DATA.

BDAT Reference No.	BDAT list constituent	Untreated waste (mg/kg)	Treated waste (mg/kg)	Treated waste TCLP (mg/l)	Scrubber water (µg/l)
43	Toluene	640	<10	NA	<10
70	Bis(2-ethylhexyl)phthalate	<250	<2.0	NA	<50
155	Arsenic	3.1	10	<0.01	0.10
156	Barium	26	150	<0.045	0.91
157	Beryllium	<0.5	0.54	<0.005	<0.005
158	Cadmium	3.9	2.1	<0.015	0.059
1559	Chromium	70	80	0.079	0.15
160	Copper	24	610	3.3	4.7
161	Lead	28	54	0.029	6.6
163	Nickel	130	110	0.20	0.10
166	Thallium	<2.5	<2.5	<0.015	<0.015
167	Vanadium	8	82	0.93	<0.1
168	Zinc	190	290	0.64	16
195	Disulfoton	171,000	<0 0335	NA	<1.00

DESIGN AND OPERATING DATA:

Kiln	Design Value	Operating Value
Temperature	1832°F	1778-1818°F
Revolutions per minute	0.2 rpm	0.2 rpm
Afterburner		
Temperature	2200°F	2043-2063°F
Excess oxygen	6-8%	8%
Carbon monoxide	<1000 ppm	<1 ppm

NA - Not Applicable

Reference. USEPA. 1987. Onsite Engineering Report for K037.

Table 3-2 Rotary Kiln Incineration
EPA Collected Data
Sample Set #2

ANALYTICAL DATA

BDAT Reference No	BDAT list constituent	Untreated waste (mg/kg)	Treated waste (mg/kg)	Treated waste TCLP (mg/l)	Scrubber water (µg/l)
43	Toluene	530	<10	NA	<10
70	Bis(2-ethylhexyl)phthalate	<250	<2.0	NA	<50
155	Arsenic	2.4	5.0	<0.01	0.26
156	Barium	39	140	<0.045	0.19
157	Beryllium	<0.5	0.51	<0.005	<0.005
158	Cadmium	3.9	<2.0	<0.015	0.062
159	Chromium	73	93	0.22	0.21
160	Copper	12	940	10	4.7
161	Lead	12	66	0.013	11
163	Nickel	90	110	0.58	<0.1
166	Thallium	<2.5	<2.5	<0.015	<0.015
167	Vanadium	7	80	1.8	<0.1
168	Zinc	89	330	0.45	4.2
195	Disulfoton	104,000	<0.0335	NA	<1 00

DESIGN AND OPERATING DATA:

Kiln	Design Value	Operating Value
Temperature	1832°F	1778-1818°F
Revolutions per minute	0.2 rpm	0.2 rpm
Afterburner		
Temperature	2200°F	2043-2063°F
Excess oxygen	6-8%	8%
Carbon monoxide	<1000 ppm	<1 ppm

NA - Not Applicable

Reference USEPA 1987 Onsite Engineering Report for K037.

Table 3-3 Rotary Kiln Incineration
EPA Collected Data
Sample Set #3

ANALYTICAL DATA

BDAT Reference No.	BDAT list constituent	Untreated waste (mg/kg)	Treated waste (mg/kg)	Treated waste TCLP (mg/l)	Scrubber water (µg/l)
43	Toluene	1,300	<10	NA	<10
70	Bis(2-ethylhexyl)phthalate	<250	<2.0	NA	<50
155	Arsenic	<2.0	25	0.022	0.22
156	Barium	18	130	0.049	0.22
157	Beryllium	<0 5	<0.5	<0.005	<0.005
158	Cadmium	3 8	<2 0	<0.015	0.073
159	Chromium	43	100	0.13	0.19
160	Copper	7.0	630	1.1	3.9
161	Lead	5.6	25	<0.01	9.6
163	Nickel	46	180	0.19	<0.1
166	Thallium	<2.5	<2.5	<0.015	<0.015
167	Vanadium	7	61	0.97	<0.1
168	Zinc	110	840	0.75	2.7
195	Disulfoton	246,000	<0.0335	NA	<1.00

DESIGN AND OPERATING DATA.

Kiln	Design Value	Operating Value
Temperature	1832°F	1778-1818°F
Revolutions per minute	0 2 rpm	0.2 rpm
Afterburner		
Temperature	2200°F	2043-2063°F
Excess oxygen	6-8%	8%
Carbon monoxide	<1000 ppm	<1 ppm

NA - Not Applicable

Reference USEPA 1987. Onsite Engineering Report for K037.

Table 3-4 Rotary Kiln Incineration
EPA Collected Data
Sample Set #4

ANALYTICAL DATA.

BDAT Reference No.	BDAT list constituent	Untreated waste (mg/kg)	Treated waste (mg/kg)	Treated waste TCLP (mg/l)	Scrubber water (µg/l)
43	Toluene	630	<10	NA	<10
70	Bis(2-ethylhexyl)phthalate	<250	<2.0	NA	<50
155	Arsenic	<2.0	15	<0.01	0.23
156	Barium	28	150	0.075	0 18
157	Beryllium	<0.5	<0.5	<0.005	<0.005
158	Cadmium	5.3	<2.0	<0.015	0.063
159	Chromium	85	110	0.074	0.090
160	Copper	21	460	3.0	4.0
161	Lead	22	15	0 017	4.0
163	Nickel	120	160	0.24	<0.1
166	Thallium	<2.5	<2.5	<0.015	<0.015
167	Vanadium	9	78	1.1	<0.1
168	Zinc	180	620	2.7	0.97
195	Disulfoton	186,000	<0.0335	NA	<1.00

DESIGN AND OPERATING DATA:

Kiln	Design Value	Operating Value
Temperature	1832°F	1830-1897°F
Revolutions per minute	0.2 rpm	0 2 rpm
Afterburner		
Temperature	2200°F	2043-2063°F
Excess oxygen	6-8%	8%
Carbon monoxide	<1000 ppm	<1 ppm

NA - Not Applicable

Reference: USEPA 1987 Onsite Engineering Report for K037.

Table 3-5 Rotary Kiln Incineration
EPA Collected Data
Sample Set #5

ANALYTICAL DATA

BDAT Reference No	BDAT list constituent	Untreated waste (mg/kg)	Treated waste (mg/kg)	Treated waste TCLP (mg/l)	Scrubber water (µg/l)
43	Toluene	201	<10	NA	<10
70	Bis(2-ethylhexyl)phthalate	<250	<2.0	NA	<50
155	Arsenic	<2 0	5 0	<0.01	0.29
156	Barium	22	140	1.1	0.30
157	Beryllium	<0.5	<0.5	<0.005	<0 005
158	Cadmium	3 3	<2.0	<0.015	0.11
159	Chromium	50	88	0 26	0.13
160	Copper	15	380	4.3	6.2
161	Lead	12	15	0.021	6 8
163	Nickel	61	110	0.41	<0 1
166	Thallium	<2.5	<2.5	<0.015	0.02
167	Vanadium	10	77	1.8	<0 1
168	Zinc	110	450	4.8	1.7
195	Disulfoton	181,000	<0 0335	NA	<1.00

DESIGN AND OPERATING DATA

Kiln	Design Value	Operating Value
Temperature	1832°F	1830-1897°F
Revolutions per minute	0.2 rpm	0.2 rpm
Afterburner		
Temperature	2200°F	2043-2063°F
Excess oxygen	6-8%	8%
Carbon monoxide	<1000 ppm	<1 ppm

NA - Not Applicable

Reference USEPA 1987 Onsite Engineering Report for K037.

Table 3-6 Rotary Kiln Incineration
EPA Collected Data
Sample Set #6

ANALYTICAL DATA

BDAT Reference No	BDAT list constituent	Untreated waste (mg/kg)	Treated waste (mg/kg)	Treated waste TCLP (mg/l)	Scrubber water (µg/l)
43	Toluene	2000	<10	NA	<10
70	Bis(2-ethylhexyl)phthalate	500	<2.0	NA	<50
155	Arsenic	<2.0	20	<0.01	0.45
156	Barium	33	170	0 1	0.39
157	Beryllium	<0.5	0.71	<0 005	<0 005
158	Cadmium	10	<2.0	<0 015	0.16
159	Chromium	93	87	<0.045	0.17
160	Copper	16	240	0.15	6.3
161	Lead	8 2	20	<0.01	11
163	Nickel	120	110	0.59	0.11
166	Thallium	<2.5	<2.5	<0.015	0.02
167	Vanadium	8	88	0.25	<0 1
168	Zinc	120	330	0.16	2.3
195	Disulfoton	192,000	<0.0335	NA	<1.00

DESIGN AND OPERATING DATA.

Kiln	Design Value	Operating Value
Temperature	1832°F	1830-1897°F
Revolutions per minute	0 2 rpm	0.2 rpm
Afterburner		
Temperature	2200°F	2043-2063°F
Excess oxygen	6-8%	8%
Carbon monoxide	<1000 ppm	<1 ppm

NA - Not Applicable.

Reference. USEPA 1987 Onsite Engineering Report for K037.

4. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY FOR K037

This section presents the rationale for selection of the best technology from the technologies that have been identified in Section 3 as demonstrated technologies for treatment of K037. The demonstrated technologies are: (1) batch distillation, and (2) incineration.

As stated previously in the introduction, BDAT is selected based on the evaluation of treatment technology performance data. These data are evaluated based on the following procedure. First, the design and operating data reported for each data set (paired influent/effluent data) are examined, and data points or data sets that reflect a poorly designed treatment system or a system that was not well operated at the time of data collection are eliminated. Once these data have been deleted, all remaining data are adjusted using analytical recovery values based on laboratory quality assurance/quality control (QA/QC) analyses. This adjustment takes into account analytical interferences associated with the sample. Finally, in cases where the Agency has data on treatment of a listed waste using more than one technology, the treatment values are compared by the analysis of variance test (ANOVA), as presented in Appendix A. This test determines if one technology performs significantly better than another.

The only treatment performance data available to the Agency are for treatment of K037 using rotary kiln incineration. The Agency believes that rotary kiln incineration achieves better treatment of the organics

in K037 waste than batch distillation. This is because incineration destroys the hazardous components, whereas distillation only places them into a lower volume, more concentrated mixture, which itself may require incineration. Also, it is expected that fluidized bed incineration could not achieve better treatment than rotary kiln incineration since the operating temperatures are lower. Furthermore, as a result of the data analysis described above and in detail below in sections 4.1 through 4.3, EPA has chosen rotary kiln incineration as the best demonstrated technology.

Rotary kiln incineration is also believed to be "available" because it is commercially available, not proprietary, and substantially diminishes waste toxicity and migration potential for hazardous constituents.

4.1 Data Screening

The available treatment data for K037 were reviewed and assessed with regard to the design and operation of the system, the quality assurance/ quality control analyses of the data, and the analytical tests used to assess treatment performance.

No performance data were deleted for treatment of K037 using rotary kiln incineration.

4.2 Data Accuracy

After the screening tests, EPA adjusted the data values based on the analytical recovery values to take into account analytical interferences associated with the chemical makeup of the treated sample. In developing

recovery data (also referred to as accuracy data), EPA first analyzed a waste for a constituent and then added a known amount of the same constituent (i.e., spike) to the waste material. The total amount recovered after spiking minus the initial concentration in the sample divided by the amount added is the recovery value. The analytical data were adjusted for accuracy using the lowest recovery value for each constituent. These adjusted values for rotary kiln incineration were then used to determine BDAT for K037. (See Appendix B for calculation of the adjusted values.)

5. SELECTION OF REGULATED CONSTITUENTS

As discussed in Section 1, the Agency has developed a BDAT list of hazardous constituents (Table 1-1) from which the constituents to be regulated are selected. The list is an expanding list that does not preclude the addition of new constituents as additional key parameters. The list is divided into the following categories: volatile organics, semivolatile organics, metals, inorganics other than metals, pesticides, PCBs, and dioxins and furans.

This section describes the step-by-step process used to select the pollutants to be regulated. The selected constituents must be present in the untreated waste and must be treatable by the chosen BDAT, rotary kiln incineration, as discussed in Section 4. Moreover, the regulated constituents are those compounds that are significantly reduced, and such reduction ensures that the recommended BDAT is the most effective treatment for the K037 waste. Using this definition and the major BDAT list constituents identified in Section 2, two constituents, toluene and disulfoton, are selected as the regulated constituents for K037 for which treatment standards are developed in Section 6 of this report.

5.1 Identification of Constituents in the Untreated Waste

Table 5-1 presents the BDAT list as discussed in Section 1 and indicates which of the BDAT list constituents were analyzed for in the untreated waste and treated waste, and which of those that were analyzed for were detected. Of the 232 BDAT constituents, 213 were analyzed and the only constituents that were detected include toluene and

Table 5 1 BDAT List Constituents Detected or Not Detected in the K037 Waste Samples

BDAT Reference No	Parameter	CAS no.	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (µg/l)
Volatile Organics						
222	Acetone	67-64-1	NL	NL	NL	NL
1	Acetonitrile	75-05-8	ND	ND	ND	ND
2	Acrolein	107-02-8	ND	ND	ND	ND
3.	Acrylonitrile	107-13-1	ND	ND	ND	ND
4	Benzene	71-43-2	ND	ND	ND	ND
5	Bromodichloromethane	75-27-4	ND	ND	ND	ND
6	Bromomethane	74-83-9	ND	ND	ND	ND
223	n-Butyl alcohol	71-36-3	NL	NL	NL	NL
7	Carbon Tetrachloride	56-23-5	ND	ND	ND	ND
8	Carbon disulfide	75-15-0	ND	ND	ND	ND
9	Chlorobenzene	108-90-7	ND	ND	ND	ND
10	2-Chloro-1,3-butadiene	108-90-7	ND	ND	ND	ND
11	Chlorodibromomethane	108-90-7	ND	ND	ND	ND
12	Chloroethane	75-00-3	ND	ND	ND	ND
13	2-Chloroethyl vinyl ether	110-75-8	ND	ND	ND	ND
14	Chloroform	67-66-3	ND	ND	ND	ND
15	Chloromethane	74-87-3	ND	ND	ND	ND
16	3-Chloropropene	107-05-1	ND	ND	ND	ND
17	,2-Dibromo-3-chloropropane	96-12-8	ND	ND	ND	ND
18	1,2-Dibromoethane	106-93-4	ND	ND	ND	ND
19	Dibromomethane	74-95-3	ND	ND	ND	ND
20.	Trans-1,4-Dichloro-2-butene	110-57-6	ND	ND	ND	ND
21	Dichlorodifluoromethane	75-71-8	ND	ND	ND	ND
22	1,1-Dichloroethane	75-35-3	ND	ND	ND	ND
23	1,2-Dichloroethane	105-06-2	ND	ND	ND	ND
24	1,1-Dichloroethylene	75-35-4	ND	ND	ND	ND
25	Trans-1,2-Dichloroethene	156-60-5	ND	ND	ND	ND
26.	1,2-Dichloropropane	78-87-5	ND	ND	ND	ND
27.	Trans-1,3-Dichloropropene	10061-02-6	ND	ND	ND	ND
28.	cis-1,3-Dichloropropene	10061-01-5	ND	ND	ND	ND
29	1,4-Dioxane	123-91-1	ND	ND	ND	ND
	n-Butyl alcohol	71-36-3	NL	NL	NL	NL
224	2-Ethoxyethanol	110-80-5	NL	NL	NL	NL
225.	Ethyl acetate	141-78-6	NL	NL	NL	NL
226	Ethyl benzene	100-41-4	NL	NL	NL	NL

Table 5-1 (Continued)

BDAT Reference No	Parameter	CAS no.	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (µg/l)
Volatile Organics (continued)						
30	Ethyl cyanide	10712-0	ND	ND	ND	ND
227	Ethyl ether	60-29-7	NL	NL	NL	NL
31	Ethyl methacrylate	97-63-2	ND	ND	ND	ND
214	Ethylene Oxide	75-21-8	NL	NL	NL	NL
32	Iodomethane	74-88-4	ND	ND	ND	ND
33	Isobutyl alcohol	78-83-1	ND	ND	ND	ND
228	Methanol	67-56-1	NL	NL	NL	NL
34	Methyl ethyl ketone	78-93-3	ND	I	ND	ND
229	Methyl isobutyl ketone	108-10-1	NL	NL	NL	NL
35	Methyl methacrylate	80-62-6	ND	ND	ND	ND
36	Methyl methanesulfonate	66-27-3	ND	ND	ND	ND
37	Methylacrylonitrile	126-98-7	ND	ND	ND	ND
38	Methylene chloride	75-09-2	ND	ND	ND	ND
39	Pyridine	110-86-1	-	-	-	-
40	1,1,1,2-Tetrachloroethane	630-20-6	ND	ND	ND	ND
41	1,1,2,2-Tetrachloroethane	79-34-5	ND	ND	ND	ND
42	Tetrachloroethene	127-18-4	ND	ND	ND	ND
43	Toluene	108-88-3	D	ND	ND	ND
44	Tribromomethane	75-25-2	ND	ND	ND	ND
45	1,1,1-Trichloroethane	71-55-6	ND	ND	ND	ND
46.	1,1,2-Trichloroethane	79-00-5	ND	ND	ND	ND
47	Trichloroethene	79-01-6	ND	ND	ND	ND
48	Trichloromonofluoromethane	75-69-4	ND	ND	ND	ND
49.	1,2,3-Trichloropropane	96-18-4	ND	ND	ND	ND
231	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	NL	NL	NL	NL
50	Vinyl chloride	75-01-4	ND	ND	ND	ND
215	1,2-Xylene	97-47-6	NL	NL	NL	NL
216.	1,3-Xylene	108-38-3	NL	NL	NL	NL
217	1,4-Xylene	106-44-5	NL	NL	NL	NL
Semivolatiles						
51	Acenaphthalene	208-96-8	ND	ND	ND	ND
52	Acenaphthene	83-32-9	ND	ND	ND	ND
53	Acetophenone	96-86-2	ND	ND	ND	ND
54	2-Acetylaminofluorene	53-96-3	ND	ND	ND	ND

Table 5-1. (Continued)

BDAT Reference No.	Parameter	CAS no	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (µg/l)
Semivolatiles (continued)						
55	4-Aminobiphenyl	92-67-1	ND	ND	ND	ND
56	Aniline	62-53-3	ND	ND	ND	ND
57	Anthracene	120-12-7	ND	ND	ND	ND
58	Aramite	140-57-8	ND	ND	ND	ND
59	Benz(a)anthracene	56-55-3	ND	ND	ND	ND
218	Benzal chloride	98-87-3	NL	NL	NL	NL
60	Benzal chloride	98-87-3	ND	ND	ND	ND
61	Benzenethiol	108-98-5	ND	ND	ND	ND
62	Benzo(a)pyrene	50-32-8	ND	ND	ND	ND
63	Benzo(b)fluoranthene	205-99-2	ND	ND	ND	ND
64	Benzo(ghi)perylene	191-24-2	ND	ND	ND	ND
65.	Benzo(k)fluoranthene	207-08-9	ND	ND	ND	ND
66.	p-Benzoquinone	106-51-4	ND	ND	ND	ND
67	Bis(2-chloroethoxy)methane	111-91-1	ND	ND	ND	ND
68	Bis(2-chloroethyl)ether	111-44-4	ND	ND	ND	ND
69	Bis(2-chloroisopropyl)ether	39638-32-9	ND	ND	ND	ND
70	Bis(2-ethylhexyl)phthalate	117-81-7	D	ND	ND	ND
71	4-Bromophenyl phenyl ether	101-55-3	ND	ND	ND	ND
72	Butyl benzyl phthalate	85-68-7	ND	ND	ND	ND
73	2-sec-butyl-4,6-dinitrophenol	88-85-7	ND	ND	ND	ND
74	p-Chloroaniline	106-47-8	ND	ND	ND	ND
75	Chlorobenzilate	510-15-6	ND	ND	ND	ND
76.	p-Chloro-m-cresol	59-50-7	ND	ND	ND	ND
77	2-Chloronaphthalene	91-58-7	ND	ND	ND	ND
78	2-Chlorophenol	95-57-8	ND	ND	ND	ND
79	3-Chloropropionitrile	542-76-7	ND	ND	ND	ND
80	Chrysene	218-01-9	ND	ND	ND	ND
81	ortho-Cresol	95-48-7	ND	ND	ND	ND
82	para-Cresol	106-44-5	ND	ND	ND	ND
232	Cyclohexanone	108-94-1	NL	NL	NL	NL
83	Dibenz(a,h)anthracene	53-70-3	ND	ND	ND	ND
84.	Dibenzo(a,e)pyrene	192-65-4	ND	ND	ND	ND
85.	Dibenzo(a,i)pyrene	189-55-9	ND	ND	ND	ND
86	m-Dichlorobenzene	541-73-1	ND	ND	ND	ND
87.	o-Dichlorobenzene	95-50-1	ND	ND	ND	ND
88	p-Dichlorobenzene	106-46-7	ND	ND	ND	ND
89	3,3'-Dichlorobenzidine	91-94-1	ND	ND	ND	ND
90	2,4-Dichlorophenol	120-83-2	ND	ND	ND	ND

Table 5-1 (Continued)

BDAT Reference No	Parameter	CAS no	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (µg/l)
Semivolatiles (continued)						
91	2,6-Dichlorophenol	87-65-0	ND	ND	ND	ND
92	Diethyl phthalate	84-66-2	ND	ND	ND	ND
93	3,3'-Dimethoxybenzidine	119-90-4	ND	ND	ND	ND
94	p-Dimethylaminoazobenzene	60-11-7	ND	ND	ND	ND
95	3,3'-Dimethylbenzidine	119-93-7	ND	ND	ND	ND
96	2,4-Dimethylphenol	105-67-9	ND	ND	ND	ND
97	Dimethyl phthalate	131-11-3	ND	ND	ND	ND
98	Di-n-butyl phthalate	84-74-2	ND	ND	ND	ND
99	1,4-Dinitrobenzene	100-25-4	ND	ND	ND	ND
100	4,6-Dinitro-o-cresol	534-52-1	ND	ND	ND	ND
101	2,4-Dinitrophenol	51-28-5	ND	ND	ND	ND
102	2,4-Dinitrotoluene	121-14-2	ND	ND	ND	ND
103	2,6-Dinitrotoluene	606-20-2	ND	ND	ND	ND
104	Di-n-octyl phthalate	117-84-0	ND	ND	ND	ND
105	Di-n-propylnitrosamine	621-64-7	ND	ND	ND	ND
106	Diphenylamine	122-39-4	ND	ND	ND	ND
219	Diphenylnitrosamine	86-30-6	ND	ND	ND	ND
107	1,2-Diphenylhydrazine	122-66-7	ND	ND	ND	ND
108	Fluoranthene	206-44-0	ND	ND	ND	ND
109	Fluorene	86-73-7	ND	ND	ND	ND
110	Hexachlorobenzene	118-74-1	ND	ND	ND	ND
111	Hexachlorobutadiene	87-68-3	ND	ND	ND	ND
112	Hexachlorocyclopentadiene	77-47-4	ND	ND	ND	ND
113	Hexachloroethane	67-72-1	ND	ND	ND	ND
114	Hexachlorophene	70-30-4	ND	ND	ND	ND
115	Hexachloropropane	1888-71-7	NL	NL	NL	NL
116	Indeno(1,2,3-cd)pyrene	193-39-5	ND	ND	ND	ND
117	Isosafrole	120-58-1	ND	ND	ND	ND
118	Methapyrilene	91-80-5	ND	ND	ND	ND
119	3-Methylcholanthrene	56-49-5	ND	ND	ND	ND
120	4,4'-Methylenebis (2-chloroaniline)	101-14-4	ND	ND	ND	ND
121	Naphthalene	91-20-3	ND	ND	ND	ND
122	1,4-Naphthoquinone	130-15-4	ND	ND	ND	ND
123	1-Naphthylamine	134-32-7	ND	ND	ND	ND
124	2-Naphthylamine	91-59-8	ND	ND	ND	ND
125	p-Nitroaniline	100-01-6	ND	ND	ND	ND
126	Nitrobenzene	98-95-3	ND	ND	ND	ND

Table 5-1. (Continued)

BDAT Reference No	Parameter	CAS no.	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (µg/l)
Semivolatiles (continued)						
127	4-Nitrophenol	100-02-7	ND	ND	ND	ND
128	N-Nitrosodi-n-butylamine	924-16-3	ND	ND	ND	ND
129.	N-Nitrosodiethylamine	55-18-5	ND	ND	ND	ND
130	N-Nitrosodimethylamine	62-75-9	ND	ND	ND	ND
131	N-Nitrosomethylethylamine	10595-95-6	ND	ND	ND	ND
132	N-Nitrosomorpholine	59-89-2	ND	ND	ND	ND
133	N-Nitrosopiperidine	100-75-4	ND	ND	ND	ND
134	n-Nitrosopyrrolidine	930-55-2	ND	ND	ND	ND
135	5-Nitro-o-toluidine	99-65-8	ND	ND	ND	ND
136	Pentachlorobenzene	608-93-5	ND	ND	ND	ND
137	Pentachloroethane	76-01-7	ND	ND	ND	ND
138	Pentachloronitrobenzene	82-68-8	ND	ND	ND	ND
139	Pentachlorophenol	87-86-5	ND	ND	ND	ND
140	Phenacetin	62-44-2	ND	ND	ND	ND
141.	Phenanthrene	85-01-8	ND	ND	ND	ND
142	Phenol	108-95-2	ND	ND	ND	ND
220	Phthalic anhydride	85-44-9	NL	NL	NL	NL
143	2-Picoline	109-06-8	ND	ND	ND	ND
144	Pronamide	23950-58-5	ND	ND	ND	ND
145	Pyrene	129-00-0	ND	ND	ND	ND
146	Resorcinol	108-46-3	ND	ND	ND	ND
147	Safrole	94-59-7	ND	ND	ND	ND
148	1,2,4,5-Tetrachlorobenzene	95-94-3	ND	ND	ND	ND
149	2,3,4,6-Tetrachlorophenol	58-90-2	ND	ND	ND	ND
150	1,2,4-Trichlorobenzene	120-82-1	ND	ND	ND	ND
151	2,4,5-Trichlorophenol	95-95-4	ND	ND	ND	ND
152	2,4,6-Trichlorophenol	88-06-2	ND	ND	ND	ND
153	Tris(2,3-dibromopropyl) phosphate	126-72-7	ND	ND	ND	ND
Metals						
154.	Antimony	7440-36-0	ND	ND	ND	ND
155.	Arsenic	7440-38-2	D	D	D	D
156	Barium	7440-39-3	D	D	D	D
157	Beryllium	7440-41-7	ND	D	ND	ND
158	Cadmium	7440-43-9	D	D	ND	D
159	Chromium (total)	7440-47-32	D	D	D	D

Table 5-1 (Continued)

BDAT Reference No	Parameter	CAS no.	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (μg/l)
Metals (cont.)						
221	Chromium (hexavalent)	NA	NL	NL	NL	NL
160	Copper	7440-50-8	D	D	D	D
161	Lead	7439-92-1	D	D	D	D
162.	Mercury	7439-97-6	ND	ND	ND	ND
163	Nickel	7440-02-0	D	D	D	D
164	Selenium	7782-49-2	ND	ND	ND	ND
165	Silver	7440-22-4	ND	ND	ND	ND
166	Thallium	7440-28-0	ND	ND	ND	D
167	Vanadium	7440-62-2	D	D	D	ND
168	Zinc	7440-66-6	D	D	D	D
Inorganics						
169	Cyanide	57-12-5	-	-	-	D
170	Fluoride	16964-48-8	-	-	-	D
171	Sulfide	8496-25-8	-	-	-	D
Organochlorine Pesticides						
172	Aldrin	309-00-2	ND	ND	-	ND
173	alpha-BHC	319-84-6	ND	ND	-	ND
174	beta-BHC	319-85-7	ND	ND	-	ND
175	delta-BHC	319-86-8	ND	ND	-	ND
176	gamma-BHC	58-89-9	ND	ND	-	ND
177	Chlordane	57-74-9	ND	ND	-	ND
178	DDD	72-54-8	ND	ND	-	ND
179	DDE	72-55-9	ND	ND	-	ND
180	DDT	50-29-3	ND	ND	-	ND
181	Dieldrin	60-57-1	ND	ND	-	ND
182	Endosulfan I	939-98-8	ND	ND	-	ND
183	Endosulfan II	33213-6-5	ND	ND	-	ND
184.	Endrin	72-20-8	ND	ND	-	ND
185	Endrin aldehyde	7421-93-4	ND	ND	-	ND
186	Heptachlor	76-44-8	ND	ND	-	ND
187	Heptachlor epoxide	1024-57-3	ND	ND	-	ND
188	Isodrin	465-73-6	ND	ND	-	ND
189	Kepone	143-50-0	ND	ND	-	ND
190	Methoxyclor	72-43-5	ND	ND	-	ND
191	Toxaphene	8001-35-2	ND	ND	-	ND

1544g

Table 5-1 (Continued)

BDAT Reference No	Parameter	CAS no.	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (μg/l)
Phenoxyacetic Acid Herbicides						
192	2,4-Dichlorophenoxyacetic acid	94-75-7	ND	ND	-	ND
193	Silvex	93-72-1	ND	ND	-	ND
194	2,4,5-T	93-76-5	ND	ND	-	ND
Organophosphorous Insecticides						
195	Disulfoton	298-04-4	D	ND	-	ND
196	Famphur	52-85-7	ND	ND	-	ND
197	Methyl parathion	298-00-0	ND	ND	-	ND
198	Parathion	56-38-2	ND	ND	-	ND
199.	Phorate	298-02-2	ND	ND	-	ND
PCBs						
200.	Aroclor 1016	12674-11-2	ND	ND	-	ND
201	Aroclor 1221	11104-28-2	ND	ND	-	ND
202	Aroclor 1232	11141-16-5	ND	ND	-	ND
203	Aroclor 1242	53469-21-9	ND	ND	-	ND
204.	Aroclor 1248	12672-29-6	ND	ND	-	ND
205	Aroclor 1254	11097-69-1	ND	ND	-	ND
206.	Aroclor 1260	11096-82-5	ND	ND	-	ND
Dioxins and Furans						
207	Hexachlorodibenzo-p-dioxins	NA	ND	ND	-	ND
208	Hexachlorodibenzofuran	NA	ND	ND	-	ND
209.	Pentachlorodibenzo-p-dioxins	NA	ND	ND	-	ND
210.	Pentachlorodibenzofuran	NA	ND	ND	-	ND
211	Tetrachlorodibenzo-p-dioxins	NA	ND	ND	-	ND
212	Tetrachlorodibenzofuran	NA	ND	ND	-	ND
213.	2,3,7,8-Tetrachlorodi-benzo-p-dioxin	NA	ND	ND	-	ND

NL = Not on list at the time analysis was performed.
ND = Not Detected
D = Detected
- = No Analysis Performed
NA = Not Applicable
I = Interference caused by Lab Contamination
Reference: USEPA 1987 Onsite Engineering Report for K037

bis(2-ethylhexyl)phthalate; certain metals such as arsenic, barium, cadmium, chromium, copper, lead, nickel, vanadium, and zinc; and the organophosphorous insecticide disulfoton. Eighteen constituents were not analyzed for because at the time the analysis was performed those constituents were not on the BDAT constituent list. For those constituents identified as not detected (ND), it was assumed that they were present at or below detection limits or that some constituents were present in the untreated waste but masking or interference prevented their detection. Detection limits for K037 constituents in treated and untreated wastes are provided in Appendix C. A summary of the detected constituents and their concentrations is given in Table 5-2.

5.2 Comparison of Untreated and Treated Waste Data for the Major Constituents

Table 5-2 also presents the concentrations of major constituents in the treated waste residues, namely ash and scrubber water. The treated waste data demonstrate that the three detected organics toluene, disulfoton, and bis(2-ethylhexyl)phthalate were reduced significantly. This further indicates that the BDAT identified is effective in reducing the major organic constituents to nontreatable levels, and the treatment residues do not need any additional organic treatment.

Because the concentrations of toluene, bis(2-ethylhexyl)phthalate, and disulfoton were reduced substantially, these compounds were regarded as potential regulated constituents. For constituents for which substantial reduction was not achieved, the Agency requires further analysis to determine if the reduction is significant. Statistical

Table 5-2 BDAT List Constituents and Their Concentrations in Untreated Waste and Treatment Residues

BDAT Reference No	BDAT List Constituent	Untreated waste (mg/kg)	Treated waste residue		
			Ash (mg/kg)	Ash TLCP (mg/l)	Scrubber water (ug/l)
43	Toluene	201-2,000	<10	NA	<10
70	Bis(2-ethylhexyl)-phthalate	<250-500	<2.0	NA	<50
155	Arsenic	<2-3.1	5.25	<0 01-0.022	0.1-0.45
156	Barium	18-39	130-170	<0 045-1.1	0.18-0 91
157.	Beryllium	<0.5	<0.5-0.54	<0.005	<0.005
158	Cadmium	3.3-10	<2.0-2.1	<2.0	0.059-0 16
159	Chromium	43-93	80-110	<0.045-0.26	0.09-0.21
160.	Copper	7-24	380-940	0.15-10	3.9-6.3
161	Lead	5.6-28	15-66	<0.01-0.029	4-11
163	Nickel	46-130	110-180	0.19-0.59	<0.1-0 11
166	Thallium	<2.5	<2 5	0.015	<0.015
167	Vanadium	7-10	61-88	0.25-1.8	<0.1
168	Zinc	89-190	290-840	0.45-4.8	0.97-16
195	Disulfoton	104,000-246,000	<0 0335	NA	<1.0

NA - Not Applicable

Reference USEPA 1987. Onsite Engineering Report for K037

analysis would be required for this determination. As seen in Table 5-2, this step was not necessary.

Untreatable concentrations of metals were detected in the scrubber water and ash residuals. The amounts are too low to warrant metals treatment. Furthermore, since none of the detected BDAT list metals were treated by rotary kiln incineration, none were regarded as potential regulated constituents.

5.3 Selection of Regulated Constituents

Toluene and disulfoton are only two BDAT list constituents selected as regulated constituents for K037. Using the analytical data for these constituents, BDAT treatment standards are developed in the following section. The Agency did not select bis(2-ethylhexyl)phthalate as a regulated constituents, because it is believed that regulation of toluene and disulfoton will control other organics present in the untreated waste.

6. CALCULATION OF BDAT TREATMENT STANDARD

The purpose of this section is to calculate the actual treatment standards for the regulated constituents determined in Section 5. EPA has six sets of influent and effluent data from one facility for treatment of K037 using rotary kiln incineration. As discussed in the introduction, the following steps were taken to derive the BDAT treatment standards for K037.

1. The Agency evaluated the data collected from the rotary kiln treatment system to determine whether any of the data represented poor design or operation of the treatment system. The available data show that none of the six data sets represent poor design or operation. All six data sets for rotary kiln incineration are used for regulation of the K037 waste.

2. Accuracy-corrected constituent concentrations were calculated for all BDAT-list constituents. An arithmetic average concentration level and a variability factor were determined for each BDAT list constituent regulated in this waste, as shown in Table 6-1. The calculation of the variability factor is presented in Appendix A.

3. The BDAT treatment standard for each constituent regulated in this rulemaking was determined by multiplying the average accuracy-corrected total composition by the appropriate variability factor.

Table 6-1 summarizes the calculation of the treatment standards for K037 nonwastewaters and wastewaters. EPA believes the treated constituent concentrations substantially diminish the toxicity of K037.

Table 6-1 Regulated Constituents and Calculated Treatment Standards for K037

Matrix	Constituent (units)	Accuracy-Corrected Concentration: Sample set #1	Sample set #2	Sample set #3	Sample set #4	Sample set #5	Sample set #6	Average Treated Waste Concentration	Variability Factor (VF)	Treatment Standard (Average x VF)
Nonwastewaters	Disulfoton (mg/kg)	0.04	0.04	0 04	0.04	0.04	0.04	0.04	2.8	0 10
	Toluene (mg/kg)	10	10	10	10	10	10	10	2.8	28
Wastewaters	Disulfoton (mg/l)	0.0011	0 0011	0 0011	0.0011	0.0011	0.0011	0.0011	2.8	0 003
	Toluene (mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	2 8	0 028

7. CONCLUSIONS

The Agency has proposed treatment standards for the listed waste code K037. Standards for nonwastewater and wastewater forms of this waste are presented in Table 7-1.

The treatment standards proposed for K037 have been developed consistent with EPA's promulgated methodology for BDAT (November 7, 1986, 51FR 40572). This waste is generated by the treatment of wastewater from disulfoton production. Only one facility is known to produce disulfoton and to generate K037 waste. The BDAT list constituents generally present in the K037 waste are disulfoton and toluene.

Through available data bases, EPA's technology testing program, and data submitted by industry, the Agency has identified the following demonstrated technologies for treatment of organic constituents present in the K037 waste: batch distillation and incineration, including fluidized bed and rotary kiln incineration.

Regulated constituents were selected based on a careful evaluation of the constituents found at treatable levels in the untreated wastes and the constituents detected in the treated wastes. All available waste characterization data and applicable treatment data consistent with the type and quality of data required by the Agency for this program were used to make this determination. For K037 these constituents also represent the BDAT list constituents present at the highest concentrations. However, if the performance data for the technology

Table 7-1 BDAT Treatment Performance Standards for K037

Organic Constituents	Total Waste Concentration	
	Nonwastewater (mg/kg)	Wastewater (mg/l)
Toluene	28	0.028
Disulfoton	0 10	0.003

selected as BDAT indicated that the constituent was not treated, then that constituent was not regulated.

In the development of treatment standards for these wastes, the Agency examined all available treatment data. The Agency also conducted tests on a rotary kiln incinerator treating K037 wastes. Design and operating data collected during the testing of the technology indicate that the technology was properly operated during each sample set; accordingly, all of the treatment performance data collected during the tests were used in the development of the BDAT treatment standards.

Two categories of treatment standards were developed for K037 waste: wastewater and nonwastewater wastes. (For the purpose of the land disposal restrictions rule, wastewaters are defined as wastes containing less than 1 percent (weight basis) filterable solids and less than 1 percent (weight basis) total organic carbon.) Nonwastewater standards for organic constituents in K037 are based on the treatment data from EPA's test of rotary kiln incineration. Wastewater standards for organic constituents in K037 are based on treatment performance as reflected by the scrubber water data collected during the rotary kiln incineration of K037 waste.

Treatment standards for these wastes were derived after adjustment of laboratory data to account for recovery. Subsequently, the mean of the adjusted data points was multiplied by a variability factor to derive the standard. The variability factor represents the variability inherent in the treatment process and sampling and analytical methods. Variability

factors were determined by statistically calculating the variability seen for a number of data points for a given constituent. For constituents for which specific variability factors could not be calculated, a variability factor of 2.8 was used.

Wastes determined to be K037 waste may be land disposed if they meet the standards at the point of disposal. The BDAT upon which the treatment standards are based, rotary kiln incineration, need not be specifically utilized prior to land disposal, provided the alternate technology utilized achieves the standards and does not pose a greater risk to human health and the environment than land disposal. These standards become effective as of August 8, 1988, as per the schedule set forth in 40 CFR 268.10.

Consistent with Executive Order 12291, EPA prepared a regulatory impact analysis (RIA) to assess the economic effect of compliance with this proposed rule. The RIA prepared for this proposal rule is available in the Administrative Record for the First Sixths' Rule.

APPENDIX A

APPENDIX A

STATISTICAL METHODS

A.1 F Value Determination for ANOVA Test

As noted earlier in Section 1.0, EPA is using the statistical method known as analysis of variance in the determination of the level of performance that represents "best" treatment where more than one technology is demonstrated. This method provides a measure of the differences between data sets. If the differences are not statistically significant, the data sets are said to be homogeneous.

If the Agency found that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA would average the long term performance values achieved by each technology and then multiply this value by the largest variability factor associated with any of the acceptable technologies. If EPA found that one technology performs significantly better (i.e., the data sets are not homogeneous), BDAT would be the level of performance achieved by the best technology multiplied by its variability factor.

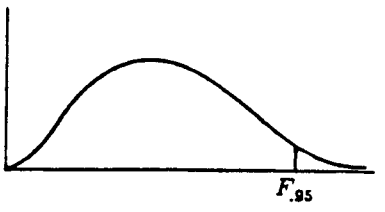
To determine whether any or all of the treatment performance data sets are homogeneous using the analysis of variance method, it is necessary to compare a calculated "F value" to what is known as a "critical value." (See Table A-1.) These critical values are available in most statistics texts (see, for example, Statistical Concepts and Methods by Bhattacharyya and Johnson, 1977, John Wiley Publications, New York).

Where the F value is less than the critical value, all treatment data sets are homogeneous. If the F value exceeds the critical value, it is

Table A-1

95th PERCENTILE VALUES FOR THE F DISTRIBUTION

n_1 = degrees of freedom for numerator
n_2 = degrees of freedom for denominator
(shaded area = .95)



n_2 \ n_1	1	2	3	4	5	6	8	12	16	20	30	40	50	100	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	238.9	243.9	246.3	248.0	250.1	251.1	252.2	253.0	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.37	19.41	19.43	19.45	19.46	19.46	19.47	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.85	8.74	8.69	8.66	8.62	8.60	8.58	8.56	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.84	5.80	5.75	5.71	5.70	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.60	4.56	4.50	4.46	4.44	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4.00	3.92	3.87	3.81	3.77	3.75	3.71	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.49	3.44	3.38	3.34	3.32	3.28	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.28	3.20	3.15	3.08	3.05	3.03	2.98	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.23	3.07	2.98	2.93	2.86	2.82	2.80	2.76	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.07	2.91	2.82	2.77	2.70	2.67	2.64	2.59	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	2.95	2.79	2.70	2.65	2.57	2.53	2.50	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.85	2.69	2.60	2.54	2.46	2.42	2.40	2.35	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.77	2.60	2.51	2.46	2.38	2.34	2.32	2.26	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.70	2.53	2.44	2.39	2.31	2.27	2.24	2.19	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.64	2.48	2.39	2.33	2.25	2.21	2.18	2.12	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.33	2.28	2.20	2.16	2.13	2.07	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.55	2.38	2.29	2.23	2.15	2.11	2.08	2.02	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.25	2.19	2.11	2.07	2.04	1.98	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.48	2.31	2.21	2.15	2.07	2.02	2.00	1.94	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.45	2.28	2.18	2.12	2.04	1.99	1.96	1.90	1.84
22	4.30	3.44	3.05	2.82	2.66	2.55	2.40	2.23	2.13	2.07	1.98	1.93	1.91	1.84	1.78
24	4.26	3.40	3.01	2.78	2.62	2.51	2.36	2.18	2.09	2.03	1.94	1.89	1.86	1.80	1.73
26	4.23	3.37	2.98	2.74	2.59	2.47	2.32	2.15	2.05	1.99	1.90	1.85	1.82	1.76	1.69
28	4.20	3.34	2.95	2.71	2.56	2.45	2.29	2.12	2.02	1.96	1.87	1.81	1.78	1.72	1.65
30	4.17	3.32	2.92	2.69	2.53	2.42	2.27	2.09	1.99	1.93	1.84	1.79	1.76	1.69	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2.00	1.90	1.84	1.74	1.69	1.66	1.59	1.51
50	4.03	3.18	2.79	2.56	2.40	2.29	2.13	1.95	1.85	1.78	1.69	1.63	1.60	1.52	1.44
60	4.00	3.15	2.76	2.53	2.37	2.25	2.10	1.92	1.81	1.75	1.65	1.59	1.56	1.48	1.39
70	3.98	3.13	2.74	2.50	2.35	2.23	2.07	1.89	1.79	1.72	1.62	1.56	1.53	1.45	1.35
80	3.96	3.11	2.72	2.48	2.33	2.21	2.05	1.88	1.77	1.70	1.60	1.54	1.51	1.42	1.32
100	3.94	3.09	2.70	2.46	2.30	2.19	2.03	1.85	1.75	1.68	1.57	1.51	1.48	1.39	1.28
150	3.91	3.06	2.67	2.43	2.27	2.16	2.00	1.82	1.71	1.64	1.54	1.47	1.44	1.34	1.22
200	3.89	3.04	2.65	2.41	2.26	2.14	1.98	1.80	1.69	1.62	1.52	1.45	1.42	1.32	1.19
400	3.86	3.02	2.62	2.39	2.23	2.12	1.96	1.78	1.67	1.60	1.49	1.42	1.38	1.28	1.13
∞	3.84	2.99	2.60	2.37	2.21	2.09	1.94	1.75	1.64	1.57	1.46	1.40	1.32	1.24	1.00

necessary to perform a "pair wise F" test to determine if any of the sets are homogeneous. The "pair wise F" test must be done for all of the various combinations of data sets using the same method and equation as the general F test.

The F value is calculated as follows:

(i) All data are natural logtransformed.

(ii) The sum of the data points for each data set is computed (T_i).

(iii) The statistical parameter known as the sum of the squares between data sets (SSB) is computed:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] \left(\left[\frac{\sum_{i=1}^{k} T_i}{N} \right]^2 \right)$$

where:

k = number of treatment technologies
n_i = number of data points for technology i
N = number of data points for all technologies
T_i = sum of natural logtransformed data points for each technology.

(iv) The sum of the squares within data sets (SSW) is computed:

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

where:

$x_{i,j}$ = the natural logtransformed observations (j) for treatment technology (i).

(v) The degrees of freedom corresponding to SSB and SSW are calculated. For SSB, the degree of freedom is given by k-1. For SSW, the degree of freedom is given by N-k.

(vi) Using the above parameters, the F value is calculated as follows:

$$F = \frac{MSB}{MSW}$$

where:

MSB = SSB/(k-1) and
MSW = SSW/(N-k).

A computational table summarizing the above parameters is shown below.

Computational Table for the F Value

Source	Degrees of freedom	Sum of squares	Mean square	F
Between	K-1	SSB	MSB = SSB/k-1	MSB/MSW
Within	N-k	SSW	MSW = SSW/N-k	

Below are three examples of the ANOVA calculation. The first two represent treatment by different technologies that achieve statistically similar treatment; the last example represents a case where one technology achieves significantly better treatment than the other technology.

Example 1
Methylene Chloride

Steam Stripping				Biological Treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]^2	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]^2
1550.00	10.00	2.30	5.29	1960.00	10.00	2.30	5.29
1290.00	10.00	2.30	5.29	2568.00	10.00	2.30	5.29
1640 00	10 00	2.30	5.29	1817.00	10.00	2.30	5.29
5100 00	12.00	2.48	6.15	1640.00	26.00	3.26	10 6
1450.00	10.00	2 30	5.29	3907.00	10.00	2.30	5.29
4600 00	10.00	2.30	5.29				
1760.00	10 00	2.30	5.29				
2400.00	10.00	2.30	5.29				
4800.00	10.00	2.30	5.29				
12100.00	10.00	2.30	5.29				
Sum.							
-	-	23.18	53.8	-	-	12.46	31.8
Sample Size							
10	10	10	-	5	5	5	-
Mean:							
3669	10.2	2.32	-	2378	13.2	2.49	-
Standard Deviation:							
3328 67	.63	.06	-	923.04	7 15	.43	-
Variability Factor:							
	1.14	-	-	-	2.48	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k}\left(\frac{T_i^2}{n_i}\right)\right] - \frac{T^2}{N}$$

$$SSW = \left[\sum_{i=1}^{k}\sum_{j=1}^{n_i} X_{i,j}^2\right] - \sum_{i=1}^{k}\left(\frac{T_i^2}{n_i}\right)$$

MSB = SSB/(k-1)

MSW = SSW/(N-k)

Example 1 (continued)

F = MSB/MSW

Where,

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural log transformed data points for all technologies

T_i = sum of log transformed data points for each technology

T = Total sum of all the natural log transformed data points for all technologies = $\sum_{i=1}^{k} T_i$

X_{ij} = the nat. log transformed observations (j) for treatment technology (i)

$n_1 = 10$, $n_2 = 5$, $N = 15$, $k = 2$, $T_1 = 23.18$, $T_2 = 12.46$, $T = 35.64$, $T^2 = 1270$,

$T_1^2 = 537.3$, $T_2^2 = 155.2$,

$$SSB = \left(\frac{537.3}{10} + \frac{155.2}{5}\right) - \frac{1270}{15} = 0.1233$$

$$SSW = (53.8 + 31.8) - \left(\frac{537.3}{10} + \frac{155.3}{5}\right) = 0.7600$$

MSB = 0.1233/1 = 0.1233

MSW = 0.76/13 = 0.0584

$$F = \frac{0.1233}{0.0584} = 2\ 109$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F
Between(B)	1	0.1233	0.1233	2.109
Within(W)	13	0.7600	0.0584	

The critical value of the F test at 0.05 significance level is 4.67. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Example 2
Trichloroethylene

Steam Stripping				Biological Treatment			
Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	[ln(effluent)]^2	Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	[ln(effluent)]^2
1650.00	10.00	2.30	5.29	200.00	10.00	2.30	5.29
5200.00	10.00	2.30	5.29	224.00	10.00	2.30	5.29
5000.00	10 00	2.30	5.29	134.00	10.00	2.30	5.29
1720.00	10 00	2.30	5.29	150.00	10.00	2.30	5.29
1560.00	10.00	2.30	5.29	484.00	16.25	2.79	7.78
10300.00	10 00	2.30	5.29	163.00	10.00	2.30	5.29
210 00	10 00	2.30	5.29	182.00	10.00	2.30	5.29
1600.00	27.00	3.30	10.9				
204.00	85.00	4.44	19.7				
160.00	10.00	2.30	5.29				
Sum							
-	-	26.14	72.9	-	-	16.59	39.5
Sample Size							
10	10	10	-	7	7	7	-
Mean.							
2760	19.2	2.61	-	220	10.89	2.37	-
Standard Deviation·							
3209 6	23 7	71	-	120.5	2.36	.18	-
Variability Factor·							
-	3 76	-	-	-	1.51	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k}\left(\frac{T_i^2}{n_i}\right)\right] - \frac{T^2}{N}$$

$$SSW = \left[\sum_{i=1}^{k}\sum_{j=1}^{n_i} X_{i,j}^2\right] - \sum_{i=1}^{k}\left(\frac{T_i^2}{n_i}\right)$$

MSB = SSB/(k-1)

MSW = SSW/(N-k)

Example 2 (continued)

F = MSB/MSW

Where,

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural log transformed data points for each technology

T = total sum of all the natural log transformed data points for all technologies = $\sum_{i=1}^{k} T_i$

X_{ij} = the natural log transformed observations (j) for treatment technology (i)

$N_1 = 10$, $N_2 = 7$, $N = 17$, $k = 2$, $T_1 = 26.14$, $T_2 = 16.59$, $T = 42.73$, $T^2 = 1826$, $T_1^2 = 683.3$

$T_2^2 = 275.2$,

$$SSB = \left(\frac{683.3}{10} + \frac{275.2}{7}\right) - \frac{1826}{17} = 0.2325$$

$$SSW = (72.9 + 39\ 5) - \left(\frac{683.3}{10} + \frac{275.2}{7}\right) = 4.856$$

MSB = 0.2325/1 = 0.2325

MSW = 4.856/15 = 0.3237

$$F = \frac{0.2325}{0.3237} = 0.7183$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F
Between(B)	1	0.2325	0.2325	0.7183
Within(W)	15	4.856	0.3237	

The critical value of the F test at 0.05 significance level is 4.54. Since F value is less than the critical value, the means are not significantly different (i e , they are homogeneous)

Example 3
Chlorobenzene

Activated Sludge Followed by Carbon				Biological Treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]^2	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln (effluent)]^2
7200.00	80.00	4.38	19.2	9206.00	1083.00	6.99	48.9
6500 00	70.00	4.25	18.1	16646.00	709.50	6.56	43.0
6075.00	35.00	3 56	12.7	49775.00	460.00	6.13	37.6
3040 00	10 00	2.30	5.29	14731.00	142.00	4.96	24.6
				3159.00	603.00	6.40	41.0
				6756.00	153.00	5.03	25.3
				3040.00	17.00	2.83	8.01
Sum:							
-	-	14.49	55.3	-	-	38.90	228.4
Sample Size.							
4	4	4	-	7	7	7	-
Mean·							
5703	49	3.63	-	14759	452.5	5.56	-
Standard Deviation.							
1835 4	32.24	95		16311.86	379.04	1.42	-
Variability Factor·							
-	7 00	-	-	-	15.79	-	-

ANOVA Calculations

$$SSB = \left[\sum_{i=1}^{k}\left(\frac{T_i^2}{n_i}\right)\right] - \frac{T^2}{N}.$$

$$SSW = \left[\sum_{i=1}^{k}\sum_{j=1}^{n_i} X_{i,j}^2\right] - \sum_{i=1}^{k}\left(\frac{T_i^2}{n_i}\right)$$

MSB = SSB/(k-1)

MSW = SSW/(N-k)

F = MSB/MSW

Where,

Example 3 (continued)

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural log transformed data points for each technology

T = total sum of all the natural log transformed data points for all technologies = $\sum_{i=1}^{k} T_i$

X_{ij} = the natural log transformed observations (j) for treatment technology (i)

$N_1 = 4$, $N_2 = 7$, $N = 11$, $k = 2$, $T_1 = 14.49$, $T_2 = 38.90$, $T = 53.39$, $T^2 = 2850$, $T_1^2 = 210.0$

$T_2^2 = 1513$,

$$SSB = \left\{\frac{210.0}{4} + \frac{1513}{7}\right\} - \frac{2850}{11} = 9.552$$

$$SSW = (55.3 + 228.4) - \left\{\frac{210.0}{4} + \frac{1513}{7}\right\} = 14.96$$

$MSB = 9.552/1 = 9.552$

$MSW = 14.96/9 = 1.662$

$F = 9.552/1.662 = 5.75$

ANOVA Table

Source	Degrees of freedom	SS	MS	F
Between(B)	1	9.552	9.552	5.75
Within(W)	9	14.96	1.662	

The critical value of the F test at 0.05 significance level is 5.12. Since F value is larger than the critical value, the means are significantly different (i.e., they are heterogeneous).

A.2. Variability Factor

$$VF = \frac{C_{99}}{Mean}$$

where:

VF = estimate of daily maximum variability factor determined from a sample population of daily data.

C_{99} = Estimate of performance values for which 99 percent of the daily observations will be below. C_{99} is calculated using the following equation: $C_{99} = Exp(y + 2.33\ Sy)$ where y and Sy are the mean and standard deviation, respectively, of the logtransformed data.

Mean = average of the individual performance values.

EPA is establishing this figure as an instantaneous maximum because the Agency believes that on a day-to-day basis the waste should meet the applicable treatment standards. In addition, establishing this requirement makes it easier to check compliance on a single day. The 99th percentile is appropriate because it accounts for almost all process variability.

In several cases, all the results from analysis of the residuals from BDAT treatment are found at concentrations less than the detection limit. In such cases, all the actual concentration values are considered unknown and hence, cannot be used to estimate the variability factor of the analytical results. Below is a description of EPA's approach for calculating the variability factor for such cases with all concentrations below the detection limit.

It has been postulated as a general rule that a lognormal distribution adequately describes the variation among concentrations. Agency data shows that the treatment residual concentrations are distributed approximately lognormally. Therefore, the lognormal model

has been used routinely in the EPA development of numerous regulations in the Effluent Guidelines program and in the BDAT program. The variability factor (VF) was defined as the ratio of the 99th percentile (C_{99}) of the lognormal distribution to its arithmetic mean (Mean).

$$VF = \frac{C_{99}}{\text{Mean}} \qquad (1)$$

The relationship between the parameters of the lognormal distribution and the parameters of the normal distribution created by taking the natural logarithms of the lognormally-distributed concentrations can be found in most mathematical statistics texts (see for example: Distribution in Statistics-Volume 1 by Johnson and Kotz, 1970). The mean of the lognormal distribution can be expressed in terms of the mean (μ) and standard deviation (σ) of the normal distribution as follows:

$$C_{99} = \text{Exp}\ (\mu + 2.33\sigma) \qquad (2)$$

$$\text{Mean} = \text{Exp}\ (\mu + .5\sigma^2) \qquad (3)$$

Substituting (2) and (3) in (1) the variability factor can then be expressed in terms of σ as follows:

$$VF = \text{Exp}\ (2.33\ \sigma - .5\sigma^2) \qquad (4)$$

For residuals with concentrations that are not all below the detection limit, the 99^{th} percentile and the mean can be estimated from the actual analytical data and accordingly, the variability factor (VF) can be estimated using equation (1). For residuals with concentrations that are below the detection limit the above equations can be used in conjunction with the assumptions below to develop a variability factor.

Step 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is assumed to be equal to one tenth of the detection limit. This assumption is based on the fact that data from well-designed and well-operated treatment systems generally falls within one order of magnitude.

Step 2: The natural logarithms of the concentrations have a normal distribution with an upper limit equal to ln (UL) and a lower limit equal to ln (LL).

Step 3: The standard deviation (σ) of the normal distribution is approximated by

$$\sigma = [(\ln (UL) - \ln (LL)] / [(2)(2.33)] = [\ln(UL/LL)] / 4.66$$

when $LL = (0.1)(UL)$ then $\sigma = (\ln 10) / 4.66 = 0.494$

Step 4: Substitution of the value from Step 3 in equation (4) yields the variability factor, VF.

$$VF = 2.8$$

APPENDIX B

APPENDIX B

ANALYTICAL QA/QC

The analytical methods used for analysis of the regulated constituents identified in Section 5 are listed in Table B-1. SW-846 methods (EPA's Test Methods for Evaluation Solid of Waste; Physical/Chemical Methods, SW-846, Third Edition, November 1986) are used in most cases for determining total constituent concentrations.

The accuracy determination for a constituent is based on the matrix spike recovery values. Tables B-2 and B-3 present the matrix spike recoveries for disulfoton and toluene total composition analyses for K037 residuals for the EPA-collected data.

The accuracy correction factors for disulfoton and toluene for each treatment residual are summarized in Tables B-2 and B-3. The accuracy correction factors were determined in accordance with the general methodology presented in the Introduction. For example, for disulfoton actual spike recovery data were obtained for analysis of both solid and liquid matrices, and the lowest percent recovery value was used to calculate the accuracy correction factor. An example of the calculation of a corrected constituent concentration value is shown below.

Analytical Value	% Recovery	Correction Factor	Corrected Value
0.0335 ppm	91	$\frac{100}{91} = 1.10$	1.10 x 0.0335 = 0.04 ppm

Table B-1 Analytical Methods for Regulated Constituents

Regulated constituent	Extraction method	Analytical method	Reference
TOTAL COMPOSITION			
Disulfoton	Specified in analytical method	8140	3
Toluene	Specified in analytical method	5030, 8240	3

Table B-2 Matrix Spike Recoveries for K037 Treated Solids - EPA-Collected Data

BDAT constituent	Original amount found (ug/l)	Sample Set #5			Sample Set #5 Duplicate			Accuracy correction factor**
		Spike added (ug/l)	Spike result (ug/l)	Percent recovery*	Spike added (ug/l)	Spike result (ug/l)	Percent recovery*	
Disulfoton	<0 007	0 173	0.157	91	0 173	0 164	95	1 10
Toluene	NC	25	NC	166	25	NC	165	1 00

NC = Not calculable because the only values available were the spike amount and the percent recovery
*Percent Recovery = [(Spike Result - Original Amount)/Spike Added]
**Accuracy Correction Factor = 100/Percent Recovery (using the lowest percent recovery value)

Reference USEPA 1987 Onsite Engineering Report for K037.

Table B-3 Matrix Spike Recoveries for K037 Scrubber Water Sample - EPA-Collected Data

BDAT constituent	Original amount found (ug/l)	Sample Set #5			Sample Set #5 Duplicate			Accuracy correction factor**
		Spike added (ug/l)	Spike result (ug/l)	Percent recovery*	Spike added (ug/l)	Spike result (ug l)	Percent recovery*	
Disulfoton	<0.2	5.18	4 88	94	5.18	5 28	102	1 06
Toluene	NC	25	NC	109	25	NC	116	1 00

NC = Not calculable because the only values available were the spike amount and the percent recovery.
*Percent Recovery = [(Spike Result - Original Amount)/Spike Added].
**Accuracy Correction Factor = 100/Percent Recovery (using the lowest percent recovery value)

Reference USEPA 1987 Onsite Engineering Report for K037

APPENDIX C

Appendix C Detection Limits for K037 Untreated and Treated Samples

BDAT Ref No	Parameter	CAS no	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (μg/l)
	Volatiles					
222	Acetone	67-64-1	NL	NL	NL	NL
1	Acetonitrile	75-05-8	10,000	1000	1000	1000
2	Acrolein	107-02-8	25,000	2500	2500	2500
3	Acrylonitrile	107-13-1	500	50	50	50
4	Benzene	71-43-2	100	10	10	10
5.	Bromodichloromethane	75-27-4	100	10	10	10
6	Bromomethane	74-83-9	500	50	50	50
223	n-Butyl alcohol	71-36-3	NL	NL	NL	NL
7	Carbon Tetrachloride	56-23-5	100	10	10	10
8	Carbon disulfide	75-15-0	500	50	50	50
9.	Chlorobenzene	108-90-7	100	10	10	10
10	2-Chloro-1,3-butadiene	126-99-8	2500	250	250	250
11.	Chlorodibromomethane	124-48-1	100	10	10	10
12.	Chloroethane	75-00-3	500	50	50	50
13	2-Chloroethyl vinyl ether	110-75-8	10,000	1000	1000	1000
14	Chloroform	67-66-3	100	10	10	10
15	Chloromethane	74-87-3	500	50	50	50
16.	3-Chloropropene	107-05-1	100	10	10	10
17	1,2-Dibromo-3-chloropropane	96-12-8	100	10	10	10
18.	1,2-Dibromoethane	106-93-4	100	10	10	10
19	Dibromomethane	74-95-3	100	10	10	10
20	Trans-1,4-Dichloro-2-butene	110-57-6	2500	250	250	250
21	Dichlorodifluoromethane	75-34-3	100	10	10	10
22	1,1-Dichloroethane	107-06-2	100	10	10	10
23	1,2-Dichloroethane	75-35-4	100	10	10	10
24	1,1-Dichloroethylene	156-60-5	100	10	10	10
25	Trans-1,2-Dichloroethene	78-87-5	100	10	10	10
26.	1,2-Dichloropropane	10061-02-6	250	25	25	25
27	Trans-1,3-Dichloropropene	10061-01-5	250	25	25	25
28	cis-1,3-Dichloropropene	123-91-1	250	25	25	25
29	1,4-Dioxane	107-12-0	NA	NA	NA	NA
224.	2-Ethoxyethanol	110-80-5	NL	NL	NL	NL

Appendix C (Continued)

BDAT Ref No	Parameter	CAS no.	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (μg/l)
	Volatiles (continued)					
225	Ethyl acetate	141-78-6	NL	NL	NL	NL
226	Ethyl benzene	100-41-4	NL	NL	NL	NL
30	Ethyl cyanide	97-63-2	NA	NA	NA	NA
227	Ethyl ether	60-29-7	NL	NL	NL	NL
31	Ethyl methacrylate	75-21-8	500	50	50	50
214	Ethylene oxide	75-21-8	NL	NL	NL	NL
32	Iodomethane	74-88-4	100	10	10	10
33	Isobutyl alcohol	78-83-1	NA	NA	NA	NA
228	Methanol	67-56-1	NL	NL	NL	NL
34	Methyl ethyl ketone	78-93-3	2500	250	250	250
229	Methyl isobutyl ketone	108-10-1	NL	NL	NL	NL
35	Methyl methacrylate	80-62-6	500	50	50	50
36	Methyl methanesulfonate	66-27-3	NA	NA	NA	NA
37	Methacrylonitrile	126-98-7	NA	NA	NA	NA
38	Methylene chloride	75-09-2	2500	250	250	250
230	2-Nitropropane	79-46-9	NL	NL	NL	NL
39	Pyridine	110-86-1	-	-	-	-
40	1,1,1,2-Tetrachloroethane	630-20-6	100	10	10	10
41	1,1,2,2-Tetrachloroethane	79-34-6	100	10	10	10
42	Tetrachloroethene	127-18-4	100	10	10	10
43	Toluene	108-88-3	100	10	10	10
44	Tribromomethane	75-25-2	100	10	10	10
45	1,1,1-Trichloroethane	71-55-6	100	10	10	10
46	1,1,2-Trichloroethane	79-00-5	100	10	10	10
47	Trichloroethene	79-01-6	100	10	10	10
48	Trichloromonofluoromethane	75-69-4	100	10	10	10
49	1,2,3-Trichloropropane	96-18-4	2500	250	250	250
231	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	NL	NL	NL	NL
50	Vinyl chloride	75-01-4	500	50	50	50
215	1,2-Xylene	97-47-6	NL	NL	NL	NL
216	1,3-Xylene	108-38-3	NL	NL	NL	NL
217	1,4-Xylene	106-44-5	NL	NL	NL	NL

Appendix C (Continued)

BDAT Ref No	Parameter	CAS no.	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (µg/l)
	Semivolatiles					
51	Acenaphthalene	208-96-8	250	2.0	50	50
52	Acenaphthene	83-32-9	250	2.0	50	50
53	Acetophenone	96-86-2	250	2.0	50	50
54.	2-Acetylaminofluorene	53-96-3	25,000	200.0	5,000	5,000
55	4-Aminobiphenyl	92-67-1	5,000	35 0	1,000	1,000
56	Aniline	62-53-3	500	3.5	100	100
57	Anthracene	120-12-7	250	2.0	50	50
58	Aramite	140-57-8	NA	NA	NA	NA
59	Benz(a)anthracene	56-55-3	250	2.0	50	50
218	Benzal chloride	98-87-3	NL	NL	NL	NL
60	Benzal chloride	98-87-3	NA	NA	NA	NA
61.	Benzenethiol	108-98-5	25,000	200 0	5,000	5,000
62.	Benzo(a)pyrene	50-32-8	250	2 0	50	50
63.	Benzo(b)fluoranthene	205-99-2	250	2.0	50	50
64	Benzo(ghi)perylene	191-24-2	250	2.0	50	50
65.	Benzo(k)fluoranthene	207-08-9	250	2.0	50	50
66.	p-Benzoquinone	106-51-4	25,000	200.0	5,000	5,000
67	Bis(2-chloroethoxy)methane	111-91-1	250	2.0	50	50
68.	Bis(2-chloroethyl)ether	111-44-4	250	2.0	50	50
69.	Bis(2-chloroisopropyl)ether	39638-32-9	250	2.0	50	50
70.	Bis(2-ethylhexyl)phthalate	117-81-7	250	2.0	50	50
71	4-Bromophenyl phenyl ether	101-55-3	250	2.0	50	50
72.	Butyl benzyl phthalate	85-68-7	250	2.0	50	50
73.	2-sec-Butyl-4,6-dinitrophenol	88-85-7	NA	NA	NA	NA
74	p-Chloroaniline	106-47-8	2,500	2.0	500	500
75.	Chlorobenzilate	510-15-6	NA	NA	NA	NA
76.	p-Chloro-m-cresol	59-50-7	250	2 0	50	50
77	2-Chloronaphthalene	91-58-7	250	2.0	50	50
78	2-Chlorophenol	95-57-8	250	2.0	50	50
79.	3-Chloropropionitrile	542-76-7	NA	NA	NA	NA
80.	Chrysene	218-01-9	250	2.0	50	50
81	ortho-Cresol	95-48-7	250	2.0	50	50
82.	para-Cresol	106-44-5	250	2.0	50	50

Appendix C (Continued)

BDAT Ref No	Parameter	CAS no.	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (µg/l)
	Semivolatiles (continued)					
232	Cyclohexanone	108-94-1	NL	NL	NL	NL
83	Dibenz(a,h)anthracene	53-70-3	250	2.0	50	50
84	Dibenzo(a,e)pyrene	192-65-4	250	2.0	50	50
85	Dibenzo(a,i)pyrene	189-55-9	250	2.0	50	50
86	m-Dichlorobenzene	541-73-1	250	2.0	50	50
87	o-Dichlorobenzene	95-50-1	250	2.0	50	50
88	p-Dichlorobenzene	106-46-7	250	2.0	50	50
89	3,3'-Dichlorobenzidine	91-94-1	500	3.5	100	100
90	2,4-Dichlorophenol	120-83-2	250	2.0	50	50
91	2,6-Dichlorophenol	87-65-0	250	2.0	50	50
92	Diethyl phthalate	84-66-2	250	2.0	50	50
93	3,3'-Dimethoxybenzidine	119-90-4	250,000	2000.0	50,000	50,000
94	p-Dimethylaminoazobenzene	60-11-7	5,000	35.0	1,000	1,000
95	3,3'-Dimethylbenzidine	119-93-7	250,000	2000.0	50,000	50,000
96	2,4-Dimethylphenol	105-67-9	250	2.0	50	50
97	Dimethyl phthalate	131-11-3	250	2.0	50	50
98	Di-n-butyl phthalate	84-74-2	250	2.0	50	50
99	1,4-Dinitrobenzene	100-25-4	2,500	20.0	500	500
100	4,6-Dinitro-o-cresol	534-52-1	1,250	10.0	250	250
101	2,4-Dinitrophenol	51-28-5	1,250	10.0	250	250
102	2,4-Dinitrotoluene	121-14-2	250	2.0	50	50
103	2,6-Dinitrotoluene	606-20-2	250	2.0	50	50
104	Di-n-octyl phthalate	117-84-0	250	2.0	50	50
105	Di-n-propylnitrosamine	621-64-7	-	-	-	-
106	Diphenylamine	122-39-4	250	2.0	50	50
219	Diphenylnitrosamine	86-30-6	250	2.0	50	50
107	1,2-Diphenylhydrazine	122-66-7	250	2.0	50	50
108	Fluoranthene	206-44-0	250	2.0	50	50
109	Fluorene	86-73-7	250	2.0	50	50
110	Hexachlorobenzene	118-74-1	250	2.0	50	50
111	Hexachlorobutadiene	87-68-3	250	2.0	50	50
112	Hexachlorocyclopentadiene	77-47-4	250	2.0	50	50
113	Hexachloroethane	67-72-1	250	2.0	50	50

Appendix C. (Continued)

BDAT Ref No	Parameter	CAS no	Untreated Waste (mg/kg)	Treated waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (µg/l)
	Semivolatiles (continued)					
114.	Hexachlorophene	70-30-4	NA	NA	NA	NA
115	Hexachloropropene	1888-71-7	250	2.0	50	50
116	Indeno(1,2,3-cd)pyrene	193-39-5	250	2.0	50	50
117	Isosafrole	120-58-1	2,500	20.0	500	500
118.	Methapyrilene	91-80-5	NA	NA	NA	NA
119	3-Methylcholanthrene	56-49-5	2500	20 0	500	500
120	4,4'-Methylenebis (2-chloroaniline)	101-14-4	5,000	35.0	1,000	1,000
121	Naphthalene	91-20-3	250	2.0	50	50
122	1,4-Naphthoquinone	130-15-4	2,500	20 0	500	500
123	1-Napnthylamine	134-32-7	2,500	20.0	500	500
124	2-Naphthylamine	91-59-8	2,500	20.0	500	500
125	p-Nitroaniline	100-01-6	1,250	10.0	250	250
126.	Nitrobenzene	98-95-3	250	2.0	50	50
127.	4-Nitrophenol	100-02-7	1,250	10.0	250	250
128	N-Nitrosodi-n-butylamine	924-16-3	2,500	20.0	500	500
129	N-Nitrosodiethylamine	55-18-5	2,500	20.0	500	500
130	N-Nitrosodimethylamine	62-75-9	2,500	20.0	500	500
131	N-Nitrosomethylethylamine	10595-95-6	2,500	20.0	500	500
132	N-Nitrosomorpholine	59-89-2	5,000	35.0	1,000	1,000
133	N-Nitrosopiperidine	100-75-4	5,000	35 0	1,000	1,000
134	n-Nitrosopyrrolidine	930-55-2	5,000	35.0	1,000	1,000
135	5-Nitro-o-toluidine	99-65-8	5,000	35.0	1,000	1,000
136	Pentachlorobenzene	608-93-5	250	2.0	50	50
137	Pentachloroethane	76-01-7	250	2.0	50	50
138	Pentachloronitrobenzene	82-68-8	2,500	20.0	500	500
139	Pentachloropnenol	87-86-5	1,250	10.0	250	250
140	Phenacetin	62-44-2	2,500	20.0	500	500
141	Phenanthrene	85-01-8	250	2 0	50	50
142	Phenol	108-95-2	250	2.0	50	50
220	Phthalic anhydride	85-44-9	NL	NL	NL	NL
143	2-Picoline	109-06-8	2,500	20.0	500	500

Appendix C (Continued)

BDAT Ref No	Parameter	CAS no	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (µg/l)
	Semivolatiles (cont)					
144	Pronamide	23950-58-5	2,500	20.0	500	500
145	Pyrene	129-00-0	250	2.0	50	50
146	Resorcinol	108-46-3	25,000	2000.0	5,000	5,000
147	Safrole	94-59-7	2,500	20.0	500	500
148	1,2,4,5-Tetrachlorobenzene	95-94-3	2,500	2.0	50	50
149	2,3,4,6-Tetrachlorophenol	58-90-2	2,500	20.0	500	500
150	1,2,4-Trichlorobenzene	120-82-1	250	2.0	50	50
151	2,4,5-Trichlorophenol	95-95-4	1,250	10.0	250	250
152	2,4,6-Trichlorophenol	88-06-2	250	2.0	50	50
153	Tris(2,3-dibromopropyl) phosphate	126-72-7	NA	NA	NA	NA
	Metals					
154	Antimony	7440-36-0	17.0	17.0	0.3	0.3
155	Arsenic	7440-38-2	2.0	2.0	0.01	0.01
156.	Barium	7440-39-3	1.0	1.0	0.045	0.045
157.	Beryllium	7440-41-7	0.5	0.5	0.005	0.005
158	Cadmium	7440-43-9	2 0	2.0	0.015	0.015
159	Chromium (total)	7440-47-32	3.5	3.5	0.045	0.045
221.	Chromium (hexavalent)		NL	NL	NL	NL
160	Copper	7440-50-8	3.0	3.0	0.05	0.05
161	Lead	7439-92-1	1 0	1.0	0.01	0.01
162	Mercury	7439-97-6	1.25	1.25	0.001	0.001
163.	Nickel	7440-02-0	7.5	7.5	0.1	0.1
164	Selenium	7782-49-2	2 0	2.0	0.015	0 015
165	Silver	7440-22-4	3.5	3.5	0.045	0.045
166	Thallium	7440-28-0	2.5	2.5	0.015	0 015
167	Vanadium	7440-62-2	4.0	4.0	0.1	0.1
168	Zinc	7440-66-6	1 0	1 0	0.03	0 03

Appendix C (Continued)

BDAT Ref. No	Parameter	CAS no	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (µg/l)
	Inorganics					
169	Cyanide	57-12-5	-	-	-	0.05
170	Fluoride	16964-48-8	-	-	-	0.05
171	Sulfide	8496-25-8	-	-	-	5
	Organochlorine Pesticides					
172	Aldrin	309-00-2	7.5	5.0	-	0.15
173	alpha-BHC	319-84-6	4 0	2.5	-	0.10
174	beta-BHC	319-85-7	7 5	5.0	-	0.15
175	delta-BHC	319-86-8	7 5	5.0	-	0.15
176.	gamma-BHC	58-89-9	5.0	5.0	-	0.10
177.	Chlordane	57-74-9	100	75	-	1.00
178	DDD	72-54-8	15.0	10.0	-	0.30
179	DDE	72-55-9	7 5	5.0	-	0.15
180	DDT	50-29-3	15.0	10.0	-	0.30
181	Dieldrin	60-57-1	7 5	5.0	-	0.15
182	Endosulfan I	939-98-8	7 5	5.0	-	0.15
183	Endosulfan II	33213-6-5	7 5	5.0	-	0.15
184	Endrin	72-20-8	7.5	5.0	-	0.15
185	Endrin aldehyde	7421-93-4	15.0	10.0	-	0.30
186.	Heptachlor	76-44-8	5 0	5.0	-	0.10
187	Heptachlor epoxide	1024-57-3	7.5	5.0	-	0.15
188	Isodrin	465-73-6	7.5	5.0	-	0.15
189.	Kepone	143-50-0	40.0	30.0	-	0.80
190	Methoxychlor	72-43-5	25.0	15 0	-	0 50
191	Toxaphene	8001-35-2	1,000	500	-	10 0
	Phenoxyacetic Acid Herbicides					
192	2,4-Dichlorophenoxyacetic acid	94-75-7	0 385	0 10	-	2 5
193.	Silvex	93-72-1	0.385	0 10	-	2.5
194	2,4,5-T	93-76-5	0.385	0.10	-	2.5

Appendix C (Continued)

BDAT Ref No	Parameter	CAS no	Untreated Waste (mg/kg)	Treated Waste (mg/kg)	Treated Waste TCLP (mg/l)	Scrubber Water (µg/l)
	Organophosphorous Insecticides					
195	Disulfoton	298-04-4	5,000	0.0335	-	1.00
196	Famphur	52-85-7	12,500	0 085	-	2.50
197	Methyl parathion	298-00-0	5,000	0 0335	-	1.00
198	Parathion	56-38-2	3,750	0 0250	-	0.75
199	Phorate	298-02-2	2,500	0.0165	-	0.50
	PCBs					
200	Aroclor 1016	12674-11-2	1,000	500	-	10.0
201.	Aroclor 1221	11104-28-2	1,000	500	-	10.0
202	Aroclor 1232	11141-16-5	1,000	500	-	10.0
203	Aroclor 1242	53469-21-9	1,000	500	-	10 0
204	Aroclor 1248	12672-29-6	1,000	500	-	10 0
205	Aroclor 1254	11097-69-1	300	250	-	3.00
206	Aroclor 1260	11096-82-5	400	250	-	4.00
	Dioxins and Furans					
207.	Hexachlorodibenzo-p-dioxins		NA	0 15*	-	5.6**
208	Hexachlorodibenzofuran		NA	0.87*	-	3 7**
209.	Pentachlorodibenzo-p-dioxins		NA	0 51*	-	2 4**
210.	Pentachlorodibenzofuran		NA	0.35*	-	2 1**
211	Tetrachlorodibenzo-p-dioxins		0 53*	0.39*	-	2 6**
212	Tetrachlorodibenzofuran		NA	0.22*	-	1.6**
213	2,3,7,8-Tetrachlorodibenzo-p-dioxin		-	-	-	-

NL = Not on list at the time analysis was performed
- = No analysis performed
* = Units are ng/g
** = Units are ng/l
NA = Not detected, however, surrogates not recovered and detection limits cannot be calculated
Reference USEPA 1987 Onsite Engineering Report.

APPENDIX D

Appendix D

METHOD OF MEASUREMENT FOR THERMAL CONDUCTIVITY

The comparative method of measuring thermal conductivity has been proposed as an ASTM test method under the name "Guarded, Comparative, Longitudinal Heat Flow Technique." A thermal heat flow circuit is used which is the analog of an electrical circuit with resistances in series. A reference material is chosen to have a thermal conductivity close to that estimated for the sample. Reference standards (also known as heat meters) having the same cross-sectional dimensions as the sample are placed above and below the sample. An upper heater, a lower heater, and a heat sink are added to the "stack" to complete the heat flow circuit. See Figure 1.

The temperature gradients (analogous to potential differences) along the stack are measured with type K (chromel/alumel) thermocouples placed at known separations. The thermocouples are placed into holes or grooves in the references and also in the sample whenever the sample is thick enough to accommodate them.

For molten samples, pastes, greases, and other materials that must be contained, the material is placed into a cell consisting of a top and bottom of Pyrex 7740 and a containment ring of marinite. The sample is 2 inch in diameter and .5 inch thick. Thermocouples are not placed into the sample but rather the temperatures measured in the Pyrex are extrapolated to give the temperature at the top and bottom surfaces of the sample material. The Pyrex disks also serve as the thermal conductivity reference material.

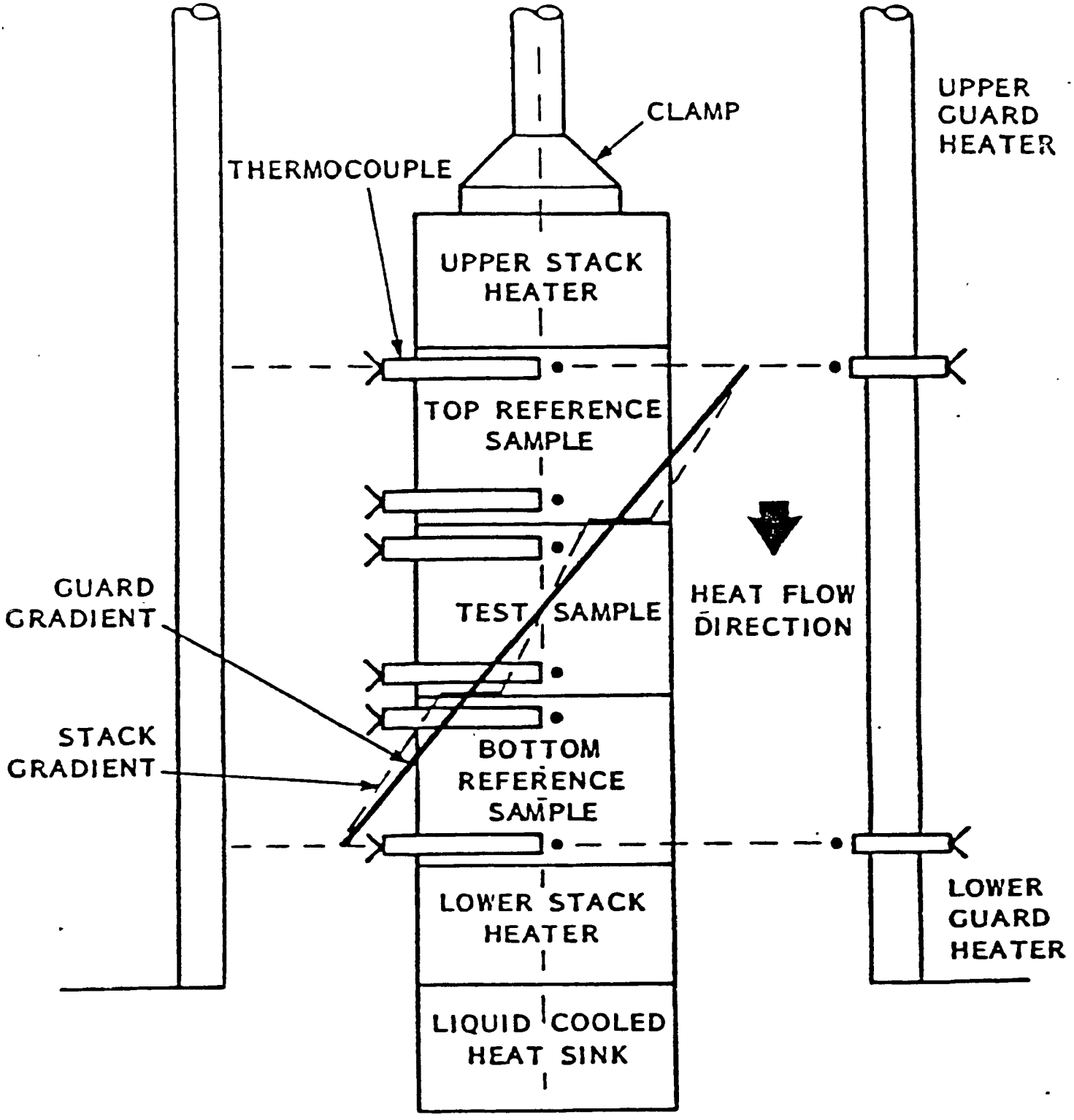


Figure 1.

SCHEMATIC DIAGRAM OF THE COMPARATIVE METHOD

The stack is clamped with a reproducible load to insure intimate contact between the components. In order to produce a linear flow of heat down the stack and reduce the amount of heat that flows radially, a guard tube is placed around the stack and the intervening space is filled with insulating grains or powder. The temperature gradient in the guard is matched to that in the stack to further reduce radial heat flow.

The comparative method is a steady state method of measuring thermal conductivity. When equilibrium is reached the heat flux (analogous to current flow) down the stack can be determined from the references. The heat into the sample is given by

$$Q_{in} = \lambda_{top}(dT/dx)_{top}$$

and the heat out of the sample is given by

$$Q_{out} = \lambda_{bottom}(dT/dx)_{bottom}$$

where

λ = thermal conductivity

dT/dx = temperature gradient

and top refers to the upper reference while bottom refers to the lower reference. If the heat was confined to flow just down the stack, then Q_{in} and Q_{out} would be equal. If Q_{in} and Q_{out} are in reasonable agreement, the average heat flow is calculated from

$$Q = (Q_{in} + Q_{out})/2$$

The sample thermal conductivity is then found from

$$\lambda_{sample} = Q/(dT/dx)_{sample}$$

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