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Solid Waste

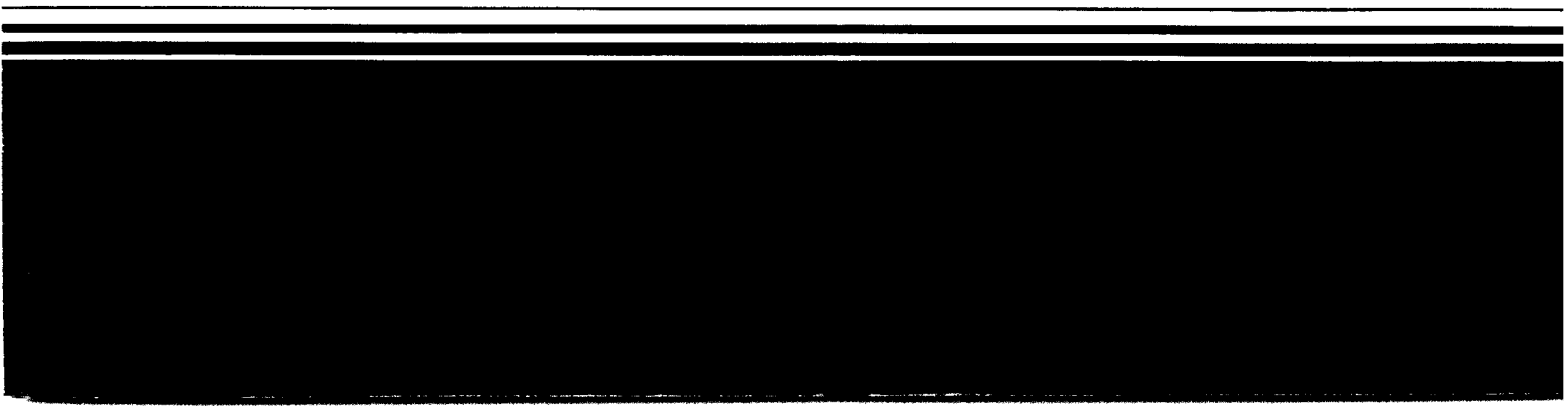
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# **Best Demonstrated Available Technology (BDAT) Background Document for K106**

# **Proposed**

## **Volume 17**



PROPOSED

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)  
BACKGROUND DOCUMENT FOR K106

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## BDAT Background Document for K106

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## EXECUTIVE SUMMARY

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 and Recovery Act (RCRA), the following treatment standards have been proposed as Best Demonstrated Available Technology (BDAT) for the listed waste identified in 40 CFR Section 261.32 as K106 (wastewater treatment sludge from the mercury cell process in chlorine production). Compliance with these treatment standards is a prerequisite for disposal of the waste in units designated as land disposal units according to 40 CFR Part 268.

Standards are established for one metal (mercury); these standards are established for both nonwastewaters and wastewaters. For nonwastewater, the standards are based on total constituent and leachate analyses and for wastewaters the standards are based on total constituent analyses of the waste. The leachate was obtained using the Toxicity Characteristic Leaching Procedure (TCLP).

BDAT standards for K106 nonwastewater forms have been established based on performance data obtained from processing of a material similar to K106 by a retorting process. For K106 wastewaters, the BDAT treatment standards have been based on the performance of sulfide precipitation followed by filtration of a mercury containing wastewater similar to K106 wastewaters. The proposed effective date for these standards is August 8, 1990.

The following table lists the specific BDAT standards for wastes identified as K106. For the purpose of determining the applicability of the BDAT treatment standards, 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). Wastes not meeting this definition must comply with treatment standards for nonwastewaters. The units for the total waste analysis are mg/kg (parts per million on a weight by weight basis). The leachate standards are based on analysis of a TCLP leachate and are in units of mg/l (parts per million on a weight by volume basis). Testing procedures for all sample analyses performed are specifically identified in Appendix B of this background document.

## BDAT Treatment Standards for K106

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### Nonwastewater:

|                       |                         |
|-----------------------|-------------------------|
| Mercury               | 630 mg/kg <sup>a</sup>  |
| (total concentration) |                         |
| (TCLP)                | 0.028 mg/l <sup>a</sup> |

### Wastewater:

|                       |            |
|-----------------------|------------|
| Mercury               |            |
| (total concentration) | 0.030 mg/l |

---

- <sup>a</sup> Facilities land-disposing of K106 nonwastewater must meet both the total concentration and the TCLP standards.

## 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), which were 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:

1. Solvents and dioxins standards must be promulgated by November 8, 1986;
2. The "California List" must be promulgated by July 8, 1987;
3. At least one-third of all listed hazardous wastes must be promulgated by August 8, 1988 (First Third);
4. At least two-thirds of all listed hazardous wastes must be promulgated by June 8, 1989 (Second Third); and
5. 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, 268.11, and 268.12.

## 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 section 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 to be 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 a 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:

- Number and types of constituents treated;
- Performance (concentration of the constituents in the treatment residuals); and
- 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: (1) identification of facilities for site visits, (2) an engineering site visit, (3) a Sampling and Analysis Plan, (4) a sampling visit, and (5) an 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 their 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 in the preamble and background document why such data were used 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 (see 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, Appendices VII and 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<br>reference<br>no. | Parameter                   | CAS no.    |
|--------------------------|-----------------------------|------------|
| <u>Volatiles</u>         |                             |            |
| 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<br>reference<br>no.     | Parameter                              | CAS no   |
|------------------------------|--|----------|
| <u>Volatiles</u> (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-trifluoro-ethane | 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 |
| <u>Semivolatiles</u>         |  |          |
| 51.                          | Acenaphthalene                         | 208-96-8 |
| 52.                          | Acenaphthene                           | 83-32-9  |
| 53                           | Acetophenone                           | 96-86-2  |
| 54.                          | 2-Acetylamino fluorene                 | 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<br>reference<br>no          | Parameter                     | CAS no.    |
|----------------------------------|-------------------------------|------------|
| <u>Semivolatiles</u> (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<br>reference<br>no.         | Parameter                              | CAS no.    |
|----------------------------------|--|------------|
| <u>Semivolatiles</u> (continued) |  |            |
| 102.                             | 2,4-Dinitrotoluene                     | 121-14-2   |
| 103.                             | 2,6-Dinitrotoluene                     | 606-20-2   |
| 104.                             | D1-n-octyl phthalate                   | 117-84-0   |
| 105.                             | D1-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.                             | Methapyriline                          | 91-80-5    |
| 119.                             | 3-Methylcholanthrene                   | 56-49-5    |
| 120.                             | 4,4'-Methylenebis<br>(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-Nitrosod1-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<br>reference<br>no          | Parameter                            | CAS no.    |
|----------------------------------|--------------------------------------|------------|
| <u>Semivolatiles</u> (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)<br>phosphate | 126-72-7   |
| <u>Metals</u>                    |                                      |            |
| 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  |
| <u>Inorganics</u>                |                                      |            |
| 169.                             | Cyanide                              | 57-12-5    |
| 170.                             | Fluoride                             | 16964-48-8 |
| 171.                             | Sulfide                              | 8496-25-8  |

Table 1-1 (continued)

| BDAT<br>reference<br>no.              | Parameter                      | CAS no.    |
|---------------------------------------|--------------------------------|------------|
| <u>Organochlorine pesticides</u>      |                                |            |
| 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.                                  | Methoxychlor                   | 72-43-5    |
| 191.                                  | Toxaphene                      | 8001-35-2  |
| <u>Phenoxyacetic acid herbicides</u>  |                                |            |
| 192.                                  | 2,4-Dichlorophenoxyacetic acid | 94-75-7    |
| 193.                                  | Silvex                         | 93-72-1    |
| 194.                                  | 2,4,5-T                        | 93-76-5    |
| <u>Organophosphorous insecticides</u> |                                |            |
| 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   |
| <u>PCBs</u>                           |                                |            |
| 200.                                  | Aroclor 1016                   | 12674-11-2 |
| 201.                                  | Aroclor 1221                   | 11104-28-2 |
| 202.                                  | Aroclor 1232                   | 11141-16-5 |

Table 1-1 (continued)

| BDAT<br>reference<br>no.  | Parameter                           | CAS no.    |
|---------------------------|-------------------------------------|------------|
| <u>PCBs (continued)</u>   |                                     |            |
| 203.                      | Aroclor 1242                        | 53469-21-9 |
| 204.                      | Aroclor 1248                        | 12672-29-6 |
| 205.                      | Aroclor 1254                        | 11097-69-1 |
| 206.                      | Aroclor 1260                        | 11096-82-5 |
| <u>Dioxins and furans</u> |                                     |            |
| 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 more 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, 18 additional constituents (hexavalent chromium, xylenes (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 five major reasons that constituents were not included on the BDAT constituent list:

1. 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.
2. 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.
3. 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 constituent list.
4. 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 chromatography (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 unknown constituents.
5. 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; and
- Dioxins and furans.

The constituents were placed in these categories based on their chemical properties. The constituents in each group are expected to behave similarly 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 that the constituent will be 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 section 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 requires only 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) use 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:

1. 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.)
2. 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.
3. 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 as to 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 is 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 than the others. 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-87-011, 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:

1. 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.

2. 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 (1) above.
3. 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.
4. 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 (1), (2), and (3) 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:

1. 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.
2. 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.

3. 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 that address 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. Consequently, these residues 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 technically valid in cases where the untested wastes are generated from similar industries, have 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 a case where only the industry is similar, EPA more closely examines the waste characteristics prior to deciding whether 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 Section 5 of this document.

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. INDUSTRIES AFFECTED AND WASTE CHARACTERIZATION

This section presents a description of the industries affected by land disposal restrictions for this waste, the process generating the waste, and a summary of available waste characterization data for the waste. As discussed in Section 1, those wastes listed in 40 CFR Section 261.32 are subject to the land disposal restriction provisions of HSWA. Within that industry-specific listing of hazardous wastes are the following three wastes generated by the chlorine industry:

- K071: Brine purification muds from the mercury cell process in chlorine production, where separately prepurified brine is not used.
- K073: Chlorinated hydrocarbon waste from the purification step of the diaphragm cell process using graphite anodes in chlorine production.
- K106: Wastewater treatment sludge from the mercury cell process in chlorine production.

The Agency has determined that each of the three waste codes described above constitute a separate waste treatability group based on the physical and chemical characteristics of the waste (see Section 1 for a discussion of waste treatability groups). As a result, EPA has examined each waste alone relative to the source of the waste, applicable technologies, and treatment performance attainable.

The listed waste K071 is discussed in a separate background document; the listed waste K073 is no longer generated from chlorine production. This background document only addresses the development of treatment standards for K106.

## 2.1 Industries Affected and Process Description

Chlorine is produced primarily from the electrolytic decomposition of either sodium chloride or potassium chloride, from which the coproducts are sodium hydroxide (caustic soda) or potassium hydroxide. All of the caustic soda and potassium hydroxide and over 90 percent of the chlorine produced in the U.S. are made by the electrolytic decomposition of sodium chloride or potassium chloride. Chlorine is also produced by other processes, including non-electrolytic oxidation of hydrochloric acid (HCl), from the production of sodium metal, and electrolytic production of magnesium metal from molten magnesium chloride.

Three types of electrolytic cells are in commercial use for the production of alkalies and chlorine: the mercury cell, the diaphragm cell, and the membrane cell. The listed waste K106 is generated in chlorine production by the mercury cell process. The Agency estimates that there are 20 facilities that produce chlorine by the mercury cell process and may generate K106 waste. The locations of these facilities are provided in Table 2-1, listed by State, and in Table 2-2, listed by EPA Region. Chlorine producers fall under SIC Code 2812, Alkalies and Chlorine.

In chlorine production by the mercury cell process, a saturated salt brine solution is prepared by dissolving sodium chloride, usually in the form of rock salt, in the depleted brine solution recycled from the mercury cells (see Figure 2-1).

Table 2-1 Number of Producers of Chlorine Using the  
Mercury Cell Process Listed by State

| State               | Number of<br>producers |
|---------------------|------------------------|
| Alabama (IV)        | 3                      |
| Delaware (III)      | 1                      |
| Georgia (IV)        | 2                      |
| Kentucky (IV)       | 1                      |
| Louisiana (VI)      | 2                      |
| Maine (I)           | 1                      |
| New York (II)       | 2                      |
| North Carolina (IV) | 1                      |
| Ohio (V)            | 1                      |
| Tennessee (IV)      | 1                      |
| Texas (VI)          | 1                      |
| Washington (X)      | 1                      |
| West Virginia (III) | 2                      |
| Wisconsin (V)       | <u>1</u>               |
| Total               | 20                     |

Reference: SRI 1987.

Table 2-2 Number of Producers of Chlorine Using the Mercury  
Cell Process Listed by EPA Region

| EPA Region | Number of<br>producers |
|------------|------------------------|
| I          | 1                      |
| II         | 2                      |
| III        | 3                      |
| IV         | 8                      |
| V          | 2                      |
| VI         | 3                      |
| X          | <u>1</u>               |
| Total      | 20                     |

Reference: SRI 1987.

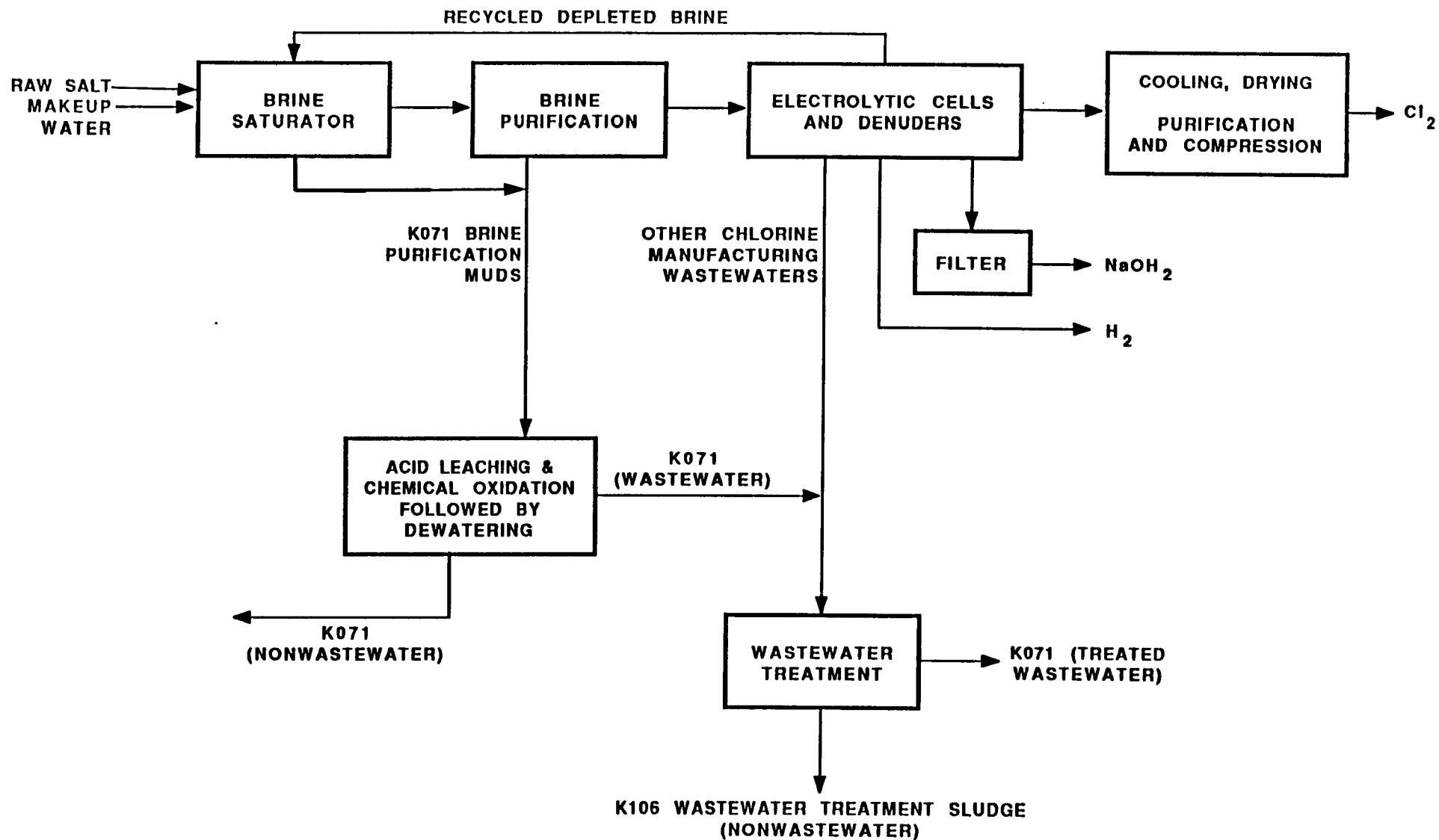


FIGURE 2-1. CHLORINE MANUFACTURE BY THE MERCURY CELL PROCESS

The brine is purified, unless prepurified brine is used. The purified saturated brine is fed to the mercury cells, where electrolytic decomposition into sodium and chlorine occurs.

Sources of wastewater from the production of chlorine by the mercury cell process include: (1) brine that is bled from the end boxes of the mercury cells, (2) wastewater collected from the floor of or basement below the room containing the mercury cells that is generated from periodic washdown of the cell room floor and equipment, and (3) any other wastewaters generated by the plant that may contain mercury, including wastewaters generated during dewatering or treatment of K071 waste. Treatment of plant process wastewaters by chemical precipitation generates a wastewater treatment sludge, which is the listed waste K106. With the exception of one facility, K106 is generated by sulfide precipitation. One facility currently uses hydrazine to treat mercury-contaminated wastewaters; this process generates a mercurous hydroxide compound. In the past K106 was generated by sodium hydroborate, but this compound is no longer used to treat mercury-contaminated wastewaters.

## 2.2 Waste Characterization

EPA has waste characterization data for both K106 generated by sulfide treatment and K106 generated by hydrazine treatment. The approximate concentrations of the major constituents for both of these K106 forms were determined from EPA analysis of the waste and other characterization data and information submitted by industry to EPA. As summarized in Tables 2-3 and 2-4, both forms of K106 are primarily

Table 2-3 Approximate Concentrations of Major Constituents for  
Untreated K106 Waste Generated by Sulfide Precipitation

| Constituent                                     | Concentration (weight percent) |
|---|--------------------------------|
| Mercury sulfide                                 | 4.4                            |
| Other metal sulfides                            | 2.0                            |
| Other solids<br>(diatomaceous earth filter aid) | 53.6                           |
| Water   | <u>40</u>                      |
|   | 100%                           |

References: USEPA 1988a.  
USEPA 1986a  
USEPA 1985.

Table 2-4 Approximate Concentrations of Major Constituents for  
Untreated K106 Waste Generated by Hydrazine Treatment

| Constituent   | Concentration (weight percent) |
|---|--------------------------------|
| Mercurous hydroxide   | 0.5                            |
| Water   | 50                             |
| Inerts (primarily diatomaceous earth and<br>small amounts of carbon from<br>filter precoatng) | <u>49.5</u>                    |
|   | 100%                           |

Reference: Waste Minimization Audit Report.

comprised of water and diatomaceous earth. The K106 generated by sulfide precipitation contains approximately 4.4 percent mercury sulfide; the K106 generated by hydrazine treatment contains approximately 0.5 percent mercurous hydroxide. The concentrations of BDAT list constituents detected in the K106 waste generated from sulfide precipitation are presented in Table 2-5.

Table 2-5 BDAT List Constituent Concentration and Other Data for  
Untreated K106 Waste Generated by Sulfide Precipitation

| Analysis                | Untreated K106 waste concentration (mg/kg) |                |                   |                   |             |
|-------------------------|--|----------------|-------------------|-------------------|-------------|
|                         | (a)  | (b)            | (c)               | (d)               | (e)         |
| <u>BDAT List Metals</u> |  |                |                   |                   |             |
| Antimony                | <3.8                                       | -              | -                 | -                 | -           |
| Arsenic                 | 1.1  | -              | -                 | -                 | -           |
| Barium                  | 74   | -              | -                 | -                 | -           |
| Beryllium               | <0.1                                       | -              | -                 | -                 | -           |
| Cadmium                 | 2.3  | -              | -                 | -                 | -           |
| Chromium                | 6.3  | -              | -                 | -                 | -           |
| Copper                  | 133  | -              | -                 | -                 | -           |
| Lead                    | 50   | -              | -                 | -                 | -           |
| Mercury                 | 25,900                                     | 2000 - 150,000 | 4300 - 17,000     | 55,000 - 146,000  | 5000 - 7000 |
| Nickel                  | 14   | -              | -                 | -                 | -           |
| Selenium                | <5.0                                       | -              | -                 | -                 | -           |
| Silver                  | 131  | -              | -                 | -                 | -           |
| Thallium                | <8.6                                       | -              | -                 | -                 | -           |
| Vanadium                | 0.46                                       | -              | -                 | -                 | -           |
| Zinc                    | 443  | -              | -                 | -                 | -           |
| <u>Other Analyses</u>   |  |                |                   |                   |             |
| Aluminum                | 168  | -              | -                 | -                 | -           |
| Calcium                 | 478  | -              | -                 | -                 | -           |
| Cobalt                  | 1.3  | -              | -                 | -                 | -           |
| Iron                    | 833  | -              | 400               | -                 | -           |
| Magnesium               | 132  | -              | -                 | -                 | -           |
| Manganese               | 6.5  | -              | -                 | -                 | -           |
| Potassium               | 7,870                                      | -              | -                 | -                 | -           |
| Sodium                  | 4,120                                      | -              | -                 | -                 | -           |
| Tin                     | <5.5                                       | -              | -                 | -                 | -           |
| Sulfide                 | -  | -              | -                 | -                 | -           |
| Total solids            | 41.5                                       | -              | -                 | -                 | -           |
| Total suspended solids  | -  | -              | -                 | -                 | -           |
| Paint filter test       | Pass                                       | -              | -                 | -                 | -           |
| Diatomaceous earth      | -  | -              | 700,000 - 950,000 | 800,000 - 950,000 | -           |
| Water                   | -  | -              | 5000 - 20,000     | 50,000 - 150,000  | -           |
| Sodium chloride         | -  | -              | 80,000 - 100,000  | -                 | -           |

- = No analysis performed.

References. (a) USEPA 1988a  
(b) USEPA 1986a.  
(c) USEPA 1985.  
(d) USEPA 1985  
(e) USEPA 1985

### 3. APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES

In the previous section, a discussion of the industry and process generating K106 waste and a major constituent analysis of this waste were presented. This section describes the applicable and demonstrated treatment technologies and performance data for treatment of K106 waste. The technologies that are considered applicable to the treatment of K106 waste are those that treat BDAT list metals by reducing their concentration and/or their leachability in the waste. Included in this section are discussions of those applicable treatment technologies that have been demonstrated on a commercial basis for treatment of K106 waste or wastes similar to K106.

As shown in the previous section, K106 generated by sulfide precipitation consists of approximately 54 percent diatomaceous earth filter aid, 40 percent water, and 4.4 percent mercury sulfide. The K106 waste generated from hydrazine treatment consists of approximately 49.5 percent diatomaceous earth, 50 percent water, and 0.5 percent mercurous hydroxide.

#### 3.1 Applicable Treatment Technologies

Based on the above waste characteristics, the technologies applicable for treatment of K106 are those that reduce the concentration of BDAT list metals in the treated residual and/or reduce the leachability of these metals in the treated residual. The only technology that the Agency has identified as applicable for treatment of K106 nonwastewaters is retorting. Retorting volatilizes mercury at high temperatures and

then condenses and collects it as the pure metal, reducing the mercury concentration in the treatment residual from that in the untreated waste.

Stabilization was identified as potentially applicable for treatment of K106 nonwastewaters. Stabilization binds BDAT list metals into a solid in a form that is more resistant to leaching than the metals in the untreated waste. EPA's testing of stabilization for treatment of K106 nonwastewaters generated by sulfide precipitation established that the technology did not provide effective treatment. Based on this test, EPA has concluded that stabilization does not appear to be applicable for this form of K106. The stabilization data are summarized in Appendix C; additional data and information on this test can be found in the K106 Administrative Record.

EPA recognizes, however, that the ineffectiveness may be a result of the fact that the mercury is present in a form that has a low leachability. It is possible that stabilization may be applicable if mercury is present in a more leachable form in untreated K106.

The retorting process generates a wastewater that contains mercury. Technologies applicable to this stream are chemical precipitation followed by filtration to remove BDAT list metals and concentrate them in the wastewater treatment sludge.

The selection of treatment technologies that are applicable for treating BDAT list metals in K106 waste is based on information obtained

from literature sources, information obtained from engineering site visits, and information submitted by industry.

### 3.2 Demonstrated Treatment Technologies

The only demonstrated technology that the Agency has identified for treatment of K106 nonwastewater is retorting. As noted above, this technology generates a wastewater that would be classified as K106 under EPA's "derived from" rule 40 CFR Part 261.3(c)(2). The only demonstrated technology that the Agency has identified for treatment of K106 wastewater is chemical precipitation followed by polishing filtration.

Retorting was previously used to treat K106 at two facilities and to treat a mixture of K071 and K106 at another facility. EPA is not aware of any facilities currently retorting K106; however, retorting is presently being used at one facility on mercury ores consisting primarily of sulfide. The concentration of mercury in these unprocessed ores is roughly 3 percent. These ores are concentrated to approximately 65 percent mercury prior to retorting. As shown in Tables 2-3 and 2-4, the concentration of mercury in nonwastewaters K106 (generated by sulfide) is 4.4 percent and K106 (generated by hydrazine) is 0.5 percent. The Agency believes that the unprocessed mercury ores are similar to both forms of K106 and as a consequence, the Agency considers retorting to be demonstrated for K106.

Chemical precipitation followed by filtration has been demonstrated on K071 wastewater; EPA does not have characterization data on K106 wastewaters generated from retorting of K106; however, the Agency believes that these wastes are similar to the K071 and other mercury-

contaminated wastewaters currently treated by sulfide precipitation (see Table 3-2). The concentration of mercury in the wastewaters for which the Agency has data is approximately 40 ppm; EPA would not expect the K106 wastewater generated from retorting to be more difficult to treat. Sulfide precipitation followed by filtration of mercury-containing wastewaters is used at 19 or more facilities. Therefore, the Agency believes that sulfide precipitation is both applicable and demonstrated for wastewater generated from treatment of K106 nonwastewaters.

The demonstrated technologies for both nonwastewater and wastewater are described in this section, and performance data are presented in Section 3.3 that indicate the relative effectiveness of the technologies evaluated for treatment of K106 wastes.

#### 3.2.1 Retorting

Retorting is a process similar to high temperature metals recovery, in that it provides for recovery of metals from wastes primarily by volatilization and subsequent collection of the volatilized components. Retorting yields a metal product for reuse and significantly reduces the quantity of metals in the residual. This technology is different from high temperature metals recovery principally with regard to the process chemistry. High temperature metals recovery is a reduction reaction involving the use of carbon or coke, while this process does not use any reducing agents. Additionally, this process differs with regard to the form of the residue generated and possibly the leachability; high temperature metals recovery generates a slag, while retorting generates a granular solid residue.

### Applicability

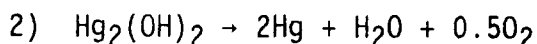
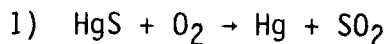
This process is applicable to any waste containing BDAT list volatile metals in the elemental form provided that the waste has a low total organic content. In addition to being applicable for BDAT list metals in the elemental form, retorting is also applicable to mercury wastes where mercury is present as an oxide, hydroxide, or a sulfide. For metals, other than mercury, the operating temperature (700-1000°F) is not high enough to decompose the metal compounds.

Generally, for most retorting designs there is a restriction that the waste have a low water content to minimize generation of water vapor. This restriction can be met by dewatering or blending. Dewatering reduces energy consumption by minimizing the amount of water to be evaporated and avoids problems involving separation of recovered mercury from large volumes of water.

### Underlying Principle of Operation

The theory of operation of retorting is that sufficient heat is transferred to the waste to cause elemental metals to vaporize. In the case of mercury present as a sulfide, hydroxide, or oxide compound, sufficient heat must be transferred to the waste to both decompose the compounds to the elemental form and then to volatilize the mercury. In general, mercury wastes are present in the form of sulfides (HgS) as a result of the use of sodium hydrosulfide treatment of mercury bearing wastewaters. In a few instances, hydrazine has been used to treat these same wastewaters; in such instances, a mercurous hydroxide is generated.

This latter compound can be more easily treated to yield elemental mercury. The equations for decomposition of both forms of mercury are presented below.



This second reaction occurs more readily than the first at the temperatures at which the process is normally operated.

#### Description of the Retorting Process

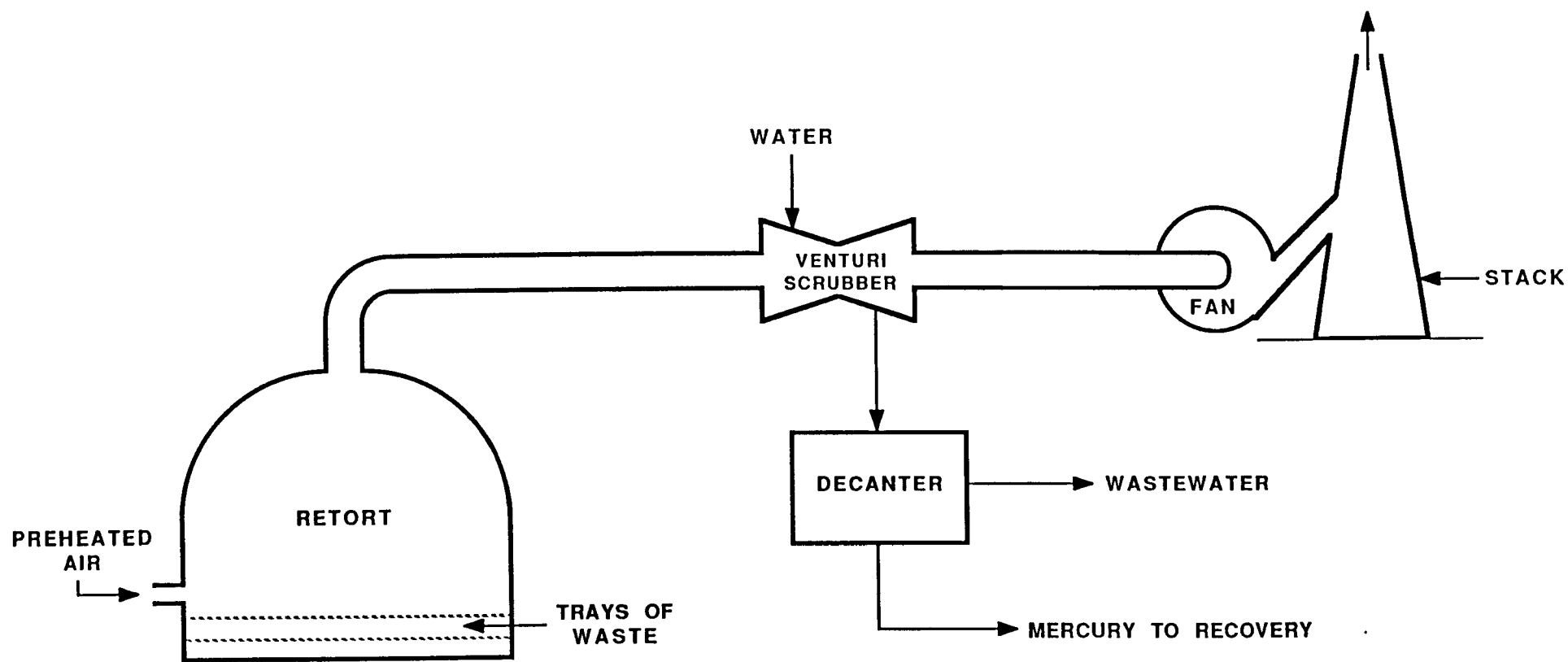
The process generally consists of three unit operations:

(1) processing in the retort or oven, (2) a metals collection system, and (3) an air pollution control system. Figures 3-1 and 3-2 show a retort system with and without a scrubber water discharge.

(1) Wastes are placed in the retort (typically, an oven) where they are heated and decomposition and volatilization occurs. In addition to an oven, retorting has been carried out in multiple hearth furnaces. Heat is typically supplied from a fossil fuel burner. Residual solids remaining in the retort (stripped of metal contaminants) are collected and disposed.

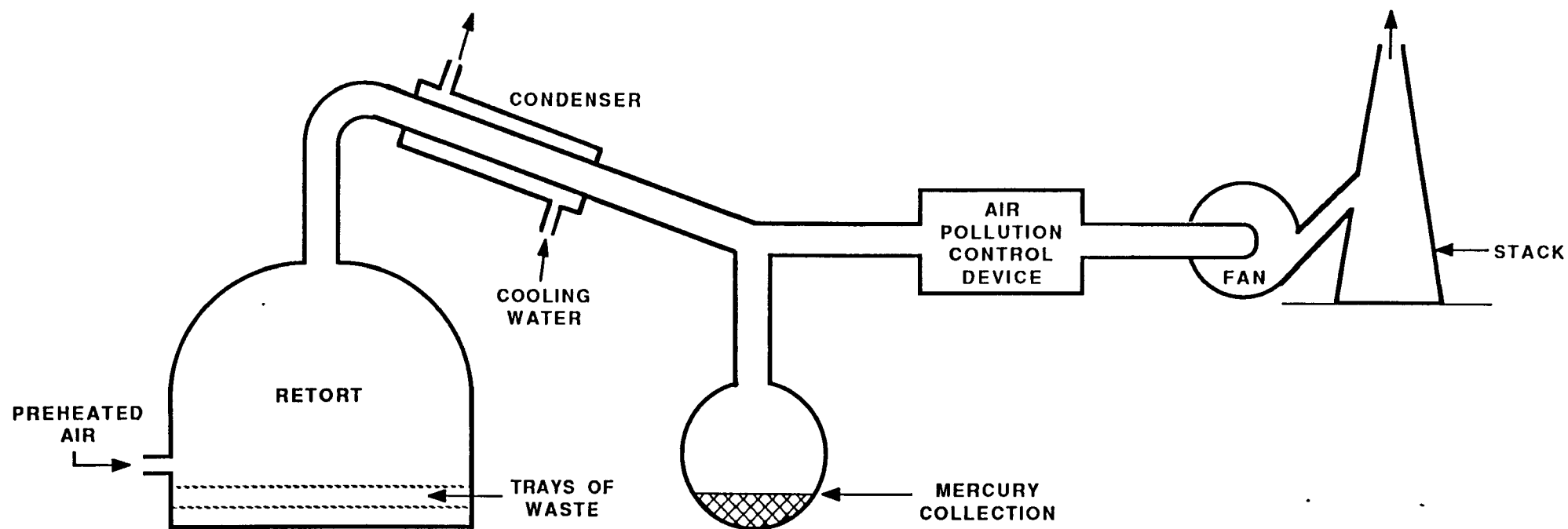
(2) The combustion gas stream from the retort is cooled in a condenser to condense the gaseous metal. Alternatively, the gas may be cooled directly in an air pollution control scrubber.

(3) If an air pollution control scrubber is not used as a condensing device, then an air pollution control system must be provided after the



**RETORTING PROCESS (WITH WASTEWATER DISCHARGE)**

FIGURE 3-1



**RETORTING PROCESS (WITHOUT WASTEWATER DISCHARGE)**

**FIGURE 3-2**

condenser to remove any residual metal in the exhaust gas stream, as well as control other potential emissions such as SO<sub>2</sub> and ash.

#### Waste Characteristics Affecting Performance (WCAP)

In determining whether performance standards can be transferred from an untested waste to a previously tested waste, EPA will examine the following waste characteristics: (1) type and concentration of metal compounds in the waste, (2) heat transfer characteristics of the waste, and (3) boiling point of the metal.

##### (1) Type and Concentration of Metal Compounds in the Waste

The presence of other volatile metals in the waste may affect the composition of the condensed metal product by co-volatilization with the metal of concern. Also, metals may be present as salts which are stable at the retorting operating temperature and, therefore, would not volatilize. In such a case, the condensed free metal may be too contaminated for reuse. A problem sometimes encountered in the case of mercury is the formation of amalgams between the elemental mercury formed in the retorting process and metallic elements present in a waste.

##### (2) Heat Transfer Characteristics

The ability to heat constituents within a waste matrix is a function of the heat transfer characteristics of the waste material. The metal which is to be recovered must be heated sufficiently to volatilize. There is no convenient direct measurement of the heat transfer characteristics of the waste. EPA believes the best measure of heat transfer characteristics of the waste is thermal conductivity. Thermal

conductivity can be measured by the "Guarded, Comparative, Longitudinal Heat Flow Technique"; this method is described in Appendix I to this technology section.

### (3) Boiling Point

EPA believes that the best measure of volatility of a specific metal constituent is the boiling point. EPA recognizes that boiling point has certain shortcomings, primarily the fact that boiling points are given for pure components, while clearly the other constituents in the waste will affect the partial pressures, and, thus, the boiling point of the mixture. Nevertheless, EPA has not identified a parameter that can better assess the volatility of the metal.

### Design and Operating Parameters

EPA's analysis of whether a retorting process is well designed will focus on whether sufficient energy in the form of heat is likely to be provided to volatilize the metals content of the waste. Additionally, in the case of mercury contaminated wastes, EPA will evaluate the blending operation, if appropriate. The particular design parameters to be evaluated are: (1) treated and untreated design concentrations, (2) retort temperature and (3) residence time.

(1) Treated and Untreated Design Concentrations. In assessing the design and operation of a retort operation, EPA will examine the treated design concentration as part of its analysis. As the Agency can not reasonably expect the retort to perform better than design, EPA will evaluate whether the design is consistent with best demonstrated practices.

In a similar manner, EPA will examine untreated waste concentrations to ensure that these values are consistent with design conditions. Operation of any treatment system outside of the waste characteristics for which it was designed can easily lead to poor performance.

(2) Retort Temperature. In order to vaporize the metal compounds, sufficient temperatures must be provided. Excessive temperatures may volatilize other, less volatile materials, contaminating the metal product and inhibiting its potential for reuse. If temperatures are too low, decomposition and volatilization may not take place. To ensure that the system is operated at design conditions during treatment, EPA would want a continuous temperature reading.

(3) Residence Time. Residence time is important because it directly impacts the total heat supplied to the waste. The retort must be designed to ensure the waste has sufficient time to reach the optimum temperature and the metal receive enough heat to completely volatilize. If the process is continuous, the residence time is a function of the physical dimensions of the retort, and the waste feed rate. EPA would want to monitor the waste feed rate during treatment as an indication of the residence time.

### 3.2.2 Chemical Precipitation Treatment System

Any wastewater produced during treatment of K106, such as scrubber water from retorting or wastewater removed by dewatering, can be treated by sulfide precipitation and filtration to remove mercury and other metals as sulfides in the wastewater treatment sludge.

### 3.2.2.1 Chemical Precipitation

#### (1) Applicability and Use of Chemical Precipitation

Chemical precipitation is used when dissolved metals are to be removed from solution. This technology can be applied to a wide range of wastewaters containing dissolved BDAT list metals and other metals as well. This treatment process has been practiced widely by industrial facilities since the 1940s.

#### (2) Underlying Principles of Operation

The underlying principle of chemical precipitation is that metals in wastewater are removed by the addition of a treatment chemical that converts the dissolved metal to a metal precipitate. This precipitate is less soluble than the original metal compound, and therefore settles out of solution, leaving a lower concentration of the metal present in the solution. The principal chemicals used to convert soluble metal compounds to the less soluble forms include: lime ( $\text{Ca(OH)}_2$ ), caustic ( $\text{NaOH}$ ), sodium sulfide ( $\text{Na}_2\text{S}$ ), and, to a lesser extent, soda ash ( $\text{Na}_2\text{CO}_3$ ), phosphate, and ferrous sulfide ( $\text{FeS}$ ). With the exception of mercury and arsenic, the BDAT list metals are generally precipitated with lime or caustic; mercury and arsenic are generally precipitated with sodium sulfide or sodium hydrosulfide.

The solubility of a particular compound will depend on the extent to which the electrostatic forces holding the ions of the compound together can be overcome. The solubility will change significantly with temperature; most metal compounds are more soluble as the temperature

increases. Additionally, the solubility will be affected by the other constituents present in a waste. As a general rule, nitrates, chlorides, and sulfates are more soluble than hydroxides, sulfides, carbonates, and phosphates.

An important concept related to hydroxide precipitation is pH; this parameter affects other types of precipitation, such as sulfide, but does not play as important a role in these other precipitation methods. This parameter, pH, provides a measure of the extent to which a solution contains either an excess of hydrogen or hydroxide ions. The pH scale ranges from 0 to 14; with 0 being the most acidic, 14 representing the highest alkalinity or hydroxide ion ( $\text{OH}^-$ ) content, and 7.0 being neutral. When hydroxide is used to precipitate the soluble metal compounds, the pH is frequently monitored to ensure that sufficient treatment chemicals are added. Although pH is important in other types of precipitation, it is generally not a good indicator of whether sufficient treatment chemical is added. When sulfide is used, for example, facilities might use an oxidation-reduction potential meter (ORP) correlation to ensure that sufficient treatment chemical is used.

Following conversion of the relatively soluble metal compounds to metal precipitates, the effectiveness of chemical precipitation is a function of the physical removal, which usually relies on a settling, but can consist of direct filtration. Filtration is discussed separately; settling is discussed below as it is the most often used form of physical removal. A particle of a specific size, shape, and composition will

settle at a specific velocity, as described by Stokes' Law. For a batch system, Stokes' law is a good predictor of settling time because the pertinent particle parameters remain essentially constant. Nevertheless, in practice, settling time for a batch system is normally determined by empirical testing. For a continuous system, the theory of settling is complicated by factors such as turbulence, short-circuiting, and velocity gradients, increasing the importance of the empirical tests.

### (3) Description of the Technology

The equipment and instrumentation required for chemical precipitation varies depending on whether the system is batch or continuous. Both operations are discussed below; a schematic of the continuous system is shown in Figure 3-3.

For a batch system, chemical precipitation requires only a feed system for the treatment chemicals and a second tank where the waste can be treated and allowed to settle. When lime is used, it is usually added to the reaction tank in a slurry form. In a batch system, the supernate is usually analyzed before discharge, thus minimizing the need for instrumentation.

In a continuous system, additional tanks are necessary, as well as instrumentation to ensure that the system is operating properly. In this system, the first tank that the wastewater enters is referred to as an equalization tank. This is where the waste can be mixed in order to provide more uniformity, minimizing wide swings in the type and concentration of constituents being sent to the reaction tank. It is

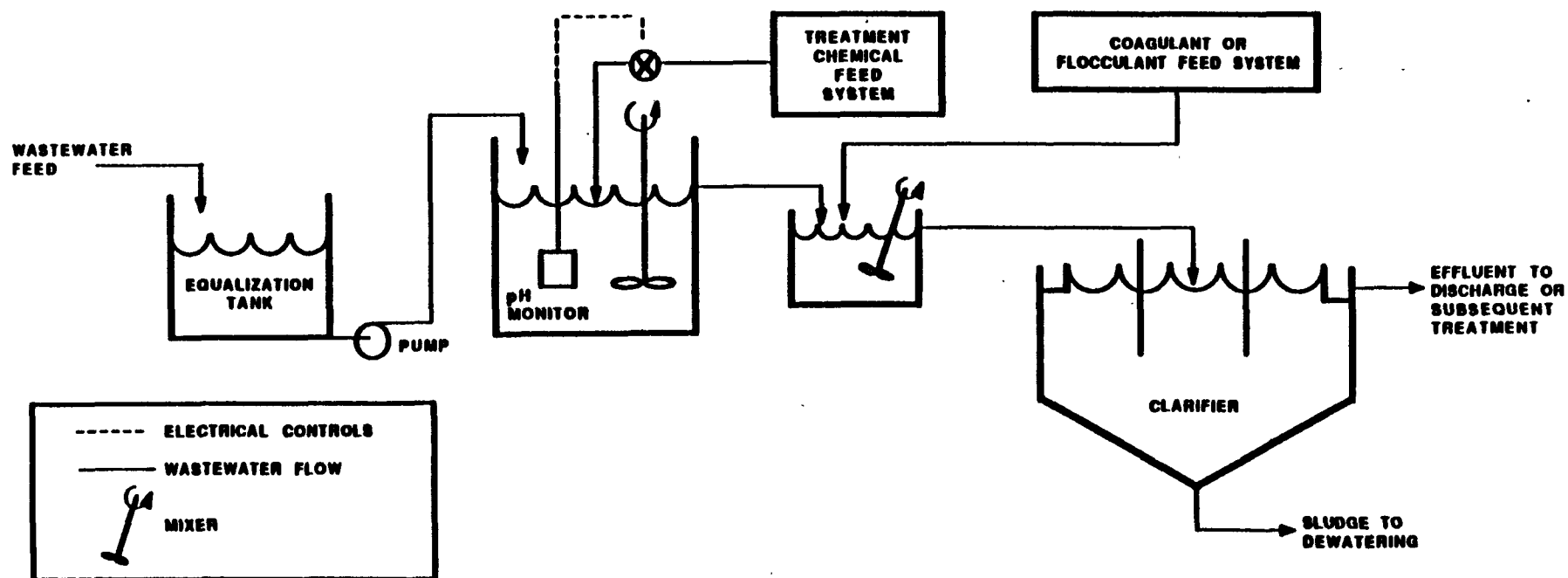


FIGURE 3-3 CONTINUOUS CHEMICAL PRECIPITATION

important to reduce the variability of the waste sent to the reaction tank because control systems inherently are limited with regard to the maximum fluctuations that can be managed.

Following equalization, the waste is pumped to a reaction tank where treatment chemicals are added; this is done automatically by using instrumentation that senses the pH of the system and then pneumatically adjusts the position of the treatment chemical feed valve such that the design pH value is achieved. Both the complexity and the effectiveness of the automatic control system will vary depending on the variation in the waste and the pH range that is needed to properly treat the waste.

An important aspect of the reaction tank design is that it be well-mixed so that the waste and the treatment chemicals are both dispersed throughout the tank, in order to ensure comingling of the reactant and the treatment chemicals. In addition, effective dispersion of the treatment chemicals throughout the tank is necessary to properly monitor and, thereby, control the amount of treatment chemicals added.

After the waste is reacted with the treatment chemical, it flows to a quiescent tank where the precipitate is allowed to settle and subsequently be removed. Settling can be chemically assisted through the use of flocculating compounds. Flocculants increase the particle size and density of the precipitated solids, both of which increase the rate of settling. The particular flocculating agent that will best improve settling characteristics will vary depending on the particular waste; selection of the flocculating agent is generally accomplished by performing laboratory bench tests. Settling can be conducted in a large

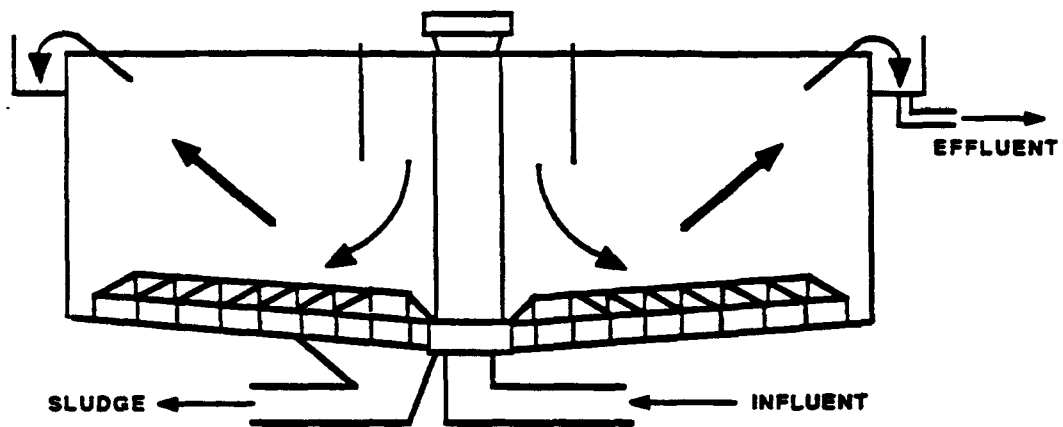
tank by relying solely on gravity or be mechanically assisted through the use of a circular clarifier or an inclined separator. Schematics of the latter two separators are shown in Figures 3-4 and 3-5.

Filtration can be used for further removal of precipitated residuals both in cases where the settling system is underdesigned and in cases where the particles are difficult to settle. Polishing filtration is discussed in a separate technology section.

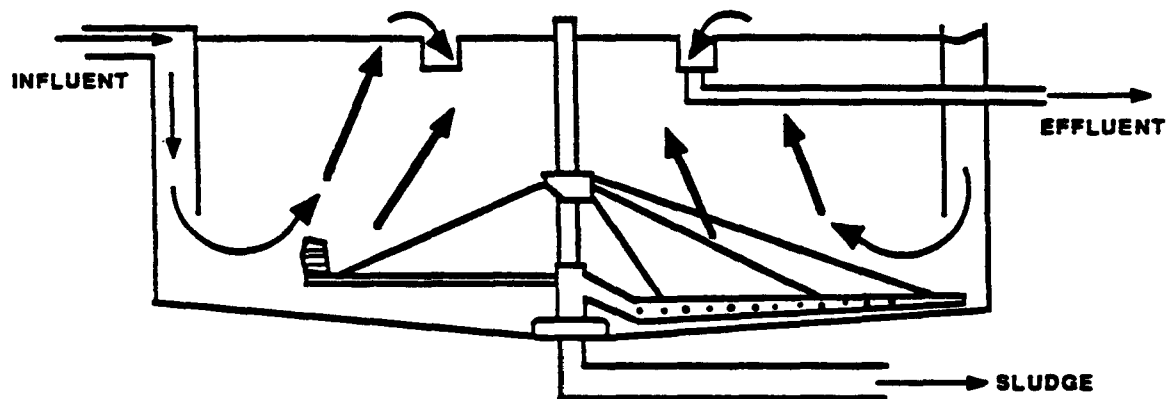
#### (4) Waste Characteristics Affecting Performance

In determining whether chemical precipitation is likely to achieve the same level of performance on an untested waste as a previously tested waste, we will examine the following waste characteristics: (1) the concentration and type of the metal(s) in the waste, (2) whether the metal exists in the wastewater as a complex, (3) the concentration of suspended solids (TSS), (4) the concentration of dissolved solids (TDS), and (5) the oil and grease content. These parameters either affect the chemical reaction of the metal compound, the solubility of the metal precipitate, or the ability of the precipitated compound to settle. If facilities used filtration directly following precipitation, the discussion of the latter three waste characteristics would not be appropriate because they apply to settling. The filtration technology documents have a separate discussion of waste characteristics affecting performance.

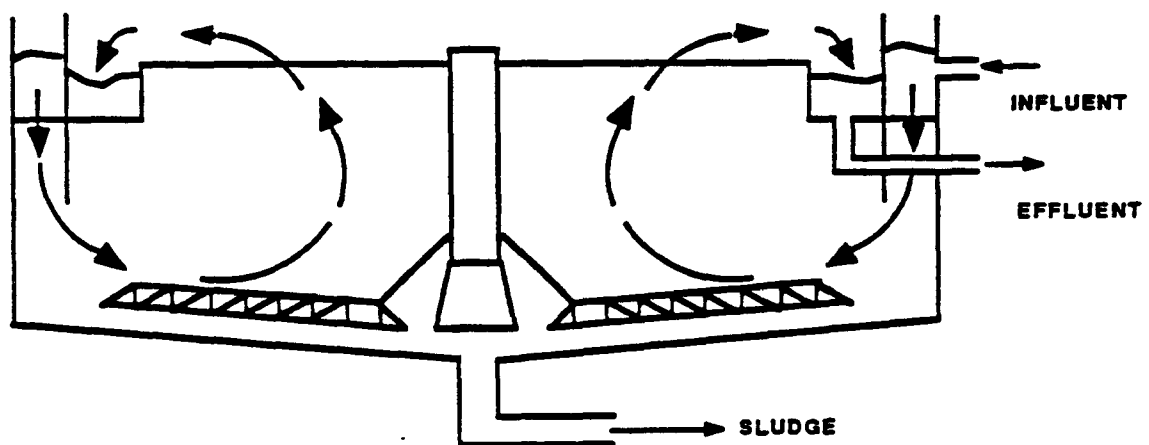
(a) Concentration and type of metals. For most metals, there is a specific pH at which the metal hydroxide is least soluble. As a result,



**CENTER FEED CLARIFIER WITH SCRAPER SLUDGE REMOVAL SUSTEM**

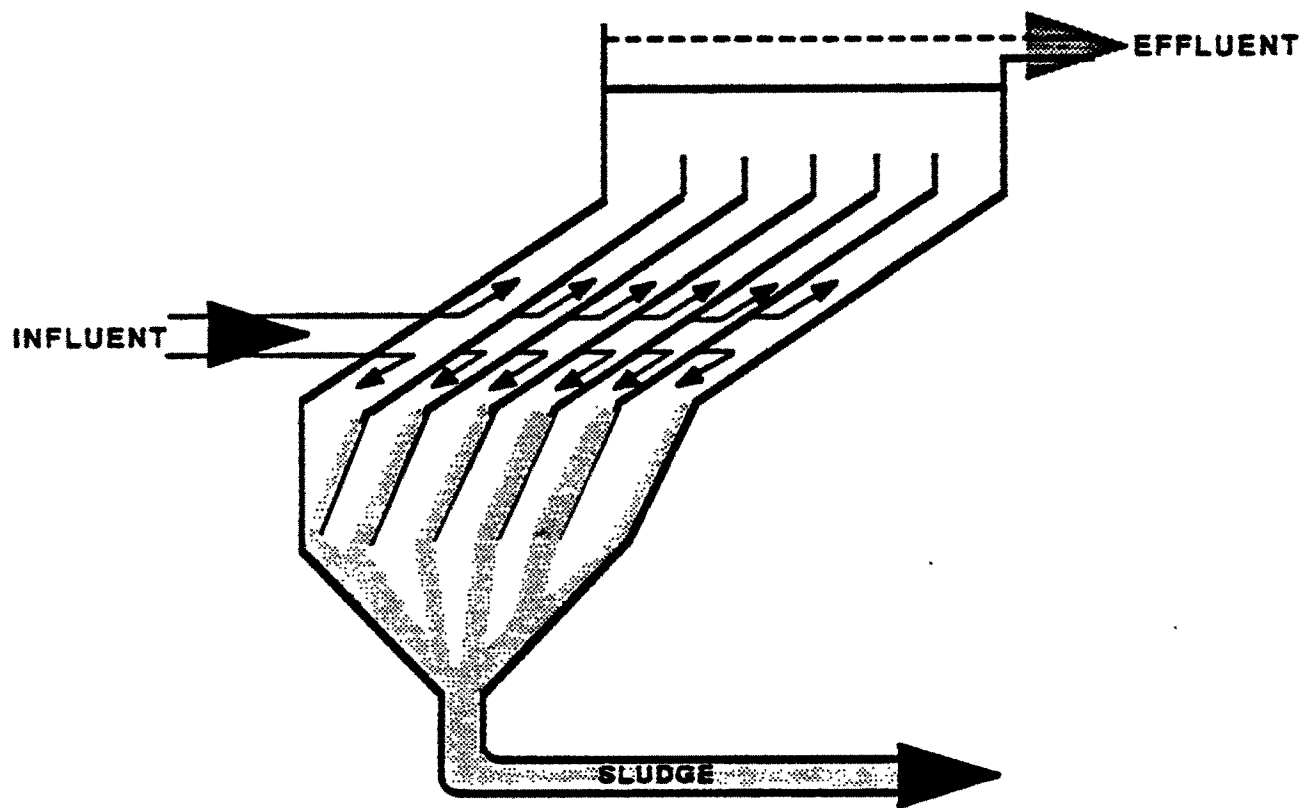


**RIM FEED - CENTER TAKEOFF CLARIFIER WITH  
HYDRAULIC SUCTION SLUDGE REMOVAL SYSTEM**



**RIM FEED - RIM TAKEOFF CLARIFIER**

**FIGURE 3-4  
CIRCULAR CLARIFIERS**



**FIGURE 3-5**  
**INCLINED PLATE SETTLER**

when a waste contains a mixture of many metals, it is not possible to operate a treatment system at a single pH which is optimal for the removal of all metals. The extent to which this affects treatment depends on the particular metals to be removed, and their concentrations. An alternative can be to operate multiple precipitations, with intermediate settling, when the optimum pH occurs at markedly different levels for the metals present. The individual metals and their concentrations can be measured using EPA Method 6010.

(2) Complexed metals. Metal complexes consist of a metal ion surrounded by a group of other inorganic or organic ions or molecules (often called ligands). In the complexed form, the metals have a greater solubility and, therefore, may not be as effectively removed from solution by chemical precipitation. EPA does not have an analytical method to determine the amount of complexed metals in the waste. The Agency believes that the best measure of complexed metals is to analyze for some common complexing compounds (or complexing agents) generally found in wastewater for which analytical methods are available. These complexing agents include ammonia, cyanide, and EDTA. The analytical method for cyanide is EPA Method 9010. The method for EDTA is ASTM Method D3113. Ammonia can be analyzed using EPA Wastewater Test Method 350.

(b) Concentration and type of total suspended solids (TSS). Certain suspended solid compounds are difficult to settle because of either their particle size or shape. Accordingly, EPA will evaluate this

characteristic in assessing transfer of treatment performance. Total suspended solids can be measured by EPA Wastewater Test Method 160.2.

(c) Concentration of total dissolved solids (TDS). Available information shows that total dissolved solids can inhibit settling. The literature states that poor flocculation is a consequence of high TDS and shows that higher concentrations of total suspended solids are found in treated residuals. Poor flocculation can adversely affect the degree to which precipitated particles are removed. Total dissolved solids can be measured by EPA Wastewater Test Method 160.1.

(d) Oil and grease content. The oil and grease content of a particular waste directly inhibits the settling of the precipitate. Suspended oil droplets float in water and tend to suspend particles such as chemical precipitates that would otherwise settle out of the solution. Even with the use of coagulants or flocculants, the separation of the precipitate is less effective. Oil and grease content can be measured by EPA Method 9071.

(5) Design and Operating Parameters

The parameters that EPA will evaluate when determining whether a chemical precipitation system is well designed are: (1) design value for treated metal concentrations, as well as other characteristics of the waste used for design purposes (e.g., total suspended solids), (2) pH, (3) ORP, (4) residence time, (5) choice of treatment chemical, (6) choice of coagulant/flocculant, and (7) mixing. Below is an explanation of why

EPA believes these parameters are important to a design and operating analysis.

(a) Treated and untreated design concentrations. EPA pays close attention to the treated concentration the system is designed to achieve when determining whether to sample a particular facility. Since the system will seldom out-perform its design, EPA must evaluate whether the design is consistent with best demonstrated practice.

The untreated concentrations that the system is designed to treat are important in evaluating any treatment system. Operation of a chemical precipitation treatment system with untreated waste concentrations in excess of design values can easily result in poor performance.

(b) pH. The pH is especially important for hydroxide precipitation because it can indicate whether sufficient treatment chemical (e.g., lime) is added to convert the metal constituents in the untreated waste to forms that will precipitate. The pH also affects the solubility of metal hydroxides and sulfides, and therefore directly impacts the effectiveness of removal. In practice, the design pH is determined by empirical bench testing, often referred to as "jar" testing. The temperature at which the "jar" testing is conducted is important in that it also affects the solubility of the metal precipitates. Operation of a treatment system at temperatures above the design temperature can result in poor performance. In assessing the operation of a chemical precipitation system, EPA prefers continuous data on the pH and periodic temperature conditions throughout the treatment period.

(3) ORP

When sodium sulfide or sodium hydrosulfide is used as a precipitant, facilities may use oxidation-reduction potential (ORP) as an indicator of whether, and how much, excess sulfide is present. In such cases, EPA would want to know the design value and the basis for selecting this value. In addition, the Agency would prefer continuous data on the ORP value during treatment to ensure that it complied with design specifications.

(c) Residence time. The residence time is important because it impacts the completeness of the chemical reaction to form the metal precipitate and, to a greater extent, amount of precipitate that settles out of solution. In practice, it is determined by "jar" testing. For continuous systems, EPA will monitor the feed rate to ensure that the system is operated at design conditions. For batch systems, EPA will want information on the design parameter used to determine sufficient settling time (e.g., total suspended solids).

(d) Choice of treatment chemical. A choice must be made as to what type of precipitating agent (i.e., treatment chemical) will be used. The factor that most affects this choice is the type of metal constituents to be treated. Other design parameters, such as pH, residence time, and choice of coagulant/flocculant agents, are based on the selection of the treatment chemical.

(e) Choice of coagulant/flocculant. This is important because these compounds improve the settling rate of the precipitated metals and allows

for smaller systems (i.e., lower retention time) to achieve the same degree of settling as a much larger system. In practice, the choice of the best agent and the required amount is determined by "jar" testing.

(f) Mixing. The degree of mixing is a complex assessment which includes, among other things, the energy supplied, the time the material is mixed, and the related turbulence effects of the specific size and shape of the tank. EPA will, however, consider whether mixing is provided and whether the type of mixing device is one that could be expected to achieve uniform mixing. For example, EPA may not use data from a chemical precipitation treatment system where an air hose was placed in a large tank to achieve mixing.

#### 3.2.2.2 Polishing Filtration

Filtration is the removal of solids from wastes by a medium that permits the flow of the fluid but retains the particles. When filtration is conducted on wastewaters with low concentrations of solid particles (generally below 1,000 ppm), the term "polishing" filtration is applied; when conducted on wastes with higher concentrations of solids, the term "sludge" filtration is applied. This section discusses "polishing" filtration; sludge filtration is discussed separately.

##### Applicability

Polishing filtration is used to treat wastewaters containing relatively low concentrations of solids. Multimedia filtration, pressure

or gravity sand filtration, and cartridge filtration are some of the types of equipment used for polishing filtration. This type of filtration is typically used as a polishing step for the supernatant after precipitation and settling (clarification) of wastewaters containing metal precipitates. In general, filtration is used to remove particles that are difficult to settle because of shape and/or density or to assist in removal of precipitated particles from an underdesigned settling device.

#### Underlying Principle of Operation

The basic principle of filtration is the separation of particles from a mixture of fluids and particles by a medium that permits the flow of the fluid but retains the particles. As would be expected, larger particles are easier to separate from the fluid than smaller particles.

Extremely small particles, in the colloidal range, may not be filtered effectively in a polishing filter and may appear in the treated wastewater. To mitigate this problem, the wastewater should be treated prior to filtration to modify the particle size distribution in favor of the larger particles, by the use of appropriate precipitants, coagulants, flocculants, and filter aids. The selection of the appropriate precipitant or coagulant is important because it affects the particles formed. For example, lime neutralization usually produces larger, less gelatinous particles than does caustic soda precipitation. For larger particles that become too small to filter effectively because of poor resistance to shearing, shear resistance can be improved by the use of

coagulants and flocculants. Also, if pumps are used to feed the filter, shear can be minimized by designing for a lower pump speed, or by use of a pump with an impeller design that minimizes shearing.

Filter aids such as diatomaceous earth are used to precoat the cloth-type filter material and provide an initial filter cake onto which additional solids will be deposited during the filtration process. The presence of the precoat allows for removal of small particles from the solution being filtered. Smaller particles will mechanically adhere to the precoat solids during the filtration process.

#### Description of Polishing Filtration System

For relatively low flows, a cartridge filter can be used. In this case a cylindrically shaped cartridge, such as a matted cloth, is placed within a sealed metal vessel. Wastewater is pumped through the cartridge until the flow drops excessively because of plugging of the filter media. The sealed vessel is then opened and the plugged cartridge removed and replaced with a new cartridge. The plugged cartridge is then disposed.

For relatively large volume flows, granulated media (such as sand or anthracite coal) are used to trap suspended solids within the pore spaces of the media. Wastewater is filtered until excessive pressure is required to maintain the flow or until the flow drops to an unacceptable level. Granular media filters are cleaned, by backwashing with filtered water that has been stored for that purpose. (Backwashing is always upflow to loosen the media granuals and resuspend the entrapped solids.)

The backwash water, which may be as much as 10 percent of the volume of the filtered wastewater, is then returned to the treatment system, so that the solids in the backwash water can be settled in the system clarifier.

#### Waste Characteristics Affecting Performance

To determine whether filtration would achieve a level of performance on an untested waste similar to that of a tested waste, EPA will examine the following waste characteristics: (1) size of suspended particles and (2) type of particles.

##### Size of particles

Extremely small particles, in the colloidal range, may not be filtered effectively in a polishing filter and may appear in the filtrate. Accordingly, EPA would examine the particle size in assessing transfer of performance. Particle size can be determined using ASTM Method D422, Particle Size Distribution.

##### Particle type

Some suspended solids are gelatinous in nature and are, therefore, difficult to filter. To the extent possible, EPA will assess the type of suspended solids particles that are present in assessing transfer of performance. EPA is not aware of any specific quantitative method to measure the particle type; accordingly, such an assessment will be based on a qualitative engineering analysis of the suspended solids particles.

#### Design and Operating Parameters

The design and operating parameters that EPA will evaluate in assessing the performance of polishing filtration are: (1) treated and

untreated design concentrations, (2) type of filter, (3) pore size, (4) waste feed pressure, and (5) use and type of filter aids. Each of these parameters is discussed below.

(1) Treated and untreated design concentrations

As with other technologies, it is important to know the level of performance that the particular unit was designed to achieve in order to ensure that the design value represents best demonstrated practice. Additionally, EPA would want to evaluate feed characteristics to the filter during treatment to ensure that the unit was operated within design specifications. Operation of the filter in excess of feed conditions could easily lead to poor performance.

(2) Type of filter

There are several different types of polishing filters including granular media, cartridge filters, and pressure filters such as plate and frame. Factors that affect filter selection include the concentration of suspended solids, particle type and size, process conditions (including flow rate and pressure), and whether the treatment system is operated on a batch or continuous process. While more than one type will generally work, it is important to know the type of filter used, as well as the basis for selecting that filter.

(3) Pore size

The pore size determines the particle size that will be effectively removed; accordingly, it is an important factor in assessing filtration effectiveness on a particular waste. EPA will need to know the pore size used as well as the basis for selection.

#### (4) Pressure Drop Across the Filter

An important filter design specification is the pressure drop across the filter. A pressure drop that is higher than the filter design can force solid particles through the filter and thus reduce the filter effectiveness. During treatment, EPA will examine pressure readings periodically to ensure that the filter is being operated within design specifications.

#### (5) Use and type of filter aids

As previously discussed, filter aids improve the effectiveness of filtering gelatinous particles, as well as increase the time that the filter can stay on line. In assessing filtration performance it is important to know both the type of filter aid used and the basis for selection.

### 3.3 Performance Data for Nonwastewater

For treatment of K106 nonwastewater, EPA has the following retorting performance data. These performance data are described below and summarized in Table 3-1.

The Agency has five untreated and treated data sets from a literature source on the treatment of a combined K071/K106 nonwastewater using dewatering followed by retorting. The K106 wastes comprised 0.5 percent of the feed to the retort furnace.

The Agency has four treated and untreated data points from one facility for the treatment of K106 by retorting. The waste retorted at this facility was a wastewater treatment sludge generated from hydrazine treatment of mercury-contaminated wastewaters.

Table 3-1 Retorting Performance Data

## Retorting Data Submitted by Industry for K071/K106 Nonwastewater

| BDAT List Metal | <u>Untreated waste</u>       | <u>Treated waste</u>         |
|-----------------|------------------------------|------------------------------|
|                 | Total concentration<br>(ppm) | Total concentration<br>(ppm) |
| Mercury         | 345                          | 0.5 - 0.8                    |
| Mercury         | 255                          | 1.6 - 3.1                    |
| Mercury         | 290                          | 1.7 - 2.6                    |
| Mercury         | 438                          | 2 - 7.2                      |
| Mercury         | 370                          | 1.6                          |

Reference: USEPA 1974.

Retorting Data Submitted by Industry for K106  
Generated From Hydrazine Treatment

| BDAT List Metal | <u>Untreated waste</u>       | <u>Treated waste</u>         |
|-----------------|------------------------------|------------------------------|
|                 | Total concentration<br>(ppm) | Total concentration<br>(ppm) |
| Mercury         | 4300                         | 100                          |
| Mercury         | 5500                         | 90                           |
| Mercury         | 2500                         | 47                           |
| Mercury         | 2000                         | 41                           |

Reference: Occidental Chemical Corporation. 1987.

## Retorting Data Submitted by Industry for Mercury Ores

| BDAT List Metal | <u>Untreated waste</u>       | <u>Treated waste</u>         |
|-----------------|------------------------------|------------------------------|
|                 | Total concentration<br>(ppm) | Total concentration<br>(ppm) |
| Mercury         | 650,000                      | 500                          |

Reference: McDermitt Mine 1988.

The Agency has one treated and untreated data point from the retorting of mercury sulfide ores. As previously discussed in this section, the Agency believes that these ores are similar to K106 and accordingly these data represent performance that can be achieved by retorting K106.

#### 3.4 Performance Data for Wastewater

EPA does not have analytical data on K106 wastewater generated as part of retorting operations. However, EPA believes that this wastewater would be similar in chemical and physical characteristics to wastewaters generated in treatment of K071 waste by acid leaching and other mercury-containing wastewaters. The Agency collected three data sets of untreated and treated data for treatment of K071 wastewater in a sulfide precipitation and filtration treatment system. The treatment performance data for K071 wastewaters are presented in Table 3-2.

Table 3-2 Sulfide Precipitation - EPA-Collected Data for K071 Wastewaters

| ANALYTICAL DATA:                 |                             |                           |                             |                           |                             |                           |                                 |               |
|----------------------------------|-----------------------------|---------------------------|-----------------------------|---------------------------|-----------------------------|---------------------------|---------------------------------|---------------|
| BDAT list constituent            | Sample Set #1               |                           | Sample Set #2               |                           | Sample Set #3               |                           | Filter cake (K106) <sup>a</sup> |               |
|                                  | Untreated wastewater (mg/l) | Treated wastewater (mg/l) | Untreated wastewater (mg/l) | Treated wastewater (mg/l) | Untreated wastewater (mg/l) | Treated wastewater (mg/l) | (total) (mg/kg)                 | (TCLP) (mg/l) |
| Arsenic                          | <0.2                        | <0.2                      | <0.1                        | <0.1                      | <0.1                        | <0.1                      | 1.1                             | <0.01         |
| Barium                           | 0.248                       | 0.103                     | 0.226                       | 0.158                     | 0.293                       | 0.144                     | 74                              | 0.74          |
| Cadmium                          | <0.03                       | <0.06                     | <0.06                       | <0.06                     | <0.06                       | <0.06                     | 2.3                             | 0.02          |
| Chromium                         | <0.06                       | 0.553                     | 0.189                       | <0.12                     | <0.12                       | <0.12                     | 6.3                             | <0.01         |
| Copper                           | 0.097                       | <0.16                     | <0.16                       | <0.16                     | <0.16                       | <0.16                     | 133                             | <0.02         |
| Lead                             | <0.66                       | <1.32                     | <1.32                       | <1.32                     | <1.32                       | <1.32                     | 50                              | 0.13          |
| Mercury                          | 23.7                        | 0.028                     | 9.25                        | 0.027                     | 77.2                        | 0.028                     | 25,900                          | 0.01          |
| Nickel                           | 0.157                       | 0.275                     | <0.26                       | <0.26                     | <0.26                       | <0.26                     | 14                              | 0.15          |
| Silver                           | 0.148                       | <0.1                      | 0.1                         | <0.1                      | 0.12                        | <0.1                      | 131                             | <0.02         |
| Vanadium                         | <0.04                       | <0.08                     | <0.08                       | <0.08                     | <0.08                       | <0.08                     | 0.46                            | <0.01         |
| Zinc                             | 0.615                       | 0.047                     | 0.88                        | <0.04                     | 0.535                       | 0.064                     | 443                             | 1.7           |
| DESIGN AND OPERATING PARAMETERS: |                             |                           |                             |                           |                             |                           |                                 |               |
| Parameter                        |                             |                           |                             |                           | Operating values            |                           |                                 |               |
|                                  | Design value                | Sample Set #1             |                             |                           | Sample Set #2               |                           | Sample Set #3                   |               |
| Excess sulfide                   | >40 mg/l                    | 85 mg/l                   |                             |                           | 101 mg/l                    |                           | 96 mg/l                         |               |

<sup>a</sup> Only one sample was collected of the filter cake (K106).

Reference: USEPA 1988a.

#### 4. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

This section presents the rationale for the determination of best demonstrated available technology (BDAT) for K106 nonwastewaters and wastewaters. As discussed in Section 1 and summarized here, the Agency examines all the available data for the demonstrated technologies to determine if one of the technologies performs significantly better than another. Next, the "best" performing treatment technology is evaluated to determine if the resulting treatment is substantial. If the "best" technology provides substantial treatment and it has been determined that the technology is also available to the affected industry, then the technology represents BDAT.

##### 4.1 BDAT for Nonwastewater

As discussed in the previous section, EPA has identified retorting as the only demonstrated technology for treatment of K106 nonwastewaters. This technology is the only demonstrated technology and is, therefore, the "best" performing technology. Consistent with EPA's methodology for determining BDAT as summarized above, the Agency also evaluated the performance data presented in Section 3 to determine whether retorting also provided substantial treatment for K106 nonwastewaters. All the available retorting treatment performance data were submitted by industry.

As a first step, EPA examined the data to determine if any data represented treatment by a poorly designed or poorly operated system. EPA did not find any such data and, therefore, used all the data in its determination of substantial treatment.

After this step, the Agency examined the treated values to ensure that the data represented accuracy corrected data. EPA requested but did not receive accuracy correction values; therefore, the Agency is assuming that these data were corrected for analytical accuracy prior to being submitted to EPA. Accordingly, no adjustments were made to the performance data shown in Table 3-1 prior to their use in EPA's determination of substantial treatment.

EPA's determination of substantial treatment is based on the reduction in total mercury concentration from 650,000 ppm to 500 ppm in mercury sulfide ores considered by EPA to be similar to K106 nonwastewaters.

The Agency believes that this reduction of hazardous constituents is substantial and that retorting is available to treat K106 wastes because it is commercially available; therefore, retorting represents BDAT for K106 nonwastewaters.

#### 4.2 BDAT for Wastewaters

EPA has identified sulfide precipitation followed by filtration as the only demonstrated technology for treatment of K106 wastewaters. This technology is the only demonstrated technology and is, therefore, the "best" performing technology. As discussed earlier, EPA does not have treatment data for K106 wastewaters generated from retorting; however, EPA does have treatment data for K071 mercury containing wastewaters believed to be similar to K106 wastewaters.

Data collected by the Agency on treatment of K071 wastewater by sulfide precipitation and filtration are shown in Table 3-2. Operating data collected during treatment of this waste show that these data represent the performance of a well-designed, well-operated treatment system.

Next, EPA adjusted the data values based on the analytical recovery values in order 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. Percent recovery values for BDAT list metals used in adjustment of the performance data are presented in Appendix B. The analytical data were adjusted for accuracy using the lowest recovery value for each constituent.

EPA's determination of substantial treatment is based on the observed reduction in total mercury concentration from 77.2 ppm to 0.28 ppm in the K071 mercury-containing wastewaters considered by EPA to be similar to K106 wastewaters.

The Agency believes that this reduction of hazardous constituents is substantial and that sulfide precipitation followed by filtration is available to treat K106 wastes because it is commercially available; therefore, sulfide precipitation followed by filtration represents BDAT for K106 wastewaters.

## 5. SELECTION OF REGULATED CONSTITUENTS

This section describes, step by step, the process used to select the constituents to be regulated for K106. The selected constituents must be present in the untreated waste at concentrations that are treatable by the chosen BDAT discussed in Section 4.

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

### 5.1 Nonwastewaters

Table 5-1 presents the BDAT constituent list and indicates which of the BDAT list constituents were analyzed for in the untreated K106 waste and which of unanalyzed constituents were detected in the untreated K106 waste.

The untreated waste sample was not analyzed for the organic compounds on the BDAT list (volatiles, semivolatiles, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorous insecticides, PCBs, and dioxins and furans) because the Agency is not aware of any in-process source of these constituents and would, therefore, not expect any of these constituents to be present at treatable concentrations. Inorganics

other than metals on the BDAT list (i.e., fluoride, sulfide, and cyanide) were not analyzed. Even though these constituents were not analyzed, EPA would not expect fluoride or cyanide to be present at treatable concentrations. However, sulfide would clearly be present in the K106 wastes generated by sulfide precipitation. EPA is not proposing regulations for sulfide in K106 wastes.

Of the 16 metals on the BDAT list of constituents, EPA analyzed for 15. Of the 15 metals analyzed, 11 were detected in the total concentration analysis and six of these metals were detected in the TCLP leachate analysis. Of the 11 metals detected in K106 waste, EPA's review of the data showed the following ten metals were not present at treatable concentrations; six of these metals (barium, copper, lead, nickel, silver, and zinc) were present in total concentrations ranging from 14 ppm for nickel to 443 ppm for zinc. EPA is not aware of a technology that can further treat these metals when found in combination with mercury at the concentrations found in K106 (roughly 44,000 ppm). For this reason and because mercury was also present at the highest concentration (44,000 ppm), mercury has been selected as the only regulated constituent for K106 nonwastewaters.

## 5.2 Wastewater

EPA does not have data on K106 wastewaters generated from retorting. However, EPA would not expect any BDAT constituent other than mercury to be present in treatable quantities in the K106 wastewater for reasons already presented under nonwastewaters. Therefore, mercury has been selected as a regulated constituent for K106 wastewaters.

Table 5-1 BDAT List of Constituents Detected in Untreated K106  
Generated from Sulfide Precipitation

| BDAT<br>reference<br>no. | Parameter                   | CAS no.    | Detection status |
|--------------------------|-----------------------------|------------|------------------|
| <u>Volatiles</u>         |                             |            |                  |
| 222.                     | Acetone                     | 67-64-1    | NA               |
| 1.                       | Acetonitrile                | 75-05-8    | NA               |
| 2.                       | Acrolein                    | 107-02-8   | NA               |
| 3.                       | Acrylonitrile               | 107-13-1   | NA               |
| 4.                       | Benzene                     | 71-43-2    | NA               |
| 5.                       | Bromodichloromethane        | 75-27-4    | NA               |
| 6.                       | Bromomethane                | 74-83-9    | NA               |
| 223.                     | n-Butyl alcohol             | 71-36-3    | NA               |
| 7.                       | Carbon tetrachloride        | 56-23-5    | NA               |
| 8.                       | Carbon disulfide            | 75-15-0    | NA               |
| 9.                       | Chlorobenzene               | 108-90-7   | NA               |
| 10.                      | 2-Chloro-1,3-butadiene      | 126-99-8   | NA               |
| 11.                      | Chlorodibromomethane        | 124-48-1   | NA               |
| 12.                      | Chloroethane                | 75-00-3    | NA               |
| 13.                      | 2-Chloroethyl vinyl ether   | 110-75-8   | NA               |
| 14.                      | Chloroform                  | 67-66-3    | NA               |
| 15.                      | Chloromethane               | 74-87-3    | NA               |
| 16.                      | 3-Chloropropene             | 107-05-1   | NA               |
| 17.                      | 1,2-Dibromo-3-chloropropane | 96-12-8    | NA               |
| 18.                      | 1,2-Dibromoethane           | 106-93-4   | NA               |
| 19.                      | Dibromomethane              | 74-95-3    | NA               |
| 20.                      | trans-1,4-Dichloro-2-butene | 110-57-6   | NA               |
| 21.                      | Dichlorodifluoromethane     | 75-71-8    | NA               |
| 22.                      | 1,1-Dichloroethane          | 75-34-3    | NA               |
| 23.                      | 1,2-Dichloroethane          | 107-06-2   | NA               |
| 24.                      | 1,1-Dichloroethylene        | 75-35-4    | NA               |
| 25.                      | trans-1,2-Dichloroethene    | 156-60-5   | NA               |
| 26.                      | 1,2-Dichloropropane         | 78-87-5    | NA               |
| 27.                      | trans-1,3-Dichloropropene   | 10061-02-6 | NA               |
| 28.                      | cis-1,3-Dichloropropene     | 10061-01-5 | NA               |
| 29.                      | 1,4-Dioxane                 | 123-91-1   | NA               |
| 224.                     | 2-Ethoxyethanol             | 110-80-5   | NA               |
| 225.                     | Ethyl acetate               | 141-78-6   | NA               |
| 226.                     | Ethylbenzene                | 100-41-4   | NA               |
| 30.                      | Ethyl cyanide               | 107-12-0   | NA               |
| 227.                     | Ethyl ether                 | 60-29-7    | NA               |
| 31.                      | Ethyl methacrylate          | 97-63-2    | NA               |
| 214.                     | Ethylene oxide              | 75-21-8    | NA               |
| 32.                      | Iodomethane                 | 74-88-4    | NA               |
| 33.                      | Isobutyl alcohol            | 78-83-1    | NA               |
| 228.                     | Methanol                    | 67-56-1    | NA               |
| 34.                      | Methyl ethyl ketone         | 78-93-3    | NA               |

Table 5-1 (continued)

| BDAT<br>reference<br>no.     | Parameter                                  | CAS no.  | Detection status |
|------------------------------|--|----------|------------------|
| <u>Volatiles (continued)</u> |  |          |                  |
| 229.                         | Methyl isobutyl ketone                     | 108-10-1 | NA               |
| 35.                          | Methyl methacrylate                        | 80-62-6  | NA               |
| 37.                          | Methacrylonitrile                          | 126-98-7 | NA               |
| 38.                          | Methylene chloride                         | 75-09-2  | NA               |
| 230.                         | 2-Nitropropane                             | 79-46-9  | NA               |
| 39.                          | Pyridine                                   | 110-86-1 | NA               |
| 40.                          | 1,1,1,2-Tetrachloroethane                  | 630-20-6 | NA               |
| 41.                          | 1,1,2,2-Tetrachloroethane                  | 79-34-6  | NA               |
| 42.                          | Tetrachloroethene                          | 127-18-4 | NA               |
| 43.                          | Toluene                                    | 108-88-3 | NA               |
| 44.                          | Tribromomethane                            | 75-25-2  | NA               |
| 45.                          | 1,1,1-Trichloroethane                      | 71-55-6  | NA               |
| 46.                          | 1,1,2-Trichloroethane                      | 79-00-5  | NA               |
| 47.                          | Trichloroethene                            | 79-01-6  | NA               |
| 48.                          | Trichloromonofluoromethane                 | 75-69-4  | NA               |
| 49.                          | 1,2,3-Trichloropropane                     | 96-18-4  | NA               |
| 231.                         | 1,1,2-Trichloro-1,2,2-trifluoro-<br>ethane | 76-13-1  | NA               |
| 50.                          | Vinyl chloride                             | 75-01-4  | NA               |
| 215.                         | 1,2-Xylene                                 | 97-47-6  | NA               |
| 216.                         | 1,3-Xylene                                 | 108-38-3 | NA               |
| 217.                         | 1,4-Xylene                                 | 106-44-5 | NA               |
| <u>Semivolatiles</u>         |  |          |                  |
| 51.                          | Acenaphthalene                             | 208-96-8 | NA               |
| 52.                          | Acenaphthene                               | 83-32-9  | NA               |
| 53.                          | Acetophenone                               | 96-86-2  | NA               |
| 54.                          | 2-Acetylamino fluorene                     | 53-96-3  | NA               |
| 55.                          | 4-Aminobiphenyl                            | 92-67-1  | NA               |
| 56.                          | Aniline                                    | 62-53-3  | NA               |
| 57.                          | Anthracene                                 | 120-12-7 | NA               |
| 58.                          | Aramite                                    | 140-57-8 | NA               |
| 218.                         | Benzal chloride                            | 98-87-3  | NA               |
| 59.                          | Benz(a)anthracene                          | 56-55-3  | NA               |
| 60.                          | Benzenethiol                               | 108-98-5 | NA               |
| 61.                          | Deleted                                    |          |                  |
| 63.                          | Benzo(b)fluoranthene                       | 205-99-2 | NA               |
| 65.                          | Benzo(k)fluoranthene                       | 207-08-9 | NA               |
| 64.                          | Benzo(ghi)perylene                         | 191-24-2 | NA               |
| 62.                          | Benzo(a)pyrene                             | 50-32-8  | NA               |
| 66.                          | p-Benzoquinone                             | 106-51-4 | NA               |

Table 5-1 (continued)

| BDAT<br>reference<br>no.         | Parameter                     | CAS no.    | Detection status |
|----------------------------------|-------------------------------|------------|------------------|
| <u>Semivolatiles</u> (continued) |                               |            |                  |
| 67.                              | Bis(2-chloroethoxy)methane    | 111-91-1   | NA               |
| 68.                              | Bis(2-chloroethyl) ether      | 111-44-4   | NA               |
| 69.                              | Bis(2-chloroisopropyl) ether  | 39638-32-9 | NA               |
| 70.                              | Bis(2-ethylhexyl) phthalate   | 117-81-7   | NA               |
| 71.                              | 4-Bromophenyl phenyl ether    | 101-55-3   | NA               |
| 72.                              | Butylbenzyl phthalate         | 85-68-7    | NA               |
| 73.                              | 2-sec-Butyl-4,6-dinitrophenol | 88-85-7    | NA               |
| 74.                              | p-Chloroaniline               | 106-47-8   | NA               |
| 75.                              | Chlorobenzilate               | 510-15-6   | NA               |
| 76.                              | p-Chloro-m-cresol             | 59-50-7    | NA               |
| 77.                              | 2-Chloronaphthalene           | 91-58-7    | NA               |
| 78.                              | 2-Chlorophenol                | 95-57-8    | NA               |
| 79.                              | 3-Chloropropionitrile         | 542-76-7   | NA               |
| 80.                              | Chrysene                      | 218-01-9   | NA               |
| 81.                              | o-Cresol                      | 95-48-7    | NA               |
| 82.                              | p-Cresol                      | 106-44-5   | NA               |
| 232                              | Cyclohexanone                 | 108-94-1   | NA               |
| 83.                              | Dibenz(a,h)anthracene         | 53-70-3    | NA               |
| 84.                              | Dibenzo(a,e)pyrene            | 192-65-4   | NA               |
| 85.                              | Dibenzo(a,i)pyrene            | 189-55-9   | NA               |
| 86.                              | 1,3-Dichlorobenzene           | 541-73-1   | NA               |
| 87.                              | 1,2-Dichlorobenzene           | 95-50-1    | NA               |
| 88.                              | 1,4-Dichlorobenzene           | 106-46-7   | NA               |
| 89.                              | 3,3'-Dichlorobenzidine        | 91-94-1    | NA               |
| 90.                              | 2,4-Dichlorophenol            | 120-83-2   | NA               |
| 91.                              | 2,6-Dichlorophenol            | 87-65-0    | NA               |
| 92.                              | Diethyl phthalate             | 84-66-2    | NA               |
| 93.                              | 3,3'-Dimethoxybenzidine       | 119-90-4   | NA               |
| 94.                              | p-Dimethylaminoazobenzene     | 60-11-7    | NA               |
| 95.                              | 3,3'-Dimethylbenzidine        | 119-93-7   | NA               |
| 96.                              | 2,4-Dimethylphenol            | 105-67-9   | NA               |
| 97.                              | Dimethyl phthalate            | 131-11-3   | NA               |
| 98.                              | Di-n-butyl phthalate          | 84-74-2    | NA               |
| 99.                              | 1,4-Dinitrobenzene            | 100-25-4   | NA               |
| 100.                             | 4,6-Dinitro-o-cresol          | 534-52-1   | NA               |
| 101.                             | 2,4-Dinitrophenol             | 51-28-5    | NA               |
| 102.                             | 2,4-Dinitrotoluene            | 121-14-2   | NA               |
| 103.                             | 2,6-Dinitrotoluene            | 606-20-2   | NA               |
| 104.                             | Di-n-octyl phthalate          | 117-84-0   | NA               |
| 105.                             | Di-n-propylnitrosamine        | 621-64-7   | NA               |
| 106.                             | Diphenylamine                 | 122-39-4   | NA               |
| 219.                             | Diphenylnitrosamine           | 86-30-6    | NA               |

Table 5-1 (continued)

| BDAT<br>reference<br>no.         | Parameter                           | CAS no.    | Detection status |
|----------------------------------|-------------------------------------|------------|------------------|
| <u>Semivolatiles</u> (continued) |                                     |            |                  |
| 107.                             | 1,2-Diphenylhydrazine               | 122-66-7   | NA               |
| 108.                             | Fluoranthene                        | 206-44-0   | NA               |
| 109.                             | Fluorene                            | 86-73-7    | NA               |
| 110.                             | Hexachlorobenzene                   | 118-74-1   | NA               |
| 111.                             | Hexachlorobutadiene                 | 87-68-3    | NA               |
| 112.                             | Hexachlorocyclopentadiene           | 77-47-4    | NA               |
| 113.                             | Hexachloroethane                    | 67-72-1    | NA               |
| 114.                             | Hexachlorophene                     | 70-30-4    | NA               |
| 115.                             | Hexachloropropene                   | 1888-71-7  | NA               |
| 116.                             | Indeno(1,2,3-cd)pyrene              | 193-39-5   | NA               |
| 117.                             | Isosafrole                          | 120-58-1   | NA               |
| 118.                             | Methapyrene                         | 91-80-5    | NA               |
| 119.                             | 3-Methylcholanthrene                | 56-49-5    | NA               |
| 120.                             | 4,4'-Methylenebis (2-chloroaniline) | 101-14-4   | NA               |
| 36.                              | Methyl methanesulfonate             | 66-27-3    | NA               |
| 121.                             | Naphthalene                         | 91-20-3    | NA               |
| 122.                             | 1,4-Naphthoquinone                  | 130-15-4   | NA               |
| 123.                             | 1-Naphthylamine                     | 134-32-7   | NA               |
| 124.                             | 2-Naphthylamine                     | 91-59-8    | NA               |
| 125.                             | p-Nitroaniline                      | 100-01-6   | NA               |
| 126.                             | Nitrobenzene                        | 98-95-3    | NA               |
| 127.                             | 4-Nitrophenol                       | 100-02-7   | NA               |
| 128.                             | N-Nitrosodimethylamine              | 924-16-3   | NA               |
| 129.                             | N-Nitrosodiethylamine               | 55-18-5    | NA               |
| 130.                             | N-Nitrosodimethylamine              | 62-75-9    | NA               |
| 131.                             | N-Nitrosomethylethylamine           | 10595-95-6 | NA               |
| 132.                             | N-Nitrosomorpholine                 | 59-89-2    | NA               |
| 133.                             | N-Nitrosopiperidine                 | 100-75-4   | NA               |
| 134.                             | N-Nitrosopyrrolidine                | 930-55-2   | NA               |
| 135.                             | 5-Nitro-o-toluidine                 | 99-65-8    | NA               |
| 136.                             | Pentachlorobenzene                  | 608-93-5   | NA               |
| 137.                             | Pentachloroethane                   | 76-01-7    | NA               |
| 138.                             | Pentachloronitrobenzene             | 82-68-8    | NA               |
| 139.                             | Pentachlorophenol                   | 87-86-5    | NA               |
| 140.                             | Phenacetin                          | 62-44-2    | NA               |
| 141.                             | Phenanthrene                        | 85-01-8    | NA               |
| 142.                             | Phenol                              | 108-95-2   | NA               |
| 220.                             | Phthalic anhydride                  | 85-44-9    | NA               |
| 143.                             | 2-Picoline                          | 109-06-8   | NA               |
| 144.                             | Pronamide                           | 23950-58-5 | NA               |
| 145.                             | Pyrene                              | 129-00-0   | NA               |
| 146.                             | Resorcinol                          | 108-46-3   | NA               |

Table 5-1 (continued)

| BDAT                                |                                   |            |                  |
|-------------------------------------|-----------------------------------|------------|------------------|
| reference no.                       | Parameter                         | CAS no.    | Detection status |
| <u>Semivolatiles (continued)</u>    |                                   |            |                  |
| 147                                 | Safrole                           | 94-59-7    | NA               |
| 148                                 | 1,2,4,5-Tetrachlorobenzene        | 95-94-3    | NA               |
| 149                                 | 2,3,4,6-Tetrachlorophenol         | 58-90-2    | NA               |
| 150                                 | 1,2,4-Trichlorobenzene            | 120-82-1   | NA               |
| 151                                 | 2,4,5-Trichlorophenol             | 95-95-4    | NA               |
| 152                                 | 2,4,6-Trichlorophenol             | 88-06-2    | NA               |
| 153                                 | Tris(2,3-dibromopropyl) phosphate | 126-72-7   | NA               |
| <u>Metals</u>                       |                                   |            |                  |
| 154                                 | Antimony                          | 7440-36-0  | ND               |
| 155                                 | Arsenic                           | 7440-38-2  | D                |
| 156                                 | Barium                            | 7440-39-3  | D                |
| 157                                 | Beryllium                         | 7440-41-7  | ND               |
| 158                                 | Cadmium                           | 7440-43-9  | D                |
| 159                                 | Chromium (total)                  | 7440-47-32 | D                |
| 221                                 | Chromium (hexavalent)             | -          | NA               |
| 160                                 | Copper                            | 7440-50-8  | D                |
| 161                                 | Lead                              | 7439-92-1  | D                |
| 162                                 | Mercury                           | 7439-97-6  | D                |
| 163                                 | Nickel                            | 7440-02-0  | D                |
| 164                                 | Selenium                          | 7782-49-2  | ND               |
| 165                                 | Silver                            | 7440-22-4  | D                |
| 166                                 | Thallium                          | 7440-28-0  | ND               |
| 167                                 | Vanadium                          | 7440-62-2  | D                |
| 168                                 | Zinc                              | 7440-66-6  | D                |
| <u>Inorganics other than Metals</u> |                                   |            |                  |
| 169                                 | Cyanide                           | 57-12-5    | NA               |
| 170                                 | Fluoride                          | 16964-48-8 | NA               |
| 171                                 | Sulfide                           | 8496-25-8  | NA               |
| <u>Organochlorine Pesticides</u>    |                                   |            |                  |
| 172                                 | Aldrin                            | 309-00-2   | NA               |
| 173                                 | alpha-BHC                         | 319-84-6   | NA               |
| 174                                 | beta-BHC                          | 319-85-7   | NA               |
| 175                                 | delta-BHC                         | 319-86-8   | NA               |

Table 5-1 (continued)

| BDAT<br>reference<br>no                      | Parameter                      | CAS no.    | Detection status |
|--|--------------------------------|------------|------------------|
| <u>Organochlorine Pesticides</u> (continued) |                                |            |                  |
| 176.   | gamma-BHC                      | 58-89-9    | NA               |
| 177.   | Chlordane                      | 57-74-9    | NA               |
| 178.   | DDD                            | 72-54-8    | NA               |
| 179.   | DDE                            | 72-55-9    | NA               |
| 180.   | DDT                            | 50-29-3    | NA               |
| 181.   | Dieldrin                       | 60-57-1    | NA               |
| 182.   | Endosulfan I                   | 939-98-8   | NA               |
| 183.   | Endosulfan II                  | 33213-6-5  | NA               |
| 184.   | Endrin                         | 72-20-8    | NA               |
| 185.   | Endrin aldehyde                | 7421-93-4  | NA               |
| 186.   | Heptachlor                     | 76-44-8    | NA               |
| 187.   | Heptachlor epoxide             | 1024-57-3  | NA               |
| 188.   | Isodrin                        | 465-73-6   | NA               |
| 189.   | Kepone                         | 143-50-0   | NA               |
| 190.   | Methoxychlor                   | 72-43-5    | NA               |
| 191.   | Toxaphene                      | 8001-35-2  | NA               |
| <u>Phenoxyacetic Acid Herbicides</u>         |                                |            |                  |
| 192.   | 2,4-Dichlorophenoxyacetic acid | 94-75-7    | NA               |
| 193.   | Silvex                         | 93-72-1    | NA               |
| 194.   | 2,4,5-T                        | 93-76-5    | NA               |
| <u>Organophosphorous Insecticides</u>        |                                |            |                  |
| 195.   | Disulfoton                     | 298-04-4   | NA               |
| 196.   | Famphur                        | 52-85-7    | NA               |
| 197.   | Methyl parathion               | 298-00-0   | NA               |
| 198.   | Parathion                      | 56-38-2    | NA               |
| 199.   | Phorate                        | 298-02-2   | NA               |
| <u>PCBs</u>                                  |                                |            |                  |
| 200.   | Aroclor 1016                   | 12674-11-2 | NA               |
| 201.   | Aroclor 1221                   | 11104-28-2 | NA               |
| 202.   | Aroclor 1232                   | 11141-16-5 | NA               |
| 203.   | Aroclor 1242                   | 53469-21-9 | NA               |
| 204.   | Aroclor 1248                   | 12672-29-6 | NA               |
| 205.   | Aroclor 1254                   | 11097-69-1 | NA               |
| 206.   | Aroclor 1260                   | 11096-82-5 | NA               |

Table 5-1 (continued)

| BDAT                      |                                     |           |                  |
|---------------------------|-------------------------------------|-----------|------------------|
| reference                 | Parameter                           | CAS no.   | Detection status |
| no.                       |                                     |           |                  |
| <u>Dioxins and Furans</u> |                                     |           |                  |
| 207.                      | Hexachlorodibenzo-p-dioxins         | -         | NA               |
| 208.                      | Hexachlorodibenzofurans             | -         | NA               |
| 209.                      | Pentachlorodibenzo-p-dioxins        | -         | NA               |
| 210.                      | Pentachlorodibenzofurans            | -         | NA               |
| 211.                      | Tetrachlorodibenzo-p-dioxins        | -         | NA               |
| 212.                      | Tetrachlorodibenzofurans            | -         | NA               |
| 213.                      | 2,3,7,8-Tetrachlorodibenzo-p-dioxin | 1746-01-6 | NA               |

D = Detected.

ND = Not detected.

NA = Not analyzed

## 6. CALCULATION OF TREATMENT STANDARDS

In this section, the performance level of the best technology for treatment of K106 waste is calculated. For nonwastewater, this calculation is based on the treatment data presented in Table 3-3 for retorting. For wastewater, this calculation is based on the treatment data presented in Tables 3-4 through 3-6 for a treatment system consisting of sulfide precipitation followed by filtration. In Section 5, mercury was selected as the regulated constituent for both nonwastewater and wastewater forms of K106.

### 6.1 Nonwastewater

As discussed in Sections 4 and 5, retorting represents BDAT for treatment of mercury in K106 nonwastewaters. As noted earlier in Section 3 of this document, EPA is aware of two forms of K106 as generated; one type is K106 generated from sulfide precipitation and the other type is K106 generated from hydrazine treatment. The mercury present in K106 generated by hydrazine can be treated to a significantly lower concentration than the mercury present in K106 generated by sulfide precipitation. However, the Agency is not establishing a separate treatability group for the K106 generated by hydrazine for the following reasons:

1. EPA has had conversations with plant personnel that indicate when sulfide is not used to treat mercury in wastewaters there can be problems with complying with wastewater treatment standards for mercury. This information suggests that the hydrazine treatment for mercury-containing wastewaters may be discontinued.
2. Nineteen of the twenty facilities currently generating K106 generate a mercury sulfide sludge or residual. Only one facility generates K106 from hydrazine treatment.

Below are discussions of how the two BDAT treatment standards for mercury were developed for K106 nonwastewaters. The first discussion concerns the development of the standard for total mercury concentration and the next discussion addresses the development of the standard for mercury concentration in the TCLP leachate.

(1) Total waste concentration. EPA first examined all the performance data for retorting of K106 to determine if any data should not be used in the calculation of the treatment data. Based on this examination, EPA did not include treatment data from the facility that treated the combined K071/K106 wastes. This is because K106 represented only a very small fraction of the waste being treated (roughly 0.5 percent). Additionally, the four treated data points that represent treatment of K106 generated by hydrazine were not included because the Agency believes that the hydrazine treatment process may be discontinued and that only one facility currently generates K106 from hydrazine treatment.

After the above analysis, EPA was left with one data point representing total mercury concentration in the residual from retorting of mercury sulfide ores similar to K106. (EPA has already presented its rationale for why these wastes are similar in Section 3) The Agency has no reason to believe that this data point does not represent a well-designed and well-operated system.

EPA requested but did not receive accuracy correction values; therefore, the Agency is assuming that these data were corrected for analytical accuracy prior to being submitted to EPA. The BDAT standard

was calculated by multiplying the total mercury concentration value by a factor, referred to by EPA as a variability factor, that represents variations in treatment performance, untreated waste composition, and sampling and analysis of treated waste. EPA could not calculate the variability factor from the performance data used to establish the average performance value because this data consisted of only one point.

The variability factor used is 1.26; this value was determined from the retorting data for the K071/K106 waste mixture. EPA believes that the variability associated with treatment of the K071/K106 mixed waste would be similar to the variability of the waste representing treatment of K106, even though use of the actual performance concentration for this mixed waste would not be appropriate. The method used to calculate the variability factor is presented in Appendix A and the calculation can be found in the K106 Administrative Record. The BDAT treatment calculation for K106 is shown in Table 6-1.

(2) TCLP leachate standard. EPA has no data representing TCLP leachate concentrations from residuals using retorting. EPA has one data point (0.01 mg/l) representing the TCLP leachate concentration of mercury in untreated K106 generated by sulfide precipitation treatment. EPA would expect that the same level of performance to be achieved in the residual from retorting of K106 because:

1. For the 19 of the 20 affected facilities, the retorting residual would have been derived from treatment of the K106 generated by sulfide precipitation. Since the total mercury concentration of the retort residual would be significantly lower than the untreated K106 total mercury concentration, it is reasonable to expect that the retorting residual would leach mercury in concentrations no greater than the untreated K106 waste.

2. One facility generates K106 from hydrazine treatment. Even though the residual from retorting this waste will not be in the mercury sulfide form, EPA would expect the TCLP leachate value to be no greater than the untreated K106 generated from sulfide precipitation. EPA's assessment is based on the fact that the initial mercury concentration in the hydrazine retort residual for K106 generated from hydrazine treatment is much lower (approximately 75 ppm) than the untreated K106 (approximately 44,000 ppm).

The BDAT treatment standard representing the TCLP leachate concentration K106 nonwastewaters was determined by multiplying the 0.01 mg/l mercury leachate value by a variability factor of 2.8. Appendix A presents the method used to calculate the variability factor, and the actual concentration can be found in the Administrative Record for K106. The calculation of the treatment standard is shown in Table 6-1.

## 6.2 Wastewater

EPA collected three sets of untreated and treated K071 wastewater data from one facility using sulfide precipitation followed by filtration. No data were submitted by industry for the treatment of K071 wastewater. The following steps were taken to derive the BDAT treatment standards for K106 wastewaters:

1. The Agency evaluated the data collected from the sulfide precipitation treatment system to determine whether any of the data represented poor design or poor operation of the treatment system. The available data show that all three data sets collected from the Agency testing for wastewater do not represent poor design or poor operation.
2. Accuracy-corrected constituent concentrations were calculated for all BDAT list constituents for wastewater. An arithmetic average concentration level and a variability factor were determined for the BDAT list constituent (i.e., mercury) regulated in this waste.

3. The BDAT treatment standard for mercury was determined by multiplying the average accuracy-corrected total concentration by the 1.05 variability factor.

Table 6-1 summarizes the calculation of the treatment standards for K106 wastewaters.

Table 6-1 Calculation of Treatment Standards for K106

| Constituent                           | Sample Set #1 | Sample Set #2 | Sample Set #3 | Average corrected treated waste concentration | Variability factor | Treatment standard Avg. x VF |
|---------------------------------------|---------------|---------------|---------------|---|--------------------|------------------------------|
| <u>Wastewater</u>                     |               |               |               |   |                    |                              |
| Mercury (mg/l)                        | 0.0295        | 0.0284        | 0.0295        | 0.0288  | 1.05               | 0.030                        |
| <u>Nonwastewater<sup>a</sup></u>      |               |               |               |   |                    |                              |
| Mercury (Total concentration) (mg/kg) | 500           | -             | -             | 500   | 1.25               | 630                          |
| (TCLP) (mg/l)                         | 0.01          | -             | -             | 0.01  | 2.8                | 0.028                        |

<sup>a</sup> Facilities land disposing of K106 nonwastewater must comply with both the total concentration and the TCLP standards.

## APPENDIX A STATISTICAL ANALYSIS

### A.1 F Value Determination for ANOVA Test

As noted in Section 1, 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 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:

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

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:

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

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.

Table A-1  
F Distribution at the 95 Percent Confidence Level

| $F_{0.95}$                           |                              |       |       |       |       |       |       |       |       |
|--------------------------------------|------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Denominator<br>degrees of<br>freedom | Numerator degrees of freedom |       |       |       |       |       |       |       |       |
|                                      | 1                            | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     |
| 1                                    | 161.4                        | 199.5 | 215.7 | 224.6 | 230.2 | 234.0 | 236.8 | 238.9 | 240.5 |
| 2                                    | 18.51                        | 19.00 | 19.16 | 19.25 | 19.30 | 19.33 | 19.35 | 19.37 | 19.38 |
| 3                                    | 10.13                        | 9.55  | 9.23  | 9.12  | 9.01  | 8.94  | 8.89  | 8.85  | 8.81  |
| 4                                    | 7.71                         | 6.94  | 6.59  | 6.39  | 6.26  | 6.16  | 6.09  | 6.04  | 6.00  |
| 5                                    | 6.61                         | 5.79  | 5.41  | 5.19  | 5.05  | 4.95  | 4.88  | 4.82  | 4.77  |
| 6                                    | 5.99                         | 5.14  | 4.76  | 4.53  | 4.39  | 4.28  | 4.21  | 4.15  | 4.10  |
| 7                                    | 5.59                         | 4.74  | 4.35  | 4.12  | 3.97  | 3.87  | 3.79  | 3.73  | 3.68  |
| 8                                    | 5.32                         | 4.46  | 4.07  | 3.84  | 3.69  | 3.58  | 3.50  | 3.44  | 3.39  |
| 9                                    | 5.12                         | 4.26  | 3.86  | 3.63  | 3.48  | 3.37  | 3.29  | 3.23  | 3.18  |
| 10                                   | 4.96                         | 4.10  | 3.71  | 3.48  | 3.33  | 3.22  | 3.14  | 3.07  | 3.02  |
| 11                                   | 4.84                         | 3.98  | 3.59  | 3.36  | 3.20  | 3.09  | 3.01  | 2.95  | 2.90  |
| 12                                   | 4.75                         | 3.89  | 3.49  | 3.26  | 3.11  | 3.00  | 2.91  | 2.85  | 2.80  |
| 13                                   | 4.67                         | 3.81  | 3.41  | 3.18  | 3.03  | 2.92  | 2.83  | 2.77  | 2.71  |
| 14                                   | 4.60                         | 3.74  | 3.34  | 3.11  | 2.96  | 2.85  | 2.76  | 2.70  | 2.65  |
| 15                                   | 4.54                         | 3.68  | 3.29  | 3.06  | 2.90  | 2.79  | 2.71  | 2.64  | 2.59  |
| 16                                   | 4.49                         | 3.63  | 3.24  | 3.01  | 2.85  | 2.74  | 2.66  | 2.59  | 2.54  |
| 17                                   | 4.45                         | 3.59  | 3.20  | 2.96  | 2.81  | 2.70  | 2.61  | 2.55  | 2.49  |
| 18                                   | 4.41                         | 3.55  | 3.16  | 2.93  | 2.77  | 2.66  | 2.58  | 2.51  | 2.46  |
| 19                                   | 4.38                         | 3.52  | 3.13  | 2.90  | 2.74  | 2.63  | 2.54  | 2.48  | 2.42  |
| 20                                   | 4.35                         | 3.49  | 3.10  | 2.87  | 2.71  | 2.60  | 2.51  | 2.45  | 2.39  |
| 21                                   | 4.32                         | 3.47  | 3.07  | 2.84  | 2.68  | 2.57  | 2.49  | 2.42  | 2.37  |
| 22                                   | 4.30                         | 3.44  | 3.05  | 2.82  | 2.66  | 2.55  | 2.46  | 2.40  | 2.34  |
| 23                                   | 4.28                         | 3.42  | 3.03  | 2.80  | 2.64  | 2.53  | 2.44  | 2.37  | 2.32  |
| 24                                   | 4.26                         | 3.40  | 3.01  | 2.78  | 2.62  | 2.51  | 2.42  | 2.36  | 2.30  |
| 25                                   | 4.24                         | 3.39  | 2.99  | 2.76  | 2.60  | 2.49  | 2.40  | 2.34  | 2.28  |
| 26                                   | 4.23                         | 3.37  | 2.98  | 2.74  | 2.59  | 2.47  | 2.39  | 2.32  | 2.27  |
| 27                                   | 4.21                         | 3.35  | 2.96  | 2.73  | 2.57  | 2.46  | 2.37  | 2.31  | 2.25  |
| 28                                   | 4.20                         | 3.34  | 2.95  | 2.71  | 2.56  | 2.45  | 2.36  | 2.29  | 2.24  |
| 29                                   | 4.18                         | 3.33  | 2.93  | 2.70  | 2.55  | 2.43  | 2.35  | 2.28  | 2.22  |
| 30                                   | 4.17                         | 3.32  | 2.92  | 2.69  | 2.53  | 2.42  | 2.33  | 2.27  | 2.21  |
| 40                                   | 4.08                         | 3.23  | 2.84  | 2.61  | 2.45  | 2.34  | 2.25  | 2.18  | 2.12  |
| 60                                   | 4.00                         | 3.15  | 2.76  | 2.53  | 2.37  | 2.25  | 2.17  | 2.10  | 2.04  |
| 120                                  | 3.92                         | 3.07  | 2.68  | 2.45  | 2.29  | 2.17  | 2.09  | 2.02  | 1.96  |
| $\infty$                             | 3.84                         | 3.00  | 2.60  | 2.37  | 2.21  | 2.10  | 2.01  | 1.94  | 1.88  |

Example 1  
Methylene Chloride

| <u>Steam stripping</u>          |                                 |                        |                            | <u>Biological treatment</u>     |                                 |                        |                            |
|---------------------------------|---------------------------------|------------------------|----------------------------|---------------------------------|---------------------------------|------------------------|----------------------------|
| Influent<br>( $\mu\text{g/l}$ ) | Effluent<br>( $\mu\text{g/l}$ ) | $\ln(\text{effluent})$ | $[\ln(\text{effluent})]^2$ | Influent<br>( $\mu\text{g/l}$ ) | Effluent<br>( $\mu\text{g/l}$ ) | $\ln(\text{effluent})$ | $[\ln(\text{effluent})]^2$ |
| 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                   | 10.63                      |
| 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                  | 53.76                      | -                               | -                               | 12.46                  | 31.79                      |
| Sample Size                     |                                 |                        |                            |                                 |                                 |                        |                            |
| 10                              | 10                              | 10                     | -                          | 5                               | 5                               | 5                      | -                          |
| Mean                            |                                 |                        |                            |                                 |                                 |                        |                            |
| 3069                            | 10.2                            | 2.32                   | -                          | 2378                            | 13.2                            | 2.49                   | -                          |
| Standard Deviation              |                                 |                        |                            |                                 |                                 |                        |                            |
| 3328.67                         | .63                             | .06                    | -                          | 923.04                          | 7.15                            | .43                    | -                          |
| Variability Factor              |                                 |                        |                            |                                 |                                 |                        |                            |
|                                 | 1.15                            | -                      | -                          |                                 | 2.48                            | -                      | -                          |

## ANOVA Calculations

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

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

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

## 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

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

$$n_1 = 10, n_2 = 5, N = 15, k = 2, T_1 = 23.18, T_2 = 12.46, T = 35.64, T^2 = 1270.21$$

$$T_1^2 = 537.31 \quad T_2^2 = 155.25$$

$$SSB = \left( \frac{537.31}{10} + \frac{155.25}{5} \right) - \frac{1270.21}{15} = 0.10$$

$$SSW = (53.76 + 31.79) - \left( \frac{537.31}{10} + \frac{155.25}{5} \right) = 0.77$$

$$MSB = 0.10/1 = 0.10$$

$$MSW = 0.77/13 = 0.06$$

$$F = \frac{0.10}{0.06} = 1.67$$

ANOVA Table

| Source     | Degrees of freedom | SS   | MS   | F    |
|------------|--------------------|------|------|------|
| Between(B) | 1                  | 0.10 | 0.10 | 1.67 |
| Within(W)  | 13                 | 0.77 | 0.06 |      |

The critical value of the  $F$  test at the 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).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 2  
Trichloroethylene

| <u>Steam stripping</u>          |                                 |                        |                            | <u>Biological treatment</u>     |                                 |                        |                            |
|---------------------------------|---------------------------------|------------------------|----------------------------|---------------------------------|---------------------------------|------------------------|----------------------------|
| Influent<br>( $\mu\text{g/l}$ ) | Effluent<br>( $\mu\text{g/l}$ ) | $\ln(\text{effluent})$ | $[\ln(\text{effluent})]^2$ | Influent<br>( $\mu\text{g/l}$ ) | Effluent<br>( $\mu\text{g/l}$ ) | $\ln(\text{effluent})$ | $[\ln(\text{effluent})]^2$ |
| 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                   | 10.89                      |                                 |                                 |                        |                            |
| 204.00                          | 85.00                           | 4.44                   | 19.71                      |                                 |                                 |                        |                            |
| 160.00                          | 10.00                           | 2.30                   | 5.29                       |                                 |                                 |                        |                            |
| Sum                             |                                 |                        |                            |                                 |                                 |                        |                            |
| -                               | -                               | 26.14                  | 72.92                      | -                               | -                               | 16.59                  | 39.52                      |
| 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                            | .19                    | -                          |
| Variability Factor:             |                                 |                        |                            |                                 |                                 |                        |                            |
| -                               | 3.70                            | -                      | -                          | -                               | 1.53                            | -                      | -                          |

ANOVA Calculations:

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

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

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

## 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

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

$$N_1 = 10, N_2 = 7, N = 17, k = 2, T_1 = 26.14, T_2 = 16.59, T = 42.73, T^2 = 1825.85, T_1^2 = 683.30,$$

$$T_2^2 = 275.23$$

$$SSB = \left( \frac{683.30}{10} + \frac{275.23}{7} \right) - \frac{1825.85}{17} = 0.25$$

$$SSW = (72.92 + 39.52) - \left( \frac{683.30}{10} + \frac{275.23}{7} \right) = 4.79$$

$$MSB = 0.25/1 = 0.25$$

$$MSW = 4.79/15 = 0.32$$

$$F = \frac{0.25}{0.32} = 0.78$$

ANOVA Table

| Source     | Degrees of freedom | SS   | MS   | F    |
|------------|--------------------|------|------|------|
| Between(B) | 1                  | 0.25 | 0.25 | 0.78 |
| Within(W)  | 15                 | 4.79 | 0.32 |      |

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

Note All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 3  
Chlorobenzene

| <u>Activated sludge followed by carbon adsorption</u> |                                 |                        |                            | <u>Biological treatment</u>     |                                 |                        |                            |
|---|---------------------------------|------------------------|----------------------------|---------------------------------|---------------------------------|------------------------|----------------------------|
| Influent<br>( $\mu\text{g/l}$ )                       | Effluent<br>( $\mu\text{g/l}$ ) | $\ln(\text{effluent})$ | $[\ln(\text{effluent})]^2$ | Influent<br>( $\mu\text{g/l}$ ) | Effluent<br>( $\mu\text{g/l}$ ) | $\ln(\text{effluent})$ | $\ln[(\text{effluent})]^2$ |
| 7200.00   | 80.00                           | 4.38                   | 19.18                      | 9206.00                         | 1083.00                         | 6.99                   | 48.86                      |
| 6500.00   | 70.00                           | 4.25                   | 18.06                      | 16646.00                        | 709.50                          | 6.56                   | 43.03                      |
| 6075.00   | 35.00                           | 3.56                   | 12.67                      | 49775.00                        | 460.00                          | 6.13                   | 37.58                      |
| 3040.00   | 10.00                           | 2.30                   | 5.29                       | 14731.00                        | 142.00                          | 4.96                   | 24.60                      |
|   |                                 |                        |                            | 3159.00                         | 603.00                          | 6.40                   | 40.96                      |
|   |                                 |                        |                            | 6756.00                         | 153.00                          | 5.03                   | 25.30                      |
|   |                                 |                        |                            | 3040.00                         | 17.00                           | 2.83                   | 8.01                       |
| Sum   |                                 |                        |                            |                                 |                                 |                        |                            |
| -   | -                               | 14.49                  | 55.20                      | -                               | -                               | 38.90                  | 228.34                     |
| Sample Size   |                                 |                        |                            |                                 |                                 |                        |                            |
| 4   | 4                               | 4                      | -                          | 7                               | 7                               | 7                      | -                          |
| Mean  |                                 |                        |                            |                                 |                                 |                        |                            |
| 5703  | 49                              | 3.62                   | -                          | 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.

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

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

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

$$F = MSB/MSW$$

## Example 3 (continued)

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

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

$$N_1 = 4, N_2 = 7, N = 11, k = 2, T_1 = 14.49, T_2 = 38.90, T = 53.39, T^2 = 2850.49, T_1^2 = 209.96$$

$$T_2^2 = 1513.21$$

$$SSB = \left( \frac{209.96}{4} + \frac{1513.21}{7} \right) - \frac{2850.49}{11} = 9.52$$

$$SSW = (55.20 + 228.34) - \left( \frac{209.96}{4} + \frac{1513.21}{7} \right) = 14.88$$

$$MSB = 9.52/1 = 9.52$$

$$MSW = 14.88/9 = 1.65$$

$$F = 9.52/1.65 = 5.77$$

ANOVA Table

| Source     | Degrees of freedom | SS    | MS   | F    |
|------------|--------------------|-------|------|------|
| Between(B) | 1                  | 9.53  | 9.53 | 5.77 |
| Within(W)  | 9                  | 14.89 | 1.65 |      |

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

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

## APPENDIX B QUALITY ASSURANCE/QUALITY CONTROL

### B.1 Analytical Methods.

The analytical methods used for analysis of the regulated pollutants identified in Section 5 are listed in Table B-1. SW-846 methods (EPA's Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-846, Third Edition, November 1986) are used in most cases, except for the TCLP extraction procedure (published in 51 FR 40643, November 7, 1986, as Appendix I to Part 268 - Hazardous Waste Management System; Land Disposal Restrictions; Final Rule.)

Specific procedures or equipment used for preparing or analyzing the regulated pollutants when alternatives or equivalents are allowed by SW-846 are listed in Table B-2.

### B.2 Accuracy Determination.

The accuracy determination for a pollutant is based on the matrix spike recovery values. The accuracy correction factors were determined in accordance with the general methodology presented in Section 1. For example, for most BDAT list metals, actual spike recovery data were obtained for each individual TCLP sample and the lowest value was used to calculate the accuracy corrected value. Table B-3 presents the matrix spike recoveries and the accuracy correction factor used to correct the concentration of mercury in the waste similar to K106 wastewaters (i.e., K071 mercury containing wastewaters), and in the untreated K106 TCLP extract.

Table B-1 Analytical Methods

| Analysis/Methods  | Method                      |
|---|-----------------------------|
| Mercury in Liquid Waste (Manual Cold-Vapor Technique)             | 7470                        |
| Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique) | 7471                        |
| TCLP  | 40 CFR Part 268, Appendix I |

Table 8-2 Specific Procedures or Equipment Used in Mercury Analysis  
When Alternatives or Equivalents are Allowed in the SW-846 Methods

| Analysis/Method      | Equipment        | Alternatives or equipment<br>allowed by SW-846 method   | Specific procedures<br>or equipment used   |
|----------------------|------------------|---|--|
| Mercury 7470<br>7471 | Perkin Elmer 50A | <ul style="list-style-type: none"> <li>• Equipment should be operated following instructions by instrument manufacturer.</li> <li>• Cold vapor apparatus as described in SW-846 or equivalent apparatus may be used.</li> <li>• Samples may be prepared using the water bath method or the autoclave method, both described in SW-846.</li> </ul> | <ul style="list-style-type: none"> <li>• Equipment was operated using procedures specified in Perkin Elmer 50A Instructions Manual.</li> <li>• Mercury was analyzed by cold vapor method using the apparatus as specified in SW-846, except that there was no scrubber.</li> <li>• Samples were prepared using the water bath method.</li> </ul> |

Reference: USEPA. 1988a. Table 6-7.

Table B-3 Matrix Spike Recoveries Used To Correct Analytical Data for K071  
Mercury Containing Wastewaters and Untreated K106 TCLP Extract

| BDAT<br>constituent | Original amount<br>found (ug/l) | Sample Set #6         |                        |                                  | Sample Set #6 Duplicate |                        |                                  | Accuracy<br>correction<br>factor <sup>b</sup> |
|---------------------|---------------------------------|-----------------------|------------------------|----------------------------------|-------------------------|------------------------|----------------------------------|---|
|                     |                                 | Spike added<br>(ug/l) | Spike result<br>(ug/l) | Percent<br>recovery <sup>a</sup> | Spike added<br>(ug/l)   | Spike result<br>(ug/l) | Percent<br>recovery <sup>a</sup> |   |
| Mercury             | 1.6                             | 4.0                   | 5.4                    | 95                               | 4.0                     | 5.5                    | 98                               | 1.05  |

NC = Not calculable.

<sup>a</sup>Percent Recovery = [(Spike Result - Original Amount)/Spike Added].

<sup>b</sup>Accuracy Correction Factor = 100/Percent Recovery (using the lowest percent recovery value).

Reference: USEJPA. 1988a. Table 6-16.

## APPENDIX C STABILIZATION DATA FOR K106

The Agency collected nine sets of untreated and treated data for treatment of K106 nonwastewater by stabilization. Stabilization tests consisted of three sets of three tests on the same untreated waste using three different binder materials. These data show no significant reduction in the leachability of mercury in the K106 waste tested.

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Table C-1 Stabilization - EPA-Collected Data  
Sample Set #1

| BDAT metals | <u>Untreated waste</u> |                | <u>Treated waste</u> |
|-------------|------------------------|----------------|----------------------|
|             | Total<br>(ppm)         | TCLP<br>(mg/l) | TCLP<br>(mg/l)       |
| Arsenic     | 1.1                    | <0.01          | <0.004               |
| Barium      | 74                     | 0.74           | 0.326                |
| Cadmium     | 2.3                    | 0.02           | <0.003               |
| Chromium    | 6.3                    | <0.01          | <0.02                |
| Copper      | 133                    | <0.02          | <0.003               |
| Lead        | 50                     | 0.13           | <0.006               |
| Mercury     | 25,900                 | 0.01           | 0.0096               |
| Nickel      | 14                     | 0.15           | <0.025               |
| Silver      | 131                    | <0.02          | 0.007                |
| Vanadium    | 0.46                   | <0.01          | <0.007               |
| Zinc        | 443                    | 1.7            | <0.013               |

Reference: USEPA 1988b.

Table C-2 Stabilization - EPA-Collected Data  
Sample Set #2

| BDAT metals | <u>Untreated waste</u> |                | <u>Treated waste</u> |
|-------------|------------------------|----------------|----------------------|
|             | Total<br>(ppm)         | TCLP<br>(mg/l) | TCLP<br>(mg/l)       |
| Arsenic     | 1.1                    | <0.01          | <0.004               |
| Barium      | 74                     | 0.74           | 0.362                |
| Cadmium     | 2.3                    | 0.02           | 0.004                |
| Chromium    | 6.3                    | <0.01          | <0.02                |
| Copper      | 133                    | <0.02          | <0.003               |
| Lead        | 50                     | 0.13           | <0.0076              |
| Mercury     | 25,900                 | 0.01           | 0.023                |
| Nickel      | 14                     | 0.15           | <0.025               |
| Silver      | 131                    | <0.02          | <0.006               |
| Vanadium    | 0.46                   | <0.01          | <0.007               |
| Zinc        | 443                    | 1.7            | <0.013               |

Reference: USEPA 1988b.

Table C-3 Stabilization - EPA-Collected Data  
Sample Set #3

| BDAT metals | <u>Untreated waste</u> |                | <u>Treated waste</u> |
|-------------|------------------------|----------------|----------------------|
|             | Total<br>(ppm)         | TCLP<br>(mg/l) | TCLP<br>(mg/l)       |
| Arsenic     | 1.1                    | <0.01          | <0.004               |
| Barium      | 74                     | 0.74           | 0.355                |
| Cadmium     | 2.3                    | 0.02           | <0.003               |
| Chromium    | 6.3                    | <0.01          | <0.02                |
| Copper      | 133                    | <0.02          | 0.005                |
| Lead        | 50                     | 0.13           | <0.006               |
| Mercury     | 25,900                 | 0.01           | 0.0093               |
| Nickel      | 14                     | 0.15           | 0.027                |
| Silver      | 131                    | <0.02          | <0.006               |
| Vanadium    | 0.46                   | <0.01          | <0.007               |
| Zinc        | 443                    | 1.7            | <0.013               |

Reference: USEPA 1988b.

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