FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) BACKGROUND DOCUMENT (ADDENDUM) FOR ALL NONWASTEWATER FORMS OF K061 AND ALTERNATIVE BDAT TREATMENT STANDARDS FOR F006 AND K062 NONWASTEWATERS

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1. INTRODUCTION AND SUMMARY

This background document is an addendum for K061, K062, and F006 nonwastewaters[*] The purpose of this background document is to present the United States Environmental Protection Agency's (EPA's) rationale and the supporting technical information for removing the existing subcategories for K061 nonwastewaters (i.e., low zinc and high zinc) and establishing one set of treatment standards that will apply to all nonwastewater forms of K061. This background document also presents the Agency's decision for establishing alternative treatment standards for F006 and K062 nonwastewaters. The treatment standards for all nonwastewater forms of K061 and the alternative treatment standards for F006 and K062 nonwastewaters are based on a transfer of High Temperature Metals Recovery (HTMR) treatment performance used to develop the final treatment standards for K061 high zinc subcategory nonwastewaters.

In the First Third Rule (August 1988), EPA established BDAT treatment standards for the listed waste identified in Title 40, Code of Federal Regulations, Part 261.32 as K061 i.e., emission control dust/sludge from the primary production of steel in electric furnaces. In that rulemaking, EPA established two subcategories for K061 nonwastewaters based on treatment technology information, i.e., the high zinc subcategory (equal to or greater than 15 percent total zinc concentration) and the low zinc subcategory (less than 15 percent total zinc concentration). The Agency determined that zinc could be recovered on a routine basis from K061 wastes containing equal to or greater than 15 percent total zinc using a process identified as High Temperature Metals Recovery (HTMR). Hence, EPA determined that 15 percent represented

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[*] For the purpose of the Land Disposal Restrictions, nonwastewaters are defined as those wastes containing greater than 1 percent (weight basis) filterable solids or greater than 1 percent (weight basis) total organic carbon (TOC). Wastes not meeting this definition are classified as wastewaters. (Treatment standards for K061 wastewaters are presented in the Third Third Rule 55 FR 22599 and in the May 1990 K061 Addendum, which can be found in the administrative record for that rulemaking. Treatment standards for F006 nonwastewaters are presented in the First Third Rule 53 FR 31153 and in the August 1988 Final BDAT Background Document for F006. Treatment standards for K062 are presented in the First Third Rule 53 FR 31165 and in the Final BDAT Background Document for K062.

a reasonable cutoff concentration for routine recovery of zinc. The Agency determined HTMR to be Best Demonstrated Available Technology (BDAT) for K061 high zinc subcategory nonwastewaters and stabilization to be BDAT for K061 low zinc subcategory nonwastewaters.

Based on recent information, EPA believes that the cutoff level based on zinc content makes little technical sense, and that HTMR is the "best" treatment technology for both high and low K061 nonwastewaters subcategories. This determination is based on the fact that HTMR decreases the amount of material sent for land disposal, recovers valuable resources, and incorporates metals that are not recovered into an extremely stable slag matrix. Furthermore, data for HTMR of low zinc subcategory K061 nonwastewaters show that HTMR of low zinc K061 achieves the same level of treatment performance for the slag residuals as HTMR of high zinc subcategory K061 nonwastewaters. Hence, the Agency is promulgating HTMR as BDAT for all K061 nonwastewaters. Because the Agency believes HTMR to be BDAT for all K061 nonwastewaters, EPA is transferring the performance of HTMR of high zinc subcategory K061 nonwastewaters to low zinc subcategory K061 nonwastewaters. EPA notes, however, that in transferring the performance of HTMR to low zinc K061 nonwastewaters, it is not requiring that this technology be used; rather, any technology that can meet the revised treatment standards can be used, including stabilization.

The Agency is also promulgating alternative treatment standards based on HTMR as BDAT for F006 and K062 nonwastewaters and is placing them in a new regulatory section for alternative standards, i.e., 40 CFR 268.45. These alternative standards are being promulgated in order to achieve the same goal of treatment using BDAT, but generally are designed to provide alternative means of compliance with the promulgated standards. The Agency is not promulgating these treatment standards as a replacement of the existing standards for F006 and K062 wastes, but rather as alternatives since it is not known if all F006 and K062 wastes are amenable to metals recovery, and the Agency has not been able to define the universe of those wastes that are recoverable. By developing treatment standards and generic exclusion levels (shown in Tables 1-1 and 1-2) based on HTMR as alternative BDAT, EPA hopes to encourage

recovery of metals from F006 and K062 wastes that are amenable to recovery technologies. F006 is listed in 40 CFR Part 261 as wastewater treatment sludges from electroplating operations. K062 is listed as spent pickle liquor generated by steel finishing operations at facilities within the iron and steel industry (SIC codes 331 and 332). Treatment standards for both wastes codes were originally established in the First Third rulemaking. (See FR at 31152 and 31164, August 17, 1988.)

In this final rule, the Agency is not promulgating a BDAT treatment standard nor a generic exclusion level for vanadium. This decision is based on the fact that the Agency determined that its data base for vanadium is insufficient to fully characterize the performance of HTMR processes for vanadium.

The Agency is promulgating generic exclusion levels for F006 and K062 HTMR nonwastewater residues. The generic exclusion levels include all the 40 CFR Appendix VIII and indicator metals that might reasonably be expected to be present in the HTMR nonwastewater residues from processing F006, K061, and K062 wastes by HTMR. (This is consistent with RCRA section 3001(f) requiring EPA to evaluate whether toxic constituents in addition to those for which a waste is listed could make a waste hazardous.) A detailed discussion of the Agency's rationale for establishing the generic exclusion levels is presented in Section 7 of this document.

Table 1-1 BDAT Treatment Standards for K061
(All Nonwastewater Forms), and Alternative Treatment
Standards for K062 and F006 Nonwastewaters

Regulated constituent	Maximum for any single composite sample TCLP (mg/l)
Antimony	2.1
Arsenic	0.055
Barium	7.6
Beryllium	0.014
Cadmium	0.19
Chromium (Total)	0.33
Lead	0.37
Mercury	0.0090
Nickel	5.0
Selenium	0.16
Silver	0.30
Thallium	0.078
Zinc	5.3
	Maximum for any single composite sample Total Concentration (mg/kg)
Cyanide[a] (total)	1.8

[a]The treatment standard for cyanide applies only to F006 nonwastewaters.

Table 1-2 Generic Exclusion Levels for K061
(All Nonwastewater Forms), K062, and F006
HTMR Residues (Nonwastewaters)

Regulated constituent	Maximum for any single composite sample TCLP (mg/l)
Antimony	0.1
Arsenic	0.055
Barium	7.6
Beryllium	0.01
Cadmium	0.05
Chromium (total) .	0.33
Lead	0.15
Mercury	0.009
Nickel	1.0
Selenium	0.16
Silver	0.30
Thallium	0.02
Zinc	70
	Maximum for any single composite sample Total Concentration (mg/kg)
Cyanide[a] (total)	1.8

[a]The exclusion level for cyanide applies only to F006 nonwastewaters.

2. INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

2.1   Industry Affected

K061 waste is generated by the iron and steel industry and is defined as emission control dust/sludge from the primary production of steel in electric furnaces. The Agency has no new data that would change the description of the iron and steel industry contained in the Final Best Demonstrated Available Technology (BDAT) Background Document for K061 (USEPA 1988a).

F006 waste is generated as the wastewater treatment sludges from the following processes: (1) common and precious metals electroplating, except tin, zinc (segregated basis)*, aluminum, and zinc-aluminum plating on carbon steel; (2) anodizing, except sulfuric acid anodizing of aluminum; (3) chemical etching and milling, except when performed on aluminum; and (4) cleaning and stripping, except when associated with tin, zinc, and aluminum plating on carbon steel. Additional information on industries affected pertaining to F006 may be found in the final BDAT Background Document for F006 waste. The Agency has no new data that would change the description of industries generating F006 wastes other than that presented in the final BDAT Background Document for F006.

K062 waste is a product of the steel industry's steel finishing operations and is defined as the spent pickle liquor generated from these operations. Further details on industries affected with respect to K062 is contained in the Final BDAT Background Document for K062, August 1988. Additional information on industries affected pertaining to K062 may be found in the final BDAT Background Document for K062 wastes. The Agency has no new data that would change

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*   "Zinc plating (segregated basis)" refers to noncyanidic zinc plating processes. For example, wastewater treatment sludges from zinc plating using baths formulated from zinc oxide and/or sodium hydroxide would be excluded from the listing while sludges from baths from zinc cyanide and/or sodium cyanide would not be excluded. Where both cyanidic and noncyanidic baths are used, the exclusion applies to sludges from the noncyanidic processes as long as they are segregated from sludges that result from cyanidic plating processes.

the description of the industry generating K062 wastes other than that presented in the final BDAT Background Document for K062.

2.2   Waste Characterization

Waste characterization data (showing the ranges of the concentrations for the untreated wastes) for nonwastewater forms of K061, F006, and K062 wastes are presented in Tables 2-1 through 2-3. Additional pertinent information with respect to data values for the untreated waste and treatment performance data are presented in the Data Document for Characterization and HTMR Treatment Performance Data for K061, K062, and F006 Nonwastewaters. This data document may be found in the Administrative Record for this rulemaking.

Table 2-1 BDAT List Constituents Composition for Untreated K061 Nonwastewaters

BDAT List Constituent	(a)		(b)		(c)	
	Total Concentration (mg/kg)	TCLP (mg/l)	Total Concentration (mg/kg)	TCLP (mg/l)	Total Concentration (mg/kg)	TCLP (mg/l)
Antimony	5.03-294	-	-	-	284-298	2.31-3.18
Arsenic	10.2-400	<0.010-<0.095	14-120	-	24-35.4	<0.004-<0.02
Barium	24-400	0.130-1.58	<0.01-690	-	<12-33.2	0.019-0.433
Beryllium	<0.5-8.08	-	-	-	<10-0.7	0.017-0.029
Cadmium	1.35-4,988	<0.015-33.2	13-17,900	<0.1-17.1	213-231	2.7-0.122
Chromium	<0.05-106,000	<0.007-9.05	3,300-156,300	<0.1-99.5	14,900-17,500	122-183
Lead	1.29-139,000	<0.300-61.2	1,600-46,600	0.2-76	10,300-14,500	.0-1
Mercury	0.0002-41	<0.002-0.0047	<4-35	-	1.8-5.04	0.0129-0.0279
Nickel	<10-22,000	-	1,000-113,700	0.2-45	11,600-15,400	0.89-11.3
Selenium	0.068-600	<0.005-0.193	9.3-260	-	20.6-27.7	0.154-0.242
Silver	2.5-71	0.021-<0.025	<2-150	-	158-192	0.046-0.099
Thallium	0.75-50	-	-	-	<3-1.8	<0.006
Vanadium	24-475	-	-	-	389-656	2.7-5.95
Zinc	3,900-320,000	-	3,200-405,100	3.2-1,475	46,600-62,000	2.43-221
Cyanide	-	-	0.5-2.3	-	0.8-1.67	-

- no data.

Source (a)   Final BDAT Background Document for K061, August 1988 (represents 17 data sources).
Source (b)   INMETCO characterization data for K061 waste treated in 1988.
Source (c)   INMETCO characterization data for the June 1991 HTMR test for K061 and other metal-bearing waste streams.

Table 2-1 (continued)

BDAT List Constituent	(d) Total Concentration (mg/kg)	(d) TCLP (mg/l)	(e) Total Concentration (mg/kg)	(e) TCLP (mg/l)
Antimony	-	-	90-1,010	-
Arsenic	-	-	20-2,510	-
Barium	-	-	200-470	-
Beryllium	-	-	-	-
Cadmium	800-1,800	-	450-2,000	-
Chromium	25,000-102,600	-	1,900-69,500	-
Lead	6,300-48,000	-	10,300-28,500	-
Mercury	-	-	-	-
Nickel	9,200-24,900	-	300-15,000	-
Selenium	-	-	-	-
Silver	-	-	70-180	-
Thallium	-	-	-	-
Vanadium	-	-	100-830	-
Zinc	83,400-311,300	-	47,700-205,000	-

- no data.

Source (d) INMETCO characterization data (March 4, 1991) for K061 nonwastewaters for the years 1989, 1990, and 1991.

Source (e) Horsehead Resource Development Co., Inc. (HRD) submitted to EPA during the comment period for the proposed rulemaking for K061 high zinc subcategory nonwastewaters. (These data show the lowest and highest averages of the concentration compiled from the HRD data listed in five tables.)

Table 2-1   (continued)

BDAT List Constituent	(f)		(g)	
	Total Concentration (mg/kg)	TCLP (mg/l)	Total Concentration (mg/kg)	TCLP (mg/l)
Antimony	-	-	-	-
Arsenic	-	-	9-80	-
Barium	-	-	40-510	-
Beryllium	-	-	-	-
Cadmium	1,100	-	100-1,600	-
Chromium	-	-	380-6,800	-
Lead	22,500	-	6,500-72,500	-
Mercury	-	-	1-29	-
Nickel	-	-	20-600	-
Selenium	-	-	0-17	-
Silver	-	-	10-168	-
Thallium	-	-	-	-
Vanadium	-	-	-	-
Zinc	138,400	-	50,000-508,000	-

- no data.

Source (f)   International Mill Service (IMS) data dated February 2, 1990.
Source (g)   Report for the Center for Metals Production by Horsehead Resource Development Co., Inc. (HRD), August 1988.

Table 2-2 BDAT List Constituents Composition for Untreated F006 Nonwastewaters

BDAT List Constituent	(a)		(b)		(c)	
	Total Concentration (mg/kg)	TCLP (mg/l)	Total Concentration (mg/kg)	TCLP (mg/l)	Total Concentration (mg/kg)	TCLP (mg/l)
Antimony	<10-22.4	-	<6-31	<0.06	<4-380	2.85-3.15
Arsenic	<0.4-5	-	3-30	<0.004	<0.4-<0.4	<0.004
Barium	0.74-85.5	-	<1-9.4	0.43-0.46	<3-270	<0.006-0.042
Beryllium	<0.1-<97.6	-	-	-	<0.3-<1	<0.005
Cadmium	0.003-22,000	-	-	<0.005-0.014	4.4-8.47	0.03-0.249
Chromium ·	<0.002-290,000	-	1,500-136,000	<0.01-2.7	565-853	0.088-0.101
Lead	<0.001-24,500	-	500-2,900	0.17-0.21	89-159	0.23-0.36
Mercury	<0.2-<1	-	<0.04-0.3	<0.0002	<0.1-0.469	<0.0002-0.0037
Nickel	0.06-170,000	-	53,400-416,000	680-920	248,000-289,000	169-1,780
Selenium	<0.03-<23	-	<1	<0.004	<0.3	<0.003
Silver	0.51-38.9	-	1.8-2.5	0.012-0.038	<0.5-11.4	<0.005-0.008
Thallium	<10-<20	-	-	0.025	<0.6	<0.006
Vanadium	1.26	-	-	-	<1.1-4.3	<0.011
Zinc	8.86-90,200	-	200-148,200	0.5-749	196,000-218,000	1,140-1,180
Cyanide (total)	<0.025-1,970	-	4.3-184	0.16-0.18	0.88-0.63	-

- no data.

Source (a)   Final BDAT Background Document for F006, August 1988 (represents 7 data sources).
Source (b)   INMETCO characterization data for F006 waste treated in 1988.
Source (c)   INMETCO characterization data for the June 1991 HTMR test for F006 and other metal-bearing waste streams.

Table 2-3 BDAT List Constituents Composition for Untreated K062 Nonwastewaters

BDAT List Constituent	(a) Total Concentration (mg/kg)	(a) TCLP (mg/l)	(b) Total Concentration (mg/kg)	(b) TCLP (mg/l)	(c) Total Concentration (mg/kg)	(c) TCLP (mg/l)
Antimony	-	-	-	-	423-1,170	0.08-0.41
Arsenic	<0.1-3	-	<2-184	-	16-22.1	<0.004-<0.008
Barium	<10	-	<0.01-<100	-	<16-236	<0.098-0.112
Beryllium	-	-	-	-	<0.3-<13	<0.005
Cadmium	<5	-	<2-4.7	0.01-0.07	11-11.8	0.018-1.14
Chromium	2-12,400	-	45,500-171,000	0.6-47.9	3,570-19,400	0.541-23
Lead	0.12-1,550	-	500-5,900	0.1-0.3	196-200	0-0.12
Mercury	-	-	-	-	0.79-1.3	<0.0002-0.0003
Nickel	4-100,310	-	26,600-85,000	1.9-669	9,790-153,000	1-10.5
Selenium	-	-	-	-	<2-7.9	<0.003-<0.015
Silver	-	-	-	-	5.4-6.8	0.022-0.024
Thallium	-	-	-	-	<4	<0.006
Vanadium	-	-	-	-	149-169	<0.011-0.29
Zinc	<0.4-9	-	190-22,000	0.1-3.7	572-601	0.854-1.08
Cyanide (total)	-	-	0.7-1.7	-	3.4-7.73	-

- no data.
Source (a)   Final BDAT Background Document for K062, August 1988.
Source (b)   INMETCO characterization data for K062 waste treated in 1988.
Source (c)   INMETCO characterization data for the June 1991 HTMR test for K062 and other metal-bearing waste streams.

3. APPLICABLE AND DEMONSTRATED METALS RECOVERY TECHNOLOGIES AND IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY

This section presents the discussion of the applicable and demonstrated metals recovery technologies for K061. These technologies are also applicable to some forms of F006 and K062 nonwastewaters. (The Agency is promulgating alternative treatment standards as opposed to revised standards because it is not known if all F006 and K062 nonwastewaters are amenable to metals recovery.) This section also discusses the Agency's determination of HTMR as BDAT for K061 nonwastewaters (all nonwastewater forms) and EPA's decision to promulgate HTMR as an alternative BDAT for F006 and K062 nonwastewaters.

3.1   Applicable Recovery Technologies

The metals recovery technologies applicable for treatment of K061 nonwastewaters and some forms of F006 and K062 nonwastewaters are those that reduce the concentration of the BDAT list metal constituents* in the treated residuals and which can generate residuals that are resistant to leaching of metals. The following recovery processes have been determined to be applicable for recovery of metal constituents present in K061 nonwastewaters and in some forms of F006 and K062 nonwastewaters.

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* Although copper is not one of the metals being regulated in K061, K062, or F006 wastes, the Agency notes that there are numerous treatment processes available for the recovery of copper from metal-bearing waste streams (e.g., copper waste streams generated from operations such as electroplating and circuit board manufacturing). HTMR is one technology that has been used to recover copper from metal-bearing waste streams. Information available to the Agency indicates that the St. Joe Company's HTMR flame reactor process (now operated by Horsehead Resource Development Company, Inc.) has been successful at recovering a salable copper-nickel-cobalt alloy from one of its internal waste streams. For copper-bearing wastewater streams, there are numerous conventional treatment technologies that include the following: evaporation, electrowinning, electrodialysis, reverse osmosis, and ion exchange. All of these technologies generally operate on the basic principle that they concentrate the dragged-out plating solution (from electroplating waste streams, for example) from the rinse water to a degree that the solution can be returned to the plating bath.

3.1.1 Recycling

Recycling is applicable to K061 nonwastewaters. Recycling of K061 directly back into the electric furnace from which it was originally produced facilitates the recovery of the metals for steelmaking while reducing or eliminating the material to be land disposed.

3.1.2 Pyrometallurgical Recovery Processes

The pyrometallurgical processes discussed are generally relative to their applicability to K061 nonwastewaters. These processes are also applicable to some forms of F006 and K062 metal-bearing nonwastewaters. Pyrometallurgical recovery processes employ physical and chemical reactions at elevated temperatures for the extraction/separation of metals from ores and other materials. Pyrometallurgical recovery process are referred to as High Temperature Metals Recovery (HTMR) for purposes of the land disposal restrictions program.

HTMR is similar to recycling in that it is used to recover metals from K061, F006, and K062 nonwastewaters for reuse, and it reduces the concentration, leachability, and volume of waste to be land disposed. Some examples of HTMR systems include rotary kilns, flame reactors, electric furnaces, plasma arc furnaces, slag reactors, and rotary hearth/electric furnaces. The following are descriptions of specific HTMR processes that may be used to recover metal constituents from K061, F006, and K062 nonwastewaters.

Davy McKee Hi-Plas Furnace

The Davy McKee Hi-Plas Furnace is a unique design that features a proprietary sleeve reactor that surrounds a long direct current (dc) transferred arc. In the Davy McKee Hi-Plas furnace, an argon stabilized dc transferred arc is struck between the nonconsumable water-cooled cathode gun and the molten pool of reactants in the furnace hearth in contact with the anode in the bottom of the furnace. The plasma column passes down a water-cooled reaction sleeve or cyclone reactor that surrounds a substantial length of the arc column. Reactants are injected tangentially into the

sleeve at a number of points above the plasma gun tip and with a sufficiently high velocity to form a uniform covering to the inner wall of the reaction sleeve. Radiant and convected heat from the arc melts the reactants to form a film of molten material flowing down the inner wall of the sleeve. The molten material then drops into the furnace hearth region where the reaction is completed in the molten bath heated by the impingement of the plasma column, which is used in the melting and smelting reactions. Radiation to the furnace walls and roof is minimized. The process is controlled by adjusting the arc power and the material feed rate.

Since the plasma torch is remotely located from the hot furnace reactants, the torch is not exposed to damage by splashing and hot fumes. The resulting long arc is stabilized by the vortex action of the injection and reaction gases in the sleeve reactor. Arc instability caused by the turbulent gases in the smelting furnace is thereby avoided.

In the process, the electric arc furnace (EAF) dust is mixed with coke and flux before being pneumatically fed into the furnace where smelting occurs. The metal oxide content of the dust is reduced at the melting temperature of about 2912°F (1600°C). A slag and the nonvolatile metals are recovered in the furnace hearth and are intermittently tapped from the furnace. The metal is recycled to the EAF, and the slag is disposed of in the same way as EAF slag.

Volatile metals such as zinc and lead are recovered from the furnace gas in a zinc splash condenser (a refractory-lined box containing a pool of molten zinc). In the condenser, the impeller of a vertical rotor is immersed in the zinc and when rotated creates a spray of fine zinc droplets. Zinc and lead vapors passing through the chamber condense on the fine droplets. Proper temperature of the zinc bath is maintained via an immersed water-cooled coil. The remaining gases leave the condenser and are combusted and cooled with excess air prior to being cleaned in a baghouse.

If an EAF scrubber slurry is being processed, it is dried prior to treatment in the furnace. In this case, the slurry is normally dried using the furnace gas from the Hi-Plas Furnace. Particulate carryover from the furnace to the zinc condenser reduces both the condenser's efficiency and the recovery of zinc and lead. Minimizing dust carryover is therefore very important. The advantage of the Hi-Plas Furnace over other systems is said to be the use of the sleeve reactor. Because the dust enters at the top of the sleeve, it is forced to the energy from the arc. Injecting the dust tangentially into the sleeve forces the dust to the inner wall where it will stick to the molten product running down the walls. This molten product drops off the bottom of the sleeve to form a falling curtain of material around the arc. The process gases

have to pass through the curtain to exit the furnace, and in doing so there is a further opportunity for dust removal.

Elkem's Electric Furnace Process

Elkem's EAF dust processing basically consists of four principal areas that are interconnected to form a complete stand-alone plant. These areas are (1) feed receiving storage and preparation, (2) thermal processing, (3) zinc condensing and casting, and (4) off-gas treatment and recycling.

In the Elkem process, EAF dust collected from Elkem's steel mill is prepared as briquettes for feed to Elkem's "Multi-Purpose Furnace." Elkem's Multi-Purpose Furnace is equipped with a self-replacing frozen slag liner which is the central component of the EAF dust processing system. The furnace is an airtight, three-electrode, slag resistance furnace, circular in design and equipped with an automatic slag-tapping flow control module. A short off-gas outlet flue is provided in the upper part of the furnace body immediately beneath the roof. Furnace off-gases, including metallic fumes, exit the furnace through the flue and enter the zinc condenser. The furnace operating temperatures are as follows: slag 2642°F (1450°C), off-gas 2012°F (1100°C), and molten metal 2732°F (1500°C) after carburization.

The major thermal movement within the bath is an upward direction from the electrodes, across the upper surface of the melt to the frozen slag side walls, and downward to the metal accumulation in the furnace hearth. This movement constantly melts and erodes the bottom of the feed layer into the slag and provides an active slag homogenizing action through thermal stirring, ensuring that nonvolatile elements remain encapsulated in the slag in a silica matrix. The furnace off-gas contains virtually no dust carryover from the raw feed material. Reacted components of the off-gas are volatilized metallic fume (zinc, lead, and cadmium), together with carbon monoxide and carbon dioxide. Small quantities of halides are also in the fume, mainly potassium chloride and sodium chloride.

The next principal area of the Elkem process involves zinc condensing and processing. Off-gas from the furnace operating at a temperature of 2012°F (1100°C) enters the condenser, where zinc is condensed. Lead volatilized in the furnace is also condensed in the zinc spray. It leaves the condenser, together with the molten zinc, through an underflow at the end of the condenser and enters a skimming sump. Periodically, zinc is transferred from the sump to a "liquation" bath. In the liquation bath, lead separates from the zinc into a lower layer. The zinc then overflows into a casting bath, where its temperature is increased to 932°F (500°C), which is suitable for tapping and casting into shapes as may be required for sale or in-plant use. Lead

accumulating in the liquation bath is pumped out periodically and cast into blocks for sale. Any iron entering the condenser dissolves in the zinc and is separated in the liquation as an intermediate alloy, "hard metal." It is periodically removed manually and recycled backed through the plant feed systems.

The next principal area of the Elkem process is the handling of the off-gas. Any uncaptured zinc, along with other components of the gas, leaves the condenser and enters the gas washing tower. Here most particulates are removed and collected in a sludge, which together with water is pumped into a clarifier. Gases leaving the washing tower, mostly carbon monoxide and carbon dioxide with minor quantities of remaining particulate, go to a Venturi scrubber. The gaseous discharge from the Venturi scrubber is then sent to a demister, where water reclaimed from the clarifier overflow is used for the second stage of scrubbing. The resultant Venturi scrubber and demister water is collected, and the captured particulates are pumped back to the gas washing tower. Remaining gases are passed through a thermal oxidizer to convert the carbon monoxide to carbon dioxide, then to a quench tower for cooling, and then to a baghouse. Liquid effluent from the quench tower is sent to the clarifier overflow sump and pumped back to the clarifier. A bleed stream from the clarifier overflow is periodically pumped to a water treatment facility before final discharge.

The clarifier underflow, containing mostly zinc and lead oxides, is filtered, and the filter cake is periodically returned to the plant feed system for drying and recycling. Any liquids are returned to the clarifier.

Enviroscience Company

Enviroscience Company uses an Cupola furnace in its high temperature metals recovery process. The Cupola furnace operates at 2800°F and produces a fully molten slag. Their HTMR process consist of blending liquids; semi solid; and solid F, D and or K series wastes to produce a chemical formation that can be smelted into metal alloys, metal oxides, and mineral wool of commercial value. The mineral wool can be used as a substitute for fiber glass. Also, zinc oxide is collected from the baghouse and sent to a refiner. Additional information on the Enviroscience HTMR process is included in the Administrative Record.

Horsehead Resource Development Company, Inc. (HRD) Series of Waelz Kilns Process

The waelz kiln is a type of rotary kiln. The term waelz is derived from the German word "waelzan," which means to trundle or roll—an accurate description of the movement of the charges through the rotating kiln. A series of waelz kilns is used

by Horsehead Resource Development Company, Inc. (HRD) to process electric arc furnace dust (averaging 18 to 19 percent zinc). Waelzing of the K061 dust is accomplished by mixing coal and appropriate amounts of limestone and silica "fluxes" to maintain the desired kiln conditions.

In the waelz kiln process, the first kiln is heated to 2372°F (1300°C). Excess carbon in the kiln bed ensures that 95 percent of the zinc is reduced to metal and volatilized along with substantial amounts of the cadmium and lead present. The volatilized metals are reoxidized in the gas stream above the bed and collected as crude oxide in a baghouse. (These materials also are stored in open piles before being calcined.) The iron-rich residual materials (IRM) are discharged continuously from the opposite end of the first kiln as granular, porous, nonvitrified slag. HRD then further purifies the crude zinc oxide by processing it in a calcining kiln to selectively volatilize cadmium, lead, chlorine, and fluorine, separating them from the zinc oxide. The calcining kilns used by HRD can be physically identical to the waelz kilns. When a kiln is operated as a calcining kiln, it is fed directly with the crude zinc oxide without coal or flux additions. No reduction takes place in the second (calcining) kiln, and all heat is provided by a natural gas or oil burner to heat the kiln to 1292-1832°F (700-1000°C). The lead and cadmium are volatilized as oxides, sulfides, sulfates, and/or chlorides in an oxidizing atmosphere. Apparently, much of the zinc chloride present or formed in the kiln reacts with lead and cadmium oxides, contributing to the efficiency of the refining step. If a purer zinc oxide product is required, the temperature and/or residence time of the kiln can be increased. This calcined material is then sent to Zinc Corporation of America (ZCA) to be smelted. It is normally not capable of being used as a product as is, but rather requires smelting to recover usable zinc.

The volatilized product of the calcining kiln, often referred to as the lead or lead cadmium concentrate, is collected in a baghouse. This material is carefully bagged in containers and is currently sent to an HRD facility in Bartlesville, Oklahoma, for processing and recovery of both the lead and cadmium values.

Horsehead Resource Development Company, Inc. (HRD) Flame Reactor Process

Horsehead Resource Development Company, Inc. (HRD) uses a flame reactor process that is a two-stage, carbon-fueled, flash-smelting system that efficiently recovers zinc, lead, and cadmium as a recyclable crude oxide and produces a slag that HRD states is nonhazardous. In summary, the process generally involves the following steps.

Fine coal, coke breeze, or natural gas is pneumatically injected into a water-cooled burner (first stage of the reactor) and intensively mixed and reacted with oxygen-enriched air (40 to 70 percent oxygen) under fuel-rich conditions at a temperature greater than 3632°F (2000°C) to produce a hot reducing gas. Then, the fine, dry metallurgical feed is pneumatically injected into the hot reducing gas stream in a second water-cooled stage to reduce zinc, lead, and cadmium compounds to metal vapors at 2912°F (1600°C) in a high-velocity particle-flame suspension.

Lead- and cadmium-free molten slag flows along with the combustion gases through the reactor. A portion of the slag freezes on the water-cooled reactor walls to form a protective layer on which the molten slag flows down into a horizontal gas/liquid separator, where it is separated from the reactor gases. The slag is then tapped, cooled, and sold as an iron-rich aggregate. Zinc, lead, and cadmium are recovered as crude, heavy metal oxide, marketable as a feedstock to industry.

According to the report from the Center for Metals Production for the "Flame Reactor Process for Electric Arc Furnace Dust" by HRD (August 1988), the crude zinc oxides produced from EAF dust processed in the flame reactor would probably not meet the feed specification for the zinc smelter of Zinc Corporation of America (ZCA). Thus, in the case of the flame reactor's zinc oxide, an upgrading step must be used to achieve the desired specifications for smelting. The report indicated that a caustic leaching process is HRD's preferred method for upgrading the crude zinc oxide.

International Metals Reclamation Company (INMETCO) Rotary Hearth Furnace Followed by Electric Furnace

INMETCO (Ellwood City, Pennsylvania) uses a rotary hearth furnace and an electric furnace in its HTMR processing of EAF dust (K061) and other metal-bearing waste streams. INMETCO uses these waste streams concentrated in nickel, chromium, and iron as feedstocks to produce chromium/nickel/iron remelt alloy which is used as a feedstock to produce stainless steel. This process is most effective in recovering wastes that ordinarily contain 1.5 percent or greater chromium/nickel combination.

In general, the pyrometallurgical process consists of the following four basic steps: (1) feed preparation, (2) reduction, (3) smelting, and (4) metal casting. The first step of the process involves blending determined quantities of nickel, chromium, and iron wastes with a reducing agent (i.e., coke or coal) and additives that are used to develop the slag matrix (i.e., lime and magnesia). All feed materials have been pretreated to ensure a uniform size. The mixture of feed materials is pelletized to

produce pellets strong enough to resist disintegration in the subsequent thermal operations.

The second step in the process involves partial reduction of the metal oxides in a rotary hearth furnace operating at 2300°F. During this stage, portions of the zinc, cadmium, and lead volatilize (approximately 50 percent of those metals that are present in the feed) and are discharged to a baghouse. Next, the sintered pellets are melted in an electric arc smelting furnace with an average metal temperature of 2720°F and an average slag temperature of 2940°F. Lime, silica, alumina, and magnesia separate to form the liquid slag, which floats on the surface of the arc furnace; the remaining zinc, cadmium, and lead volatilize; the gas containing these volatilized materials is discharged to a wet scrubber. The metal remaining after the slag is removed is poured into a refractory-lined ladle from which it is cast into "pigs," which are sold to steel mills. The wastes generated from the treatment of the off-gas streams are sent as K061 hazardous waste (i.e., manifested as K061) to another facility to recover the zinc, lead, and cadmium. The slag is air cooled as it is poured down a sand ramp and then is used as road aggregate.

International Mill Service (IMS) Plasma Furnace

International Mill Service (IMS) Incorporated uses a plasma furnace to process K061 EAF dust. In the IMS process, the electric arc furnace dust (K061) feedstock is transported through a totally enclosed conveyance system from the IMS electric furnace baghouse (from the production of steel). The EAF dust is then blended with a coke breeze or coal fines reductant and metered into the plasma furnace vessel by two conveying screws. The metallurgic endothermic reactions occur at high temperatures. The energy required is supplied by a hollow, direct current graphite electrode. Argon or nitrogen gas is blown through the middle of the electrode to provide a path for electrical energy transfer, as well as for arc stabilization. The current passes from the electrode to the anodes fixed in the bottom of the furnace hearth.

The resulting bath is operated within a temperature range of 2522° to 2732°F (1400° to 1500°C) to ensure that the reduction reaction occurs. Within the metallurgical process, iron is only partially reduced in the furnace and will remain in the hearth in its oxide state as a slag. In this temperature range, the zinc, cadmium, and lead will vaporize off the bath. All remaining elements remain in the furnace as a slag and are tapped on an as-required basis. The metal vapors, as well as the mix of emitted carbon monoxide and carbon dioxide gases, pass through a hole in the top of the furnace roof to the "zinc splash condenser" through a refractory-lined duct.

The metal vapors and carbon monoxide/carbon dioxide gas mixture enter the condenser, where they are rapidly cooled to ensure condensation. As the metallic vapors are condensed into their molten states, the zinc and lead reportedly exist as two separate liquid phases. Because of the higher density of the lead, it sinks to the bottom of the condenser into a "liquation" vessel, where controlled cooling occurs. The molten zinc is cooled and held at 968° to 851°F to facilitate final separation of the zinc and lead for quality purposes. The zinc is poured into molds, and the zinc-rich lead at the bottom of the vessel is cast into separate molds as a secondary product.

The carbon monoxide and carbon dioxide gas mixture and any remaining metallic vapors enter an afterburner upon exiting the condenser main chamber. They are mixed with outside air, the remaining metallic vapors are oxidized, and the carbon monoxide is burned to its stable state of carbon dioxide. Dilution air is added downstream of the carbon monoxide burner to cool the gas mixture prior to its entering a baghouse. The cooled streams from the afterburner (less than 270°F (132°C)) enter the baghouse. The particulate metallic oxides formed in the afterburner are collected in the baghouse and recycled back to the furnace for further recovery of metallics.

SKF Plasmadust Process

The Plasmadust process was developed by SKF Plasma Technologies AB in Sweden for processing electric arc furnace baghouse dust (K061) and similar waste oxides from the steel industry. The dust is decomposed in the process, and the metals in it are recovered. According to SKF Plasma Technologies, the Plasmadust process has the capability to effectively treat dusts from both carbon and alloy steelmaking.

In general, in the SKF Plasmadust process, the dust is mixed with coal powder, sand, and internally recycled process wastes. This mix is then injected pneumatically into the lower part of a coke-filled shaft furnace provided with three plasma generators that supply the thermal energy needed to reduce the metal oxides in the dust. Consequently, there are three separate reaction zones in the coke column. The injected material mix is heated by the plasma gas generated by the plasma generator, which converts the electrical energy to highly concentrated thermal energy in the form of gas. The material mix is melted and reduced in the three reaction zones. Molten iron and slag drop down through the coke column and collect in the hearth. The iron is tapped at a temperature of about 2552°F (1400°C); the slag, which floats on the iron, is tapped at a somewhat higher temperature. The molten iron is cast into pigs or other shapes before shipping back to steel mills for resmelting. Zinc, lead, and cadmium from the original furnace feed dust leave the furnace as metal vapors

in the off-gases. The slag is well reduced and has a very low content of volatile metals.

Sumitomo Molten Slag Reactor Process

The Nippon Magnetic Dressing Co.; an agent for Sumitomo Corporation of America, uses molten slag to process EAF dust (K061). Generally, the process involves the following steps. The EAF dust and coal fines are pelletized, dried, and preheated with a chemical modifier called "Fukenite." Exhaust gas from the subsequent reactor is used to dry and preheat the feed mix. The feed mix is then injected into the reactor for reduction. The heat necessary to proceed with the reduction is partially provided by an oil burner. Heavy metals are dissolved simultaneously with the molten slag and a modifier (Fukenite) and then fixed within the granulated slag. Less volatile metals become incorporated into the slag that is formed. More volatile metals such as zinc are volatilized. The volatilized zinc gas stream is cooled, and the zinc is recovered in a baghouse. The zinc content of the baghouse dust is around 45 percent.

Ticron Corporation

Ticron Corporation uses an Extended Plasma Arc HTMR process for processing EAF dust (K061) and other metal bearing waste streams. Ticron states that their process can be installed on-site and be an extension of the principal steel melting operations as an adjunct to the existing baghouse and dust filtering system. Ticron states that its process can yield metals of commercial grade.

The Ticron process operates by employing a standard AC three phase electric arc steel making furnace which has been scaled up to a one mega watt unit. A stable extended plasma arc is achieved which sustains a processing temperature of more than 5000°C between extended electrodes, with furnace temperatures of 1500 to 1700°C. Ticron states that the plasma processing zone is more than a meter in diameter and generates uniform heat transfer that is diffused throughout the furnace cavity. The non-turbulent internal processing environment is stated to be especially well suited to treating ore fines, dust and other particulates without pelletizing or sinterring. Ticron adds that another benefit of their process is low electrode consumption and refractory wear.

ZIA Technologies

The HTMR processing of K061 by ZIA Technologies is performed in an Inclined Rotary Reduction System (IRRS). In the HTMR IRRS process, electric arc furnace dust is mixed with a small amount of binder and pulverized coal to provide sufficient reductant (carbon) for the reduction of metal oxides. The resulting mixture is fed onto a standard pelletizing disk to produce 3/8- to 1/2-inch pellets. Before the mixture is fed to the pelletizer, the dust, pulverized coal, and binder are all transported pneumatically or in screw conveyors to prevent dust from escaping to the atmosphere. The "greenball" pellets are next conveyed by belt directly to the IRRS furnace, which is essentially a specially designed kiln fired by an oxy-fuel burner. Under controlled conditions of temperature and atmosphere, the pellets are heated, the moisture and volatile matter contained in the coal are driven off, and the pellet temperature is raised to the level needed for the reduction reactions to occur. The pellets are heated in the rotating IRRS furnace to a maximum temperature of 1150°F (2102°C). (Exceeding 2102°F would result in melting of the pellet surface and sticking of pellets into lumps or formation of rings in the kiln.) When the temperatures are kept below 2102°F, the formation of zinc chloride is prevented. Zinc chloride can be detrimental to the ultimate condensation of zinc metal.

At approximately 1652°F (900°C), reduction of the metallic oxides of lead, zinc, cadmium, and iron begins to occur. At this temperature, the reduced zinc, lead, and cadmium are vaporized and carried as a metallic vapor in the off-gas stream. The iron, contained as oxide in the pellet, is reduced to metallic form and remains in the pellet, together with various slag-forming compounds that came from the electric arc furnace as part of the dust. The pellet is now a form of direct reduction iron (DRI) from which virtually all the other metals have been removed, and which also contains a significant portion of the slagmaking materials needed to refine steel. The DRI pellets, which are self-fluxing, are discharged from the IRRS furnace directly into a water bath for quenching to a temperature below the ignition point to avoid reoxidation. The water quench bath also acts as an atmospheric seal enabling continuous withdrawal of the iron-containing pellets while avoiding the entry of large quantities of air to the zinc vapor-containing exhaust gas stream.

ZIA states that the reduced iron pellets are then suitable for charging directly back into an electric arc furnace to reclaim those iron units that were previously lost with the waste dust. Copper and sulfur impurities contained in the charged pellets remain with the pellets.

The off-gases from the IRRS furnace are comprised of zinc, lead, and cadmium metal vapors, evaporated pellet moisture, volatile matter driven from the coal in the pellets, and the products of combustion. The off-gases exit the IRRS furnace directly into

the afterburner and retort section of the system. This off-gas stream may also contain a small amount of product dust which results from minor pellet degradation caused by the rotary action of the furnace. Air is admitted to the afterburner system to reoxidize the metal vapors and to combust any carbon monoxide gas and volatile matter from the coal. The amount of air is also adjusted to control the afterburner temperature to a maximum of 2012°F (1100°C). The hot gases circulate around the retort and provide the energy needed to drive the secondary reduction process (described below). The hot gases then proceed through a section of duct where they are cooled by radiation before entering cartridge-type filter units. It is in these filter units that the metal oxides and any product dust are collected prior to discharge of the products of combustion to the atmosphere. Cartridge filters were chosen over a more typical baghouse because of the inherently higher efficiency. Dilution air is also introduced into the off-gas stream following the retort section to further assist in reducing the waste-gas temperature. .

After all of the volatile metals removed from the electric arc furnace dust and concentrated as an enriched zinc oxide dust, the next stage is the production of Prime Western Grade zinc. Except for trace carryover amounts, any undesirable elements to this operation (chlorides and iron) are retained in the fluxed iron pellets. Rather than combining reduction and condensation in one process, two separate operations are employed. By allowing the IRRS furnace to reduce the oxides and then collect the concentrated reoxidized metals, the concentrated material can then be repelletized with coal (carbon) as the reductant together with a binder. These pellets are then reduced in a vertical retort to form a concentrated metal vapor stream. By using a vertical retort technology with its low waste gas volume, no iron or copper dust is carried over to contaminate the product from the condensation process. The off-gas stream from the vertical retort is essentially pure zinc, lead, and cadmium vapors. To make this two-step technology economically viable, a retort was built inside the final stage of the afterburner where an excess of high temperature energy existed that had to be removed prior to admitting the IRRS furnace off-gas stream to the filters. To eliminate the need to preheat the oxide pellets and precoke them prior to entering the retort, a retort with two outlets was developed. The upper outlet vents the moisture driven off from the "greenball" pellets, as well as the volatile matter evolved from the coal during the drying and pre-heating stage. These gases are ducted back into the afterburner, where they are combusted.

A second outlet is provided at the point where pellet temperature inside the retort reaches approximately 1652°F (900°C). Metal vapors exit the retort from the second outlet and are ducted to a standard Imperial Smelting Process (ISP) zinc splash condenser. If some heavy metal vapors form above this second outlet, they will condense on the colder material above and will be refluxed back down the retort to the higher vaporizing temperature zone. It is important that no water vapor is

allowed to reach the vapor outlet because water vapor would permit the reoxidation of metal vapors and reduce the overall efficiency of condensation. Metal vapors that pass through the splash condenser without condensing are ducted back to the afterburner for reoxidation and collection. Because of the closed-loop design, all zinc and lead eventually have to exit the process as a condensed material. The residue remaining in the retort after reduction exits the bottom of the retort column, is cooled and then sent back to the beginning of the process where it is pulverized and reintroduced as part of the primary pellet feed. In this way, any leachable metals that were not reduced and removed in the vertical retort are circulated back through the system until 100 percent of the leachable metals are recovered. The remainder of the residue ends up as the slag constituent of the DRI pellets and returns to the electric arc furnace, where it is removed as furnace slag. The slag component of the pellets is the same as the material used for making electric arc furnace slag. It can be used to replace that amount of material normally added to the furnace so that furnace slag volume remains unchanged.

3.1.3   Hydrometallurgical Recovery Processes

Hydrometallurgical recovery processes extract and recover metals from materials by processes in which solutions play a predominant role. Some hydrometallurgical processes include chemical precipitation, leaching, ion exchange, solvent extraction, and electrowinning.

The Agency has limited information indicating that some facilities are using a series of technologies, which include chemical precipitation, ion exchange, and electrowinning, to recover from waste materials the same metals present in K061 wastes. These hydrometallurgical technologies may also be applicable for recovering metals from other metal-bearing waste streams such as F006 and K062 wastes. Some of these facilities claim that these hydrometallurgical processes, unlike other processes, could generate no residues for land disposal. The Agency notes that the concentration-based treatment standards are based on BDAT, i.e., HTMR; however, non-HTMR recovery processes are not precluded from being used to achieve the concentration-based treatment standards, provided the standards are not achieved through the use of impermissible dilution.

Encycle Texas

In Encycle's hydrometallurgical process there are two major options for processing K061 dust: (1) by a sulfuric acid-based process and (2) by a caustic leach process.

Acid Process: In the acid-based process, the metals are solubilized at a low pH (near 1). Metals are then removed from solution by chemical precipitation, crystallization, and/or electrowinning. For example, the iron is primarily present in the ferric state and can be selectively precipitated from solution at a pH of about 3. The purity of this floc can be controlled by washing and subsequent processing. The ferric hydroxide is then removed by various solid/liquid separation techniques such as filtration.

The recovered ferric hydroxide can then be used directly in such applications as paint pigments or it can be made into a variety of products. If further refining is required, the ferric hydroxide can be solubilized in sulfuric acid and then recrystallized as ferric sulfate. The crystallization is controlled to improve product quality and minimize impurities. Alternatively, the recovered ferric hydroxide is blended with a reductant, such as coke breeze, and fluxing agents, such as lime, and then agglomerated, for instance, by pelletization, to produce a feedstock for direct-iron reduction typically carried out in HTMR processes.

The lead and zinc remaining in solution are then removed by chemical precipitation as a hydroxide with a base (lime, caustic, etc.) or as a carbonate with either sodium carbonate or carbon dioxide, as a sulfide using sodium sulfide or hydrogen sulfide, or as a sulfate using an evaporator/crystallizer.

The nickel and/or chrome solubilized in the acid leach is then extracted. A variety of technologies are available for this processing. Nickel is removed by standard, commercially available, ion-exchange resins in which the solution is passed through these resins. The resins initially adsorb both zinc and nickel. However, as the resins become fully loaded, nickel crowds out the zinc. The resins are staged in sequential order based on the level of loading. Once a resin is fully loaded, it is stripped of the nickel by a strong acid wash, usually sulfuric acid. The resulting nickel solution can be processed to produce a wide variety of nickel products including nickel sulfate, nickel metal, nickel hydroxide, and nickel chloride. Each of these end products produces various amounts of residuals depending on the purity of the product and process employed.

The chrome in solution can be isolated from the other metals by oxidizing it to the hexavalent state and then raising the pH of the solution to around 9 to remove the other metals present (via filtration). The resulting hexavalent chrome can then be reduced to produce chrome hydroxide, a chrome-ore substitute, or it can be converted into a variety of chrome chemicals such as sodium dichromate.

<u>Caustic Leach Process</u>: The other basic technique for processing K061 dust is to perform a caustic leach on the dust to solubilize the zinc as a zincate. Zinc is removed from this solution as metal by electrowinning (or as a hydroxide by adjusting the pH downward to about 8.5 with an acid).

The iron, nickel, and chrome left behind in the solid is then processed by techniques similar to those in the acid leach process.

Metals Recycling Technologies Corporation (MRTC) Process

This process involves placing K061 and potentially other metal-bearing waste systems into a heated ammonium chloride solution. The metallic oxides, with the exception of iron oxide and a small amount of sand, are soluble in the ammonium chloride solution. The iron and sand are filtered into a reusable cake form, which can be resmelted by the steel manufacturers. The filtrate solution contains metallic oxides. Zinc dust is added to the filtrate solution, cementing out all metals except zinc oxide. The remaining zinc oxide is crystallized out and the filtrate liquor is reused in the next batch.

Approximately 95 percent of the original ammonium chloride solution remains following the process and is reused in the batch process. The remaining ammonium chloride solution binds to the zinc oxide crystals and the iron filter cake. It is then removed by washing; MRTC expects that the resultant wash water can then be reused in the recycling process.

Recontek

In the first stage of Recontek's processing, industrial wastes are classified into four groups: acids, cyanides, alkalines, and solids. The wastes are separated and stored in four different storage areas based on waste type. Thermal decomposition is then used for the destruction of cyanide. At this point, the treated cyanide wastes are combined with acid, alkaline, and solid waste streams to form a metal-rich solution. The types and concentration of metals in the solution are controlled by mixing and matching the storage tanks from which the ingredients are selected. In the next stage, water is distilled from the solution to concentrate the precious and base metals, and the solution is then sent to the precious metals refinery for final purification into gold, silver, platinum, and palladium.

Next, any iron is precipitated from the solution and converted into ferrous sulfate for use in the water purification or fertilizer industries. An electrowin cell house is then used to recover copper and tin metal from the solution. After electrowinning, the solution is

concentrated and nickel is crystallized as nickel sulfate. The nickel sulfate can then be reused by the plating industry.

Chromium is then precipitated from the remaining solution by controlling both the pH and the oxidation-reduction potential (ORP) of the solution. The precipitated chromium is filtered, washed, and dried. The chromium can then be sold as an additive for the stainless steel industry. A "zinc cementation" process is used on the remaining solution for extraction of cadmium, which can then be sold to cadmium refiners. Zinc remains in solution and is then electrowinned in a manner similar to that used for copper. The recovered zinc can be sent to zinc smelters for sale. "Magnesium cementation" is used to recover trace metals, and the residual solution is converted back to usable acid and sodium hydroxide, which are reused in the process or sold.

3.2 Demonstrated Treatment Technologies

EPA considers a technology demonstrated if it is or has been used on a commercial basis. Based on available information, waelz kilns, flame reactors, plasma furnaces, electric furnaces, and combination rotary hearth/electric furnaces have been demonstrated for K061 nonwastewaters and for some F006 and K062 nonwastewater streams.

With respect to the HTMR processes (i.e., pyrometallurgical processes), the Agency does not have sufficient treatment performance data from the other applicable HTMR processes (e.g., molten slag reactor, the Enviroscience HTMR process, or the Elkem pyrometallurgical processes) to determine whether they are effective for treating K061 nonwastewaters or F006 and K062 nonwastewaters. Treatment performance data for the Davy McKee Hi-Plas Furnace for K061 nonwastewaters were submitted during the comment period (for the high zinc K061 subcategory nonwastewaters rulemaking). However, since these data were only preliminary, a full assessment of this HTMR process could not be made. The Agency has not received treatment performance data for the Inclined Rotary Reduction HTMR System; thus, it could not be evaluated to determine whether it is demonstrated for HTMR of K061 nonwastewaters or F006 and K062 nonwastewaters.

Regarding the hydrometallurgical processes, Recontek states that its hydrometallurgical process was developed targeting waste streams F006, K061, K062, D002, D008, D009, and D011. However, the Agency notes limitations to the types of wastes that are accepted by Recontek (albeit some were stated to be economical). Encycle provided the Agency with information on its process but did not provide any treatment performance data for its process residuals in order for the Agency to evaluate process efficiency. MRTC provided information and treatment performance data for its hydrometallurgical process. The treatment performance data (toxicity characteristic leaching procedure (TCLP) leachate analysis) appear promising; however, the Agency notes that data for some metals show high leachate levels with respect to the BDAT treatment standards. The Agency notes that it has not received information showing that this process has been demonstrated on a full-scale basis for treatment of K061, F006, or K062 nonwastewaters.

3.3   Identification of Best Demonstrated Available Technology (BDAT)

In the First Third Rule, EPA determined HTMR to be BDAT for K061 nonwastewaters containing 15 percent or greater zinc content. The Agency believes HTMR, rather than stabilization, to be the BDAT for low zinc K061 because HTMR decreases the amount of material sent for land disposal, recovers valuable resources, and incorporates metals that are not recovered into an extremely stable slag matrix.

Data indicate that residuals for land disposal generated from HTMR units generally leach concentrations of metals that are comparable to (and, for most metals, lower than) those residues from stabilization of K061 wastes. These comparable leachability results for slag (i.e., residues for land disposal) from HTMR processes are occurring in spite of the fact that HTMR slag residues are generally more concentrated in toxic metals. As a result, it appears that the HTMR processes are achieving stabilization of metals through chemical reactions with materials such as lime and silica at elevated temperatures. This seems to indicate that an overall, more

effective stabilization is being achieved at the high temperatures. In some instances, HTMR residues may leach at higher levels than stabilized matrices, but this is typically related directly to the high concentrations of metals in the influent materials. For instance, performance data for stabilization of F006 nonwastewaters (used to develop nickel and chromium treatment standards for low zinc subcategory K061 nonwastewaters) represented treatment of less concentrated wastes than the HTMR data shown in Table 3-1 (i.e., representing inputs to the INMETCO HTMR processes for 1988). The average concentration of nickel in F006 (untreated stabilization data) was 6,449 mg/kg compared to 180,400 mg/kg (untreated HTMR data for INMETCO).

The use of HTMR is also consistent with the national policy, identified in the Hazardous and Solid Waste Amendments (HSWA) of the Resource Conservation and Recovery Act (RCRA), to reduce the quantity of hazardous constituents disposed. Since HTMR is a technology that recovers valuable constituents from waste materials, there is typically no increase in the volume of the waste residuals resulting from recovery treatment. For example, percent metal recovery data for some HTMR processes show that HTMR processes can recover the following: 99 percent of the nickel, 97 percent of the cadmium, 87 percent of the chromium, 86 percent of the lead, and 99 percent of the iron. This is in contrast to nonrecovery technologies such as stabilization, which is not intended to reduce the total metal concentration or waste volume. In addition, because metals are being recovered instead of land disposed, they do not have to be processed from ore concentrate; this saves energy and pollution of another source.

Table 3-1 Comparison Characterization Data and Treatment Performance Data for Inputs to an HTMR Process
Versus Inputs to Stabilization

BDAT List Constituent	Untreated F006 (Stabilization)		Untreated F006 (HTMR)		Untreated K061 (HTMR)		Untreated K062 (HTMR)	
	Average Value Total (mg/kg)	Average Value TCLP mg/l	Average Value Total (mg/kg)	Average Value TCLP mg/l	Average Value Total (mg/kg)	Average Value TCLP mg/l	Average Value Total (mg/kg)	Average Value TCLP mg/l
Antimony	-	-	10.3	<0.06	-	-	-	-
Arsenic	-	<0.01	15	<0.004	47	-	69	-
Barium	24.7	0.47	5.9	-	148	-	1.1	-
Beryllium	-	-	-	-	-	-	-	-
Cadmium	85	2.8	<4	0.007	2,204	5.4	2.4	0.03
Chromium	6,176	43	38,100	1.3	84,200	14.1	85,000	13
Lead	2,556	78	1,400	0.19	11,900	6.3	1,600	0.23
Mercury	-	<0.001	0.17	<0.0002	15	-	-	-
Nickel	6,449	173	180,400	800	1,000-113,700	9.0	46,200	176
Selenium	-	<0.01	<1	<0.004	57	-	<5	-
Silver	11.2	0.25	2.1	0.025	36	-	<6	-
Thallium	-	-	-	-	-	-	-	-
Vanadium	-	-	-	-	-	-	-	-
Zinc	17,626	498	23,600	375	51,000	456	1,800	0.8
Cyanide	-	-	70.4	0.17	0.94	-	0.4	-

Source: INMETCO characterization data for metal-bearing waste treated at INMETCO and submitted to the Agency in 1988 and the Final BDAT Background Document for F006 (August 1988).

- = No data

Table 3-1 (continued)

BDAT List Constituent	Treated F006 (Stabilization)		Treated F006 (HTMR), K061, K062, and Characteristic Wastes Containing Metals	
	Concentration Total (mg/kg)	Concentration* TCLP (mg/l)	Concentration Total (mg/kg)	Concentration TCLP (mg/l)
Antimony	-	-	<3-391	<0.06
Arsenic	-	<0.01-<0.02	<0.4-0.7	<0.04-<0.005
Barium	-	0.04-1.18	3.8-285	0.44-3.17
Beryllium	-	-	<0.5-6.7	<0.005-0.135
Cadmium	-	<0.01-3.23	<0.5-17.8	0.006-0.104
Chromium	-	0.03-1.21	930-32,500	<0.03-2.17
Lead	-	0.20-2.39	<4-86.1	<0.04-0.38
Mercury	-	<0.001	<0.1	<0.0002
Nickel	-	0.02-16.5	<1.6-289	<0.04-1.93
Selenium	-	<0.01-0.20	<1.5-53.2	<0.003-<0.015
Silver	-	<0.01-0.15	<0.5-9.75	0.005-0.048
Thallium	-	-	<0.6-<1.2	<0.006
Vanadium	-	-	<1.1-190	<0.011-0.07
Zinc	-	<0.01-36.9	<0.4-217	0.098-1.25
Cyanide	-	-	<0.05	

Source: Final BDAT Background Document for F006 (August 1988) and data from INMETCO, submitted to EPA, October 1991 for the HTMR test for K061 and other metal-bearing waste streams.

- No data

*Includes data for different binder-to-waste ratio (i.e., 0.2-1.5).

4. PERFORMANCE DATA

The following paragraphs discuss the performance data used to develop the treatment standards. The treatment standards being promulgated in this final rule are based on the performance of HTMR and were originally developed for K061 high zinc nonwastewaters; however, much of the performance data used was representative of mixed influent waste streams. Data used to develop the HTMR treatment standards consisted of mixtures of K061 (both high and low zinc subcategories), K062, F006, and characteristic wastes containing metals such as D001, D002, D006, and D007. As long as K061 high zinc subcategory wastes were present in the feed influent, the Agency used the HTMR performance data to develop treatment standards.

The Agency is transferring the treatment performance of HTMR for K061 high zinc subcategory to other metal wastes, since this treatment performance was actually based on recovery of metals from different wastes. Additionally, pyrometallurgical principals indicate that metals will consistently partition in accordance with their metal properties at high temperatures. As long as the waste material contains high concentrations of metals and does not contain constituents that can adversely affect metal product specifications, metals will predictably partition regardless of the waste matrix. (See Section 5 for more information about metal properties as related to partitioning.) The HTMR data presented below explain why they were or were not used to develop concentration-based treatment standards for K061 high zinc subcategory nonwastewaters.

4.1 Data Reviewed and Selected to Develop the Treatment Standards Based on HTMR

When EPA developed the treatment standards based on HTMR, the Agency considered only data which met the following criteria: (1) treatment data for well-designed and well-operated HTMR processes; (2) data for treatment of high zinc subcategory K061 nonwastewaters (containing equal to or greater than 15 percent zinc) or data from HTMR processes treating a mixture of high zinc subcategory nonwastewaters and other metal wastes; and (3) TCLP leachate

data. Accordingly, for the final rulemaking for K061 high zinc subcategory nonwastewaters, the data selected (which met the above criteria) consisted of four data sets. With respect to the "four" data sets (discussed below) used to develop treatment standards, the term data set represents a set of data from a particular HTMR facility; some facilities may have more than one set of data. The first set of data (Table 4-1, at the end of this section) consists of 14 data points (including some data points that were below detection limits) for most of the BDAT list metal constituents in HTMR slag. This data set was submitted to EPA (prior to the proposed rule for high zinc subcategory K061 nonwastewaters) by Horsehead Resource Development Company, Inc. (HRD), from HTMR units (waelz kilns) operated at its Calumet, Illinois, and Palmerton, Pennsylvania, facilities. Another data set (Table 4-2) from HRD, which consisted of three data points for all the metal constituents (for its waelz kiln HTMR process), was collected by EPA during the First Third rulemaking. This data set is included as part of the first data set, i.e., HRD data. A second data set (Table 4-3) was submitted to the Agency by SKF Plasma Technologies during the First Third rulemaking. This data set consisted of one data point for most metal constituents and represented treatment of electric arc furnace (EAF) flue dust (K061) in a plasma arc reactor. The third data set (Table 4-4), from International Mill Service (IMS), was submitted to the Agency after the comment period for the proposed rule for K061 high zinc subcategory nonwastewaters. These data consisted of 16 data points for each of the metal constituents for HTMR of high zinc subcategory K061 nonwastewaters in a plasma furnace. A fourth data set (Table 4-5), from International Metals Reclamation Company (INMETCO), consisted of three data points for each of the metal constituents representing treatment of K061, K062, F006, and several characteristic wastes in an HTMR system made up of a rotary hearth furnace followed by an electric furnace.

Note, because cyanide is a common constituent of F006 and the Agency has no treatment performance data for destruction of cyanide in an HTMR system, EPA is transferring the K048-K052 treatment performance of incineration of cyanide. These data are presented in Table 4-6. The Agency believes HTMR will achieve a level of destruction similar to incineration because HTMR operates at longer residence times and occurs at higher temperatures than incineration

(i.e., most HTMR units operate at approximately 1,200-1,600°C while incinerators typically operate at less than 1,100°C).

4.2   Data Reviewed But Not Selected to Develop Treatment Standards Based on HTMR

The Agency also reviewed other HTMR treatment performance data; however, these data were not used to develop the treatment standards based on HTMR for the reasons discussed in the following sections. Additional data has been received since the development of the final K061 high zinc subcategory rulemaking. (See Section 4.2.2.) The Agency believes that it is not always necessary to revise treatment standards when new data are received, especially in instances where the existing standards are being met. The Agency has reviewed the new data and believes that although some data may show higher leachate levels than treatment standards, in the past, many facilities operated in a manner that would produce a slag leaching metal levels below the toxicity characteristic (TC) levels. Now, it seems that facilities are exploring slag chemistry options and process operation alternatives to improve the performance of their technologies to achieve the treatment standards and generic exclusion levels. Thus, the Agency believes that the standards are achievable by a wide variety of HTMR processes.

4.2.1 Horsehead Resource Development Co., Inc. (HRD) Data

4.2.1.1   Waelz Kiln

Four sets of treatment performance data, submitted during the First Third rulemaking, were available demonstrating recovery of zinc from K061 nonwastewaters using a series of waelz kilns (rotary kilns). These data were determined (in the First Third Rule) to be from an HTMR system that was not well-operated. These data are presented in Table 4-7. HRD submitted comments disputing the Agency's earlier findings that these data did not represent a well-operated HTMR system. The Agency remained convinced of its earlier findings; however, it did not use these data for setting final treatment standards. The Agency responded to HRD's

objections to EPA's determination of the fact that four of HRD's data sets were not well-operated in the First Third Rule. Additional information on the Agency's response to HRD's objections not to use some of their data is contained in the First Third Rule's administrative record for K061.

The Agency remained convinced of its findings and was not persuaded to reverse them. In summary, EPA determined that these four data sets were from HTMR processes that were not well-operated. The reasons for this determination (made in the First Third Rule) were that the Agency found that these processes were operating at insufficient operating temperatures and/or had deficient calcium to silica ratios. EPA notes that some of HRD's operating parameters are Confidential Business Information (CBI) and, thus, are not presented here. However, this CBI is located in the CBI portion of the administrative record for the K061 First Third rulemaking. The Agency also notes that HRD acknowledged that sample set number 5 (sample set number 3 in Table 4-7 of this background document), "is properly excluded due to an upset condition in the kiln which caused a ring accretion to form requiring that the kiln be shut down during the collection of sample 5 in order to remove the accretion and restore proper kiln operation" (Comment Reference: LDR7 L009).

These HRD data (cited in Table 4-7 of this background document) show generally higher total concentrations for zinc in the treated wastes, i.e., 6,710, 23,600, 24,300, and 27,400 ppm. Conversely, the values for the three sets of data from the well-operated processes (shown in Table 4-2) indicate generally lower total zinc levels, i.e., 4,550, 4,680, and 11,200 ppm. The Agency noted that this variation in treated waste total levels for zinc (from the processes that were not well-operated) occurred even though the untreated zinc total concentrations from all seven data sets (Tables 4-2 and 4-7) were fairly stable, ranging from 129,000 to 155,000 ppm. As noted above, the Agency concluded that poor operating conditions, i.e., improper operating temperature and/or insufficient calcium to silica ratios, were related to the poor performance with respect to these data.

In addition to other operating parameters, the Agency was convinced that zinc (TCLP leachate levels) is a good indicator of how effectively the HTMR process is recovering zinc. Poor zinc recovery seems to be related to poor maintenance of proper operating parameters, as discussed above. This can cause more metals to be found in the slag, resulting in both greater slag volumes and the potential for more metals to leach into the environment. EPA concluded that improper removal of zinc can likewise relate to less immobilization of hazardous constituents.

As previously mentioned, the Agency determined in the First Third Final Rule (and has not changed the determination) that the treatment performance data from the four data sets referenced above were not from well-operated processes. EPA further noted that the HRD data submitted prior to the proposed rule for K061 high zinc subcategory nonwastewaters (Table 4-1) show relatively consistent TCLP leachate values for all the metals compared to the values observed in the First Third data, notably those from the processes that were not well-operated (shown in Table 4-7). This finding showed that the process could be better operated.

4.2.1.2 Flame Reactor HTMR Process

HRD also submitted treatment performance data for its flame reactor HTMR process (much of the data came from the company's earlier filed delisting petitions). These data are shown in Tables 4-8 and 4-9. The Agency reviewed these data and believes that the flame reactor process may not have been properly operated for optimum metals recovery. The Agency also reviewed the recent treatment performance data submitted by the commenter for its flame reactor process for HTMR of K061. EPA considered using these data but determined, as explained below, that these data were from an HTMR process that could not have been well-operated. Thus, EPA decided not to use either the earlier or the recent flame reactor data based on the reasons discussed below. The Agency reviewed the report, Flame Reactor Process for Electric Arc Furnace Dust, prepared by HRD for the Center for Metals Production (CMP Report No. 88-1, August 1988). EPA believes that some problems with the flame reactor discussed in

the report confirm the same concerns it noted when evaluating the current flame reactor data submitted during the comment period.

The report provided information on all aspects of using the flame reactor process for EAF dust. In particular, the source test involved testing dust from different sources covering a wide range of compositions to demonstrate the reactor's flexibility. This test was also performed to show the effects of feed ratios and combustion air composition on the flame reactor's performance. The Agency noted that the report concluded that "specific questions were left unanswered, including those regarding the suitability of the process for variations in dust composition" (p. 4-1 of the report). In addition, the report pointed out that the test results must be evaluated in light of several deviations from the original operating plans (p. 4-7 of the report).

In the source test, lead was the only element (zinc was not analyzed since it was not an EP toxic metal) that exceeded the delisting limits (according to the report (pp. 1-3 and 4-19), the delisting criteria are 6.3 times the Federal drinking water standards) in a few of the tests. In fact, the report (and also in the commenter's recent TCLP data, showed lead levels to be much higher than delisting limits in the EP leachates. The report concluded that in some cases where the lead delisting levels were exceeded, these instances occurred in tests having "high feed rates and high levels of oxygen enrichment" (p. 4-19 of the report). The conclusion of the report further stated that "proper operating conditions will eliminate this problem" (emphasis added) (p. 4-19 of the report). Hence, EPA might conclude that where lead leachate levels are high, operating conditions (such as temperature, carbon monoxide to carbon dioxide ratios (CO/CO_2), fuel, combustion air rates, and combustion air composition) must be improper. Additionally, in the discussion of zinc recovery, the report found that there was considerable variability over a wide range depending on EAF dust composition, dust feed rate, and the level of oxygen enrichment. Zinc recovery decreased as both dust feed rate and oxygen enrichment increased; the effects were more significant for dust containing high levels of zinc. With respect to coke usage, the report concluded that "kinetic factors become increasingly dominant as the

zinc content of the EAF dust increases, and tend to limit the reactor's capacity for zinc fuming" (p. 4-14 of the report). In other words, it appears to be more difficult to recover high percentages of zinc from high zinc dust. Thus, for high zinc dust more zinc is left in the slag and, therefore, is more likely to leach.

The report further suggested that operating conditions (i.e., proper coke and combustion usage) affect the volume of combustion gas generated, thus controlling the reaction kinetics and, ultimately, affect the reactor's performance; hence, zinc recovery. According to the report, "the reactor could easily be scaled based upon the combustion gas volume needed to achieve a specific zinc recovery (emphasis added) and production rate. Scaling calculations would also be needed to consider such factors as retention time and gas velocities. Higher temperatures and higher carbon monoxide/carbon dioxide ratios may also enhance reaction kinetics and lessen the importance of combustion gas volume" (p. 4-14 of the report). Hence, EPA might conclude that adjustments in operating conditions, such as retention time, could improve zinc recovery and probably reduce zinc concentration in the slag leachate.

The Agency remained convinced that zinc residuals (TCLP leachate levels) are a good indicator of how effectively the system is recovering zinc. Poor zinc recovery seems to be related to poor maintenance of proper operating temperatures and other parameters. These can lead to more metals in the slag, causing greater slag volumes and the potential for more metals to leach into the environment. EPA concluded that improper removal of zinc can likewise relate to less immobilization of hazardous constituents.

Noting that the report described the experimental flame reactor program, the Agency concluded that there is a relationship between the experimental flame reactor program described in the report and the current flame reactor's operation, since problems were observed with respect to lead and zinc. Thus, the treatment of other metals may also have not been optimized. EPA believed that the flame reactor process was not designed to optimize the performance with respect to BDAT levels promulgated in the final rule for K061 high zinc subcategory. In light

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of the aforementioned reasons, the Agency chose not to use the current flame reactor data. The Agency noted that the data in the commenter's delisting petition showed better performance than the data that HRD wanted EPA to use in the final rule. EPA believed that this difference in results indicates that there were problems with the flame reactor process.

Further, the Agency noted the recent performance of HRD's flame reactor under EPA's Superfund Innovative Technology Evaluation (SITE) program. (See the administrative record for the Superfund Innovative Technology Evaluation Demonstration Bulletin, Flame Reactor, Horsehead Resources Development Company, Inc.) Tests conducted under this program to demonstrate the flame reactor's suitability for treating secondary lead smelters slag show treated TCLP slag analysis for lead averaging 0.33 mg/l for 18 data points. The Agency acknowledged that these data were from a different waste matrix; however, these data show relatively low and consistent levels for lead in the TCLP extract, while noting that the total concentration of lead for the untreated waste averaged 54,066 mg/kg.

4.2.2 International Metals Reclamation Company (INMETCO) Data

INMETCO submitted three data sets during the First Third rulemaking and one data set dated July 11, 1990.. Three sets of treatment performance data were available demonstrating the recovery of chromium/nickel and the separation of zinc using a rotary hearth furnace/electric furnace system (Table 4-10). These data were not used because the Agency had information concerning INMETCO's process which indicated that these data would represent chromium/nickel recovery of low zinc subcategory K061 nonwastewaters mixed with F006, K062, and several characteristic wastes. Insufficient information was provided to determine whether high zinc subcategory K061 nonwastewaters were also being treated along with these wastes. (The Agency notes that although some low zinc K061 nonwastewater data were used to develop the final treatment standards for K061 high zinc subcategory, they were used only when the Agency was certain that the HTMR process was treating a mixture of low and high zinc subcategory nonwastewaters.)

INMETCO also submitted additional TCLP slag analysis data from HTMR units. These data were submitted to the Agency prior to the proposed rule for K061 high zinc subcategory nonwastewaters. These data (Table 4-11) consisted of four data sets, but there was no information to determine whether high zinc K061 nonwastewaters or a mixture of low and high zinc K061 wastes were being treated in this process at that time. Further, the Agency determined that these data indicated that the treatment performance of the process would achieve the treatment standards.

Additionally, INMETCO recently submitted total concentration and TCLP slag analysis data from a HTMR test for K061 conducted at INMETCO in June 1991. These data (Table 4-12) consisted of 16 data sets. The preliminary indication is that some of the data points for chromium may not meet the proposed BDAT levels. However, these data are from grab sampling as opposed to composite sampling from which the proposed standards for K061 (all nonwastewaters) and alternative standards for K062 and F006 nonwastewaters are based. The Agency notes, however, that the most recent composite sampling data for INMETCO's slag analyses for the year 1991 indicate that the treatment standards are achievable. These total concentration data and TCLP leachate slag analysis data (shown in Table 4-13) were submitted from INMETCO for composite sampling of their slag for the years 1990 and 1991.

4.2.3 Sumitomo Corporation of America Data

During the First Third rulemaking, Sumitomo submitted two sets of treatment performance data demonstrating recovery of zinc from K061 using a molten slag reactor system. However, these data, presented in Table 4-14, did not provide treated TCLP leachate values.

4.2.4 International Mill Service Inc. (IMS) Data

IMS submitted to the Agency (December 21, 1990) 10 sets of treatment performance data demonstrating recovery of zinc from K061 electric arc furnace (EAF) dust (K061). In the

proposed rule for the K061 high zinc subcategory, EPA reviewed process information from IMS indicating that the data were not for treatment of high zinc subcategory K061 nonwastewaters. During the comment period to the proposed rule, the Agency was informed that these data did, in fact, represent high zinc subcategory K061 waste. However, IMS later informed EPA that these data were not from TCLP analysis but, rather, were from the Synthetic Precipitation Leaching Procedure (SPLP or Method 1312), which is not appropriate for setting treatment standards in accordance with the Land Disposal Restrictions BDAT methodology. The Agency noted that the TCLP analysis is used in accordance with the BDAT methodology because it is designed to reflect leaching in a landfill scenario. These data are presented in Table 4-15.

4.2.5 St. Joe Company Data

One set of treatment performance data demonstrating recovery of zinc from K061 using a flame reactor was submitted during the First Third rulemaking. These data, presented in Table 4-16, did not provide any treated TCLP leachate values.

4.2.6 Heckett Technologies Data

Heckett Technologies submitted data (shown in Table 4-17) that represented the preliminary results of their HTMR process, i.e., Davy McKee Hi Plas Furnace. The Agency considered these data. Because these data were only preliminary, however, EPA chose not to use them since other data were available that were not preliminary and represented well-designed and well-operated HTMR processes.

4.2.7 SKF Plasma Technologies Data

One set of treatment performance data, submitted during the First Third rulemaking, was available demonstrating recovery of zinc from K061 in a plasma arc reactor. These data, presented in Table 4-18, were not used because no TCLP leachate values were given.

Table 4-1 Performance Data for HTMR of Zinc (Series of Waelz Kilns) of High Zinc Subcategory K061 Nonwastewaters

Constituent	K061 untreated total concen-tration (mg/kg)	Treated slag concentration (mg/l, TCLP leachate) sample sets													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Antimony	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	--	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0 005
Barium	--	0.77	0.42	2.15	1.4	0.62	0.61	1.40	0.61	1.0	0.48	0.39	0.76	1.30	0 56
Beryllium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cadmium	--	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	--	0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0 01
Lead	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Mercury	--	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	--	<0.02	<0.02	<0.02	<0.02	<0.02	0.11	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.04
Selenium	--	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.01	0.01	<0.01	<0 01
Silver	--	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02
Thallium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vanadium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Zinc	170,000 - 185,000	--	--	--	--	--	--	--	--	--	--	--	--	--	--

-- = No data.

Source: Horsehead Resource Development Company, Inc. data submitted to the Agency on September 7, 1990.

4-11

Table 4-2 Performance Data (1988d) for HTMR of Zinc (Series of Waelz Kilns)
of High and Low Zinc Subcategory K061 Nonwastewaters

Constituent	Total untreated K061 concentration (mg/kg) Sample set			Treated slag concentration (mg/kg) Sample set			Treated slag TCLP concentration (mg/l) Sample set		
	1	2	3	1	2	3	1	2	3
Antimony	73	80	78	162	405	155	0.769	0.853	0.344
Arsenic	56	65	127	75	113	79	0.013	<0.010	<0.010
Barium	184	190	204	346	467	381	4.320	2.93	3.690
Beryllium	0.18	1.5	<0.5	1.9	4.0	1.7	<0.001	0.0018	<0.001
Cadmium	394	808	290	15	<1.5	<1.5	<0.060	<0.003	<0.003
Chromium	1,190	903	1,080	748	978	476	<0.080	<0.080	<0.040
Lead	15,500	20,800	6,400	1,940	365	2,370	0.0053	<0.005	<0.005
Mercury	1.0	1.6	1.1	<0.1	<0.1	<0.1	<0.0002	0.0027	<0.0002
Nickel	449	261	295	579	952	683	0.097	0.153	0.024
Selenium	5.2	8.2	20	4.2	5.2	8.8	<0.005	<0.005	<0.005
Silver	23	29	44	42	39	59	<0.080	<0.004	<0.040
Thallium	1.5	1.3	<1.0	<1.0	<0.5	<1.0	<0.010	<0.010	<0.010
Vanadium	37	25	33	32	44	41	<0.060	<0.060	<0.030
Zinc	145,000	135,000	155,000	11,200	4,680	4,550	0.241	0.128	0.080

Source: USEPA 1988d. Onsite engineering report for Horsehead Resource Development Company, Inc. for K061. Draft report.

Table 4-3 Performance Data for HTMR of Zinc (Plasma Arc Reactor) of High Zinc Subcategory K061 Nonwastewaters

Constituent	BDAT constituents detected		
	Untreated total waste concentration (mg/kg)	Treated total waste concentration (slag) (mg/kg)	Treated waste (slag) TCLP (mg/l)
Antimony	50-150	<20	–
Arsenic	<100-400	<4-13	<0.005
Barium	–	<3,000	2.5
Beryllium	–	–	–
Cadmium	200-900	<10-500	<0.005
Chromium	400-5,000	2,000-12,000	0.013
Copper	1,500-2,800	10-1,500	–
Lead	24,000-50,000	50-1,500	<0.05
Mercury	7-41	<5	<0.0002
Nickel	1,000-3,000	200-1,000	0.22
Selenium	–	–	<0.05
Silver	–	–	0.014
Thallium	–	–	–
Vanadium	–	–	<0.02
Zinc	150,000-320,000	50-2,000	–

– = No data.

Source: SKF Plasma Technologies data submitted to EPA in the First Third rulemaking (USEPA 1988a).

Table 4-4 Performance Data for HTMR of Zinc (Plasma Arc Reactor) of High Zinc Subcategory of K061 Nonwastewaters

| Constituent | Untreated total waste concentration (mg/kg) | Treated waste (slag) TCLP (mg/l) Sample sets | | | | | | | | | | | | | | |
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Antimony	-	0.057	0.076	<0.073	0.051	0.032	0.024	<0.010	0.064	0.042	0.013	0.030	<0.010	<0.010	<0.010	<0.010	<0.010
Arsenic	-	0.017	0.029	0.026	0.022	0.008	0.009	<0.005	0.028	0.019	0.007	0.008	<0.005	<0.005	<0.005	0.006	<0.005
Barium	-	1.30	2.19	1.48	1.43	1.99	1.68	0.47	0.95	1.27	0.81	3.78	0.35	0.41	0.42	2.03	0.44
Beryllium	-	<0.001	<0.003	<0.003	<0.001	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cadmium	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.004	<0.004	<0.004	0.009	0.006	0.012	<0.004	<0.004	<0.004	0.006
Chromium	-	<0.011	<0.011	0.012	<0.011	<0.011	<0.011	<0.011	<0.011	0.030	0.015	0.054	0.012	0.018	<0.011	0.012	0.015
Lead	-	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	0.20	<0.11	<0.11	<0.11	<0.11	<0.11
Mercury	-	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Nickel	-	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026	<0.026
Selenium	-	<0.025	<0.050	<0.025	<0.050	<0.050	<0.050	0.041	<0.005	0.025	0.032	0.037	<0.005	<0.005	0.025	0.040	0.035
Silver	-	0.018	0.017	0.024	0.012	0.015	0.015	0.013	0.015	0.016	0.016	0.016	0.011	0.012	0.013	0.013	0.016
Thallium	-	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Vanadium	-	0.087	0.17	0.114	0.078	0.066	0.099	0.072	0.093	0.12	0.081	0.16	0.042	0.048	0.066	0.16	0.066
Zinc	*	0.066	0.12	0.135	0.039	1.23	0.29	0.27	0.50	0.048	6.42	0.060	0.37	<0.019	0.024	0.033	0.057

-- No data.

*Information supplied in the IMS comments state that these data represent treatment of high zinc subcategory K061 nonwastewaters.

Source: International Mill Service (IMS) submitted to EPA during the comment period for the proposed rule for K061 high zinc subcategory nonwastewaters.

Table 4-5 Performance Data for HTMR (Rotary Hearth Furnace/Electric Furnace)
of K061 (High and Low Zinc), K062, F006, and Characteristic
Wastes Containing Metals

Constituent	Untreated total waste concentration (mg/kg)	Treated slag TCLP leachate concentration (mg/l)		
		Sample sets		
		1	2	3
Antimony	—	<0.3	<0.3	<0.3
Arsenic	—	<0.008	<0.008	<0.008
Barium	—	0.540	0.282	0.180
Beryllium	—	0.010	<0.006	<0.006
Cadmium	—	<0.010	<0.010	<0.010
Chromium	—	<0.03	<0.03	<0.03
Lead	—	0.0114	0.0086	0.0036
Mercury	—	<0.0004	<0.0004	<0.0004
Nickel	—	3.41	2.18	2.04
Selenium	—	<0.03	<0.03	<0.03
Silver	—	<0.010	<0.010	<0.010
Thallium	—	<0.012	<0.024	<0.012
Vanadium	—	<0.04	<0.04	<0.04
Zinc	*	0.114	0.240	0.206

*Information provided in INMETCO comments states that these data represent high zinc K061 subcategory.
— No data.
Source: INMETCO presented to EPA during the comment period for high zinc K061 nonwastewaters proposed rule.

Table 4-6 Performance Data for Incineration (Fluidized Bed) of Cyanide in K048 and K052 Nonwastewaters

Constituent	Untreated Waste (mg/kg)						Treated Waste (mg/kg)					
	Sample sets						Sample sets					
	1	2	3	4	5	6	1	2	3	4	5	6
Cyanide (total)	0.7/0.8*	<0.1/0.5*	<0.1/<0.1*	1/1.4*	<0.1/<0.1*	0.9/0.6*	<0.1	0.4	<0.1	0.5	<0.1	0.5

Source: Final BDAT Background Document for K048-K052 (August 1988).

*First value is for K048 waste and the second value is for K051.

Table 4-7 Performance Data for HTMR of Zinc (Series of Waelz Kilns) of Low Zinc Subcategory K061 Nonwastewaters

Constituent	Untreated total waste concentration (mg/kg)				Treated total waste concentration (mg/kg)				Treated slag TCLP (mg/l)			
	Sample sets				Sample sets				Sample sets			
	1	2	3	4	1	2	3	4	1	2	3	4
Antimony	89	65	52	58	196	187	146	111	<0.021	0.795	0.700	0.532
Arsenic	59	55	56	42	77	77	105	76	<0.010	0.068	<0.010	<0.010
Barium	169	164	158	193	348	363	383	331	1.42	2.66	2.64	2.35
Beryllium	0.55	<0.5	0.83	<0.5	1.9	1.9	3.3	2.6	0.001	0.017	0.022	<0.001
Cadmium	737	345	857	298	<1.5	<1.5	<1.5	<1.5	<0.0042	<0.060	<0.060	<0.003
Chromium	905	959	803	909	662	741	205	477	<0.004	0.103	<0.080	<0.080
Copper	2,080	1,620	2,610	1,460	3,180	3,370	4,560	3,610	<0.004	0.100	<0.080	<0.080
Lead	14,400	14,900	21,900	15,400	1,720	2,080	738	4,270	<0.025	<0.025	<0.005	<0.046
Mercury	1.4	1.4	2.0	1.1	<0.1	<0.01	<0.01	<0.01	<0.0002	<0.0002	<0.002	<0.000
Nickel	184	185	202	234	434	422	588	460	0.203	1.40	0.445	0.579
Selenium	13	18	4.2	8.0	2.5	5.7	3.6	4.4	<0.025	<0.025	<0.025	<0.025
Silver	30	23	25	37	32	35	33	32	<0.004	<0.099	<0.080	<0.080
Thallium	2.7	1.5	0.75	<1.0	<1.0	<1.0	<1.0	<1.0	<0.010	<0.010	<0.010	<0.010
Vanadium	24	26	27	34	8.6	20	<1.5	16	<0.060	<0.060	<0.060	<0.060
Zinc	129,400	145,000	145,000	148,000	24,300	23,600	6,710	27,400	2.64	65.7	26.7	61.1

Source: USEPA 1988d. Onsite Engineering Report for Horsehead Resource Development Company, Inc. for K061. Draft report.
Comments on data: The Agency determined that these data were derived from HTMR processing that was not well-operated. (See discussion in Section 4.2.1.1 of this background document.)

Table 4-8 Performance Data for HTMR of Zinc (Flame Reactor) of High and
Low Zinc Subcategory K061 Nonwastewaters

Treated Slag Residuals TCLP (mg/l)

Sample sets	Sb	As	Ba	Be	Cd	Cr	Pb	Hg	Ni	Se	Ag	Tl	V	Zn
1	--	0.01	1.10	-	0.005	0.010	7.50	<0.002	0.36	<0.010	<0.01	-	-	-
2	--	0.01	2.10	-	0.010	0.080	1.50	<0.001	0.50	<0.005	0.01	-	-	-
3	--	<0.01	0.19	-	<0.004	0.020	<0.03	<0.002	0.90	<0.010	<0.01	-	-	-
4	--	<0.01	0.70	-	<0.010	0.070	0.10	<0.001	0.70	<0.005	0.02	-	-	-
5	--	0.02	0.36	-	<0.004	0.006	0.40	<0.002	0.10	<0.010	<0.01	-	-	-
6	--	0.01	1.20	-	<0.010	<0.010	0.10	<0.001	0.20	<0.005	0.02	-	-	-
7	--	0.02	0.07	-	<0.004	<0.006	0.70	<0.002	0.16	<0.010	<0.01	-	-	-
8	--	0.02	1.60	-	<0.010	0.040	0.20	<0.001	0.20	<0.005	0.02	-	-	-
9	--	<0.13	1.90	-	<0.020	<0.100	<0.20	<0.100	0.70	<0.250	<0.01	-	-	-
10	<0.10	<0.01	1.37	0.002	<0.010	0.040	<0.10	<0.001	0.49	<0.050	<0.02	<0.01	0.11	1.7
11	--	<0.13	2.00	-	<0.020	.<0.100	<0.20	<0.100	2.40	<0.250	<0.01	-.	-	-
12	<0.10	<0.01	1.45	0.002	<0.010	0.050	<0.10	<0.001	1.26	<0.100	<0.02	<0.01	0.10	2.6
13	--	<0.01	2.50	-	0.030	<0.006	2.10	<0.002	0.17	<0.020	0.01	-	-	69.0
14	--	<0.13	3.00	-	0.060	<0.100	2.70	<0.100	0.30	<0.250	<0.01	-	-	-
15	--	<0.01	1.90	-	0.004	<0.006	1.50	<0.002	0.20	<0.020	0.01	-	-	87.0
16	--	<0.13	1.50	-	0.050	<0.100	1.10	<0.100	0.30	<0.250	<0.01	-	-	-
17	<0.10	<0.01	1.32	0.003	<0.010	0.030	1.10	<0.001	0.18	<0.050	<0.02	<0.01	0.08	12.8
18	--	<0.01	2.70	-	<0.004	<0.006	1.90	<0.002	0.13	<0.020	0.01	-	-	73.0
19	--	<0.13	3.20	-	<0.020	<0.100	1.80	<0.100	0.20	<0.250	<0.01	-	-	-
20	--	0.20	1.60	-	<0.004	<0.006	0.93	<0.002	0.23	<0.020	0.01	-	-	29.0
21	--	<0.13	1.80	-	0.060	<0.100	1.30	<0.100	0.20	<0.250	<0.01	-	-	-
22	0.10	0.01	1.72	0.003	<0.010	0.040	1.70	<0.001	0.15	<0.050	<0.02	<0.01	0.12	26.2
23	--	<0.13	2.80	-	<0.020	<0.100	0.50	<0.100	0.10	<0.250	<0.01	-	-	-

Table 4-8 (c   ied)

Sample sets	Sb	As	Ba	Be	Cd	Cr	Pb	Hg	Ni	Se	Ag	Tl	V	Zn
24	<0.10	0.01	1.76	0.005	0.060	0.030	1.10	<0.001	0.08	<0.050	<0.02	<0.01	0.27	114.0
25	--	<0.13	1.60	-	<0.020	<0.100	<0.20	<0.100	<0.10	<0.250	<0.01	-	-	-
26	--	<0.13	1.90	-	<0.020	<0.100	<0.20	<0.100	0.10	<0.250	<0.01	-	-	-
27	<0.10	0.02	2.04	0.001	<0.010	0.010	0.10	<0.001	0.07	<0.050	<0.02	<0.01	0.34	6.2
28	1.40	<0.13	1.54	<0.100	0.080	0.110	0.50	<0.100	0.40	<0.250	<0.01	0.30	<0.10	12.0
29	0.90	<0.13	4.14	<0.100	0.030	<0.100	6.10	<0.100	0.20	<0.250	<0.01	0.20	<0.10	47.0
30	0.60	<0.01	2.60	<0.100	<0.020	<0.100	2.40	<0.100	0.20	<0.250	<0.01	0.20	0.20	10.0
31	1.10	<0.01	4.10	<0.100	<0.020	<0.100	0.40	<0.100	0.30	<0.250	<0.01	0.20	0.40	8.0
32	1.00	<0.01	4.70	<0.100	0.020	<0.100	1.10	<0.100	0.30	<0.250	<0.01	0.20	0.20	15.0

-- No data.

Comments: These data were not used by the Agency as they were determined to be from not well-operated HTMR processing of K061. Further information on this determination is presented in Section 4.2.1.2 of this background document.

Source: Horsehead Resource Development Company, Inc. submitted to EPA during the comment period for K061 high zinc subcategory nonwastewaters.

Table 4-9 Performance Data for HTMR of Zinc (Flame Reactor)
of K061 Nonwastewaters

(Treated Slag Residuals)

Sample set	EP Toxicity (mg/l)				TCLP (mg/l)			
	Pb	Cd	Cr	Ni	Pb	Cd	Cr	Ni
1	<0.25	<.004	<.006	0.07	4.5	0.008	0.045	0.43
2	0.09	0.004	0.02	0.09	0.063	<0.007	0.045	0.80
3	<.025	<.004	<.006	0.03	0.25	<0.007	<.008	0.15
4	0.13	<.004	<.006	<.02	0.45	<0.007	0.023	0.18
5	<0.02	<0.01	<0.01	<0.023	<0.2	<.02	<0.1	0.7
6	<0.02	<0.01	<0.01	<0.02	<0.2	<.02	<0.1	2.4
7	<0.02	<0.01	<0.01	0.085	2.7	0.06	<0.1	0.3
8	<0.002	<0.01	<0.001	0.11	1.1	0.05	<0.01	0.3
9	<0.027	<0.01	<0.015	0.10	1.8	<0.02	<0.1	0.2
10	<0.048	<0.01	<0.01	0.098	1.3	0.06	<0.1	0.2
11	<0.02	<0.01	<0.01	<0.02	0.5	<0.02	<0.1	<0.1
12	<0.02	<0.01	<0.01	<0.02	<0.2	<0.02	<0.1	<0.1
13	<0.02	<0.01	<0.012	<0.02	<0.2	<0.02	<0.1	0.1

Comments: These data were not used by EPA as they were determined to be from not well-operated HTMR processing of K061.

Source: Horsehead Resource Development Company, submitted these data to EPA during the comment period for the proposed rule for K061 high zinc subcategory nonwastewaters.

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Table 4-10 Performance Data for HTMR (Rotary Hearth Furnace/Electric Furnace) of K061, K062, F006, and Characteristic Wastes Containing Metals

Constituent	Sample set #1		Sample set #2		Sample set #3	
	Untreated waste TCLP (mg/l)	Treated waste (slag) TCLP (mg/l)	Untreated waste TCLP (mg/l)	Treated waste (slag) TCLP (mg/l)	Untreated waste TCLP (mg/l)	Treated waste (slag) TCLP (mg/l)
Cadmium	–	–	–	–	56	0.05
Chromium	256	0.65	6.8	0.40	<0.10	<0.01
Chromium (+6)	213	0.62	5.4	0.28	–	–
Lead	–	–	0.39	0.35	365	0.38
Zinc	–	–	–	–	4,973	0.94

– = No data.

Comments on data: Unknown zinc concentration; however, other information presented to the Agency concerning INMETCO's HTMR process indicates that these data do not represent metals recovery from waste in the high zinc K061 nonwastewaters. Further, there is no information to suggest that these data were derived from K061 in the low zinc subcategory that were mixed with K061 wastes in the high zinc subcategory.

Source: Final BDAT Background Document for K061, August 1988, from INMETCO, Inc. (USEPA 1988a).

Table 4-11 Performance Data for HTMR (Rotary Hearth Furnace/Electric Furnace) of
K061, K062, F006, and Characteristic Wastes Containing Metals

Constituent	Untreated waste concentration	Treated slag concentration TCLP (mg/l)			
		1	2	3	4
Antimony	—	<0.04	<0.04	<0.04	<0.04
Arsenic	—	0.05	<0.04	<0.04	<0.04
Barium	—	<0.01	<0.01	<0.01	<0.01
Beryllium	—	—	—	—	—
Cadmium	—	0.06	0.06	0.05	0.06
Chromium	—	<0.01	<0.01	0.05	0.07
Lead	—	0.15	0.14	0.08	0.23
Mercury	—	0.002	0.0013	0.0017	0.0018
Nickel	—	2.79	2.93	1.43	0.37
Selenium	—	<0.04	<0.04	<0.04	<0.04
Silver	—	<0.01	<0.01	<0.01	<0.01
Thallium	—	—	—	—	—
Vanadium	—	—	—	—	—
Zinc	—	0.37	0.48	0.51	0.14

— = No data.

Comments on data: Unknown zinc concentration; however, other information presented to the Agency
concerning INMETCO's HTMR process indicates that these data do not represent metals recovery from wastes
in the high zinc K061 nonwastewaters subcategory. Further, there is no information to indicate that these data
are representative of low zinc K061 that was mixed with high zinc K061.

Source: INMETCO, dated July 11, 1990.

Treated Slag Total Concentration (mg/kg)

	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10	Set 11	Set 12	Set 13	Set 14	Set 15	Set 16
Antimony	<3	285	<3	<3	<3	<3	<3	<30	246	68.3	49.2	33.5	121	80 1	289	391
Arsenic	<0.4	<0.8	<0.4	<0.4	<0.4	<0.4	<08	<0.4	<04	0.8	0.7	<04	<04	<04	0.5	<04
Barium	5.7	181	3.8	205	3.8	159	179	232	277	262	244	223	223	285	277	242
Beryllium	<0.5	6.7	<0.5	<0.5	<0.5	<0.5	<05	<0.5	3.2	1.5	<0.5	<0.5	<1	21	12	<05
Cadmium	<0.5	17.8	<0.5	3.3	<0.5	4.9	128	4.5	5.7	2.6	3.0	3.1	27	36	2.1	17
Chromium	13,700	17,300	15,900	1,270	23,700	1,130	930	1,440	2,310	1,920	4,250	3,800	10,300	1,030	27,500	32,500
Lead	<4	86.1	<4	31	<4	6	38	47	26	25	6	4	<4	25	30	25
Mercury	<0.1	<0.1	<0.1	<01	<0.1	<0.1	<0.1	<0.1	<0.1	<01	<0.1	<0.1	<0.1	<01	<01	<01
Nickel	<1.6	14	<1.6	218	<1.6	282	289	278	130	57.0	3.5	6.07	3.9	104	287	89
Selenium	6.20	53.2	5.05	23.0	4.76	22.1	22.1	36.6	10.8	14.1	<1.5	<1.5	48	5.9	33.6	15
Silver	0.9	9.75	1.5	5.6	<0.5	4.6	4.2	6.6	5.5	3.8	2.8	4.5	3.3	8.1	6.0	3.0
Thallium	<0.6	<1.2	<0.6	<0.6	<0.6	<0.6	<0.6	<3	<3	<3	<0.6	<0.6	<0.6	<06	<0.6	<06
Cyanide	·	<0.05	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Vanadium	<1.1	190	<1.1	22.9	<1.1	29.6	20.0	36.2	24.7	28.7	<1.1	<1.1	<1.1	134	506	<1.1
Zinc	<0.4	165	1.1	143	<0.4	211	152	206	48.8	31.9	2.92	8.21	123	140	217	99

Treated Slag TCLP (mg/l)

	Set 1	Set 2	Set 2	Set 3	Set 4	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9	Set 10	Set 11	Set 12	Set 13	Set 14	Set 15	Set 16
Antimony	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<006	<0.06	<006	<006
Arsenic	<0.004	<0.004	<0.004	<0.004	<0.004	0.005	<0.004	0.005	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Barium	1.03	0.901	0.997	0.958	1.22	0.440	0.723	0.955	1.38	0.737	1.35	0.957	1.49	1.49	3.17	1 15	1.14	2 07
Beryllium	0.037	0.028	<0.005	<0.005	0.135	0.02	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0 005	<0 005
Cadmium	0.008	0.008	0.006	0.007	0.017	0.015	0.016	0.012	0.003	0.030	0.031	0.051	0.104	0.030	0065	0.041	0 023	0 031
Chromium	<0.06	<0.03	<0.03	0.311	0.415	0.413	<0.06	1.27	0.200	0.245	0.323	0.1276	0.229	0.236	2.17	0.084	0.147	0.617
Lead	0.20	0.08	0.09	<0.04	0.25	0.14	0.30	0.18	0.12	0.11	0.15	0.14	0.21	0.24	0.38	0.24	0.18	0 23
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0 0002	<0 0002
Nickel	0.25	0.29	0.69	0.23	0.08	0.13	0.17	1.93	<0.04	0.23	0.28	0 97	0.17	0.45	0.26	0.27	0.04	0.39
Selenium	<0.015	<0.015	<0.003	0.006	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0 003
Silver	0.028	0.037	0.020	0 032	0 005	0.030	0.025	0.023	0.028	0.048	0.032	0.032	0.014	0.017	0.042	0.012	0027	0 023
Thallium	<0.006	<0.006	<0.006	<0 006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0 006	<0.006	<0 023	<0.006	<0 006	<0 006
Vanadium	<0.011	<0.011	<0.011	<0.011	0 070	<0.011	<0.011	0.058	0 020	<0.011	<0.011	0 020	<0.011	0 023	<0.14	<0.011	<0 011	0.022
Zinc	0.153	0.162	0.503	0.110	0.250	0.129	0.138	1.25	0.101	0.098	0.208	0.364	0 168	0.365	0.100	0.161	0.370	0.521

Table 4-13 Performance Data for HTMR (Rotary Hearth/Electric Furnace) of K061, K062, F006, and Characteristic Wastes Containing Metals

BDAT List Constituent	Sample set #1 Treated Waste		Sample set #2 Treated Waste	
	Total (mg/kg)	TCLP (mg/l)	Total (mg/kg)	TCLP (mg/l)
Antimony	ND	ND	< 500	< 0.06
Arsenic	ND	ND	–	< 0.008
Barium	ND	0.02-0.7	100-400	0.18-0.8
Beryllium	–	ND	< 500	0.01-< 0.006
Cadmium	300-500	0.03-0.04	< 100	< 0.01-0.06
Chromium	33,000-39,000	0.12-0.76	30,000-37,000	< 0.03-0.14
Lead	1,500-2,700	0.02-0.2	< 100-220	0.004-0.18
Mercury	ND	ND	–	< 0.0004
Nickel	800-1,100	0.35-1.7	200-400	0.88-3.41
Selenium	38-41	ND	< 500	< 0.03
Silver	ND	ND	< 500	< 0.01-0.02
Thallium	–	–	–	–
Vanadium	–	–	–	–
Zinc	100-400	0.24-0.26	130-300	0.04-0.240

Source: INMETCO monthly composites of slag samples for 1990 and 1991, for chromium and nickel-bearing feed stocks, i.e., K061, K062, F006, D001, D007, and D002/D006.

– = No data.

ND = Not detected.

Set 1 - 1990 performance data, Set 2 - 1991 performance data.

Table 4-14 Performance Data for HTMR of Zinc (Molten Slag Reactor System)
of High Zinc Subcategory K061 Nonwastewaters

Constituent	Sample set #1		Sample set #2	
	Total untreated waste concentration (mg/kg)	Treated waste concentration (mg/kg)	Total untreated waste concentration (mg/kg)	Treated waste concentration (mg/kg)
Antimony	--	--	--	--
Arsenic	trace	trace	--	--
Barium	--	--	--	--
Beryllium	--	--	--	--
Cadmium	600	trace	20.2-30.0	0.01-0.07
Chromium	3,900	6,500	0.7-1.4	0.04-0.3
Lead	4,500	200	348-556	0.05-0.80
Mercury	--	--	--	--
Nickel	--	--	--	--
Selenium	--	--	--	--
Silver	--	--	--	--
Vanadium	--	--	--	--
Zinc	188,200	12,200	--	--

-- = No data.

Comments on data: No TCLP leachate values.

Source: Final BDAT Background Document for K061, August 1988, from Sumitomo Corporation (USEPA 1988a).

Table 4-15 Performance Data for HTMR of Zinc (Plasma Arc Furnace) of High Zinc Subcategory K061 Nonwastewaters

Constituent	Untreated waste concentration (mg/kg)	Treated waste (slag) SPLP (mg/l)									
		1	2	3	4	5	6	7	8	9	10
Antimony	–	–	–	–	–	–	–	–	–	–	–
Arsenic	–	<0.01	<0.01	0.005	<0.005	<0.01	<0.01	0.005	<0.005	0.01	0.04
Barium	–	1.223	0.75	0.26	1.76	1.40	1.12	0.93	1.47	1.41	1.21
Beryllium	–	–	–	–	–	–	–	–	–	–	–
Cadmium	–	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	–	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Lead	–	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	–	<0.05	<0.05	<0.005	<0.005	<0.05	<0.05	<0.005	<0.005	<0.05	<0.05
Nickel	–	<0.02	<0.01	<0.02	<0.02	<0.02	<0.01	<0.02	<0.02	–	–
Selenium	–	<0.01	<0.005	<0.006	<0.005	<0.01	<0.005	<0.006	<0.005	<0.5	<0.05
Silver	–	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Thallium	–	–	–	–	–	–	–	–	–	–	–
Vanadium	–	–	–	–	–	–	–	–	–	–	–
Zinc	greater than 23%	–	–	–	–	–	–	–	–	–	–

– = No data.
Sample Sets 1, 2, 3, and 4 are grab samples.
Sample Sets 5, 6, 7, and 8 are composite samples.
Sample Sets 9 and 10 were not specified as either grab or composite.

Comments: IMS provided information in the comment period to indicate that these data are for treatment of high zinc subcategory K061 nonwastewaters. (IMS later indicated to the Agency that these data are not from TCLP analysis but rather SPLP analysis. (See discussion in 4.2.5.)
Source: International Mill Service Incorporated data submitted to EPA in December 1990.

Table 4-16 Performance Data for HTMR of Zinc (Flame Reactor)
of High Zinc Subcategory K061 Nonwastewaters

Constituent	Untreated total waste concentration (mg/kg)	Treated total waste concentration (mg/kg)
Antimony	--	--
Arsenic	--	--
Barium	--	--
Beryllium	--.	--
Cadmium	1,000	50
Chromium	8,000	13,000
Lead	30,000	2,000
Mercury	--	--
Nickel	--	--
Selenium	--	--
Silver	--	--
Thallium	--	--
Vanadium	--	--
Zinc	220,000	40,000

-- = No data.

Comments on data: No TCLP leachate values.

Source: Final BDAT Background Document for K061, August 1988, from St. Joe Company. (Note: St. Joe Company Flame Reactor is currently owned by Horsehead Resource Development Company, (USEPA 1988a).)

Table 4-17 Performance Data for HTMR of Zinc (Plasma Reactor)
of High Zinc Subcategory K061 Nonwastewaters

Constituent	Untreated Waste (mg/kg)			Treated slag TCLP (mg/l)		
	Sample set #1	Sample set #2	Sample set #3	Sample set #1	Sample set #2	Sample set #3
Antimony	-	-	-	0.011	0.013	0.013
Arsenic	-	-	-	0.0012	0.0009	0.0024
Barium	-	-	-	3.07	0.59	0.35
Beryllium	-	-	-	0.033	0.033	0.033
Cadmium	180	-	-	0.01	0.01	<0.01
Chromium	34,200	84,100	84,100	<0.05	1.25	0.68
Lead	13,000	4,200	4,200	0.24	0.1	<0.10
Mercury	-	-	-	<0.001	<0.001	<0.001
Nickel	3,100	8,800	8,800	0.13	0.24	3.54
Selenium	-	-	-	<0.0005	<0.0005	<0.0005
Silver	-	-	-	<0.01	0.01	<0.01
Thallium	-	-	-	<0.10	<0.10	<0.10
Vanadium	-	-	-	<0.05	<0.05	<0.05
Zinc	93,400	173,500	173,500	0.100	0.374	0.708

-- = No data.

Comments on data: These data were preliminary data from the Davy McKee Hi-Plas Furnace.

Source: Heckett Technologies, submitted to EPA during the comment period for K061 high zinc subcategory rulemaking.

Table 4-18 Performance Data for HTMR of Zinc (Plasma Arc Reactor) of Low Zinc Subcategory K061 Nonwastewaters

Constituent	Untreated total waste concentration (mg/kg)	Treated slag concentration (mg/kg)
Antimony	--	20
Arsenic	--	2.1
Barium	--	< 200
Beryllium	--	--
Cadmium	100-600	< 2
Chromium	60,000-100,000	40,000-170,000
Lead	600-14,000	< 5
Mercury	0.7-16	< 1
Nickel	15,000-22,000	300-2,200
Selenium	--	--
Silver	--	--
Thallium	--	--
Vanadium	--	--
Zinc	22,000-53,000	50-98

-- = No data.

Comments on data: No TCLP leachate data for treated residuals.

Source: SKF Plasma Technologies data submitted to EPA in August 1987.

5. SELECTION OF REGULATED CONSTITUENTS

This section presents EPA's rationale for selection of the regulated constituents in HTMR residuals generated from the recovery of metals present in K061, K062, and F006 nonwastewaters. EPA is promulgating standards for 13 (as discussed earlier, the Agency is not promulgating a treatment standard for vanadium) metals in all nonwastewater forms of K061 and in the alternative standards for F006 and K062 nonwastewaters. EPA believes this is a valid approach because all 13 metals have the potential to be present in K061, K062, and F006 as generated, and it is a common industry practice to combine K061, F006, K062, and other metal bearing waste streams as feed sources to the HTMR process. As a result, all 13 metals can potentially be present at treatable levels. Furthermore, as some metals are removed in HTMR processes, others will be concentrated in the treated residues (i.e., slag, baghouse dust). As a result, these concentrated metals may have the potential to be present at elevated levels (above the untreated levels) in the treated residuals.

5.1   Constituents Identified in the Waste as Generated

Generally, the constituents to be regulated are selected from a list of hazardous constituents known as the BDAT list constituents. (See methodology document for developing BDAT treatment standards, USEPA 1988a.) This 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. EPA may revise this list as additional data and information become available.

To identify potential constituents for regulation, the Agency reviews the characteristics of the waste as generated and those of the residuals, as well as the elevated potential for constituents to be present based on the waste generating process. Furthermore, the Agency may

choose to regulate BDAT list waste constituents that control the operation of the treatment process.

5.1.1 Organics

The available characterization data show no BDAT list organic constituents present at detectable levels for K061 and K062 nonwastewaters. For F006, the available characterization data do not show organic constituents present at detectable levels. However, based on the Agency's knowledge of the generating process for F006, EPA believes that it is highly probable that organics from solvents may be present in F006 wastes. The Agency, however, believes that it is not necessary to regulate any organic constituents that may be present in K061, K062, or F006 nonwastewaters since it is believed that they will be destroyed to nondetectable levels due to the high temperatures and long residence times at which HTMR processes operate.

5.1.2 Cyanide

The available characterization data for F006 indicate that cyanide is present at detectable levels. Hence, the Agency is regulating cyanide because it is a common constituent in most F006 wastes. The majority of the characterization data for K061 and K062 do not show cyanide at detectable levels; however, characterization data from INMETCO show some low levels of cyanide (ranging from 0.5-7.7 mg/kg) in the untreated waste. EPA, however, believes that any cyanide that may be present in F006, K061, or K062 nonwastewaters will be destroyed to nondetectable levels by the high temperatures and long residence times at which HTMR processes operate.

5.1.3   Metals

Based on the available characterization data, all metals on the BDAT list are present in the K061 untreated waste (raw waste) at detectable levels and have the potential to be present in high concentrations depending on the metal concentration in the scrap materials smelted to produce steel. Table 5-1 shows the potential sources of metals that may be present in K061 as a result of the smelting of scrap metals.

The available characterization data for K062 nonwastewaters show detectable levels of all 13 metals except beryllium and thallium. K062 wastes are generated by steel finishing operations. Since pickling of steel removes oxides that form on the steel's surface, these spent pickling agents (e.g., acid solutions) may contain all 13 metals because the steel that is pickled can be derived from scrap metals and produce many different grades of steel containing varying metal concentrations. EPA has determined that scrap metals and the different grades of steel may potentially contain all 13 metals; hence, it is possible that all 13 metals have the potential to be present in K062 nonwastewaters.

The available characterization data for F006 nonwastewaters show detectable levels of all 13 metals with the exception of beryllium and selenium. The metal processing operations that generate F006 consist of electroplating, anodizing, chemical etching and milling, and metal cleaning and stripping. These processes are performed on various types of metals and steels (e.g., carbon steel, stainless steel, etc.) using various other metals and chemicals. For example, the electroplating of metals involves the process in which ferrous or nonferrous base materials are electroplated with cadmium, copper, nickel, chromium, brass, bronze, silver, gold, zinc, tin, lead, iron, aluminum, etc. As a result, the Agency believes that all 13 metals may potentially be present in F006 nonwastewaters.

Table 5-1 Possible Sources of Metals in Scrap Used in Steelmaking

Constituent	Source
Antimony	Antimony may be found in older, non-maintenance free batteries, cast iron and ductile iron, bearings, gears, and ammunition.
Arsenic	Some potential sources of arsenic are lead acid batteries, lead ammunition, automotive body solder, locomotive fireboxes, staybolts, straps, and plates for heat exchangers and condenser tubes.
Barium	Barium may be found in lead acid batteries, lubricants in vacuum X-ray tubes, and television picture tubes.
Beryllium	Beryllium may be found in electrical contacts, switches, clips, springs, die casts for plastics, and nonsparking safety tools.
Cadmium	Cadmium may be found in nickel-cadmium batteries, solar photovoltaic cells, cadmium plating applications, and cadmium pigments.
Chromium	Chromium is used in electroplating processes, flame and arc welding, and stainless steel.
Lead	Lead may be found in battery plates, drosses, skimmings, and industrial scrap such as solders, babbits, cable sheathing, etc.
Mercury	Mercury may be found in discarded dental amalgams, batteries, lamps, switches, measuring devices, control instruments, and wastes and sludges generated in laboratories and electrolytic refining plants.
Nickel	Nickel scrap may be found in old and/or new sheet, plate, bar, tube, and other wrought nickel scrap solids, copper-nickel peelings, plating racks, hangers, and stainless and specialty steel alloys.
Selenium	Selenium is added in trace amounts to various grades of stainless steels, indicating that it may be found at higher levels in dusts with high chromium and nickel contents.
Silver	Silver-bearing materials include jewelry, electrical assemblies, batteries, punchings, brazing alloys, electric motors, coins, dental material, film, filters, paints, electronic plated parts, silver-lined bearings for diesel locomotives and aircraft, plating sludges, and sterling silver.
Thallium	Thallium may be found in specialty metals used to make materials such as bearings. Thallium may be alloyed with lead, tin, and silver.
Zinc	Scrap sources of zinc include old or used zinc-base die cast automotive grills, jar lids, clean unalloyed castings, anti-corrosion plates, pure zinc sheets or stampings, and printer's zinc, such as engraver's zinc, lithograph sheets, and addressograph plates.

Sources: Kirk Othmer Encyclopedia of Chemical Technology, Third Edition.
   Institute of Scrap Recycling Industries, Inc., Scrap Specifications Circular 1990 Guidelines for Ferrous Scrap Nonferrous Scrap Paper Stock. 1990.
   Recycled Metals of the 1980's by the National Association of Recycling Industries, 1982.
   Steel Castings Handbook, Fifth Edition, Peter F. Werser, Editor, by the Steel Founders Society of America, 1980.
   Steel Product Manual, by the American Iron and Steel Institute, 1982.

5.2 Constituents Identified in the HTMR Residuals

Based on the principles of the pyrometallurgical processes, different metals partition to different HTMR residues (or products) at different concentrations depending on the design and operating conditions of the HTMR processes along with the chemical and physical properties of the metals. In essence, treatment of metals when using HTMR is directly related to partitioning of the metals based on their volatility and their compounds as the waste is exposed to the high temperatures of the HTMR process. (See Table 5-2.) Low-boiling point metals are volatilized and subsequently recovered. High-boiling point metals are either reduced to form an immiscible layer of molten metal (slag layer floats on top of the metal layer) or thermo-chemically stabilized in HTMR residues such as slags. The relative stability may depend on the solubility of the metal and/or metal compound in the slag matrix. This thermo-chemical stabilization of the relatively nonvolatile metals occurs because of high temperatures, the relatively efficient mixing conditions, the oxidation-reduction conditions in the primary furnace, and the presence of other inorganic constituents that act, in effect, as stabilization reagents. In fact, many of the same conventional cementitious stabilization reagents, such as calcium, silica, and alumina, are also used as additives in some HTMR processes to achieve desirable HTMR operating conditions, as well as to enhance desirable slag properties.

5.3 Constituents Selected for Regulation

For K061 in general, the Agency is regulating 13 metals (vanadium is not being regulated in this final rule) for several reasons. The original standards for K061 (promulgated in the First Thirds Rule) were considered interim standards, 53 FR 31164, based on stabilization performance data and not the performance of HTMR which is BDAT for K061 nonwastewaters. These interim standards were set until HTMR capacity could come on-line, enabling the Agency to better examine the performance of HTMR units. Further, at that time, the Agency was unaware of the wide variety of metals composition in K061 wastes; hence, the Agency did not

Table 5-2 Chemical and Physical Properties for 13 Metals in HTMR Processes

Metal	Ease of Oxidation	Ease of Oxide Reduction	Boiling Point of Metal (°C)	Boiling Point of Oxide (°C)	Solubility of Oxide in Slag	Expected Disproportionation of Metal Compounds in the HTMR Processes
Antimony	Metal, easily oxidized to Sb_2O_3.	Reducible with carbon at higher temperatures (over 600°C)	631	1,550	Low; requires good mixing to ensure solution. Otherwise, Sb_2O_3 will remain as a separate phase.	Some will be reduced to Sb metal, volatilized and converted to Sb_2O_3 in gas phase. Most will exit in the gas phase.
Arsenic	Metal, easily oxidized to As_2O_3.	Reducible at higher temperatures with carbon.	813	193	Limited; requires good mixing to ensure solution. Otherwise, As_2O_3 will remain as a separate phase; will react with alkaline slags to form calcium arsenate, which is slag soluble.	Most will volatilize as As_2O_3 and become incorporated into the crude ZnO produced.
Beryllium	Metal, easily oxidized to BeO.	Very difficult to reduce.	2,970	3,900	High; BeO will react with molten silicates to form beryllium silicate.	Almost totally incorporated into the slag unless high reducing conditions are present. Beryllium silicate is a natural mineral.
Barium	Metal, very easily converted to BaO.	Very difficult to reduce.	1,640	2,000	High; BaO reacts with molten silicates to form barium silicate.	Almost totally incorporated into slag.
Cadmium	Easily oxidized to CdO at elevated temperatures.	Easily reduced with coke (C) to the metal at elevated temperatures.	765	1,559	Oxide is somewhat soluble after conversion to the silicate.	Most oxide will be reduced to the metal. The metal will volatilize and become oxidized and collected. Remainder will be incorporated as slag.
Chromium	Will react with oxygen above 200°C to form Cr_2O_3.	Cr_2O_3 can be reduced with coke to CrO. CrO difficult to reduce. CrO_3 decomposes to Cr_2O_3 and oxygen above 196°C.	2,872	CrO_3 decomposes 196 Cr_2O_3 decomposes 4000 CrO decomposes <2800	Low, except at high temperatures.	Cr_2O_3 will partially dissolve in the slag and partially be present as a separate molten metal. Volatilization as metal or oxide will be negligible.
Lead	Easily converted to PbO.	All oxides easily reduced with carbon to the metal.	1,740	PbO—868 PbO_2 decomposes 290 Pb_3O_4 decomposes 500	Somewhat soluble as lead silicate.	Most oxide will be converted to metal. The metal will volatilize and be oxidized and recovered as oxide. A minority will be dissolved as lead silicate in the slag.

Table 5-2 (continued)

Metal	Ease of Oxidation	Ease of Oxide Reduction	Boiling Point of Metal (°C)	Boiling Point of Oxide (°C)	Solubility of Oxide in Slag	Expected Disproportionation of Metal Compounds in the HTMR Processes
Mercury	Above 500°C, oxide reverts to elemental metal.	Easily reduced.	351	Decomposes to metal and oxygen at 500°C	Mercury metal will volatilize at these temperatures.	Mercury vaporizes and is recovered as metal particulates.
Nickel	Above 1000°C, the metal is readily oxidizes to NiO.	Above 400°C, the reduction with carbon will occur.	2,732	>2,000	Nickel oxide will react to form nickel silicate, which will dissolve in slag.	Nickel will primarily dissolve in the slag, unless furnace conditions are highly reducing, it will form an inmisicible molten metal layer below the slag layer.
Silver	Oxide reverts to metal at 230°C.	Easily reduced to metal.	2,212	Decomposes at 230	Oxide decomposes at 230°C.	Most metal will volatilize and be recovered as particulate.
Selenium	Easily burns to Se_2O.	SeO_2 is a gas at elevated temperatures.	685	350	SeO_2 is somewhat soluble in silicate matrices.	Most selenium will volatilize and be recovered as selenite-containing particulates. Small amounts will be incorporated in slag.
Thallium	At 900°C, metal easily oxidized to Tl_2O.	Tl_2O_3 readily reduced. Tl_2O difficult to reduce completely.	1,457	Tl_2O–1,865 Tl_2O_3 decomposes at 875	Tl_2O dissolves in slag to form thallous silicate.	Most thallium will volatilize as metal, be converted to and collected as an oxide impurity in the crude zinc oxide produced A small amount will be incorporated into slag.
Zinc	Metal easily oxidized to ZnO.	Reduced to metal at process temperatures.	907	1,975	Dissolves in silicate slags as zinc silicate.	Mostly volatilizes as metal, converts to and is collected as the oxide. Some zinc will become incorporated into slag.

Source: G.V. Samsonov, 1973. The Oxide Handbook, Plenum Press, NY.

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establish stabilization standards for all 13 metals. Information now available to the Agency suggests that all 13 metals have a reasonably high potential for being present in any given K061 waste because of the nature of the steel manufacturing process from which K061 is generated. Data on the composition of K061 indicate that these 13 metals are present at varying concentrations in K061 wastes from different generating facilities. This appears to be related to the types of scrap materials smelted in the electric furnace, the metals added to make certain types of steel alloys, and/or the grade of steel produced. (Table 5-1 presents information on the possible sources of metals that may be present in scrap metals.)

With respect to F006 and K062 nonwastewaters, the Agency believes that all 13 metals also have the potential to be present in these wastes. EPA believes this because the processes generating these wastes involve metal processing such as electroplating, etching, anodizing, milling, pickling, and metals finishing that produce residues that may contain components of the substrate steel. Since steel is typically made from scrap metals and can be produced in different grades with varying metal concentrations, all 13 metals have the potential to be present. (See Section 5.1.3.)

Since all 13 metals have the potential to be present in K061, K062, and F006, they also have the potential to be in the HTMR residues depending upon where the metals partition in the recovery process. The Agency believes that improper operation of the HTMR process could result in shifts in partitioning of certain metals to products (e.g., metal alloys), intermediates, slag, or other nonwastewater residues. Hence, the metal distribution in the HTMR process is highly dependent upon parameters such as the operating temperature of the heat zones, the composition of metals and other elements in the feed, zone residence times, flow rates, oxidation/reduction conditions, and mixing. The Agency believes that there is also an inherent metallurgical interdependency between certain metals, based on their atomic structure. Based on these factors, the Agency concludes that all metal-bearing materials (nonhazardous as well as hazardous) placed into HTMR processes could affect the ultimate composition and leachability of metals from HTMR nonwastewater residues. Hence, the Agency believes that regulation of

13 metals (vanadium is not being regulated) will provide a means of ensuring that the HTMR processes, when used to treat K061, K062, and/or F006 wastes, are well-designed and well-operated (i.e., truly BDAT) with due consideration of all feed materials. Since all 13 metals are potentially present in the treatment residues and may be hazardous to either human health or the environment, EPA is promulgating treatment standards that will ensure control of the leachability of all 13 metals.

6. DEVELOPMENT OF BDAT TREATMENT STANDARDS

The final treatment standards, based on the performance of HTMR, were calculated from data that are representative of properly designed and properly operated HTMR processes. The HTMR processes have been demonstrated to recover metals from high zinc K061 nonwastewaters or mixtures of K061 nonwastewaters containing high and low zinc subcategory K061 nonwastewaters. Some of these data also represented the treatment performance of F006 and K062 nonwastewaters since these wastes are often mixed with K061 to achieve a desired feed mixture. Data that meet these requirements include: (1) 3 TCLP leachate analyses for all 13 metals and 13 TCLP leachate analyses for the 9 toxicity characteristic (TC) metals in the slag (i.e., IRM) generated by the HRD waelz kilns process (Tables 4-1 and 4-2); (2) 16 TCLP leachate analyses for all 13 metals in the slag generated by the IMS plasma furnace process (Table 4-4); (3) 1 TCLP leachate analysis for 10 metals in the slag generated by the SKF plasma furnace process (Table 4-3); and (4) 3 TCLP leachate analyses for all 13 metals in the slag generated by the INMETCO electric furnace process (Table 4-5). Performance data are discussed in Section 4 of this document.

Given that all of these technologies are capable of achieving substantial immobilization of hazardous constituents (though not identical levels of performance), EPA believes it to be appropriate to combine the performance achievability when developing treatment standards. EPA further notes that certain apparent differences in performance result from different reported detection limits. For many of the metals, all reported data show nondetectable levels of metals in the HTMR slag, but different limits of detection due to different slag matrices (or perhaps due to differing levels of performance by analytical laboratories). In these cases, EPA uses the highest analytical detection limits in order to accommodate performance of as many of the well-operated HTMR technologies as possible.

As a result, the final treatment standards, based on the performance of HTMR, have been calculated using the following BDAT methodology. First, treatment standards were determined individually for each process. Then, the four sets of standards were compared to one another. Based on this comparison, the Agency selected the highest standard for each metal from each of the four processes to allow for process variability and detection limit difficulties. This approach derives limits achievable by all of the major HTMR technologies (and probably achievable by stabilization as well) since, properly operated, these technologies all appear capable of substantially reducing the mobility of metals in HTMR slags.

The following discussion details the specific methodology[*] used to calculate the final treatment standards based on the performance of HTMR as BDAT. Before the treatment standards were calculated, the treated data were corrected for analytical accuracy by using the available matrix spike percent recovery values to calculate accuracy correction factors (ACFs). These corrected data are shown in Table 6-1. The Agency had matrix spike percent recovery data from two HTMR process residuals (i.e., slag) that were considered from well-designed and well-operated HTMR processes. These data were (1) matrix spike percent recovery data from Horsehead Resource Development Company, Inc. (HRD) obtained by EPA in the First Third Rule and (2) matrix spike percent recovery data submitted from International Mill Service (IMS) during the comment period to the proposed rule for K061 high zinc subcategory nonwastewaters. The HRD matrix spike percent recovery data were used to correct HRD's data, shown in Table 6-5. The IMS matrix spike percent recovery data were used to correct its data, shown on Table 6-3. Because no matrix spike percent recovery data were available for the data from SKF Plasma Technologies and INMETCO, the Agency used the matrix spike percent recovery data from IMS to correct the data from SKF Plasma Technologies and INMETCO. The Agency considered it appropriate to use the matrix spike percent recovery data from IMS because the slag from IMS's technology was more similar to SKF Plasma Technologies' and INMETCO's

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[*] For more information on the methodology for calculating BDAT treatment standards, see Methodology for Developing BDAT Treatment Standards (USEPA 1989).

slag than the slag from HRD. HRD's technology does not form a true molten slag, whereas, technologies from SKF, INMETCO, and IMS do form a molten slag.

Next, the Agency calculated the Accuracy Correction Factors (ACFs), i.e., the reciprocal of the lowest matrix spike percent recovery value for each constituent. The ACFs were multiplied by the treated values to yield the corrected data. The accuracy-corrected data used to calculate the final treatment standards are shown in Table 6-1. The ACFs, percent recoveries, and calculation of the final treatment standards are also shown in Tables 6-2 to 6-7.

As discussed earlier, in determining the treatment standards, the Agency used four sets (representing the performance of four different HTMR processes) that were considered representative of well-designed and well-operated HTMR processes. The first step in developing the treatment standards, based on the different HTMR processes, was to calculate treatment standards from each of the four sets of treatment performance data. The next step was to select the highest treatment standard for each metal derived from the four individual data sets.

The calculation of final treatment standards for each of the four data sets is discussed below. Each discussion is immediately followed by a table showing the corrected data, the descriptive summary statistics for these data, and the specific methodology used to calculate the treatment standard for each metal constituent and for cyanide in F006.

Table 6-1 Corrected Data Used in the Calculation of Treatment Standards Based on Performance of HTMR

Corrected data	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
					Horsehead Resource Development Co. (HRD) Data								
1	0.8382	0.013	4.8	<0.0011	<0.0696	<0.1176	0.007	<0.00022	0.105	<0.0104	<0.106	<0.0104	0.2458
2	0.929	<0.010	3.25	0.002	<0.0035	<0.1176	<0.0066	0.003	0.1652	<0.0104	<0.005	<0.0104	0.1306
3	0.3749	<0.010	4.09	<0.0011	<0.0035	<0.059	<0.0066	<0.00022	0.0259	<0.0104	<0.0528	<0.0104	0.0816
4	-	<0.005	0.467	-	<0.0115	0.0147	<0.132	<0.0011	<0.0216	0.0208	<0.0264	-	-
5	-	<0.005	2.39	-	<0.0115	<0.0147	<0.132	<0.0011	<0.0216	<0.0208	<0.0264	-	-
6	-	<0.005	1.55	-	<0.0115	<0.0147	<0.132	<0.0011	<0.0216	<0.0208	<0.0264	-	-
7	-	<0.005	0.689	-	<0.0115	<0.0147	<0.132	<0.0011	<0.0216	<0.0208	<0.0264	-	-
8	-	<0.005	0.678	-	<0.0115	<0.0147	<0.132	<0.0011	0.1188	<0.0208	<0.0264	-	-
9	-	<0.005	1.55	-	0.023	0.0882	<0.0132	<0.0011	0.0324	<0.0208	0.0396	-	-
10	-	<0.005	0.679	-	<0.0115	<0.0147	<0.132	<0.0011	<0.0216	0.0208	<0.0264	-	-
11	-	<0.005	1.11	-	<0.0115	<0.0147	<0.132	<0.0011	<0.0216	0.0208	<0.0264	-	-
12	-	0.005	0.53	-	<0.0115	<0.0147	<0.132	<0.0011	<0.0216	0.0147	<0.0264	-	-
13	-	<0.005	0.43	-	<0.0115	<0.0147	<0.132	<0.0011	<0.0216	0.0208	<0.0264	-	-
14	-	<0.005	0.84	-	<0.0115	<0.0147	<0.132	<0.0011	<0.0216	0.0208	<0.0264	-	-
15	-	<0.005	1.44	-	<0.0115	<0.0147	<0.132	<0.0011	<0.0216	<0.0208	0.0264	-	-
16	-	<0.005	0.62	-	<0.0115	0.0147	<0.132	<0.0011	0.0432	<0.0208	<0.0264	-	-
17	-	<0.005	0.854	-	<0.0115	<0.0147	<0.132	<0.0011	<0.0216	<0.0208	<0.0264	-	-
					SKF Plasma Technologies, Inc. Data								
1	-	<0.0057	2.70	-	<0.0053	0.0133	<0.052	<0.0002	0.231	<0.056	0.014	-	-

Table 6-1 (continued)

Corrected data	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
					International Mills Service (IMS) Data								
1	0.057	0.0194	1.404	<0.001	<0.0053	<0.0112	<0.113	<0.0032	<0.027	<0.0278	0.018	0.0058	0.067
2	0.077	0.031	2.19	<0.003	<0.0052	<0.0011	<0.11	<0.003	<0.026	<0.050	0.017	<0.0054	0 12
3	<0.074	0.027	1.48	<0.003	<0.0052	0.012	<0.11	<0.003	<0.026	<0.025	0.024	<0.0054	0 135
4	0.052	0.023	1.43	<0.001	<0.0052	<0.011	<0.11	<0.003	<0.026	<0.050	0.012	<0.0054	0.039
5	0.0323	0.0085	1.99	<0.003	<0.0052	<0.011	<0.11	<0.003	<0.026	<0.050	0.015	<0.0054	1.23
6	0.024	0.0095	1.68	<0.003	<0.0052	<0.011	<0.11	<0.003	<0.026	<0.050	0.015	<0.0054	0.29
7	<0.010	<0.0057	0.51	<0.003	<0.0042	<0.0112	<0.113	<0.0032	<0.027	0.0455	0.013	<0.0058	0.275
8	0.064	0.0319	1.03	<0.003	<0.0042	<0.0112	<0.013	<0.0032	<0.027	<0.0055	0.015	<0.0058	0.51
9	0.042	0.0216	1.37	<0.003	<0.0042	0.0306	<0.113	<0.0032	<0.027	0.0278	0.016	<0.0058	0.0489
10	0.013	0.00798	0.875	<0.003	0.0095	0.0153	<0.113	<0.0032	<0.027	0.0355	0.016	<0.0058	6.548
11	0.030	0.0091	4.08	<0.003	0.0064	0.0551	<0.113	<0.0032	<0.027	0.0411	0.016	<0.0058	0.0612
12	<0.010	<0.0057	0.378	<0.003	0.0127	0.0122	0.206	<0.0032	<0.027	<.0055	0.011	<0.0058	0.377
13	<0.010	<0.0057	0.443	<0.003	<0.0042	0.0184	<0.113	<0.0032	<0.027	<0.0055	0.012	<0.0058	<0.0194
14	<0.010	<0.0057	0.454	<0.003	<0.0042	<0.0112	<0.113	<0.0032	<0.027	0.0278	0.013	<0.0058	0.0245
15	<0.010	0.0068	2.19	<0.003	0.0042	0.0122	<0.113	<0.0032	<0.027	0.0444	0.013	<0.0058	0.0337
16	<0.010	<0.0057	0.475	<0.003	0.0064	0.0153	<0.113	<0.0032	<0.027	0.0389	0.016	<0.0058	0.058

IMS' samples 2-6 are 50 gram samples.
IMS' samples 1 and 7-16 are 100 gram samples.

Corrected data	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
				International Metals Reclamation Company (INMETCO) Data									
1	<.3	<0.0091	0.583	0.010	<0.0106	<0.0306	0.01174	<0.00042	3.581	<0.033	<0.010	<0.0139	0.116
2	<.3	<0.0091	0.305	<0.006	<0.0106	<0.0306	0.0885	<0.00042	2.29	<0.033	<0.010	<0.0278	0.245
3	<.3	<0.0091	0.194	<0.006	<0.0106	<0.0306	0.0037	<0.00042	2.14	<0.033	<0.010	<0.0139	0.210

6.1 Treatment Standards Calculation Based on HTMR Treatment Performance Data from SKF Plasma Technologies (See Table 6-2.)

Only one data point was available for 9 metal constituents. The Agency considered this HTMR process to represent a well-designed and well-operated HTMR process and, thus, calculated treatment standards for 9 metals using the corrected data multiplied by a variability factor of 2.8. These calculations are shown on Table 6-2. The Agency reiterates that the methodology was modified wherein the highest treatment standard was selected for each metal constituent from four sets of treatment performance data. Hence, the Agency has not relied on just one datum point in the consideration of the treatment standard.

Table 6-2 Calculation of Treatment Standards Based on HTMR Performance Data
From SKF Plasma Technologies

	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
Number of samples	-	1	1	-	1	1	1	1	1	1	1	-	-
Percent recovery (PR)(%)[1]	-	88	93	-	94	98	97	95.2[2]	95	90	100	-	-
Accuracy correction factor (ACF)[3]	-	1.136	1.075	-	1.064	1.021	1.031	1.05	1.052	1.11	1.0	-	-
Mean of corrected data (CD)	-	<0.0057	2.70	-	<0.0053	0.0133	<0.052	<0.0002 1	0.231	<0.056	0.014	-	-
Variability factor (VF)	-	2.8	2.8	-	2.8	2.8	2.8	2.8	2.8	2.8	2.8	-	-
Formula for calculating treatment standard	-	CD x 2.8	CD x 2.8	-	CD x 2.8	CD x 2.8	CD x 2.8	CD x 2.8	CD x 2.8	CD x 2.8	CD x 2.8	-	-
Treatment standard (TS) (mg/l)	-	0.016	7.6'	-	0.015	0.037	0.15	0.00059	.0.65	0.16	0.039	-	-

CD = Corrected data.
< = Detection limit value.
- = No data.
[1] Matrix spike data were transferred from the IMS plasma furnace matrix spike slag data (100 gram samples). No matrix spiked data were available for these data. Thus, the Agency decided it was appropriate to use the matrix spike data from another HTMR plasma furnace process that has a true molten slag.
[2] The matrix spike recovery value is the average of the matrix spike data for all the metals, since no value for this metal was available from a molten slag matrix.
[3] ACF = 100/PR.

6.2 Treatment Standards Calculations Based on HTMR Treatment Performance Data from International Mill Service (See Table 6-3.)

Antimony and Arsenic

There were detection limit values and detected values for these two metals. For antimony, there were detected values above and below the highest detection limit; for arsenic, none of the detected values were below the highest detection limit. Thus, the treatment standards for these two metals were calculated using the standard BDAT formula, i.e., Treatment Standard (TS) equals Exponent (EXP) (mean logtransformed data + 2.33 (standard deviation of the log transformed data)).

Barium, and Silver

All values for these two metals were detected values; hence, the treatment standard calculation was derived from the standard BDAT formula, i.e.,

TS = Exp (mean of logtransformed data + 2.33 (standard deviation of the logtransformed data))

Beryllium and Nickel

All values for these two metals were nondetected values; hence, the treatment standards were calculated by multiplying the highest detection limit times a 2.8 variability factor.

Cadmium, Chromium, Lead, Thallium, and Zinc

For these five metals, there were detected values and detection limit values. Since all of the detected values were equal to or greater than the highest detection limit, the treatment standards were calculated using the standard BDAT formula, i.e.,

TS = Exp (mean of logtransformed data + 2.33 (standard deviation of the logtransformed data)).

Mercury and Selenium

For these two metals, there were detection limit values and detected values. Since the detected values were below the highest detection limit value and none were above it, the Agency selected the highest detection limit and multiplied it times a 2.8 variability factor.

Table 6-3 Calculation of Treatment Standards Based on HTMR Performance Data from International Mill Service

	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
Number of samples	16	16	16	16	16	16	16	16	16	16	16	16	16
Percent recovery (PR) (%)[1]	100 98.6[3]	88 94	93 100	100 100	94 97	98 100	97 100	95.2[3] 98.6[3]	95 100	90 100	100 100	86 93	98 100
Accuracy correction factor (ACF)[4]	1.0 1.01	1.136 1.064	1.075 1.0	1.0 1.0	1.064 1.031	1.021 1.0	1.031 1.0	1.05 1.01	1.052 1.0	1.11 1.0	1.0 1.0	1.16 1.075	1.021 1.0
Mean of corrected data (CD) or HDL	0.0328 (Mean)	0.01402 (Mean)	1.37 (Mean)	<0.003 (HDL)	0.0057 (Mean)	0.016 (Mean)	0.1179 (Mean)	<0.0032 (Mean)	<0.027 (HDL)	<0.05 (HDL)	0.015 (Mean)	0.0055 (Mean)	0.615 (Mean)
Variability factor (VF)	5.2	3.9	4.2	2.8^2	1.9	2.5	1.4	2.8^2	2.8^2	2.8^2	1.5	1.2	8.6
Formula for calculating treatment standard	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))	TS= HDLx2.8	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))	TS= HDLx2.8	TS= HDLx 2.8	TS= HDLx2.8	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))
Treatment standard (TS) (mg/l)	0.17	0.055	5.7	0.0084	0.011	0.041	0.17	0.0090	0.076	0.14	0.023	0.0065	5.3

HDL = Highest detection limit.
TS = Treatment standard.
y = Mean of logtransformed corrected data.
sy = Standard deviation of logtransformed corrected data.
< = Detection limit value.

[1] = First recovery value was for the 100 gram samples from IMS data, and the second recovery value was from the 50 gram samples from IMS data. (See Table 6-1.) (Any value over 100 percent recovery was considered to be just 100 percent.)

[2] = The variability factor shown for these constituents is 2.8; the formula used for calculating the treatment standards for this specific constituent (from this data set) i.e., HDL x 2.8; other variability factors shown were derived by dividing the treatment standard by the mean of the corrected data.

[3] = Matrix spike value is the average of the matrix spike data for all the metals since no value was given for this metal.

[4] = ACF = 100/PR.

6.3 Treatment Standards Calculations Based on HTMR Treatment Performance Data from International Metals Reclamation Company (INMETCO) (See Table 6-4.)

Antimony, Arsenic, Cadmium, Chromium, Mercury, Selenium, Silver, and Thallium

All values for these eight metals were nondetected values; hence, the treatment standards were calculated by selecting the highest detection limit and multiplying it times a 2.8 variability factor.

Barium, Nickel, Lead, and Zinc

For these four metals, all the values were detected values; hence, the treatment standards were calculated using the standard BDAT formula, i.e.,

TS = Exp (mean of the logtransformed data + 2.33 (standard deviation of the logtransformed data)).

Beryllium

There were detection limits and one detected value for beryllium; however, this detected value was not below the highest detection unit. Thus, the Agency used the standard BDAT formula to calculate the treatment standard, i.e.,

TS = Exp (mean of the logtransformed data + 2.33 (standard deviation of the logtransformed data)).

Table 6-4 Calculation of Treatment Standards Based on HTMR Performance Data from International Metals Reclamation Company

.	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
Number of samples	3	3	3	3	3	3	3	3	3	3	3	3	3
Percent recovery (PR) (%)[1]	100	88	93	100	94	98	97	95.2[3]	95	90	100	86	98
Accuracy correction factor (ACF)[4]	1.0	1.136	1.075	1.0	1.064	1.021	1.031	1.05	1.052	1.11	1.0	1.16	1.021
Mean of corrected data (CD) or (HDL)	<0.30 (HDL)	<0.0091 (HDL)	0.3607 (Mean)	0.0073 (Mean)	<0.0106 (HDL)	<0.0306 (HDL)	0.00809 (Mean)	<0.00042 (HDL)	2.67 (Mean)	<0.033 (HDL)	<0.010 (HDL)	0 0278 (HDL)	0 1903 (Mean)
Variability factor (VF)	2.8^2	2.8^2	3.3	1.9	2.8^2	2.8^2	3.7	2.8^2	1.9	2.8^2	2.8^2	2.8^2	2.4
Formula for calculating treatment standard	TS= HDLx2.8	TS= HDLx2.8	TS=Exp (y+2.33(sy))	TS=Exp (y+2.33(sy))	TS= HDLx2.8	TS= HDLx2.8	TS=Exp (y+2.33(sy))	TS= HDLx2.8	TS=Exp (y+2.33(sy))	TS= HDLx2.8	TS= HDLx2.8	TS= HDLx2.8	TS=Exp (y+2.33(sy))
Treatment standard (TS) (mg/l)	0.84	0.025	1.2	0.014	0.030	0.086	0.030	0.0012	5.0	0.092	0.028	0 078	0 46

HDL = Highest detection limit.
TS = Treatment standard.
y = Mean of logtransformed corrected data.
sy = Standard deviation of logtransformed corrected data.
< = Detection limit value.

[1] = Matrix spike data were transferred from the IMS' plasma furnace matrix spike slag data (100 gram samples). No matrix spike data were available for these data, so the Agency decided it was appropriate to use other matrix spike data from another HTMR process that had a true molten slag (i.e., IMS).

[2] = The variability factor shown for this constituent is 2.8, the formula used for calculating the treatment standards for this constituent from this data set, i.e., HDL x 2.8; other variability factors were derived by dividing the treatment standard by the mean of the corrected data.

[3] = Matrix spike recovery value is the average of the matrix spike data for all the metals since no value was available from a molten slag matrix for this metal.

[4] = ACF = 100/PR.

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6.4 Treatment Standards Calculations Based on HTMR Treatment Performance Data from Horsehead Resource Development Co., Inc. (HRD) (See Table 6-5.)

Antimony, Barium, and Zinc

For these three metals, all the values were detected values; hence, the formula used for calculating the treatment standards was the standard BDAT formula, i.e.,

$$TS = Exp \text{ (mean of the logtransformed data} + 2.33 \text{ (standard deviation of the logtransformed data))}.$$

Arsenic

For arsenic, the detected values were above and below the highest detection limit; hence, the standard BDAT formula was used to calculate the treatment standards, i.e.,

$$TS = Exp \text{ (mean of the logtransformed data} + 2.33 \text{ (standard deviation of the logtransformed data))}.$$

Beryllium, Mercury, Nickel, and Selenium

For these four metals, there were detection limits and detected values. Since none of the detected values were below the highest detection limit, the standard BDAT formula was used to calculate the treatment standards, i.e.,

$$TS = Exp \text{ (mean of the logtransformed data} + 2.33 \text{ (standard deviation of the logtransformed data))}.$$

Cadmium, Chromium, Lead, and Silver

There were detection limits and detected values for all four metals. Since the detected values were only below and not above the highest detection limit, the treatment standard calculation was derived by taking the highest detection limit and multiplying it times a 2.8 variability factor.

Thallium

All values for thallium were nondetected values; hence, the Agency selected the highest detection limit and multiplied it times a variability factor of 2.8.

Table 6-5 Calculation of Treatment Standard based on HTMR Performance Data from Horsehead Resource Development Company, Inc.

	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
Number of samples	3	17	17	3	17	17	17	17	17	17	17	17	3
Percent[2] recovery PR (%)	92	100	90	90	87	68	76	90	93	48	76	96	98
Accuracy correction factor (ACF)	1.09	1.0	1.11	1.11	1.15	1.47	1.32	1.11	1.08	2.08	1.32	1.04	1.02
Mean of corrected data or HDL	0.714 (Mean)	0.006 (Mean)	1.528 (Mean)	<0.0013 (Mean)	<0.0689 (HDL)	<0.1176 (HDL)	<0.132 (HDL)	0.0011 (Mean)	0.0427 (Mean)	0.0202 (Mean)	<0.105 (HDL)	<0.0104 (HDL)	0.1527 (Mean)
Variability factor (VF)	2.9	2.0	4.4	2.1	2.8[1]	2.8[1]	2.8[1]	3.6	3.7	2.1	2.8[1]	2.8[1]	3.3
Formula for calculating treatment standard	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))	TS= HDLx2.8	TS= HDLx2.8	TS= HDLx2.8	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))	TS= HDLx2.8	TS= HDLx2.8	TS=Exp (y+2.33 (sy))
Treatment standard (TS) (mg/l)	2.1	0.012	6.7	0.0030	0.19	0.33	0.37	0.0041	0.16	0.042	0.30	0.029	0.50

HDL = Highest detection limit.
TS = Treatment standard.
y = Mean of logtransformed corrected data.
sy = Standard deviation of logtransformed corrected data.
< = Detection limit value.

[1] The variability factor shown for this constituent is 2.8, due to the formula used for calculating the treatment standard for this specific constituent from this data set, i.e., HDL x 2.8; other variability factors shown were derived by dividing the treatment standard by the mean of the corrected data.

[2] Recovery values were taken from the Onsite Engineering Report for Horsehead Resource Development Co., Inc., March 29, 1988.

6.5 Treatment Standards Calculation for Cyanide (See Table 6-6.)

The alternative treatment standard for cyanide in F006 is based on the incineration treatment performance data used to develop the K048-K052 cyanide treatment standard. (See Table 4-6.) The Agency has no data on the treatment performance of HTMR for destruction of cyanide but believes that HTMR will achieve a level of destruction for cyanide similar to incineration. EPA believes the levels will be similar, since HTMR occurs at higher temperatures than incineration (i.e., most HTMR units operate at 1,220°C-1,600°C while incineration typically operates at less than 1,100°C). Further, HTMR typically operates with longer residence time.

Table 6-6 Calculation of Treatment Standards for Cyanide in F006 Based on Incineration
Treatment Performance Data for Cyanide in K048 and K052 Nonwastewaters

Regulated Constituent	Unstabilized Incinerator Ash from Plant A (mg/kg)	Arithmetic Average of Corrected Treatment Value (mg/kg)	Variability Factor (VF)	Treatment Standard* Average x VF (mg/kg)
Cyanide	0.5-1.4	0.274	6.37	1.8

Source: Final BDAT Background Document for K048-K052 (August 1988).

*The values shown on this table for treatment standards have been rounded to show significant figures only.

6.6 Treatment Standards Calculations for Metals (i.e., Highest Standard from the Four Sets of Treatment Performance Data) (See Table 6-7.)

Table 6-7 presents the treatment standards and summary data for the standards that resulted from the highest value selected among the four sets of standards (as previously discussed in the Introduction to Section 6).

	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc
Number of samples	3	16	1	3	17	17	17	16	3	1	17	3	-	16
Sources	HRD	IMS	SKF	INMETCO	HRD	HRD	HRD	IMS	INMETCO	SKF	HRD	INMETCO	-	IMS
Percent recovery (PR) (%)	92	88	93	100	87	68	76	95.2	95	90	76	86	-	98
Accuracy correction factor (ACF)	1.09	1.14	1.08	1.0	1.15	1.47	1.32	1.02	1.05	1.11	1.32	1.16	-	1.02
Mean of corrected data or HDL or CD	0.714 (Mean)	0.014 (Mean)	2.70 (CD)	0.0073 (Mean)	<0.0689 (HDL)	<0.1176 (HDL)	<0.132 (HDL)	<0.0032 (HDL)	2.67 (Mean)	0.056 (CD)	<0.1050 (HDL)	<0.0278 (HDL)	-	0.615 (Mean)
Variability factor (VF)	2.9	3.9	2.8[1]	1.9	2.8[1]	2.8[1]	2.8[1]	2.8[1]	1.9	2.8[1]	2.8[1]	2.8[1]	-	8.6
Formula for calculating treatment standard	TS=Exp (y+2.33 (sy))	TS=Exp (y+2.33 (sy))	TS= CDx2.8	TS=Exp (y+2.33 (sy))	TS= HDLx2.8	TS= HDLx2.8	TS= HDLx2.8	TS= HDLx2.8	TS=Exp (y+2.33 (sy))	TS= CDx2.8	TS= HDLx2.8	TS= HDLx2.8	-	TS=Exp (y+2.33 (sy))
Treatment standard (TS) (mg/l)	2.1	0.055	7.6	0.014	0.19	0.33	0.37	0.0090	5.0	0.16	0.30	0.078	NR	5.3

NR   = Not regulated.
CD   = Corrected datum point.
HDL   = Highest detection limit.
TS   = Treatment standard.
y   = Mean of logtransformed corrected data.
sy   = Standard deviation of logtransformed corrected data.
SKF   = SKF Plasma Technologies Company
HRD   = Horsehead Resource Development Company, Inc.
IMS   = International Mill Service
INMETCO = International Metals Reclamation Company

1   The variability factor shown for this constituent is 2.8, due to the formula used for calculating the treatment standard for this specific constituent from this data set, i.e., HDL x 2.8; other variability factors shown were derived by dividing the treatment standard by the mean of the corrected data

2   See Tables 6-2 to 6-5 for explanation of where recovery values were taken from

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7. GENERIC EXCLUSION FOR K061, F006, AND K062 NONWASTEWATER RESIDUES (SUCH AS SLAG) GENERATED FROM HTMR PROCESSES AND RELATED ISSUES

This section discusses the development of the generic exclusion levels for HTMR nonwastewater residues. The Agency concluded in the final rulemaking for K061 high zinc subcategory nonwastewaters that K061 (both low and high zinc) HTMR nonwastewater residues that meet generic exclusion levels for all constituents and that exhibit no characteristics of a hazardous waste will not be hazardous. The decision to generically exclude nonwastewater HTMR residues is based on the fact that the treatment process is well-defined and, thus, does not require an in-depth evaluation of each facility's processes. The Agency believes that the "derived-from" rule's presumption of hazardousness no longer should apply to HTMR residues which have treated toxic metals to specific levels. The Agency has made this determination after considering the protectiveness factors in § 3001(f) and after satisfying the underlying philosophy of the delisting provisions.

The generic exclusion levels include all the Appendix VIII and indicator metals that might reasonably be expected to be present in the HTMR nonwastewater residues from processing F006, K061, and/or K062 wastes by HTMR. (This is consistent with RCRA section 3001(f) which requires EPA to evaluate whether toxic constituents, in addition to those for which a waste is listed, could make a waste hazardous.) The Agency notes that it is not setting exclusion levels for organic constituents that could be common in F006 wastes. The Agency does not have specific performance data on the destruction of organics in HTMR units. However, since HTMR units operate at higher temperatures and longer residence times than incinerators, the Agency believes that HTMR will achieve a level of destruction similar to or better than incineration. Consequently, the Agency believes that the regulation of organic constituents in HTMR residues is not necessary since any organic constituent will be destroyed to nondetectable levels in HTMR units, and the regulation of 13 metals (vanadium is not being regulated in the final rule) will ensure the proper operation of HTMR systems.

Residues from HTMR of K061 (and with this rulemaking residues from F006 and K062 wastes) wastes in units identified as rotary kilns, flame reactors, electric furnaces, plasma arc furnaces, slag reactors, and rotary hearth furnace/electric furnace combinations or industrial furnaces (as defined in 40 CFR 260.10(6), (7), and (12)) are excluded from the hazardous waste regulations when disposed of in a Subtitle D landfill. The exclusions are provisional upon the residues meeting the generic exclusion levels for all constituents, and that they do not exhibit one or more of the hazardous waste characteristics. The reasons for specifying HTMR for the exclusion are provided in Section 7.5 of this document titled, "Applicability of Generic Exclusion to Other Treatment Residues." In addition, the residues will be subject to the tracking and testing requirements described in Sections 7.3 and 7.4.

The Agency evaluated the treatment standard levels using the EPA Composite Model for Landfills (EPACML), which predicts the potential for ground-water contamination from wastes that are land disposed. The EPACML simulates the movement of contaminants for a Subtitle D waste management unit and migration through the subsurface to a potential drinking water well. This model estimates a dilution-attenuation factor (DAF) for contaminants, which represents the reduction in concentration expected to occur during migration. The Agency used the EPACML previously in establishing the Toxicity Characteristic (TC) (see 55 FR 11826; March 29, 1990), and recently adapted it for use in evaluation of petitions to exclude ("delist") hazardous wastes under 40 CFR 260.22 (see 56 FR 67197, December 30, 1991 and 56 FR 32993, July 18, 1991).

The EPACML uses a Monte Carlo simulation technique to account for the wide range of hydrogeologic settings found at municipal waste landfills, as well as the uncertainty in the data. The Monte Carlo analysis generates a distribution of DAFs which can be represented by a cumulative frequency distribution (i.e., probability) curve. DAFs along this curve decrease as the cumulative frequency increases (high DAFs) to "worst case" situations at high cumulative frequencies (low DAFs). See the above cited TC rule for more details on the development of the EPACML.

For use in delisting evaluations, the Agency modified the model somewhat to allow the use of the volume of the petitioned waste to be used as a fixed input value. Delistings are facility specific, and the volume of waste (e.g., annual generation volume) is defined in the petition. Furthermore, EPA also selected the 95th percentile as being the most appropriate cumulative frequency for use in delisting. The modified use of the EPACML is described in detail in a recent proposal (56 FR 32993; July 18, 1991).

The Agency believes that a DAF of 10 is most appropriate for use in evaluating the treatment standard levels, based on the past DAFs calculated for the TC rule and for use in delisting. A DAF of 10 corresponds to approximately the 95th percentile level generated from EPACML simulations used to support the TC rule (see 55 FR 11826; March 29, 1990). The Agency used a DAF of 100 for establishing the TC regulatory levels for wastes that are "clearly hazardous", and noted that it was appropriate to set the level on an "order-of-magnitude" precision. A DAF of 100 corresponds to a cumulative frequency close to the 85th percentile. An exclusion establishes regulatory levels below which the waste may reasonably be expected to be nonhazardous, therefore, the Agency believes it is appropriate that the cumulative frequency used be somewhat higher than the percentile used to establish the clearly hazardous TC levels.

The EPACML as modified for delisting generates DAFs that vary from a maximum of 100 for relatively small volume waste generated (1,000 cubic yards/yr.) to DAFs approaching 10 for larger volume generators) (300-400 cubic yards/yr.). A table for DAFs for different rates of waste generation is given in Table 7-1. Note that this table is applicable to the delisting of an ongoing waste generation process. To account for the total amount of waste generated and ultimately land-disposed, the annual waste volume has been multiplied by a factor of 20, based

Table 7-1 EPACML-Derived Dilution and Attenuation Factors for Landfills

	95th Percentile DAF
Waste Volume (cubic yards per year)	EPACML Landfill
1,000	100*
1,250	96
1,500	90
	84
2,000	79
2,500	74
3,000	68
4,000	57
5,000	54
6,000	48
7,000	45
8,000	43
9,000	40
10,000	36
12,500	33
15,000	29
20,000	27
25,000	24
30,000	23
40,000	20
50,000	19

Table 7-1 (continued)

Waste Volume (cubic yards per year)	95th Percentile DAF
	EPACML Landfill
60,000	17
80,000	17
90,000	16
100,000	15
150,000	14
200,000	13
250,000	12
300,000	12
400,000	10

*DAF maximum is 100 corresponding to the Toxicity Characteristic.

on a 20-year active lifetime of a Subtitle D unit. Therefore, the table reflects DAFs calculated for landfills sized to be 20 times the annual generation rate shown in the table (e.g., the DAF for an annual waste volume of 10,000 cubic yards was calculated for a landfill unit containing 200,000 cubic yards of wastes).

A DAF of about 10 also results from the use of the EPACML DAFs generated for use in delisting. For the purpose of establishing a generic exclusion level, rather than a facility-specific delisting, the volume of waste to be excluded is not well defined. Therefore, the Agency believes it is appropriate to assume a reasonable worst case landfill size, i.e., a landfill corresponding to the 95th percentile in size for the Subtitle D landfill units contained in the EPA . database. The data contained in Table 7-2 shows the distribution in the size of active landfills, and indicates that the 95th percentile size landfill would be on the order of 8 million cubic yards (or in terms of the units in Table 7-2, about 6 million cubic meters). A landfill of this size is equivalent to an annual generation rate of approximately 400,000 cubic yards, which would have a corresponding DAF of about 10 (see Table 7-1).

Under a DAF of 10, and the appropriate health-based level (e.g., drinking water standard) EPA evaluated the BDAT-based levels and established generic exclusion levels which it considers safe to human health and the environment. The following section (i.e., Section 7.1) provides details on the health-based levels shown on Table 7-3.

7.1 Development of Health-Based Generic Exclusion Levels and Calculation of Allowable Concentrations

The Delisting Section of EPA's Office of Solid Waste, in its review of delisting petitions and generic exclusions, evaluates levels of carcinogens and systemic toxicants listed in Appendices VII, VIII, and IX of 40 CFR Part 261. The exposure assumption used to assess the hazard of a petitioned waste is ingestion of contaminated ground water, leachate, or wastewater. For both carcinogens and systemic toxicants, the water intake assumption is 2-liters per-day for

Table 7-2 Data Source: Subtitle D Landfill Survey
Active Units
Univariate

Variable = LFA4								Total Volume of Active LF Unit (CU M)	
Moments				Quantiles (DEF = 4)				Extremes	
H	1180	Sum Wgts	1180	100% Max	177471293	99%	25754902	Lowest	Highest
Mean	1711939	Sum	2020088436	75% Q3	861551	95%	6296676	189.541	60308590
Std Dev	7586576	Variance	5.756E+13	50% Med	201029	90%	3100205	191.264	61216090
Skewness	13.9915	Kurtosis	271.13	25% Q1	38416.1	10%	10396	236.065	63180427
USS	7.132E+16	CSS	4.786E+16	0% Min	189.541	5%	4439.97	251.573	88124060
CV	443.157	Std Mean	220854			1%	681.774	305.564	177471293
T:Mean=0	7.75146	Prob>|T|	0.0001	Range	177471103				
Sgn Rank	348395	Prob>|S|	0.001	Q3-Q1	823135				
Num = 0	1180			Mode	28718.4				
				Missing Value Count	116				
				% Count/Nobs	8.95				

Table 7-3 Generic Exclusion Levels for K061, K062, and F006
HTMR Residues (Nonwastewaters)

Regulated constituent	Maximum for any single composite sample TCLP leachate (mg/l)
Antimony	0.01
Arsenic	0.055
Barium	7.6
Beryllium	0.01
Cadmium	0.05
Chromium (total)	0.33
Lead	0.15
Mercury	0.0090
Nickel	1.0
Selenium	0.16
Silver	0.30
Thallium	0.02
Zinc	70
	Maximum for any single composite sample Total Concentration (mg/kg)
Cyanide* (total)	1.8

*The level for cyanide applies only to F006 nonwastewaters.

an average 70-kilogram (kg) adult over a 70-year lifetime. The use of a 70-year lifetime considers the effects of carcinogens as a function of cumulative doses, rather than doses received by any small subsection of the population. In addition, in cases where constituents are both carcinogens and systemic toxicants, the more conservative carcinogenic slope factor takes precedence over the toxicant reference dose.

The following equation is used to calculate the delisting and exclusion health-based levels for carcinogens:

$$D_c = (R \times W \times LT) / (CSF \times I \times A \times ED)$$

where: D_c = delisting health-based level for carcinogen (mg/l)

R = assumed risk level = 10^{-6}

W = body weight = 70 kg

LT = assumed lifetime = 70 years

CSF = carcinogenic slope factor = experimental potency $(mg/kg/day)^{-1}$

I = intake assumption = 2 l/day

A = absorption factor = 1

ED = exposure duration = 70 years

The following equation is used to calculate the delisting health-based levels for systemic toxicants:

$$D_s = (RfD \times W) / (I \times A)$$

where:

D_s = delisting health-based level for systemic toxicant (mg/l)

RfD = reference dose (mg/kg/day)

W = body weight = 70 kg

I = intake assumption = 2 l/day

A = absorption factor = 1

Constituents that have verified health-based levels are listed in EPA's Integrated Risk Information System (IRIS), which is maintained by the Office of Health and Environmental Assessment in the Office of Research and Development. The information listed in IRIS is designed to be a guide for the evaluation of potential health problems and is included in IRIS only after an intra-office work group of EPA toxicologists and other scientists have reviewed the facts. IRIS provides verified information for oral and/or inhalation reference doses, risk estimates for carcinogenicity, drinking water health advisories, risk management summaries, and other supplemental data. (IRIS provides the carcinogenic slope factors and the reference doses that are needed in the above equations.) IRIS is currently available to EPA staff through the EPA electronic mail system as well as to the general public, who can access the system through various on-line networks such as DIALCOM, Inc., the Public Health Network (PHN), and the National Library of Medicine's TOXNET. The general public should contact any of the latter networks to obtain an IRIS account. Hard copies of IRIS information for all constituents with verified delisting health-based levels is provided by the Delisting Section upon request.

Some constituents used in delisting are not in IRIS. In these cases, other references, such as Health and Environmental Effects Documents (HEEDs), Office of Drinking Water (ODW) health advisories, Carcinogen Assessment Group (CAG) recommendations, and various chemical files are used and will be provided by the Delisting Section upon request. The same equations presented above are used to calculate delisting health-based levels.

During a delisting determination, EPA often uses appropriate fate and transport models and waste-specific information (e.g., waste volume and constituent concentration data) to predict the impact of a petitioned waste on human health and the environment. In selecting appropriate models, the Agency chooses a reasonable worst-case management scenario for the petitioned waste and considers plausible exposure routes for hazardous constituents present in the waste. The Agency believes a reasonable worst-case scenario is appropriate when evaluating whether a waste should be relieved of the protective management constraints of RCRA Subtitle C.

Under a landfill disposal scenario, the plausible exposure route of concern for hazardous constituents is ingestion of contaminated ground water. The EPACML model approximates the transport processes likely to occur in a drinking water aquifer below a waste disposal site. The waste-specific parameters used in the EPACML model are the leachate concentrations of constituents of concern and the volume of the waste generated annually. Typically, the leachate concentrations are provided in a delisting petition by an appropriate leaching test (e.g., the Toxicity Characteristic Leaching Procedure) on a constituent-specific basis. The result calculated by the model for a given constituent of concern should be less than or equal to the respective drinking water standard, or other EPA health-based level (HBL) as appropriate, to pass a delisting evaluation.

The maximum allowable leachable concentration (C_{max}) for a delisting constituent of concern can be calculated by multiplying the level of regulatory concern (i.e., HBL) by the EPACML model dilution factor (D_F). The dilution factor, which is dependent on waste volume, decreases from a maximum of 100 for small waste volumes (1,000-cubic yards) to a value approaching 10 as waste volumes approach 300,000- to 400,000-cubic yards.

In cases where the estimated waste volume approaches 300,000 to 400,000 cubic yards, a dilution factor of 10 is used in the following equation:

$$C_{max} = (HBL)(D_F) \qquad D_F = 10$$

For example, using the current HBL for cadmium of 0.005 mg/l, the maximum constituent leachate concentration is calculated as:

$$C_{max} = (0.005 \text{ mg/l})(10)$$

$$C_{max} = 0.05 \text{ mg/l}$$

If the maximum leachate concentration reported for a constituent of concern exceeds the calculated maximum allowable concentration, the Agency may conclude that the waste could present a threat to either human health or the environment.

When available, HBLs are Maximum Contaminant Levels (MCLs), which can be obtained from EPA's IRIS. MCLs are promulgated under the Safe Drinking Water Act (SDWA) of 1974, as last amended in 1988, and consider technology and economic feasibility as well as health effects. Finalized MCLs are used as HBLs for delisting for carcinogens and systemic toxicants when available. Proposed MCLs are used as HBLs for delisting for carcinogens and systemic toxicants when finalized MCLs are not available. Table 7-4 summarizes the regulatory levels of concern for certain inorganics and the maximum allowable concentrations for a solid waste currently used in delisting and exclusion determinations.

In the absence of formal MCLs, the Agency has also used other appropriate HBLS to establish delisting levels. In the absence of a new MCL for lead, the Agency believes that prudence requires that the exclusion level be established using the more conservative action level of 0.015 mg/l. EPA established the new treatment standard for lead instead of an MCL because, as EPA concluded in the preamble to the final rule for K061 high zinc subcategory nonwastewater, there is no apparent threshold for various health effects associated with lead.

Table 7-4 Health-Based Levels (HBL) and Maximum Contaminant Levels (MCL) for Constituents of Concern

CAS No.	Compound	HBL (mg/l)	HBL Source	Maximum allowable concentration[a] (mg/l)
7440-36-0	Antimony	1×10^{-2}	1	0.1
7440-38-2	Arsenic	5×10^{-2}	2	0.5
7440-39-3	Barium	1	2	10
7440-41-7	Beryllium	1×10^{-3}	1	0.01
7440-43-9	Cadmium	5×10^{-3}	3	0.05
7440-47-3	Chromium	1×10^{-1}	3	1.0
57-12-5	Cyanide	2×10^{-1}	1	2.0
7439-92-1	Lead	1.5×10^{-2}	5	0.15
7439-97-6	Mercury	2×10^{-3}	3	0.02
7440-02-0	Nickel	1×10^{-1}	1	1.0
7782-49-2	Selenium	5×10^{-2}	3	0.5
7440-22-4	Silver	5×10^{-2}	2	0.5
7440-28-0	Thallium	2×10^{-3}	1	0.02
7440-66-6	Zinc	7	6	70

[a]Assumes a DAF of 10.

Sources:

1. 1990 National Primary and Secondary Drinking Water Regulations: Proposed Rule. 55 FR 30370-30448. USEPA (July 25).
2. Maximum Contaminant Levels for Organic and Inorganic Chemicals. 45 FR 57332. USEPA (August 27)
3. 1991 National Primary and Secondary Drinking Water Regulations: Final Rule. 56 FR 3526-3597. USEPA (January 30).
4. EPA's Integrated Risk Information System (IRIS) (verified health-based levels).
5. Maximum Contaminant Level Goals and National Primary Drinking Water Regulation for Lead and Copper: Final Rule 56 FR 26460.
6. 1990 Health Effects Assessment Summary Table, Third Quarter OERR, 9200.b-303-(90-3).

Given the Agency's goal is to minimize lead exposure among sensitive populations, the treatment standard with an action level was established. While the action level is not a formal MCL, EPA stated in the preamble to the lead rule that the level of 0.015 mg/l is "associated with substantial public health protection." (See 56 FR 26477.)

Although the existing lead MCL of 0.05 mg/l will remain in effect until November 9, 1992, the Agency believes the use of this level in setting the exclusion level is inappropriate. The effective date for the action level and accompanying treatment standard for lead were delayed in order to allow public drinking water systems sufficient time to comply with this new rule. The Agency believes that establishing exclusion levels using an old MCL that will soon be superseded by a more stringent standard is not sufficiently protective of public health.

As previously stated, the BDAT standard and EPACML-based levels are not identical, since each set was calculated for a different purpose: the BDAT standards are technology-based levels, while the EPACML results are derived from health-based modeling. In order to be eligible for the generic exclusion, the residues must meet the concentration levels shown in Table 7-3.

For five of these metal constituents (barium, chromium, mercury, selenium, and silver), the technology-based treatment standards are slightly lower than the health-based levels. EPA does not regard these values as significantly different; however, the difference ranges from 0.011 ppm (mercury) to 2.4 ppm for barium. In addition, since HTMR is a destruction technology for cyanide, the Agency has chosen to regulate total cyanide instead of leachable cyanide as the generic exclusion level. Given that the Agency is excluding these wastes generically, rather than after a more individualized examination as part of a facility-specific delisting, EPA believes that it is appropriate to use the slightly lower value for this exclusion. It should be noted that this action is consistent with the Agency's position in the Third Third rule, where it maintained that land disposal prohibitions can apply to wastes that are hazardous when they are generated, even

if they are not hazardous after disposal. (See 55 FR 22652-22653.) However, EPA is not invoking that principle to justify its decision here, given that the exclusion is generic and the values practically equivalent in any case. Because of the large discrepancy (> tenfold) between the health-based and technology-based levels for zinc (i.e., 70 mg/l opposed to 5.3 mg/l), the Agency has decided to designate the health-based level as the generic exclusion requirement.

7.2 Product Uses of HTMR Residues

The generic exclusion of K061, K062, and F006 HTMR residues applies only to residues which are disposed of in Subtitle D units (i.e., landfills or piles). However, the majority of these slags are not landfilled, but rather are used in a manner constituting disposal as road base material or (less often) as an anti-skid material (56 FR 15024). The Agency has decided that its regulatory tools for evaluating road base and anti-skid uses are too uncertain to determine whether residues used as road base or anti-skid material should be excluded. The EPACML model evaluates possible risks posed by landfill disposal. It may also be suitable for evaluating residue used as a road base material, since this situation may be viewed as similar to (or more protective than) a capped landfill. The Agency has not had time to make a full technical assessment of this point. The EPACML model alone may not be fully suitable for evaluating the safety of slag used as an anti-skid material, because this apparently uncontrolled use may present exposure pathways (i.e., airborne inhalation and surface runoff) that the model does not consider. Thus, the exclusion levels apply only for those modes of management that EPA currently feels confident in evaluating with the EPACML model, namely, disposal in a land disposal unit.

Under current regulations, if a hazardous waste is used in a manner constituting disposal, it is exempt from further regulation, provided it undergoes a chemical reaction so as to be inseparable by physical means and provided it meets the land disposal restrictions treatment standards for each hazardous constituent that it contains (40 CFR 266.20). Thus, in this final

rule, such practices as the use of the HTMR residue for road base or anti-skid material are not immediately prohibited (provided the residue meets the treatment standard and any existing state requirements).

This case differs from other delistings in that the HTMR K061 residuals would be used in a manner constituting disposal, raising the concern that a ground-water model alone may not be adequate to simulates a worst-case scenario. (EPA notes that it has considered air-blown dust exposure pathways in past delistings, but views the situation presented in this rulemaking as different. Previous situations involved possible exposures from air-born losses under land disposal conditions, whereas, today's action potentially involves continual deposit of waste over a wide expanse of road systems.)

7.3 Tracking Requirements

The generic exclusion for K061, F006, and K062 HTMR residues that meet the exclusion levels (in Part 261) and that do not exhibit any hazardous characteristics is limited, as already discussed, to such waste that is disposed of in Subtitle D units. Because K061, K062, and F006 HTMR residues are still defined as hazardous at the point of initial generation, EPA believes that tracking and certification are needed to ensure proper handling. This final rule is amending 40 CFR Section 268.9(d) and 261.3(c)(2)(ii)(C) to require that the generator or treater prepare the notification and certification for the initial shipment only, place one copy in the generator's or treater's own files, and send another copy to the appropriate EPA region or authorized state. The documentation must be retained by the generator or treater for at least five years. The notification and certification must be updated if the process or operation generating the waste changes and/or if the subtitle D facility receiving the waste changes. The document must include the name and address of the subtitle D facility receiving the waste, a waste description, applicble treatment standards, and a certification that the standards have been met. For K061,

K062, and F006 high residues from high temperature metal recovery, the recordkeeping requirements in 40 CFR 261.3(c)(2)(ii)(C) supersede those in 268.7(a)(6).

7.4 Testing Requirements

The land disposal restriction program imposes site-specific testing requirements in order to verify that regulatory requirements have been satisfied. Treatment facilities which wish to meet the exclusion requirements must test treated wastes at a frequency specified in their waste analysis plan in order to determine whether they have met the exclusion levels. (See 40 CFR 268.7(b) and 55 FR 22669.) In the case where treatment is performed at the generator's site in a way not requiring a permit, testing is required at a frequency specified in the self-implementing waste analysis plan required by 40 CFR 268.7(a)(4). However, at a minimum, a facility's waste analysis plan (or a generator's self-implementing waste analysis plan) must specify that composite samples of the K061, K062, and F006 HTMR slag residues be collected and analyzed quarterly and/or when the process or operation changes. (See 40 CFR 264.13(a)(3) and 265.13 (a)(3).) The Agency believes that it is appropriate to allow the frequency of testing, beyond the quarterly minimum, to be determined in the waste analysis plan, taking into account facility-specific factors such as waste types, waste variability, quantity, batch size, and type of treatment unit. The Agency believes that permit writers will consider these factors when establishing testing conditions in the waste analysis plans.

The following sections, beginning with Section 7.4.1, present examples of testing criteria that could be followed for residues to be considered "generally excluded" or nonhazardous that are generated from: (1) the thermal treatment of electric arc furnace dust (EPA Hazardous Waste No. K061), originating from the primary production of steel; (2) the thermal treatment of wastewater treatment sludges (EPA Hazardous Waste No. F006) from the following processes: (a) common and precious metals electroplating except tin, zinc (segregated basis), aluminum, and zinc-aluminum plating on carbon steel, (b) anodizing, except sulfuric and

anodizing of aluminum, (c) chemical etching and milling, except when performed on aluminum, and (d) cleaning and stripping, except when associated with tin, zinc, and aluminum plating on carbon steel; and (3) the thermal treatment of spent pickle liquor (EPA Hazardous Waste No. K062). The exclusion for these wastes is conditioned upon the receipt and review of data obtained from the facility's HTMR unit after it is established as an operational treatment furnace and from each additional HTMR unit that may be established in the future. To ensure that each HTMR unit operates properly and that hazardous constituents are not present in the generated residual slag at levels of regulatory concern once the HTMR unit has been established, the facility must implement a testing program for each HTMR unit. The following example provides one approach in establishing these testing conditions. Depending on the specific case (e.g., expected variability in waste feed, waste volume treated), testing frequency could be reduced, but must be completed on at least a quarterly basis.

7.4.1 Operating Conditions (Condition 1)

The facility would submit information to the Agency pertaining to the design and operation of the HTMR unit as stated below. This requirement is referred to as Condition 1.

(A) Initial Verification Testing: During the first 20 days of operation of an on-line, full-scale HTMR unit, (as an operational treatment furnace), the facility must monitor and submit to EPA the reclamation furnace design operating conditions (including, but not limited to: temperature range of the furnace; EAF dust feed rate and composition; carbon source feed rate; oxygen/air feed rate; target feed compositions and feed rates; information concerning composition and feed rate of other materials added to the system; detailed information about the destiny of all other residuals (i.e., where are they sent for further recovery, time frame, and storage/handling procedures); and reclamation furnace reaction time of the raw materials). This information on operating conditions should encompass all conditions used for preliminary testing runs and those anticipated for subsequent waste processing. During initial verification testing, the petitioner must also demonstrate to EPA how the range of operating conditions could affect the process (i.e., submit analyses of representative grab samples, as specified under Condition 2, of the residual slag generated under the expected range of operating

conditions). The facility must submit the information specified in this condition and obtained during this initial period no later than 90 days after the first full-scale treatment of untreated EAF dust (K061).

(B)   **Subsequent Verification Testing**:   During subsequent verification testing, the facility must monitor the performance of the HTMR unit at all times to ensure that it falls within the range of operating conditions demonstrated during initial verification testing to be adequate to maintain the levels of hazardous constituents below the delisting levels specified in Condition 4.   Records of the operating conditions of the reclamation furnace (including, but not limited to: temperature range of the furnace; waste feed rate and composition; carbon source feed rate; oxygen/air feed rate; target feed compositions and feed rates; information concerning composition and feed rate of other materials added to the system; detailed information about the destiny of all other residuals (i.e., where are they sent for further recovery, time frame, and storage/handling procedures); and reclamation furnace reaction time of the raw materials should be maintained onsite for a minimum of 3 years.   This information must be furnished upon request and made available for inspection by any employee or representative of EPA or the State where the HTMR unit is located.

7.4.2 Testing (Condition 2)

Sample collection and analyses (including quality control (QC) procedures) must be performed according to SW-846 and BDAT methodologies. These requirements are discussed below and are referred to as Condition 2.

(A)   **Initial Inorganics Verification Testing**: During the first 20 days of operation of an on-line, full-scale HTMR unit (as an operational treatment furnace), the facility must collect and analyze daily composites of residual slag. Daily composites must be composed of representative grab samples collected every 3 hours during each 24-hour furnace operating cycle. The residual slag samples must be analyzed, prior to the disposal of the residual slag, for the inorganic constituents listed in Condition 4. The facility must report the analytical test data, including QC information, obtained during this initial period no later than 90 days after the first full-scale treatment of untreated EAF dust (K061).

(B)   **Subsequent Verification Testing**: Following the initial 20-day testing period and provided that the results of initial verification testing support an exclusion, the

facility must collect and analyze weekly composites of residual slag. Weekly composites must be composed of representative grab samples collected every 8 hours during a 24-hour furnace operating cycle. These samples must be analyzed, prior to the disposal of the residual slag, for the leachable concentrations of the inorganic constituents listed in Condition 4. The analytical data, including QC information, must be compiled, summarized, and maintained onsite for a minimum of 5 years. These data must be furnished upon request and made available for inspection by any employee or representative of EPA or the State where the HTMR unit is located.

(C)   <u>Changes in Operating Conditions</u>: If after completing the initial verification test period in Conditions 1(A) and 2(A), the facility changes the operating conditions developed under Condition 1(A), then the facility must repeat the testing required in Conditions 1(A) and 2(A) with the new conditions. Following this period, the facility must collect and analyze weekly samples according to Condition 2(B).

7.4.3   Waste Holding and Handling (Condition 3)

The facility will be required to store, as hazardous, all HTMR residual slag generated until it has completed and compared initial verification testing (for daily composites as specified in Condition 2(A)) or subsequent analyses (for weekly composites as specified in Condition 2(B)), as appropriate, with the delisting levels set forth in Condition 4. If the levels of hazardous constituents measured in the samples of HTMR residual generated do not exceed the levels set forth in Condition 4, then the HTMR residual is nonhazardous for purpose of disposal in a Subtitle D landfill and may be managed and disposed of in accordance with all applicable solid waste regulations. If hazardous constituent levels in any sample exceed any of the generic exclusion levels set in Condition 4, the HTMR residual generated during the time period corresponding to this sample must be retreated until it meets these levels (analyses must be repeated) or managed and disposed of in accordance with Subtitle C of RCRA. Residual generated for which the required analysis is not complete or valid must be managed and disposed of in accordance with Subtitle C of RCRA until valid analysis demonstrates that Condition 4 is satisfied.

7.4.4 Exclusion Levels (Condition 4)

For K061, K062, and F006 HTMR residues, the TCLP leachate concentrations for the metals may not exceed the following levels (mg/l): antimony 0.10; arsenic 0.055; barium 7.6; beryllium 0.010; cadmium 0.05; chromium 0.33; lead 0.15; mercury 0.0090; nickel 1.0; selenium 0.16; silver 0.30; thallium 0.02; zinc 70; and cyanide 1.8. Metal concentrations must be measured in the waste leachate by the TCLP method, except for cyanide for which analysis must be based on total concentration (mg/kg).

7.4.5 Data Submittals (Condition 5)

At least 6 months prior to operation of a new HTMR unit, the facility must notify EPA when the HTMR unit is scheduled to be on-line. Relevant information including, but not limited to, design and proposed operation parameters, projected average annual waste generation volume, and specific areas where the new HTMR unit differs from the facility's other HTMR unit(s) on file must be submitted to EPA within the time period specified. At EPA's request, the facility must submit any other analytical data obtained through Conditions 1(B) and 2(B) within the time period specified. Failure to submit the required data within the specified time period or to maintain the required records onsite for the specified time will be considered by the Agency, at its discretion, sufficient basis to revoke the exclusion or exclusion amendment to the extent directed by EPA. All data must be accompanied by a signed copy certifying all statements attest to the truth and accuracy of the data submitted.

7.5 Applicability of Generic Exclusion to Other Treatment Residues

The generic exclusion applies only to those nonwastewater residues generated by HTMR processes and not to others, such as hydrometallurgical processes or stabilization. The Agency has insufficient data to fully evaluate the residues from hydrometallurgical processes. However,

the limited available information indicates a high leachability. Moreover, given the Agency's current paucity of information, EPA has no idea what an appropriate testing regime for residues from hydrometallurgical processes would be, even assuming that these residues could meet the exclusion levels. EPA, thus, believes it unwarranted to make residues from hydrometallurgical recovery processes eligible for this generic exclusion at this time.

There are several reasons for not excluding stabilized residues generically. The HTMR residues demonstrate consistent leaching behavior, whereas, stabilized matrices are quite variable. The chemical bonding that occurs in the high temperature and oxidation/reduction conditions within the HTMR units is inherently different than the bonding that forms the basis of cementitious and pozzolanic stabilization. In addition, the kinetics of the reaction forming the bonds in these HTMR processes are superior to the kinetics of bond formation in cementitious reactions. (Cement is not typically considered set until after a minimum of 72 hours and often not considered fully cured until after 28 days.) Stabilization has also been documented as a process that is highly matrix-dependent and prone to chemical interference. (Data in support of this conclusion are located in the background documents to the First, Second, and Third Third Rules.) Most commercial stabilization facilities have to develop special mixes to control curing time and/or product integrity (often measured by comprehensive strength).

Another reason for not allowing stabilized residues to be generically excluded is the possibility of impermissible dilution, which must be considered on a case-by-case basis with stabilization, but not with HTMR. Hence, facility-specific delistings are preferred for stabilized wastes so that the Agency can evaluate waste-to-binder and waste-to-waste ratios and make a determination about treatment versus dilution. Finally, the Agency believes that HTMR is a preferred technique for managing the K061, K062, and F006 waste over stabilization technologies, in light of its resource recovery potential and the differences in volumes of treated wastes. Stabilization generally increases volume, while HTMR generally decreases volume.

Thus, the Agency does not believe it is warranted to develop a somewhat technically sketchy generic exclusion for stabilization.

EPA notes that it is not precluding the use of stabilization as treatment for K061, K062, and F006 wastes, and that facility-specific delisting remains an option for stabilized K061, K062, and F006 wastes. However, due to the inherent differences between HTMR and stabilization stated above and the fact that insufficient data currently exist to promulgated a generic exclusion for stabilized K061, K062, and F006 wastes, the Agency has determined that the generic exclusion levels are not applicable to stabilized K061 residues. The Agency believes that more individualized consideration of stabilization is warranted before residues from the process are delisted.

The Agency, however, wishes to note that the issue of uniform exclusion levels is presently under consideration by the Agency as part of the Hazardous Waste Identification Rule (HWIR). (See 57 FR 21450, May 20, 1992).

7.6 Regulatory Status of Nonwastewater Residues From HTMR That Do Not Meet the Generic Exclusion Levels

Under the Federal regulations, hazardous wastes destined for reclamation remain classified as solid and hazardous wastes until reclamation is complete. Reclamation is normally incomplete until the end product of the process is fully recovered (50 FR 15 633, 634, and 655). The line the Agency has traditionally drawn between partially and fully reclaimed material when thermal mercury recovery is involved is that secondary materials remain wastes until smelting is completed. Id. at 634 (recovered metals only needing to be refined [the processing step following smelting] are products, not wastes). This interpretation is consistent with RCRA's cradle-to-grave mandate by retaining authority until a usable metal is recovered (Cf. API v EPA, 906 F.2d at 741).

7.6.1 Application of the Variance From Solid Waste Classification

The rules also provide for a variance from solid waste classification for materials that have been partially but not fully reclaimed (40 CFR 261.30(c)). Criteria for granting a variance include the degree of processing that the material has undergone, the degree of further processing required, the value of the material after it has been reclaimed, the degree of which the initially reclaimed material is like an analogous raw material, the extent to which an end market for the material is guaranteed, and (perhaps most important) the extent to which the initially reclaimed material is handled to minimize loss (40 CFR 260.31(c)).

Applying these rules to the dross from HTMR splash condensers, EPA has decided to amend its rules by excluding from Subtitle C jurisdiction the splash condenser dross residue (hereafter referred to SCDR) generated by certain HTMR processes. This material is specifically generated as the nonproduct skimming from the splash condenser along with recovered zinc and lead meeting Western grade zinc metal specifications (i.e., 98 percent pure metals), which are products under the rules (40 CFR 261.3(c)(2) final sentence). The dross is presently a solid waste because it is partially but not fully reclaimed (i.e., it still requires smelting or other recovery before a usable metal is extracted) and, thus, would remain a K061, K062, and F006 waste until it is excluded from the rules. (See 40 CFR 261.2(a)(1) and 56 FR at 7144.) Based on public comment and corroborating information contained in the record for today's rule, the SCDR is collected directly from the splash condenser and drummed. It is then stored for short periods (not exceeding 2 weeks) and sold to a thermal zinc processing facility where it is used as a source of zinc or reused onsite in the HTMR process. (The SCDR normally contains 50 to 60 percent zinc.) At the thermal processing facility, the drums are stored indoors in a secure manner (on concrete flooring and with controls against airborne migration). The material is then processed for recovery by crushing and, in combination with other feedstocks, grinding, and by thermal recovery of zinc.

The SCDR stream is small in volume. In addition, most of the toxic metals that originate in the K061 do not partition to the SCDR: approximately 90 percent partition to zinc and lead products·or to baghouse dusts. Those toxic metals remaining in the SCDR have reduced mobility from the original K061, (and EPA believes is similarily reduced in K062, and F006). The SCDR does not exhibit characteristics of hazardous waste. In the case of K061 nonwastewaters, the (EAF dust) SCDR is also changed in physical form from the original K061; it is no longer a dust but rather a solidified matrix.

The Agency evaluated the material against the criteria for determining whether a waste that is partially but not fully reclaimed should still be classified as a solid waste (40 CFR 260.31(c)). Although these criteria were established for a variance determination, EPA believes that they are relevant in determining whether this material should be considered to be "discarded" within the meaning of Section 260.31(c)(1). The Agency has received adequate information in this case to exclude the material by rule. Table 7-5 presents TCLP leachate analysis data for International Mill Service Oxidized Zinc Material (OZM), i.e., dross residue from its zinc splash condenser. In particular, the Agency finds that the SCDR results from substantial processing (as shown by the volume reduction, partitioning of toxic metals to other outputs of the process, change in physical form, and reduction in mobility of toxic metals) (40 CFR 260.31(c)(1)); that the material is sold for the value (or reprocessed onsite to recover high concentrations of zinc) (40 CFR 260.31(c)(1)); that the material contains zinc concentrations comparable to those of other nonwaste secondary sources of zinc (and more zinc than natural ones) (40 CFR 260.31(c)(3)); that an end market for the material appears assured (40 CFR 260.31(c)(4)); and that it is handled safely up to the point of final reclamation (40 CFR 260.31(c)(5)).

Table 7-5 Treatment Performance Data (TCLP Analysis) for Residues (Dross), i.e., Oxidized Zinc Material (OZM) from HTMR of K061 High Zinc Subcategory Nonwastewater

Sample Sets	Constituent (mg/l)													
	As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Ni	Zn	Sb	Tl	Be	V
1	<0.025	2.82	0.018	<0.011	2.34	<0.003	<0.050	0.016	<0.026	1488.0	<0.010	<0.005	<0.003	<0.009
2	<0.025	6.03	0.015	<0.011	1.33	<0.003	<0.050	0.029	<0.026	1656.0	<0.010	<0.005	<0.003	<0.009
3	<0.005	1.31	<0.069	<0.011	3.57	<0.003	<0.025	0.008	<0.026	1284.0	<0.010	<0.005	<0.003	<0.009
4	<0.005	0.85	0.13	<0.011	4.53	<0.003	<0.025	0.006	<0.026	1146.0	<0.010	<0.005	<0.003	<0.009

Source: International Mill Service data for "OZM" submitted to the Agency after the comment period to the proposed rule.

Based on these facts, the Agency has decided to exclude the K061, F006, and K062 SCDR from RCRA jurisdiction when it is utilized as a source of zinc in the zinc recovery operations, provided it is shipped in drums (if it is sent offsite), and that there is no land disposal of the material before it is recycled. Thus, for example, the material remains a solid waste if it is stored in piles on the land. In such a case, it would be "part of the waste disposal problem," and discarded. [(American Mining Congress v. EPA), 907 F.2d at 1186.] In addition, in order for this exclusion to be implementable and to serve as a check against mishandling, EPA is interpreting current rules to require that the HTMR facility maintain a one-time notice in its operating record or other files stating that the SCDR is generated, then excluded, and what its disposition is. (See 40 CFR 268.7(a)(6), 56 FR 3878.)

7.6.2 Application of the Derived-From Rule

The Agency is, hereby, classifying the application of the derived-from rule to all residues from HTMR that do not meet the generic exclusion levels or qualify for a variance from solid waste classification. In general, two categories of HTMR materials have been identified by the Agency. These categories are: (1) nonwastewater residues (including slag) into which a significant portion of the relatively nonvolatile hazardous metals have partitioned and that are generated from a furnace from which zinc and other relatively volatile hazardous metals have been separated, and (2) residues generated by removing particulates from the furnace off-gas such as baghouse dusts and scrubber sludges into which volatile hazardous constituents (e.g., lead and cadmium) have partitioned.

Application of the derived-from rule to residues such as slag generated during HTMR of K061, K062, and F006 is soundly based because toxic nonvolatile metals (such as chromium, nickel, and vanadium) partition into these residues. Because of the high operating temperatures of the HTMR furnaces (approximately 1,600°C), low boiling-point inorganic constituents present in K061, K062, and F006, such as zinc, lead, and cadmium volatilize and are subsequently recovered, while high-boiling point constituents such as chromium, nickel, barium, iron, and

silica remain in the molten mixture which is typically considered slag. (See Section 5, Table 5-2 for details about the behavior of the 13 metal constituents in HTMR processes.) Since the latter residues are typically land disposed or used on the land (e.g., as road aggregate or as road slippage material) and since the hazardous metals contained in them have the potential to leach from these residues, the Agency believes these residues are appropriately considered K061, K062, and/or F006 unless they meet the generic exclusion levels for HTMR nonwastewater residues.

Typically, all HTMR units use some form of Air Pollution Control Device (APCD) to capture particulate matter present in the off-gases. Two of the most popular devices, baghouses and wet scrubbers, generate residuals. These HTMR residues contain the low-boiling point metals (e.g., baghouse dusts and scrubber sludges) and would also be considered listed wastes by virtue of the derived-from rule. These residues, although rich in desirable metals, often contain contaminant constituents that must be removed by pretreatment processes before the material can be sent for refinement or used as a feedstock.

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