ASSESSMENT OF INDUSTRIAL HAZARDOUS WASTE PRACTICES
IN THE METAL SMELTING AND REFINING INDUSTRY

Volume III

Ferrous Smelting and Refining

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ABSTRACT

Investigations of on-land disposal of process and pollution control residuals from the United States metal smelting and refining industry were conducted. This volume presents the results of studies of the U.S. ferrous smelting and refining industry including iron and steel (SIC 3312), iron and steel foundries (SIC 332), ferroalloys (SIC 3313), and primary metal products not elsewhere classified (SIC 3399). Volume II of this report includes the results of investigations of hazardous waste generation and treatment and disposal in the primary and secondary nonferrous smelting and refining industry. Volume I summarizes major findings in both ferrous and nonferrous categories. Characteristics of each industry sector, including plant locations, production capacities, and smelting and refining processes, have been identified and described.

Land-disposed or stored residuals, including slags, dusts, and sludges, have been identified and characterized by physical and chemical properties. State, regional and national estimates have been made of the total quantities of land-disposed or stored residuals and potentially hazardous constituents thereof.

Current methods employed by the ferrous metals industry for the disposal or storage of process and pollution control residuals on land are described. Principal methods include lagoon storage of sludges, and open dumping of slags, sludges and dusts. Methods of residual treatment and disposal considered suitable for adequate health and environmental protection have been provided. Finally, the costs incurred by typical plants in each smelting and refining category for current and environmentally sound residual disposal or storage on land have been estimated.

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SECTION I

CONCLUSIONS

The ferrous smelting and refining industry disposes or stores large quantities of process and pollution control residuals on land. These residuals are predominantly inorganic slags, sludges, and dusts containing oxides and other compounds of iron, silicates, and trace metals. The only highly organic sludge encountered is decanter tar sludge from iron and steel industry byproduct coke plants. In addition to slags, sludges and dusts, the iron and steel foundries dispose of significant quantities of waste sand on land. Significant quantities of acid waste pickle liquor and waste oil are produced at iron and steel plants and usually handled by contract disposal services for reclamation or disposal.

The principal potentially hazardous constituents found in ferrous smelting and refining residuals are heavy metals including chrome, copper, zinc, lead, and nickel, and fluorides. Coke plant wastes contain phenols, cyanides, ammonia, oils and greases. Phenol and cyanide appear to a much lesser extent in blast furnace dust and wet scrubber sludges as well. Foundry sands may contain phenol as a result of the use of phenolic binders which are not degraded by process heat. Some mill scales from steel plant rolling mills contain significant amounts of oils and grease.

The predominant practice used in the ferroalloy and iron and steel industries for the disposal of non-recyclable slag and dust residuals is open dumping. Because the iron and steel industry generally dewaters sludges before disposal, sludges are more often open dumped rather than contained in lagoons. The foundry industry produces relatively small quantities of sludge and generally mixes them with waste sands and dusts before land disposal. The ferroalloy industry is more likely to employ lagoons for containment of sludges.

The iron and steel industry generally reclaims iron from slags before land disposal or sale as road ballast or aggregate. A much higher percentage of blast furnace slag is sold because of lower density and greater chemical stability than basic oxygen or electric furnace slag. Approximately 80% of mill scales generated in steel mills is recycled to recover iron value. Blast furnace dust is normally recycled to sinter or blast furnaces while basic oxygen furnace dust is occasionally recycled to sinter. The high zinc content of electric furnace dust and many basic oxygen furnace (BOF) dusts generally makes it impractical to recycle these dusts. The industry is attempting to develop technology for accepting greater quantities of dusts and sludges as sinter or blast furnace inputs. In a similar manner the ferroalloy industry which generally cannot accept dusts as furnace inputs because of trace metal contamination is exploring technology for greater recycling of dusts.

The foundry industry directly recycles significant quantities of mold sand and reclaims significant quantities of core sand for recycle.

The presence of potentially hazardous constituents in slags, sludges, sands, and dusts has been shown including heavy metal and fluorides. Solubility tests described in Appendix B of this report indicates that some of these hazardous constituents may be leached from some wastes. In general, slags were found to solubilize to a lesser extent than sludges or dusts. Process wastes have been categorized as potentially hazardous or not hazardous based on the results of the solubility tests and consideration pf physical (i.e. particle size) and chemical properties.

Practices to protect ground and surface waters in the event of demonstrated significant leaching of potentially hazardous constituents include the use of lined lagoons for storage or permanent disposal of sludges. Leachable sludges which are dredged or pumped from lagoons or settling pits and dumped on land can often be chemically "fixed" so that leaching of heavy metals is prevented according to fixing chemical manufacturers. Alternatively, sealing of soil in disposal areas with bentonite or other sealants should prevent leachate percolation.

For those slags, dusts, sludges, and or other land-disposed or stored solid residues shown to, or suspected to solubilize toxic constituents significantly, then soil sealing of disposal or storage areas would be needed. Collection of runoff from disposal dumps containing slags, sludges or dusts with leachable heavy metals or other potentially hazardous constituents may be needed. Collected runoff would require treatment before discharge or retention and evaporation in lagoons.

Costs for present and environmentally adequate potentially hazardous waste treatment and disposal are given for each smelting and refining category.

SECTION II

INTRODUCTION

This report is the result of study commissioned by the U.S. Environmental Protection Agency to assess "Industrial Hazardous Waste Practices in the Smelting and Refining Industry. Concurrently, the USEPA is pursuing similar studies of other industry categories. This program is intended to provide the USEPA with as detailed and pertinent information on the generation, management, treatment, disposal, and costs related to wastes considered to be "potentially hazardous." Such information will be used by the USEPA in developing guidelines or standards for the management of hazardous wastes.

Throughout this report whenever the terms "hazardous wastes" or "potentially hazardous wastes" are used, it should be kept in mind that no final judgements are intended as to such classification. It is recognized and understood that additional information will be required as to the actual fate of such materials in a given "disposal" or "management" environment before a final definition of "hazardous waste" evolves and is used. As an example, for certain of the waste streams identified in this report, the USEPA is currently supporting other studies designed to investigate leaching characteristics in various soil and moisture conditions.

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SECTION III

FERROUS METAL SMELTING AND REFINING

This section presents the results of investigations and analyses of on-land disposal or storage of process and pollution control residuals from the United States ferrous smelting and refining industry including iron and steel,, iron and steel foundries, ferroalloys and ferrous metals not elsewhere classified such as metal powders. Characteristics of each industry sector including plant locations, production capacities and smelting and refining processes have been identified and described.

Land disposed or stored residuals including slags, dusts, sands and sludges have been identified and characterized physically and chemically. State, regional and national estimates have been made of the total quantities of land disposed or stored residuals and potentially hazardous constituents thereof for 1974, 1977, and 1983.

Current methods employed by the ferrous metals industry for the disposal or storage of process and pollution control residuals on land are described. Principal methods include lagoon storage of sludges and open dumping of slags, sludges, dusts and sands. Methods of residual treatment and disposal considered suitable for adequate health and environmental protection have been provided. Finally, the costs incurred by typical plants in each primary smelting and refining industry for current and environmentally sound residual disposal or storage on land have been estimated.

1.0 IRON AND STEEL

1.1 INDUSTRY CHARACTERIZATION

The United States steel industry is very large. The industry ranks third in the nation, behind the automotive and petroleum industries, in the value of its total shipments and, with approximately 487,000 employees, is second only to the automotive industry in the number of people on the direct payroll. Over the decade since 1962, steel industry sales have increased 60%, from sales of $14.0 to over $22.0 billion (Ref. 1). Steel mills may range from comparatively small plants to completely integrated steel complexes. Even the smallest of plants will generally represent a fair sized industrial complex. Because of the wide product range, the operations will vary with each facility.

Approximately ninety-two per cent of the 1972 total United States annual steel ingot production was produced by fifteen major steel corporations. This total also represents 22.5% of the world total of 556,875,000 metric tons (625,000,000 tons). Table 1 presents the production breakdown by corporation. Tables 2 and 3 list the number of steel plants by state, EPA regional, and national total iron and steel capacity. The capacity by each of the three major steel producing modes (i.e. basic oxygen furnace, open hearth furnace, and electric furnace) are also given in these tables.

Three basic steps are involved in the production of steel. First, coal is converted to coke. Second, coke is then combined with iron ore and limestone and fired in a blast furnace to produce iron. Third, the iron is purified into steel in either an open hearth or basic oxygen, or furnaces. Electric furnaces remelt and refine predominantly scrap iron and steel. Further refinements include degassing by subjecting the steel to a high vacuum. Molten steel is usually cast into ingot molds but the use of a process called continous casting is increasing steadily. These processes are discussed in more detail in Section 1.2.

Coke plants are operated as parts of integrated steel mills to supply the coke necessary for the production of iron in blast furnaces. Nearly all coke plants today are byproduct plants, i.e., products such as coke oven gas, coal tar, crude and refined light oils, ammonium sulfate, anhydrous ammonia, ammonia liquor, and naphthalene, are produced in addition to coke. A very small portion of coke is also produced in the beehive coke process. A byproduct coke plant consists essentially of the ovens in which bituminous coal is heated, out of contact with air, to drive off the volatile components. The residue remaining in the ovens is coke; the volatile components are recovered and processed in the byproduct plant to produce tar, light oils, and other materials of potential value, including coke oven gas.

Table 1

MAJOR UNITED STATES STEEL INGOT PRODUCERS, 1972

	Metric Tons/Year	Tons/Year
United States Steel	31,750,000	35,000,000
Bethlehem Steel	19,960,000	22,000,000
Republic Steel	9,980,000	11,000,000
National Steel	9,520,000	10,500,000
Armco Steel	7,710,000	8,500,000
Jones & Laughlin Steel	7,280,000	8,000,000
Inland Steel	6,800,000	7,500,000
Youngstown Sheet & Tube	5,440,000	6,000,000
Wheeling Pittsburgh	3,540,000	3,900,000
Kaiser	2,720,000	3,000,000
McLouth	1,819,000	2,000,000
Colorado Fuel & Iron	1,360,000	1,500,000
Sharon	1,360,000	1,500,000
Interlake	907,000	1,000,000
Alan Wood	907,000	1,000,000

Source: Development Document For Proposed Effluent Limitations Guidelines For the Steel Making Segment of the Iron and Steel Manufacturing Point Source Category, U.S. Environmental Protection Agency, February, 1974.

TABLE 2

ESTIMATED STATE DISTRIBUTION OF UNITED STATES IRON AND STEEL PLANTS AND PRODUCTION CAPACITY, 1974 (METRIC TONS)

State	No. of Plants	Estimated Iron Capacity (Blast Furnace)	Estimated Steel Capacity			Estimated Total Steel Capacity
			Basic Oxygen Furnace	Open Hearth Furnace	Electric Furnace	
Alabama	5	5,208,500	2,656,700	1,024,000	601,800	4,282,500
Arizona	1	0	0	0	82,500	82,500
Arkansas	1	0	0	0	57,800	57,800
California	10	2,194,300	1,600,400	1,904,700	674,400	4,179,500
Colorado	1	938,800	1,066,900	0	165,000	1,231,900
Connecticut	1	0	0	0	234,400	234,400
Delaware	1	0	0	0	524,700	524,700
Florida	2	0	0	0	257,600	257,600
Georgia	1	0	0	0	302,000	302,000
Hawaii	1	0	0	0	20,600	20,600
Illinois	16	6,906,700	7,261,500	841,800	4,427,000	12,530,300
Indiana	8	15,977,300	15,239,100	5,790,500	1,013,200	22,042,800
Kentucky	4	1,039,700	1,717,900	0	790,400	2,508,300
Maryland	3	5,558,500	2,528,700	2,729,800	343,700	5,602,200
Michigan	5	7,815,600	8,830,800	0	1,382,400	10,213,200
Minnesota	1	0	0	0	209,900	209,900
Mississippi	1	0	0	0	72,800	72,800
Missouri	1	0	0	0	961,900	961,900
New Jersey	2	0	0	0	453,000	453,000
New York	7	4,807,600	5,469,200	0	503,900	5,973,100
North Carolina	2	0	0	0	213,200	213,200
Ohio	20	17,181,100	11,213,800	8,881,300	4,642,700	24,737,800
Oklahoma	1	0	0	0	244,800	244,800
Oregon	2	0	0	0	301,300	301,300
Pennsylvania	42	21,179,600	15,224,000	11,932,400	4,500,500	31,656,900
South Carolina	1	0	0	0	346,400	346,400
Tennessee	2	0	0	0	122,000	122,000
Texas	9	634,100	0	1,160,600	2,832,200	3,992,800
Utah	1	1,779,500	0	2,483,300	0	2,483,300
Virginia	1	0	0	0	71,100	71,100
West Virginia	2	3,106,302	4,062,200	0	106,600	4,168,800
Washington	3	0	0	0	536,600	536,600
Totals	158	94,327,600	76,871,200	36,748,400	26,996,400	140,616,000

Source: Iron and Steel Works Directory of the United States and Canada, Iron and Steel Institute, 1974.

TABLE 3

EPA REGIONAL DISTRIBUTION OF U.S. IRON AND STEEL PLANTS AND PRODUCTION CAPACITY, 1974 (METRIC TONS)

EPA Region	No. of Plants	Estimated Iron Capacity (Blast Furnace)	Estimated Steel Capacity Basic Oxygen Furnace (BOF)	Open Hearth	Electric Furnace	Estimated Total Steel Capacity
I	1	0	0	0	234,400	234,400
II	10	4,807,600	5,469,200	0	1,481,500	6,950,700
III	48	29,844,400	21,814,900	14,662,200	5,021,900	41,499,000
IV	18	6,248,200	4,374,700	1,024,000	2,706,200	8,104,900
V	50	47,880,700	42,545,200	15,513,500	11,675,100	69,733,800
VI	11	634,100	0	1,160,600	3,134,800	4,295,400
VII	1	0	0	0	961,900	961,900
VIII	2	2,718,300	1,066,900	2,483,300	165,100	3,715,300
IX	12	2,194,300	1,600,400	1,904,700	777,600	4,282,700
X	5	0	0	0	837,900	837,900
	158	94,327,600	76,871,300	36,748,300	26,996,400	140,616,000

1.2 WASTE CHARACTERIZATION

This section contains descriptions of production technology at iron and steel plants and the resultant byproducts or wastes which are either recycled, handled by contract disposers, or disposed of on site. Estimates are given for the quantities of wastes and potentially hazardous constituents thereof which are disposed of on land, either in lagoons or dumps.

1.2.1 Process Descriptions

Integrated steel mills perform all the operations required to convert the principal raw materials of iron ore, limestone, and coal into finished steel products. The principal operations consist of raw material processing, iron making, steel making, primary rolling or roughing, and hot and cold finishing. Additional operations might include forging, annealing, tempering, tin plating and galvanizing. The interrelationships between the operations carried out in a typical large integrated steel plant are shown in the flow diagram of Figure 1. Smaller plants might lack the facilities for some of the operations shown, such as sintering, continuous casting, tin plating and galvanizing. The major operations are described in the following paragraphs.

Sintering. The sintering operation takes natural fine iron ores and metallic fines derived from residues of other steel plant facilities (e.g., flue dust from the blast furnace and scale from hot rolling mills) and fuses them into pieces large enough to be charged into the blast furnaces. In a typical sintering machine the fine material is mixed with coke breeze or powdered coal and spread on a moving bed. The mixture is ignited as it passes under an intense flame. The reaction is sustained by the combustion of the coke or coal as air is drawn downward through the bed. At combustion temperatures, the particles fuse together into a caked layer which is usually quenched with air and broken into pieces of the desired size. Particulates collected by one or more of a variety of emission control systems are generally recycled back into the sintering process. Therefore, no significant amounts of wastes are generated at sintering plants.

Coke and Byproduct Production. Coke serves both as a fuel and as a reducing agent in the making of iron. To produce the required coke, bituminous coal is heated to drive off the volatile components. Two methods of producing metallurgical coke are in use today, the byproduct method and the beehive process, although the beehive process accounts for less than two percent of all metallurgical coke produced.

In the beehive process, the volatile components are burned through the addition of controlled amounts of air into the coking chambers. The heat generated by burning of the combustible volatiles provides energy for maintaining the distillation process.

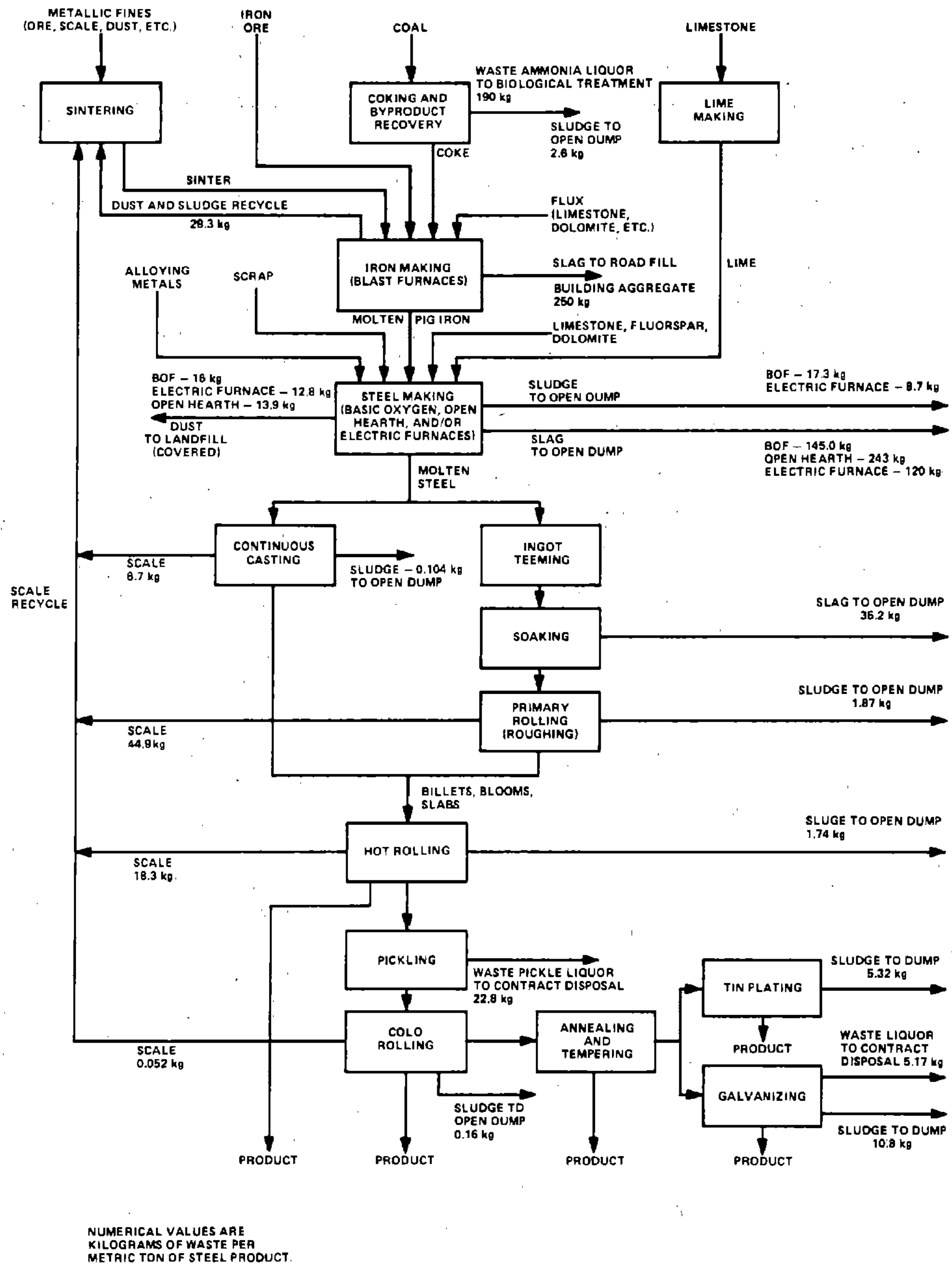

Figure 1 FLOW DIAGRAM FOR STEEL MAKING

In the byproduct process, no air is admitted to the coking chambers, the heat for distillation being provided by the combustion of fuel gas in contact with the walls of the coke ovens. The volatiles driven off during distillation are piped from the coke ovens and processed for recovery of useful byproducts. After coking is completed (16 to 24 hours), the hot coke is pushed from the ovens into a waiting car which transfers it to a quenching tower where it is cooled by water sprays.

Iron and Steel Making. In iron and steel making, fluxes are added which combine with impurities to form slag. Fluxes include limestone, lime, dolomite, and fluorspar. Lime is often made onsite at the steel plant by the calcination of limestone. The dusts generated in the required crushing, screening, and handling of the materials are generally collected and recycled.

Blast Furnace. Almost all of the basic iron required for steel making is produced in blast furnaces. Input materials, consisting of iron ore, sinter, coke, and fluxes (primarily limestone), are charged into the top of the furnace. Air preheated to 1400 to 2100 ^{o}F (760 to 1150 ^{o}C) is forced into the bottom of the furnace. The coke reacts with the oxygen in the air to produce carbon monoxide which, in turn, reduces the ore to metallic iron which settles to the bottom. The molten iron is tapped off into transfer ladles known as submarine cars for transfer to the steel making shop. Slag is drawn off at the surface of the molten metal.

The hot gases leaving the top of the blast furnace have fuel value and are commonly used in the blast furnace stoves to preheat the incoming air and for underfiring the coke ovens. Prior to use, the gases are cleaned by passing them first through a dust catcher to remove the coarser particulates and then through a wet scrubber. Electrostatic precipitators are also used at some plants. The water from the wet scrubber system is generally piped to a clarifier where the particulates settle to form a sludge or slurry which is subsequently dewatered, often by a vacuum filter system. Thus, the wastes derived from blast furnace operations generally consist of slag, flue dust and sludge.

Steel Making. For making steel, three different furnace types are in use: the basic oxygen furnace (BOF), the electric furnace, and the open hearth furnace. As stated previously, open hearth furnaces are gradually being phased out and being replaced by BOF's. Electric furnaces are particularly well suited for making high quality and alloy steels because of better control on operating conditions such as temperature and oxygen input.

The metal charge to the basic oxygen furnace consists of about 70 percent molten iron and 30 percent cold steel scrap. The open hearth generally operates with a metal charge of 50 percent molten iron and 50 percent scrap, although it can also accept a metal charge of 100 percent scrap. The charge to electric furnaces is predominantly cold scrap.

All three furnaces use limestone and/or fluorspar fluxes to facilitate the removal of impurities as slag.

For control of emissions from basic oxygen furnaces, the use of high energy wet scrubbers appears to be predominant. Of the ten steel plants visited during this program, seven plants had BOF furnaces; and of these plants, six were controlled by wet scrubbers. One plant used a dry electrostatic precipitator preceded by a wet spray system for gas cooling.

Five of the plants visited had electric furnaces. Three of these plants used dry baghouses for dust collection. The other two used a wet scrubber followed by a clarifier and vacuum filter for handling the scrubber water.

Four of the plants had open hearth furnaces and, in all cases, emission control was handled by dry electrostatic precipitators.

Thus, wastes from steel making consist of slag for all furnace types, and dusts and/or sludges, depending on the type of furnace and the associated emission control system. For BOF furnaces, sludges appear to be the most common form of pollution control waste, while for electric furnaces and open hearths dry dust appears to be most common. In addition to the above wastes, particulates called "kish" are released to the air during the pouring of the molten pig iron. In BOF shops, this material is commonly collected in baghouses.

Ingot Molding and Rolling. Molten steel is tapped from the steel making furnaces into teeming ladles and then transferred to a teeming area or to a continous casting area. In the teeming area, the molten steel is poured into ingot molds. Upon solidification, the ingots are placed in soaking pits to bring them to the desired uniform temperature. They are then rolled into billets, blooms, or slabs which are blocks having different shapes and weights. Wastes consist of slag that accumulated at the bottoms of the soaking pits, scale generated in the rolling operations and sludges from treatment of scale pit water.

Continous Casting. In continous casting, the molten steel in the teeming ladles is cast directly into billets, blooms, or slabs, thereby eliminating the need for ingot molds, soaking pits and primary rolling described in the next paragraph. As the castings leave the molds, they are sprayed with cooling water. As a result of coming in direct contact with the steel, this water contains fine scale that is removed as sludge during treatment of the water. Coarser scale accumulates in settling pits.

Rolling. The billets, blooms, and slabs formed in the roughing mill or in the continous caster are sent to the hot rolling mills where they are converted into a wide variety of finished or semi-finished products, including bars, rods, tubes, rails, structured shapes, sheets, and plates. These hot rolling operations produce scale which is collected in pits. Sometimes surface defects in billets, blooms and slabs are removed prior to rolling by automatic or hand scarfing, an operation in which oxygen under pressure is directed at the surface. Grinding and chipping are also used for removing surface defects. Thus, scarfing scale and grinding and chipping residues are additional wastes generated at the rolling mills.

Hot rolling is often followed by cold-rolling and cold-forming operations. Prior to cold processing, the steel is pickled by passing it through vats of hydrochloric or sulfuric acid solution to clean the surface. Waste pickle liquor is sometimes disposed of directly on land and, therefore, constitutes a waste of interest to this program. Neutralization of the waste pickle liquor is sometimes accompanied by the formation of sludges which are also land disposed.

In cold rolling, sheet steel becomes hardened and usually requires annealing (i.e. softening by heat treatment). Coils of sheet steel are annealed by heating them in a controlled atmosphere. After cooling, the annealed steel is then generally passed through a temper mill which gives it the desired hardness, flatness, and surface quality. No wastes are generated in the annealing and tempering operations.

Coating and Plating. Further processing of the sheet steel might include coating the surface with nonferrous metal, paint, or other coatings. Two common coating operations, tin plating and galvanizing, are included in the flow diagram of Figure 1. One common method of tin plating involves electrolytic deposition. The steel is first washed and scrubbed and then cleaned in a dilute acid solution. It is then passed through an electrolytic solution, washed, and rinsed. The coated sheets are then heated so the tin flows to form a surface coating of high luster. Finally, the surface is water quenched, electrochemically treated, and coated with oil. In galvanizing, the sheet steel is cleaned, heated, dipped in molten zinc, cooled, and chemically treated. In galvanizing and tin plating, sludges are generated containing residuals from the cleaning lines and from neutralization of the acid rinse water.

Capacity of Typical Plant

For the typical plant an annual capacity of 2,500,000 metric tons of molten steel was selected. This value is slightly greater than the average ingot steel production for 45 of the major steel making plants in the United States. Facilities at the typical plant consist of a sinter plant, blast furnaces, basic oxygen furnaces, electric furnaces, coke ovens, a continuous caster, primary (or roughing) mills, other hot rolling mills (hot strip, bar, etc.), cold mills, annealing and tempering mills, a tin plating mill and a galvanizing mill. Table 4 gives the annual production figures for each major facility at the typical plant. The figures are generally internally consistent, but in any one plant the relative amounts of products of different types will vary as will the amount of home scrap produced. In addition, intermediate products such as blooms, billets or slabs might be purchased and/or sold in any given year, so that the ratio of weight of finished products-to-weight of steel produced will vary.

TABLE 4 - PRODUCTION DATA FOR TYPICAL INTEGRATED STEEL PLANT

Facility	Product	Annual Amounts (Metric tons)
Coke Ovens	Coke	1,120,000
Blast Furnaces	Iron	1,600,000
Basic Oxygen Furnaces	Steel	2,000,000
Electric Furnaces	Steel	500,000
Soaking Pits	Steel Ingots	1,560,000
Primary Mills	Billets, Blooms, Slabs	1,350,000
Continuous Caster	Billets, Blooms, Slabs	790,000
Hot Rolling Mills	Sheet Steel, Bars, Rods Structural Shapes, etc.	1,800,000
Cold Rolling Mills	Sheet Steel	700,000
Tin Plating Mill	Tin Plated Sheets	100,000
Galvanizing Mill	Zinc Coated Sheets	125,000

1.2.2 Description of Waste Streams

This section describes the types of wastes associated with each of the steel making processes previously described. Generation factors for each type of wastes are given as well as an assessment of their potential environmental hazard.

Coke and Byproduct Plants. Wastes generated from coke and byproduct coke plants include waste ammonia liquor, ammonia still lime sludge and decanter tank tar. The relative amounts of these wastes will vary considerably from plant to plant depending on the specific design of the byproduct recovery plant.

Waste Ammonia Liquor. Ammonia is recovered from coke gas by one of two methods. In some plants ammonia is recovered in the form of ammonium sulfate by passing the coke gas through dilute sulfuric acid. This produces a waste ammonia liquor generated at a rate of 190 kg/MT of coke produced or 125 kg/MT of steel produced based on the use of 0.66 MT of coke for 1 ton of steel. Waste ammonia liquor contains significant concentrations of phenol and cyanide and is therefore considered potentially hazardous.

Ammonia Still Lime Sludge. At other plants ammonia is removed initially from the coke oven gas by spray cooling and scrubbing and sold as a concentrated ammonia liquor. Concentration of the liquor is achieved in a ammonia still which produces a waste lime sludge formed as a result of adding milk of lime to decompose ammonium salts. Ammonia still lime sludge along with decanter tank tar to be described is generated at a rate of 0.28 kg/MT of finished steel product (dry weight). This sludge will contain significant concentrations of cyanide, phenol, and oils and greases. In solubility tests described in Appendix B ammonia still lime sludge was found to leach significant concentrations of phenol and cyanide (198 ppm Cn, 20 ppm phenol). It is therefore considered potentially hazardous.

Decanter Tank Tar. The spray cooling of coke oven gases also condenses tars which are sent to a decanter tank where lighter recoverable oil fractions are decanted off. The heavier tar generated at a rate of 2.3 kg/MT steel along with ammonia still lime sludge is sent to open dumps. In solubility tests described in Appendix B decanter tank tar was found to leach significant concentrations of phenol (500 ppm) and oil and grease (198 ppm) and is therefore considered potentially hazardous.

Wastes generated from iron and steel making include slags, sludges and dusts. The quantities and nature of these residuals are described in the following paragraphs as well as an assessment of their hazardousness or non-hazardousness.

Blast Furnace. Residuals from blast furnace processing of iron ore to produce molten iron metal include slag, dusts from dry air emissions controls or sludge from wet air emissions controls.

Slag. Blast furnace slag is generated at a rate of 348 kg/MT of iron output from the blast furnace or 250 kg/MT of finished steel. It is normally granulated by quenching the molten slag with water. This produces sand size to large chunks of a hard vesicular slag containing predominantly silica, lime, iron, sulfur and traces of minor metals including chromium, manganese, lead, copper and zinc. In solubility tests described in Appendix B blast furnace slag did not leach toxic constituents in significant concentrations and is therefore not considered potentially hazardous.

Dust. Dust from dry emissions controls on blast furnaces including baghouses and electrostatic precipitators is predominantly iron oxide, silica and lime but contains significant concentrations of chromium, copper, manganese, nickel, lead and zinc. Concentrations of these metals is significantly higher in dusts than in slag. It is generated at a rate of 16.2 kg/MT of blast furnace iron output or 11.7 kg/MT of steel product. In solubility tests described in Appendix B blast furnace dust did not leach toxic heavy metals significantly and is therefore not considered potentially hazardous at this time.

Sludge. Sludge from wet emissions controls on blast furnaces including wet electrostatic precipitators, venturi scrubbers, and spray towers is also predominantly iron oxide, silica and lime and contains significant concentrations of the trace metals chromium, copper, manganese, nickel, lead and zinc. Concentrations of these metals is significantly higher in sludges than in slags. It is generated at a rate of 24.4 kg per metric ton of blast furnace iron output or 17.6 kg/MT of steel (dry weights). In solubility tests described in Appendix B blast furnace sludge was not found to leach toxic constituents in significant concentrations and is therefore not considered a potentially hazardous waste.

Basic Oxygen Furnace (BOF). Residuals from BOF processing of iron, scrap and alloying metals to produce steel while reducing carbon sulfur, phosphorus and other impurities, include slag, dusts and sludges.

Slag. A dense slag containing large amounts of silica, iron and lime, minor amounts of sulfur and phosphorus and significant concentrations of the trace metals chromium, copper, manganese, nickel, lead and zinc is generated at a rate of 145 kg/MT of steel output. In solubility tests described in Appendix B blast furnace slag was not found to leach significant concentrations of toxic constituents and is therefore not considered potentially hazardous.

Dust. Fine dust from dry air emissions controls is mainly iron oxide, silica oxide and lime but also contains significant concentrations of trace metals including chrome, copper, manganese, nickel, lead and zinc. Dust is generated at a rate of 16 kg/MT of steel product. Data indicates zinc and lead are more concentrated in dusts and sludges whereas chrome tends to stay with slag. In solubility tests described in Appendix B BOF sludge did not leach appreciable concentrations of toxic constituents. The low solubility of BOF sludge indicates that dust will also not leach significantly. For this reason BOF dust is not considered potentially hazardous at this time.

Sludge. Sludge from wet control of air emissions from BOF's is also predominantly iron oxides, silica oxide and lime with small but significant concentrations of the trace metals chrome, copper, manganese, nickel, lead and zinc. It is generated at a rate of 17.3 kg/MT of steel product (dry weight). In solubility tests described in Appendix B BOF sludge did not leach significant concentrations of toxic constituents and is therefore not considered potentially hazardous at this time.

Open Hearth Furnaces. Residuals generated from open hearth furnaces include slag, dusts and sludges.

Slag. A dense, hard slag is generated at a rate of 243 kg/MT of steel product. It is mainly iron oxides, silica oxide and lime, with minor amounts of sulfur and phosphorus compounds. Trace metals present in significant concentrations include chromium, copper, manganese, nickel, lead and zinc. In solubility tests described in Appendix B toxic constituents did not leach to a significant extent. Open hearth slag is therefore not considered hazardous at this time.

Dust. Dust from dry emissions control is generated at a rate of 13.7 kg/MT of steel product. It is predominantly iron oxides, silica oxides and lime but contains significant concentrations of chrome, copper, manganese, nickel, lead and zinc. As with BOF furnaces data indicates that lead zinc, and to a lesser extent copper concentrate to a greater extent in dusts whereas chrome stays with the slag. Solubility tests described in Appendix B showed no appreciable leaching of toxic constituents. For this reason open hearth dust is not considered potentially hazardous at this time.

Sludge. None of the plants visited or surveyed during this study used wet emissions controls on open hearth furnaces. Thus no generation factors could be developed or chemical analyses made. The sludge would be similar in composition to dust and would not be expected to leach significantly so as to be considered hazardous.

Electric Furnaces. Residuals from electric furnaces include slag, dust and sludge.

Slag. A dense hard slag is generated at a rate of 120 kg/MT of steel. It is composed principally of iron, silica and calcium compounds with minor amounts of sulfur and phosphorus compounds. Trace metals include chromium, copper, manganese, nickel, lead, and zinc. In solubility tests described in Appendix B toxic constituents did not leach significantly. Electric furnace slag is therefore considered non-hazardous at the present time.

Dust. Dust from dry emissions controls is generated at a rate of 12.8 kg/MT of steel. It is principally iron and silica oxides and lime with significant concentrations of the trace metals chromium, copper, manganese, nickel, lead, and zinc. Zinc, lead and copper are much more concentrated in dusts and sludges than in slag. In solubility tests described in Appendix B lead was found to leach at appreciable concentrations (150 ppm). Electric furnace dust is therefore considered potentially hazardous.

Sludge. Sludge from wet emissions controls is generated at a rate of 8.7 kg/MT of steel product. It is comprised principally of iron and silica oxides and lime and contains significant concentrations of the trace metals chromium, copper, manganese, nickel, lead and zinc. In solubility tests described in Appendix B electric furnace sludge leached chromium (94 ppm) and lead (2.0 ppm) in significant concentrations. Electric furnace sludge is therefore considered potentially hazardous at this time.

Soaking Pits. Soaking pit slag of gravel to boulder size is generated at a rate of 35.2 kg/MT of steel. It is composed principally of iron and contains significant concentrations of trace metals including chromium, copper, manganese, nickel, lead and zinc. In solubility tests described in Appendix B this slag did not leach significant concentrations of toxic metals. It is therefore considered non-hazardous at this time.

Mill Sludges. Mill sludges are produced from a number of steel plant facilities as a result of water pollution control operations. Generation factors for various mill sludges are as follows:

Primary Mills (production of ingots, slabs, billets 1.87 kg/MT steel
Continuous Casting Mill - 0.104 kg/MT steel
Hot Rolling Mill - 1.74 kg/MT steel
Cold Rolling Mill - 0.16 kg/MT steel
Tin Plating Mill - 5.32 kg/MT steel
Galvanizing Mill 10.8 kg/MT steel

Samples of two of the above types of sludges were obtained and chemically analyzed including hot rolling mill sludge and tin plating mill sludge. Both of these sludges contained significant concentrations of trace metals including chromium, copper, manganese, nickel, lead, zinc and oil and grease.

Solubility tests were not conducted on mill sludges. They are believed to be susceptible to leaching of oil and grease and quite possibly some toxic metals because of the presence of these constituents and fine size of sludge particulates.

Mill Scales. Mill scales containing over 50% iron are generated from the following mills:

Primary Mills 44.9 kg/MT steel
Continuous Casting Mills 8.7 kg/MT steel
Hot Rolling Mills 18.3 kg/MT steel
Cold Rolling Mills 0.052 kg/MT steel

Mill scales contain over 50% iron as well as small but significant concentrations of trace metals including chromium, copper, manganese, nickel, lead and zinc. Mill scales can also contain as much as 0.4% oil and grease. Oil and grease can be leached from mill scale and pose a threat of ground water contamination. For this reason mill scales are considered potentially hazardous at this time.

Pickle Liquors. Acid pickle liquors (HCl, H_2SO_4) are used in cold rolling mills and galvanizing mills to clean iron and steel metal surfaces. Spent acid is generated at a rate of 22.8 kg/MT steel from cold rolling mills and 5.17 kg/MT steel from galvanizing mills. Waste pickle liquor contains about 4-6% acidity and large concentrations of dissolved and suspended iron. Chromium, copper, nickel, lead and zinc are also present in minor concentration (less than 20 ppm). The high acidity (pH less than 1.0) of waste pickle liquor and resultant solubilization of toxic metal constituents are reasons why waste pickle liquor is considered potentially hazardous.

1.2.3 Waste Quantities

During the conduct of this study, intensive sampling and chemical analyses of steel plant residuals were carried out. Ten steel plants located in the North Central and Great Lakes region of the United States provided personnel to obtain daily samples of steel plant production and pollution control residuals, including slags, sludges, dusts, scales, and pickle liquor. These samples were shipped to the Calspan Laboratory at Buffalo, New York, where the daily samples were composited into weekly samples and then chemically analyzed. Steel plant residuals were therefore well characterized as to average chemical content and variability in composition. Results of chemical analyses from the ten steel plants are given in Appendix A.

Table 5 gives generation factors for the various residuals from iron and steel production as well as concentration factors for potentially hazardous constituents. These factors were computed by averaging all available data collected from the 10 iron and steel plants visited on generation rates and chemical analyses data from collected residuals samples of slags, sludges, dusts and other wastes.

Using the residuals generation factors given in Table 5 the yearly amount of residuals generated from a typical integrated steel plant producing 2,500,000 MT of molten steel as described in Table 4 were estimated. Quantities of potentially hazardous constituents were also calculated for the typical integrated plant. These estimates are given in Table 6.

TABLE 5

WASTE GENERATION FACTORS - IRON & STEEL PLANTS

Type of Waste	Generation Factors: Kg/MT of Steel Produced or Processed	Generation Factors: Kg/MT of Facility Output	Concentration Factors (ppm): Cr	Cu	Mn	Ni	Pb	Zn	Oil & Grease
Coke Oven - Sludge	2.6*	5.5	10.0	4.0	102	5.5	30.5	96.5	203,070
Blast Furnace - Slag	250*	348	46.9	21.9	3000	<7.5	21.5	8.2	--
Blast Furnace - Dust	11.7*	16.2	92.4	93.2	8800	57.6	302	516	--
Blast Furnace - Sludge	17.6*	24.4	56.1	37.4	3700	38.4	1210	11,650	--
Basic Oxygen Furnace - Slag	145	145	1290	31.3	41,600	12.2	12.0	16.2	--
Basic Oxygen Furnace - Dust	16.0	16.0	315	202	11,400	115	7350	3350	--
Basic Oxygen Furnace - Kish	0.14	0.14	110	45.7	3810	56.6	137	660	--
Basic Oxygen Furnace - Sludge	17.3	17.3	708	174	10,300	130	4190	10,094	--
Open Hearth Furnace - Slag	243	243	2360	49.8	42,710	23.7	57.4	47.9	--
Open Hearth Furnace - Dust	13.7	13.7	568	1130	4810	314	11,650	113,000	--
Electric Furnace - Slag	120	120	4820	79.0	50,580	53.9	32.7	80.5	--
Electric Furnace - Dust	12.8	12.8	1380	1940	42,610	246	24,220	95,710	--
Electric Furnace - Sludge	8.7	8.7	2690	1130	34,100	421	7900	13,540	--

*Approximately 0.72 MT of pig iron required to produce 1 MT of steel (on the average). Approximately 0.66 MT of coke required to produce 1 MT pig iron. Coke oven sludge consists of ammonia still lime sludge and decanter tank tar. Values are averages for data from a number of steel plants. Plus or minus variation for individual plants from averages may be a factor of 2 to 3.

TABLE 5 (Continued)

WASTE GENERATION FACTORS - IRON & STEEL PLANTS

Type of Waste	Generation Factors: Kg/MT of Steel Produced or Processed	Generation Factors: Kg/MT of Facility Output	Concentration Factors (ppm): Cr	Cu	Mn	Ni	Pb	Zn	Oil & Grease
Soaking Pit - Slag	35.2	35.2	373	278	5280	117	760	59.3	--
Primary Mill - Sludge	1.87	1.87	--	--	--	--	--	--	--
Primary Mill - Scale	44.9	44.9	318	449	5410	385	58	32.5	10,180
Continuous Caster - Sludge	0.104	0.104	--	--	--	--	--	--	--
Continuous Caster - Scale	8.7	8.7	--	--	--	--	--	--	--
Hot Rolling Mill - Sludge	1.74	1.74	198	232	3280	253	1050	669	45,290
Hot Rolling Mill - Scale	18.3	18.3	208	274	3170	545	154	26.9	42,246
Cold Rolling Mill - Sludge	0.16	0.16	--	--	--	--	--	--	--
Cold Rolling Mill - Scale	0.052	0.052	--	--	--	--	--	--	--
Cold Rolling Mill - Waste Pickle Liquor	22.8	22.8*	12.7	7.35	179	19.2	1.1	8.3	63.9
Tin Plating Mill - Sludge	5.32	5.32	2760	2730	1040	250	688	2260	--
Galvanizing Mill - Sludge	10.8	10.8	--	--	--	--	--	--	--
Galvanizing Mill - Waste Pickle Liquor	5.17	5.17*	--	--	--	--	--	--	--

* Wet weight - all other factors are dry weight.

TABLE 6

YEARLY GENERATION OF RESIDUALS BY TYPICAL IRON AND STEEL PLANT*

	Total Quantity of Waste (MT)	Quantity of Potentially Hazardous Constituents (MT)						
		Cr	Cu	Mn	Ni	Pb	Zn	Oil & Grease
Coke Oven - Sludge	6,200	0.062	0.025	0.628	0.034	0.188	0.594	1250
Blast Furnace - Slag	557,000	26.1	12.2	1670	4.2	12.0	4.57	--
Blast Furnace - Dust	25,900	2.40	2.42	228	1.49	7.83	13.4	--
Blast Furnace - Sludge	39,000	2.19	1.46	144	1.50	47.2	455	--
Basic Oxygen Furnace - Slag	290,000	374	9.08	12064	3.54	3.48	4.70	--
Basic Oxygen Furnace - Dust	280	0.031	0.013	1.07	0.016	0.038	0.185	--
Basic Oxygen Furnace - Sludge	34,600	24.5	6.02	356	4.50	145	349	--
Electric Furnace - Slag	60,000	289	4.74	3035	3.23	1.96	4.83	--
Electric Furnace - Dust	6,400	8.83	12.4	273	1.57	155	613	--
Electric Furnace - Sludge	4,350	11.7	4.92	148	1.83	34.4	58.9	--
Soaking Pit - Slag	54,900	20.5	15.3	290	6.42	41.7	3.26	
Primary Mill - Sludge	2,520	--	--	--	--	--	--	--
Primary Mill - Scale	60,600	19.3	27.2	328	23.3	3.52	1.97	617
Continuous Caster - Sludge	82.2	--	--	--	--	--	--	--
Continuous Caster - Scale	6,900	--	--	--	--	--	--	--

TABLE 6 (Continued)

YEARLY GENERATION OF WASTE RESIDUALS BY TYPICAL IRON AND STEEL PLANT

Type of Waste	Total Quantity of Waste (MT)	Quantity of Potentially Hazardous Constituents (MT)						
		Cr	Cu	Mn	Ni	Pb	Zn	Oil & Grease
Hot Rolling Mill - Sludge	3,130	0.620	0.727	10.3	0.792	3.29	2.10	141
Hot Rolling Mill - Scale	32,900	6.85	9.03	104	18.0	5.07	0.886	1392
Cold Rolling Mill - Sludge	112	--	--	--	--	--	--	--
Cold Rolling Mill - Scale	36.4	--	--	--	--	--	--	--
Cold Rolling Mill - Waste Pickle Liquor	16,000	0.203	0.117	2.86	0.306	0.018	0.132	1.02
Tin Plating Mill - Sludge	532	1.47	1.45	0.553	0.133	0.366	1.20	--
Galvanizing Mill - Sludge	1,350	--	--	--	--	--	--	--
Galvanizing Mill - Waste Pickle Liquor	646	--	--	--	--	--	--	--

*Quantities calculated from generation and concentration factors given in Table 5 based on annual production figures given in Table 4. Divide by 365 to obtain daily quantities. Multiply by 1.1 to convert to short tons.

Using state-by-state production capacities as previously given and waste generation and hazardous constituent factors per unit of product as previously given in Table 5 estimates were made of the state, regional, and national land-disposed wastes and hazardous constituents from iron and steel production. These estimates are given in Tables 7a to 71 for 1974, 1977 and 1983. Extrapolations of waste quantities to 1977 and 1983 were based on an annual growth rate of the steel industry (and accompanying residuals generation) of 2.1% from 1974-1977 and 2.5% from 1974 to 1977. This compares with annual growth of 2.5% predicted by the industry over the same period (Reference 9).

Tables 7a to 7c contain estimates of the total quantity of slags from all sources (blast furnace, BOF, open hearth, electric furnaces, soaking pit) which are or which will be generated in the iron and steel industry in 1974, 1977, and 1983. Although practices may vary widely from plant to plant it is estimated that approximately 90% of generated slag is processed for recovery of contained iron and steel and then sold for use as road fill building aggregate and other purposes. It may be stored for many months before use. The remainder is open dumped.

Tables 7d through 7f gives estimates of sludges generated from all sources in the iron and steel industry for the years 1974, 1977, and 1983. Approximately 55 percent of the total sludge generation originates from wet scrubbers of the blast furnace and is considered non-hazardous. Approximately 70% of blast furnace sludge is recycled to the sinter strand for recovery of iron.

Approximately 20% of the sludge estimated in Tables 7a to 7c originates from wet emissions controls on BOF furnaces, 10% of which is recycled to sinter strands. In total some 75% of estimated sludge generated is from blast furnaces plus BOF furnaces and is not considered potentially hazardous.

The remaining 25% of the sludge estimates given in Tables 7d through 7f consists of sludges from electric furnaces, galvanizing mills, primary and secondary rolling mills, lime pit sludges, and tin mill sludges. These sludges are considered potentially hazardous.

Tables 7g through 7i contain estimates of the total quantities of dust generated by the iron and steel industry for 1974, 1977 and 1983 through dry emissions controls on blast furnaces. Approximately 57% of the state, regional and national estimates consists of blast furnace dust. Approximately 90% of blast furnace dust is recycled to the sinter for iron reclamation with the remainder being placed on land dumps. Blast furnace dust is not considered potentially hazardous.

Approximately 12% of the dust generated in the iron and steel industry is from electric furnaces and is considered potentially hazardous. Electric furnace dust is not presently recycled. The remaining 31% of the dust quantity estimates given in Tables 7g through 7i consist predominantly of BOF dust with a small percentage of open hearth dust. BOF dust and open hearth dust are not considered potentially hazardous.

Tables 7j through 7l contain estimates of quantities of scale generated in the iron and steel industry from hot rolling mill, cold rolling mills, primary mills, and continuous casting mills. It is estimated that 80% of mill scales are recycled for reclamation of iron content. The presence of high contents of oil and grease prevents complete recycle, and for the same reason causes mill scales to be a danger to the environment and be considered potentially hazardous.

Tables 7m through 7o contain estimates of the quantities of spent pickle liquor (dilute solutions of sulfuric or hydrochloric acid containing iron oxide and iron metal particles and traces of other metals) generated in the iron and steel industry. They are normally disposed of by contract disposal services but may be regenerated for reuse. Pickling liquors are considered potentially hazardous.

Generation of slags, sludges, and dusts follows production patterns. The largest producers of total iron and steel residuals and potentially hazardous wastes from the iron and steel industry are the states of Pennsylvania, Ohio, and Indiana followed by Illinois, Michigan and New York in that order. Alabama, West Virginia, California, and Utah also generate significant quantities of total and hazardous wastes.

1.3 TREATMENT DISPOSAL TECHNOLOGY

1.3.1. Current Treatment and Disposal Practices

This section will describe the prevalent methods used by the iron and steel industry for the treatment and disposal of all waste types be they considered hazardous or non-hazardous. Sections 1.3.2 through 1.3.4 will present more detailed discussions of the technologies used to treat and/or dispose of those waste streams which are considered to be potentially hazardous. Waste types are discussed with reference to the plant facilities from which they originate.

Coke Plant. Land disposed wastes from the coke plant of an integrated steel facility includes waste ammonia liquor, ammonia still lime sludge and decanter tank tar. All of these wastes are considered potentially hazardous because of the presence of phenols, and cyanides which are susceptible to leaching. The ususal treatment of waste ammonia liquor is input to biological wastewater treatment plants. This is environmentally acceptable since the toxic constituents (phenol, cyanide) will be detoxified in the biological treatment. Sometimes this waste is disposed of in deep wells.

Ammonia still lime sludge and decanter tank tar are normally disposed of by open dumping which is not environmentally acceptable because of the suspectibility to leaching of phenol, cyanide and oils.

Blast Furnace. Residuals from blast furnaces include slag, dust from dry emissions control, or sludge from wet emissions controls. Slag is usually processed for recovery of iron metal before sale as road fill,

Table 7a

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL INDUSTRY TOTAL SLAG, 1974 (METRIC TONS)

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS						
					Cr	Cu	F	Mn	Ni	Pb	Zn
ALABAMA	2,666,500	0	0	SOLD AS ROAD BASE OR BUILDING AGGREGATE OR OPEN DUMPED	1,571.52	110.86	6,369.48	36,521.48	45.29	172.51	47.59
ARIZONA	12,800				48.78	1.58	20.21	516.05	0.87	2.49	0.97
ARKANSAS	6,900				33.38	0.55	14.14	350.52	0.37	0.23	0.56
CALIFORNIA	1,870,500				1,865.20	89.91	3,581.06	38,496.00	39.16	148.06	46.48
COLORADO	542,800				325.82	25.15	1,268.88	8,637.32	10.26	41.17	8.25
CONNECTICUT	38,000				138.41	4.43	57.37	1,464.22	2.44	6.94	2.73
DELAWARE	71,800				306 58	7.44	128.44	3,231.34	4.43	8.80	5.58
FLORIDA	30,900				148.90	2.44	63.06	1,563.51	1.67	1.01	2.49
GEORGIA	46,500				178.37	5.70	73.83	1,886.92	3.14	6.94	3.52
HAWAII	2,500				11.93	0.20	5.06	125.26	0.13	0 08	0.20
ILLINOIS	4,597,700				4,863.26	250.80	10,159.10	88,756.10	111.58	401.61	113.37
INDIANA	9,931,400				7,250.51	446.80	22,558.00	178,180.00	182.32	711.87	186.12
KENTUCKY	782,000				823.58	44.44	1,894.40	16,647.20	19.75	71.84	19.16
MARYLAND	3,192,900				2,396.25	142.29	6,453.48	52,459.10	68.76	227.84	68.01
MICHIGAN	4,511,200				2,706.97	208.79	10,431.90	71,637.30	86.17	341.56	78.86
MINNESOTA	25,200				121.31	1.99	51.38	1,273.83	1.36	0.82	2.03
MISSISSIPPI	8,700				42.06	0.69	17.81	441.65	0.47	0.29	0.70
MISSOURI	147,900				568.12	18.16	235.47	6,009.85	10.01	28.48	11.22
NEW JERSEY	62,000				264.68	8.42	110.89	2,789.73	3.82	7.58	4.83
NEW YORK	2,728,300				1,467.88	122.41	6,356 61	42,131.40	49.00	200.86	43.40
N. CAROLINA	25,600				123.23	2.02	52.19	1,293.98	1.38	0.84	2.06
OHIO	11,114,100				10,446.10	554.32	23,335.00	210,113.00	238.37	893.68	270.68
OKLAHOMA	29,400				141.54	2.32	59.96	1,486.35	1.58	0.98	2.37
OREGON	46,300				177.85	5.69	73.76	1,882.45	3.13	8.82	3.51
PENNSYLVANIA	14,033,500				13,010.20	700.38	29,890.00	270,448.00	298.43	1,141.38	338 82
S. CAROLINA	41,600				200 24	3.28	84.80	2,102.60	2.24	1.36	3.35
TENNESSEE	14,600				70.56	1.16	29.88	740.90	0.79	0.48	1.18
TEXAS	877,600				2,382.68	83.27	1,747.62	30,608.40	42.38	134.59	50.68
UTAH	1,308,400				1,483.85	67.45	2,486.87	29,081.30	28.93	113.06	39.06
VIRGINIA	10,900				41.97	1.34	17.40	444.01	0.74	2.10	0.83
WASHINGTON	82,500				316.90	10.13	131.35	3,352.33	5.68	15.88	6.26
W. VIRGINIA	1,769,700				904.53	67.32	4,401.98	28,851.20	28.12	96.83	24.59
EPA REGION											
I	38,000				138.41	4.43	57.37	1,464.22	2.44	6.94	2.73
II	2,790,300				1,732.56	128.83	6,467.50	44,921.13	52.82	208.45	48.23
III	19,078,800				16,659.53	918.77	40,891.30	355,433.65	388.48	1,476.85	437.84
IV	3,816,400				3,168.46	170.68	7,585.55	61,197.96	74.73	257.27	80.06
V	30,179,600				25,188.15	1,462.50	66,535.38	548,960.23	618.81	2,349.64	659.06
VI	1,013,800				2,537.60	86.14	1,821.72	32,445.27	44.33	135.78	53.61
VII	147,900				568.12	18.16	235.47	6,009.85	10.01	28.48	11.22
VIII	1,851,200				1,809.67	92.60	3,743.76	38,718.62	39.19	154.23	48.31
IX	1,885,800				1,925.91	91.69	3,806.31	37,137.31	40.16	150.82	47.65
X	128,800				494.85	15.82	205.11	5,234.78	6.71	24.80	9.77
NATIONAL TOTALS	60,528,600				54,213.26	2,869.63	131,249.48	1,130,522.7	1,279.68	4,793.16	1,398.47

*~ 90% OF SLAG IS PROCESSED FOR RECOVERY OF METALLICS AND THEN SOLD FOR USE AS ROAD FILL, ETC. REMAINDER IS LAND DISPOSED, AND/OR USED AS FLUX. SLAGS FROM BLAST FURNACES, OPEN HEARTH FURNACES, BASIC OXYGEN FURNACES, ELECTRIC FURNACES, AND SOAKING PITS NOT CONSIDERED HAZARDOUS ON THE BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B.

SOURCE: CALSPAN CORPORATION

Table 7b

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL INDUSTRY TOTAL SLAG, 1977 (METRIC TONS)

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS						
					Cr	Cu	F	Mn	Ni	Pb	Zn
ALABAMA	2,826,500	0	0	SOLD AS ROAD BASE OR BUILDING AGGREGATE OR OPEN DUMPED	1,665.81	117.62	5,691.66	38,712.50	48.01	182.86	50.45
ARIZONA	13,520				51.70	1.67	21.42	547 01	0.92	2.84	1.02
ARKANSAS	7,350				35.38	0.58	14.99	371.55	0.40	0.24	0.59
CALIFORNIA	1,771,000				1,877.11	85.31	3,795.91	38,685.87	41.51	156.93	49.27
COLORADO	576,400				345.37	26 66	1,332.29	9,155.56	10.87	43.64	8.80
CONNECTICUT	38,200				146.72	4 69	60.81	1,652.07	2.58	7.35	2.90
DELAWARE	76,130				324.97	7 89	136 14	3,425.22	4.69	9.32	5.83
FLORIDA	32,770				157.83	2.59	66.84	1,657.32	1.77	1.07	2.64
GEORGIA	49,230				189 07	6 05	76.37	2,000.14	3.33	8.48	3 73
HAWAII	2,625				12 64	0.21	5.36	132.78	0.14	0.09	0.21
ILLINOIS	4,873,500				4,943 08	265.63	10,768 65	94,081.47	118.28	425 70	120.18
INDIANA	10,527,300				7,685 54	473.61	23 911.69	188,870 80	193.25	754.69	207.88
KENTUCKY	829,000				872.99	47.11	2,008.06	17,646 03	20 84	76.18	20.31
MARYLAND	3,384,500				2,540.03	150.82	6,840.69	5,566.65	62 29	241.51	72.09
MICHIGAN	4,781,900				2,869.39	221.32	11,057.81	75,935.54	80.28	382.05	81.48
MINNESOTA	28,700				128.59	2.11	54.46	1,350.26	1.44	0.87	2.15
MISSISSIPPI	9,255				44.58	0 73	18.88	468.15	0.50	0.30	0.75
MISSOURI	156,800				602.21	19.25	249.60	6,370.44	10.61	30.19	11.89
NEW JERSEY	66,730				280.56	6 81	117.54	2,957 11	4.05	8.05	5.12
NEW YORK	2,892,000				1,655 95	129 75	6,738 01	44,659.28	51.83	212.81	48.01
N. CAROLINA	27,120				130 62	2 14	55.32	1,371.62	1.46	0.89	2.18
OHIO	11,781,000				11,072 87	587.58	24,735.10	222,719.78	252.67	947 31	286 92
OKLAHOMA	31,160				150.03	2.46	63.56	1,575.53	1.68	1 02	2.51
OREGON	49,120				188.63	6.03	78.18	1,996 40	3 32	8.46	3.73
PENNSYLVANIA	14,875,500				13,790.81	742 41	31,789.72	286,674.90	316 33	1,209.86	359.16
RHODE ISLAND	NA				NA	NA	NA	NA	NA	NA	NA
S CAROLINA	44,060				212.26	3 46	89.89	2,228.82	2.38	1.44	3.55
TENNESSEE	15,530				74.79	1 23	31.67	785.35	0.84	0.51	1.25
TEXAS	1 036,100				2,504 44	88 27	1,852 48	32,444.90	44.92	142.66	53 72
UTAH	1,386,900				1,572 88	71.50	2,636 08	28,766.18	30.66	119.84	41.41
VIRGINIA	11,590				44 49	1.42	18 44	470.65	0.78	2.23	0.88
WASHINGTON	87,470				335.91	10.74	139.23	3,553.47	5.92	18.84	0.63
W. VIRGINIA	1,875,900				959.60	71.36	4,666 10	30,682.27	27.68	102.64	26.07
EPA REGION											
I	38,200				146 72	4 69	60.81	1,652.07	2.58	7.35	2.90
II	2,957,730				1,836.51	136.56	6,855.55	47,616.39	55.88	220.96	61.13
III	20,223,620				17,659.10	973.80	43,451.09	376,759.69	411.76	1,565.56	464.12
IV	3,833,466				3,347.95	180.95	8,040.68	64,869.93	79.23	272.71	84.86
V	31,980,400				26,699 45	1,550.25	70,527 71	582,957.85	655.93	2,490.62	898.61
VI	1,074,610				2,689 85	91.31	1,931.03	34,391.98	47.00	143.92	60.82
VII	156,800				602.21	19.25	249.60	6,370.44	10.61	30.19	11.89
VIII	1,962,300				1,918.25	98 16	3,968 37	38,921.74	41.63	163.48	51.21
IX	1,787,145				2,041.45	97 19	3,822.69	39,365.66	42.57	159.68	50.50
X	136,590				524.54	16 77	217.41	6,548.87	8 24	26.30	4.36
NATIONAL TOTALS	64,160,880				57,468.03	3,169.03	139,124.94	1,198,354.3	1,356.43	6,080.76	1,478.40

*DISPOSAL PRACTICE FOR 1977 IS EXPECTED TO BE ESSENTIALLY THE SAME AS CURRENT PRACTICE (SEE 1974 SLAG TABLE) INCLUDES SLAGS FROM BLAST FURNACES, OPEN HEARTH FURNACES, BASIC OXYGEN FURNACES, ELECTRIC FURNACES AND SOAKING PITS SLAG CONSIDERED NON-HAZARDOUS ON BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B.

SOURCE CALSPAN CORPORATION

Table 7c

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL INDUSTRY TOTAL SLAG, 1983 (METRIC TONS)

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS						
					Cr	Cu	F	Mn	Ni	Pb	Zn
ALABAMA	3,279,800	0	0	SOLD AS ROAD BASE OR BUILOING AGGREGATE OR OPEN DUMPED	1,932.97	136.48	6,804.46	44,921.08	55.71	212.18	58.54
ARIZONA	15,700				59.99	1.94	24.85	634.74	1.06	3.06	1.19
ARKANSAS	8,500				41.06	0.67	17.39	431.14	0.46	0.28	0.69
CALIFORNIA	2,054,700				2,294.20	110.59	4,404.69	44,890.20	48.17	182.10	57.17
COLORADO	667,700				400.76	30.93	1,545.96	10,623.90	12.61	50.64	11.38
CONNECTICUT	44,300				170.25	5.44	70.57	1,800.99	3.00	8.53	3.36
DELAWARE	88,300				377.09	9.15	157.98	3,974.55	5.44	10.82	6.88
FLORIDA	38,000				183 14	3.00	77.56	1,923.12	2.05	1.24	3.06
GEORGIA	57,100				219.40	7.01	90 94	2,320.91	3.87	11.00	4.33
HAWAII	3,000				14.67	0.24	6.21	154.07	0.16	0.10	0 25
ILLINOIS	5,655,100				5,735.81	308.23	12,495.69	109,170.00	137.26	493.97	139.45
INDIANA	12,215,600				8,918.13	549.56	27,746.59	219,161.40	224.25	875.73	241.22
KENTUCKY	961,900				1,013.00	54.66	2,330 11	20,476.06	24.29	88.37	23.57
MARYLAND	3,927,300				2,947.39	175.01	7,837.78	64,524.69	72.27	280.25	83.65
MICHIGAN	5,548,800				3,329.57	256.82	12,831.24	88,113.88	104.76	420.11	94.54
MINNESOTA	31,000				149.21	2.45	63.19	1,566.81	1.67	1.01	2.49
MISSISSIPPI	10,700				51.73	0.85	21.81	543.23	0.58	0.35	0.86
MISSOURI	182,000				898.79	22.34	289.63	7,392 12	12.31	35.03	13.80
NEW JERSEY	76,300				325.56	7 90	136.39	3,431 37	4.70	8.34	5.94
NEW YORK	3,355,800				1,805 49	150.56	7,818.63	51,821.62	60.26	247.06	53.38
N. CAROLINA	31,500				151.57	2 49	64.20	1,591.60	1.70	1.03	2.53
OHIO	13,670,300				12,842 70	681.81	28,702.05	258,439.00	293.19	1,099.23	332.94
OKLAHOMA	36,200				174.09	2.86	73.75	1,828.21	1.95	1.18	2.91
OREGON	57,000				218.88	7.00	90.72	2,315.41	3.66	10.97	4.32
PENNSYLVANIA	17,261,200				16,002.55	861.47	36,888.07	332,651.00	367.07	1,403.90	416.75
RHODE ISLAND	–				–	–	–	–	–	–	–
S. CAROLINA	51,100				246.30	4.04	104.31	2,586.27	2.76	1.67	4.12
TENNESSEE	18,000				86.79	1 42	36.75	911.30	0.97	0.59	1.45
TEXAS	1,202,300				2,906.10	102.43	2,149.57	37,648.33	62 12	165.54	62.33
UTAH	1,609,300				1,826.14	82.97	3,058.65	34,540 00	35.58	139.06	48.05
VIRGINIA	13,400				51.62	1.65	21.40	546.13	0.81	2.59	1.02
WASHINGTON	101,500				389 78	12.46	161.56	4,123.37	6.67	18.54	7.70
W. VIRGINIA	2,176,700				1,112.57	82.81	6,414.44	35,488.98	32.12	119.10	30.25
EPA REGION											
I	44,300				170.25	5.44	70 67	1,800 99	3.00	8.53	3.36
II	3,432,100				2,131.05	158.46	7,955.02	55,252.99	64.96	256.40	59.32
III	23,466,900				20,491.22	1,130 09	50,419.67	437,183.35	477.61	1,816.66	538.55
IV	4,448,100				3,884.90	209.95	9,330.24	75,273.57	81.83	318.43	98.48
V	37,120,800				30,981.42	1,798.87	81,838.76	676,451.09	761.13	2,890.05	810.84
VI	1,247,000				3,121.25	105 96	2,240 71	39,907.68	64.53	167.00	65.93
VII	182,000				898.79	22.34	289.63	7,392.12	12.31	35.07	13.80
VIII	2,277,000				2,225.90	113.90	4,604.81	46,163.90	48.19	189.70	59.43
IX	2,073,400				2,369.86	112.77	4,435.76	45,679 01	49.29	186.26	68.61
X	158,500				608.66	19.46	252.28	6,438.78	10.73	30.51	12.02
NATIONAL TOTALS	74,450,100				86,882.30	3,677.24	161,437.44	1,390,543.48	1,573.98	5,896.61	1,720.12

*DISPOSAL PRACTICE FOR 1983 IS EXPECTED TO BE ESSENTIALLY THE SAME AS CURRENT PRACTICE (SEE 1974 SLAG TABLE). INCLUDES SLAGS FROM BLAST FURNACES, OPEN HEARTH FURNACES, BASIC OXYGEN FURNACES, ELECTRIC FURNACES AND SOAKING PITS. SLAG CONSIDERED NONHAZARDOUS ON BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B

SOURCE: CALSPAN CORPORATION

Table 7d

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM THE IRON AND STEEL INDUSTRY TOTAL SLUDGE, 1974 (METRIC TONS) DRY WEIGHTS

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS								OIL & GREASE	PHENOL
					Cr	Cu	Mn	Ni	Pb	Zn	Cn	F		
ALABAMA	198,300	49,580	1,926.43	OPEN DUMP OR RECYCLE	34.13	16.96	860.39	13.76	309.07	1,999.71	2.69	229.48	4,202.32	38.26
ARIZONA	302	75.5	2.99		0.25	0.16	3.47	0.11	0.69	1.04	NA	0.29	5.87	NA
ARKANSAS	141	35.3	1.90		0.15	0.08	2.01	0.05	0.49	0.74	NA	0.20	3.87	NA
CALIFORNIA	97,740	24,430	996.28		24.60	15.89	471.58	9.71	180.12	1,200.71	1.13	113.67	1,941.61	16.12
COLORADO	43,940	10,880	393.85		11.11	4.33	229.84	3.66	80.68	391.37	0.48	67.73	789.56	6.90
CONNECTICUT	1,880	470	8.68		0.72	0.47	9.94	0.31	1.94	2.98	NA	0.81	17.65	NA
DELAWARE	1,600	400	18.13		1.50	0.87	20.17	0.54	4.38	6.66	NA	1.82	38.86	NA
FLORIDA	850	213	7.88		0.66	0.33	8.68	0.16	2.11	3.24	NA	0.89	14.61	NA
GEORGIA	1,400	350	10.96		0.93	0.59	12.69	0.38	2.50	3.82	NA	1.06	21.86	NA
HAWAII	87.5	21.9	1.17		0.08	0.04	0.84	0.03	0.21	0.29	NA	0.07	3.15	NA
ILLINOIS	321,300	80,330	3,022.05		87.82	38.76	1,758.69	30.74	609.96	3,021.82	3.58	420.58	8,065.77	50.73
INDIANA	735,800	184,000	6,844.98		211.23	120.96	3,564.48	64.44	1,355.19	7,503.68	8.23	902.84	13,831.70	117.36
KENTUCKY	60,640	15,160	612.74		18.77	7.46	346.61	6.04	120.42	502.64	0.54	81.23	969.76	7.64
MARYLAND	109,060	27,270	2,148.59		38.71	24.48	901.38	16.20	349.30	2,426.56	2.86	238.71	4,557.35	40.83
MICHIGAN	349,100	87,280	3,275.00		92.16	38.03	1,900.32	30.47	669.00	3,252.47	4.03	479.20	8,678.99	67.40
MINNESOTA	514	129	4.40		0.56	0.29	7.32	0.17	1.77	2.68	NA	0.73	14.06	NA
MISSISSIPPI	487	122	2.38		0.19	0.10	2.64	0.06	0.61	0.93	NA	0.25	4.87	NA
MISSOURI	3,950	888	34.89		2.95	1.89	40.41	1.23	7.95	12.16	NA	3.34	69.62	NA
NEW JERSEY	1,590	398	15.88		1.30	0.75	17.43	0.47	3.78	5.75	NA	1.57	31.87	NA
NEW YORK	217,000	54,250	2.06		65.97	21.62	1,159.47	18.42	410.47	2,000.53	2.48	294.62	4,028.55	35.31
N. CAROLINA	452	113	6.35		0.55	0.27	7.18	0.15	1.74	2.68	NA	0.74	12.10	NA
OHIO	719,200	179,800	7,208.70		167.33	100.26	2,390.30	64.51	1,290.03	8,031.48	8.85	840.86	14,815.10	128.19
OKLAHOMA	600	150	8.04		0.65	0.33	8.54	0.19	2.06	3.12	NA	0.85	18.40	NA
OREGON	1,100	275	10.93		0.92	0.59	12.66	0.38	2.49	3.81	NA	1.05	21.81	NA
PENNSYLVANIA	901,300	225,300	9,000.13		218.46	130.06	4,311.72	81.64	1,865.19	10,242.10	10.81	1,073.62	18,111.40	155.56
RHODE ISLAND	204	51.0	0.03		NEGLIGIBLE		0.02	—	NEGLIGIBLE	—	NA	NA	0.11	NA
S. CAROLINA	970	243	10.37		0.91	0.45	11.83	0.25	2.84	4.38	NA	1.20	19.65	NA
TENNESSEE	500	125	4.01		0.32	0.17	4.26	0.10	1.03	1.56	NA	0.42	8.18	NA
TEXAS	33,650	8,410	385.45		11.60	9.61	200.71	5.93	67.56	449.43	0.33	29.88	762.09	4.68
UTAH	61,360	15,340	731.38		6.85	9.10	213.50	5.41	106.84	1,005.33	0.82	65.03	1,610.50	13.07
VIRGINIA	260	65.0	2.58		0.22	0.14	2.99	0.09	0.59	0.90	NA	0.25	5.14	NA
WASHINGTON	1,963	491	19.46		1.65	1.05	22.54	0.68	4.43	6.78	NA	1.86	38.84	NA
W. VIRGINIA	157,300	39,330	1,360.25		57.86	32.26	816.79	14.75	293.35	1,364.28	1.60	204.55	2,633.31	22.82
EPA REGION														
I	2,084	521	8.71		0.72	0.47	9.96	0.31	1.94	2.96	NA	0.81	17.66	NA
II	218,590	54,648	17.74		67.27	22.37	1,176.90	18.89	414.25	2,006.28	2.48	296.19	4,058.22	35.31
III	1,269,520	292,365	12,529.68		316.25	187.81	6,063.05	113.17	2,312.81	14,040.49	15.37	1,516.96	25,343.76	219.21
IV	263,800	65,908	2,480.93		56.46	26.33	1,254.17	20.91	440.32	2,518.84	3.22	314.26	5,243.35	45.90
V	2,126,014	531,539	20,355.13		569.10	298.30	10,621.01	190.33	3,925.95	21,812.13	24.67	2,644.31	41,005.62	351.67
VI	34,391	8,595	395.39		12.40	10.02	211.26	6.17	70.10	453.29	0.33	30.93	782.36	4.66
VII	3,950	888	34.89		2.95	1.89	40.41	1.23	7.95	12.16	NA	3.34	89.62	NA
VIII	105,300	26,320	1,125.03		17.86	13.43	442.34	8.06	187.49	1,396.70	1.40	112.76	2,300.05	19.97
IX	99,130	24,527	1,000.44		24.91	16.09	475.89	9.85	181.01	1,202.04	1.13	114.03	1,960.73	16.12
X	3,063	766	30.39		2.57	1.64	35.20	1.06	6.92	10.59	NA	2.91	60.65	NA
NATIONAL TOTALS	4,124,612	1,008,175	37,978.33		1,060.59	576.35	20,320.20	370.86	7,568.74	43,455.48	48.60	5,036.48	80,831.02	692.84

*APPROXIMATELY 55 PERCENT OF THE TOTAL SLUDGE IS FROM THE WET SCRUBBERS ON THE BLAST FURNACES. PROBABLY MORE THAN 70 PERCENT OF THIS IS RECYCLED VIA SINTERING OR OTHER AGGLOMERATING PROCESSES. ABOUT 20 PERCENT OF THE SLUDGE IS FROM BASIC OXYGEN FURNACES, ~ 10 PERCENT OF WHICH IS CURRENTLY RECYCLED. BLAST FURNACE SLUDGE AND BOF SLUDGE ARE NOT CONSIDERED HAZARDOUS THE REMAINING SLUDGE (25% OF TOTAL GENERATED) IS LAND DISPOSED AND CONSIDERED HAZARDOUS THIS CONSISTS OF SLUDGES FROM ELECTRIC FURNACES, GALVANIZING MILLS, PRIMARY AND SECONDARY MILLS, DECANTER SLUDGE, LIME PIT SLUDGE AND TIN MILL SLUDGE

NOTE: NA DENOTES THAT DATA WERE NOT AVAILABLE.

SOURCE: CALSPAN CORPORATION

Table 7e

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM THE IRON AND STEEL INDUSTRY TOTAL SLUDGE, 1977 (METRIC TONS) DRY WEIGHTS

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS								OIL & GREASE	PHENOL
					Cr	Cu	Mn	Ni	Pb	Zn	Cn	F		
ALABAMA	210,200	52,550	2,042.02	OPEN DUMP OR RECYCLE	36.18	17.98	812.00	14.58	327.62	2,119.68	0.84	242.19	4,454.46	40.55
ARIZONA	320	80	3.17		0.27	0.17	3.78	0.11	0.72	1.11	NA	0.30	6.33	NA
ARKANSAS	150	38	2.0		0.16	0.08	2.14	0.06	0.52	0.78	NA	0.21	4.10	NA
CALIFORNIA	103,610	25,800	1,056.06		26.08	16.84	499.88	10.29	201.53	1,272.76	1.20	120.48	2,058.11	17.08
COLORADO	46,570	11,640	417.27		11.78	4.59	242.67	3.87	85.48	414.85	0.51	61.20	836.92	7.31
CONNECTICUT	1,990	498	9.20		0.77	0.50	10.54	0.33	2.06	3.14	NA	0.86	18.81	NA
DELAWARE	1,700	425	19.21		1.58	0.92	21.38	0.57	4.64	7.06	NA	1.93	39.76	NA
FLORIDA	900	225	8.14		0.70	0.35	9.20	0.19	2.23	3.44	NA	0.85	16.49	NA
GEORGIA	1,490	373	11.61		0.98	0.63	13.45	0.41	2.65	4.05	NA	1.11	23.17	NA
HAWAII	93	23	1.24		0.07	0.04	0.89	0.03	0.23	0.31	NA	0.08	3.34	NA
ILLINOIS	340,560	85,140	3,203.37		93.09	41.08	1,864.11	32.58	646.56	3,203.13	3.77	445.82	6,429.72	53.77
INDIANA	780,000	195,000	7,255.67		223.81	128.22	3,776.35	68.31	1,438.50	7,953.90	8.73	967.01	14,343.80	124.39
KENTUCKY	64,280	16,070	543.51		19.89	7.91	367.41	6.40	127.64	532.68	0.57	66.10	1,017.34	8.09
MARYLAND	221,600	55,400	2,277.51		41.03	25.85	855.46	17.17	370.26	2,672.14	3.04	250.91	4,830.79	43.28
MICHIGAN	370,000	92,500	3,471.50		97.69	38.19	2,014.34	32.29	709.14	3,447.62	4.27	507.95	6,873.73	60.85
MINNESOTA	545	138	7.30		0.59	0.30	7.76	0.18	1.87	2.84	NA	0.77	14.90	NA
MISSISSIPPI	517	129	2.53		0.20	0.10	2.69	0.06	0.65	0.98	NA	0.27	5.17	NA
MISSOURI	4,190	1,050	36.98		3.13	2.00	42.84	1.30	8.43	12.89	NA	3.54	73.80	NA
NEW JERSEY	1,680	420	16.82		1.37	0.80	18.48	0.50	4.00	6.10	NA	1.67	33.57	NA
NEW YORK	230,000	57,500	2,126.73		59.33	22.92	1,229.04	19.53	435.10	2,120.56	2.63	312.29	4,268.14	37.43
N. CAROLINA	480	120	6.74		0.58	0.29	7.82	0.15	1.85	2.85	NA	0.78	12.82	NA
OHIO	762,300	190,580	7,641.23		177.36	106.27	3,593.72	68.38	1,387.43	8,513.37	9.38	891.42	15,704.00	133.76
OKLAHOMA	636	159	8.77		0.69	0.35	8.05	0.20	2.19	3.31	NA	0.90	17.38	NA
OREGON	1,170	293	11.58		0.98	0.63	13.42	0.41	2.64	4.04	NA	1.11	23.12	NA
PENNSYLVANIA	955,400	238,850	9,640.13		231.56	137.87	4,570.42	86.54	1,765.10	10,856.63	11.57	1,248.04	19,198.10	164.80
RHODE ISLAND	218	54	0.04		NEGLIGIBLE		0.02	—	NEGLIGIBLE	—	NA	NA	0.12	NA
S. CAROLINA	1,030	258	11.00		0.86	0.48	12.64	0.27	3.01	4.63	NA	1.27	20.83	NA
TENNESSEE	529	132	4.25		0.34	0.18	4.51	0.10	1.09	1.65	NA	0.45	8.67	NA
TEXAS	35,670	8,920	408.57		12.30	10.19	212.75	6.28	71.60	476.40	0.35	31.67	807.81	4.94
UTAH	65,040	16,260	775.27		7.26	9.84	226.31	5.73	113.26	1,065.66	0.97	58.33	1,600.08	13.85
VIRGINIA	276	69	2.73		0.23	0.15	3.18	0.10	0.62	0.95	NA	0.26	5.45	NA
WASHINGTON	2,080	520	20.63		1.75	1.12	23.90	0.72	4.70	7.19	NA	1.97	41.17	NA
W. VIRGINIA	166,700	41,680	1,441.88		60.80	34.20	865.80	15.58	310.95	1,446.14	1.70	216.83	2,791.31	24.18
EPA REGION														
I	2,206	552	9.24		0.77	0.50	10.56	0.33	2.08	3.14	NA	0.88	18.73	NA
II	231,680	57,920	2,143.35		60.70	23.72	1,247.52	20.03	439.10	2,126.66	> 2.63	313.96	4,301.71	> 37.43
III	1,345,676	336,424	13,281.46		335.21	199.09	6,418.22	119.96	2,461.57	14,882.92	>18.31	1,607.97	28,864.40	>232.38
IV	279,426	69,857	2,629.80		59.83	27.92	1,329.42	22.16	466.74	2,869.98	> 3.41	331.12	5,557.95	> 48.64
V	2,253,405	563,358	21,579.07		592.64	314.08	11,258.28	201.74	4,161.50	23,120.86	>26.15	2,802.97	43,488.95	>372.77
VI	36,456	9,117	418.34		13.15	10.62	223.94	6.53	74.31	480.48	>0.35	32.78	829.29	> 4.94
VII	4,190	1,050	36.98		3.13	2.00	42.84	1.30	8.43	12.88	NA	3.54	73.80	NA
VIII	111,610	27,900	1,182.54		19.04	14.23	468.88	9.60	186.73	1,480.50	1.48	119.53	2,437.00	21.18
IX	104,023	26,003	1,060.47		26.42	17.06	504.55	10.43	202.48	1,274.17	>1.20	120.88	2,087.79	> 17.08
X	3,250	813	32.21		2.73	1.76	37.32	1.13	7.34	11.23	NA	3.08	64.29	NA
NATIONAL TOTALS	4,371,922	1,092,992	42,284.46		1,113.67	610.94	21,639.63	393.21	8,012.28	48,062.84	>51.53	5,336.87	85,680.90	>734.38

*DISPOSAL METHODS WILL PROBABLY FOLLOW PRESENT PRACTICES (SEE 1974 TABLE) WITH GREATER TENDENCY TOWARD RECYCLE.

NOTE: NA DENOTES THAT DATA WERE NOT AVAILABLE.

SOURCE: CALSPAN CORPORATION

Table 7f

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM THE IRON AND STEEL INDUSTRY TOTAL SLUDGE, 1983 (METRIC TONS) DRY WEIGHTS

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS								OIL & GREASE	PHENOL
					Cr	Cu	Mn	Ni	Pb	Zn	Cn	F		
ALABAMA	243,960	60,990	2,369.51	OPEN DUMP OR RECYCLE	41.98	20.87	1,058.26	16.91	380.16	2,459.64	3.30	281.03	6,168.85	47.06
ARIZONA	371	93	3.58		0.31	0.20	4.27	0 13	0.84	1.28	NA	0.36	7.36	NA
ARKANSAS	174	44	2.33		0.19	0.10	2.48	0.06	0.60	0.91	NA	0.26	4.78	NA
CALIFORNIA	120,200	30,050	1,225.43		30.26	19.55	580 06	11.94	233.85	1,476.87	1.39	139.81	2,388.18	19.82
COLORADO	54,040	13,510	484.19		13.67	5.33	281.47	4.49	99.19	481.38	0.59	71.01	971.16	8.48
CONNECTICUT	2,310	578	10.68		0.89	0.58	12.23	0.38	2.39	3.65	NA	1.00	21.59	NA
DELAWARE	1,970	493	22.30		1.85	1.07	24.81	0.67	5.39	8.19	NA	2.24	44.97	NA
FLORIDA	1,040	260	9.44		0.82	0.40	10.68	0.22	2.59	3.99	NA	1.10	17.88	NA
GEORGIA	1,730	433	13.47		1.14	0.73	15.61	0.47	3.07	4.70	NA	1.29	28.89	NA
HAWAII	108	27	1.44		0.09	0.04	1.03	0.03	0.26	0.36	NA	0.09	3.88	NA
ILLINOIS	395,180	98,790	3,717 12		108.02	47.67	2,163.07	37.81	750.28	3,716.84	4.38	517.31	7,460.90	62.40
INDIANA	905,100	226,280	8,419 32		259.82	148.78	4,384.31	79.27	1,866.53	8,229.53	10.12	1,110.50	16,643.99	144.34
KENTUCKY	74,590	18,650	630 67		23.09	9.18	428.33	7.43	148.12	618.12	0.66	99.81	1,180.50	9.39
MARYLAND	157,140	39,290	2,642.77		47.61	30.11	1,108.69	19.93	429.84	2,884.66	3.52	291.15	5,805.54	60.22
MICHIGAN	428,400	107,350	4,028.25		113.35	44.31	2,337.39	37.47	822.87	4,000.54	4 95	589.42	8,092.16	70.81
MINNESOTA	832	158	6.47		0.68	0.35	9.00	0.20	2.17	3.29	NA	0.90	17.29	NA
MISSISSIPPI	600	150	2.93		0.24	0.12	3.12	0.07	0.75	1.14	NA	0.31	6.99	NA
MISSOURI	4,860	1,220	42.91		3.63	2.32	48.71	1.51	9 78	14.96	NA	4.11	85.64	NA
NEW JERSEY	1,950	488	19.29		1.60	0.93	21.44	0.58	4.65	7.07	NA	1.93	38.95	NA
NEW YORK	267,000	66,750	2,467.8		68.84	26.59	1,428.15	22.68	2,460.66	2,460.66	3.05	362.38	4,852.66	43.43
N. CAROLINA	556	139	7.82		0.66	0.33	8.84	0 18	2.14	3.30	NA	0.81	14.88	NA
OHIO	884,600	221,150	8,866.7		205.81	123.32	4,170.07	79.35	1,586.74	8,878.72	10.89	1,034.38	18,222.60	155.22
OKLAHOMA	738	185.	8.89		0.80	0.41	10.50	0.24	2.54	3.84	NA	1.06	20.17	NA
OREGON	1,355	339	13.44		1.14	0.73	15.57	0.47	3.06	4.69	NA	1.29	26.82	NA
PENNSYLVANIA	1,108,600	277,150	11,070 16		288.70	158 98	5,303.42	100.41	2,048.18	12,597.80	13.42	1,320.55	22,277.00	191.34
RHODE ISLAND	251	63	0.04		NEGLIGIBLE		0.02		NEGLIGIBLE		NA	NA	0.14	NA
S. CAROLINA	1,193	298	12.76		1.11	0.56	14.55	0.31	3.49	5.37	NA	1.48	24.17	NA
TENNESSEE	614	154	4.93		0.40	0 20	5.24	0.12	1.26	1.91	NA	0.52	10.06	NA
TEXAS	41,390	10,350	474.10		14.27	11.82	248.88	7.29	63.09	552.80	0.40	38.75	937.37	5.73
UTAH	75,480	18,870	898 60		8.42	11.19	262.61	5.65	131 41	1,236.56	1.13	67.69	1,856.70	16.08
VIRGINIA	320	80	3.17		0.27	0.17	3.87	0.11	0.72	1.11	NA	0.30	6.33	NA
WASHINGTON	2,410	603	23.94		2.02	1.29	27.73	0.64	5 45	8.34	NA	2.29	47.77	NA
W. VIRGINIA	193,460	48,370	1,673.10		70.55	39.68	1,004.66	18.08	360.82	1,676.06	1.87	261.60	3,238.87	28.06
EPA REGION														
I	2,581	641	10.72		0.89	0.58	12.25	0.38	2.39	3.65	NA	) 1.00	21.73	NA
II	268,950	67,238	2,487.09		70.44	27.52	1,447.59	23.24	509.52	2,467.72	) 3.05	364.31	4,891.61	) 43.43
III	1,581,490	365,383	15,411.49		388.88	231.01	7,445.25	139.20	2,844.75	17,269.82	)18.91	1,865.84	31,172.81	)269.62
IV	324,293	81,074	3,051.53		69.46	32.39	1,542.63	25.71	541.68	3,098.17	) 3.96	386.55	6,449.32	) 56.44
V	2,614,912	653,728	25,039.89		687.68	363.43	13,083.84	234.10	4,828.92	26,828.92	)30.34	3,252.51	50,436.94	)432.57
VI	42,302	10,578	488.32		15.26	12.33	259.86	7.59	88.23	557.65	) 0.40	39.05	962.30	) 5.73
VII	4,860	1,220	42.81		3.63	2.32	48.71	1.51	9.78	14.96	NA	4.11	85.64	NA
VIII	129,620	32,380	1,383.79		22.09	16.52	544.08	11.14	230.80	1,717.98	1.72	138.70	2,827.85	24.56
IX	120,679	30,170	1,230.65		30.65	19.79	585 35	12.10	234.96	1,478.51	)1.39	140.26	2,399.41	) 19.82
X	3,765	942	37.38		3.16	2.02	43.30	1.31	8.51	13.03	NA	3.58	74.59	NA
NATIONAL TOTALS	5,073,322	1,243,356	48,181.67		1,292.24	708.91	24,993.66	456.28	9,297.23	53,450.31	) 59.77	)6,194.90	99,422.20	652.17

*METHODS OF HANDLING SLUDGE WILL PROBABLY FOLLOW CURRENT PRACTICE, BUT WITH INCREASED EMPHASIS ON RECYCLING.

NOTE: NA DENOTES THAT DATA WERE NOT AVAILABLE.

SOURCE: CALSPAN CORPORATION

Table 7g

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL INDUSTRY TOTAL DUST, 1974 (METRIC TONS)

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS								
					Cr	Cu	F**	Mn	Ni	Pb	Zn	CN**	PHENOL**
ALABAMA	117,280	14,060	461	OPEN DUMP OR RECYCLE	28.16	38.45	26.22	1,280.29	11.66	427.33	1,865.05	0.77	0.12
ARIZONA	950	114	19		1.31	1.85	2.29	40.52	0.23	23.03	91.01	0	0
ARKANSAS	650	78	13		0.92	1.29	1.60	28.35	0.16	16.11	63.67	0	0
CALIFORNIA	72,400	8,690	540		28.14	42.74	38.44	842.48	11.26	498.48	3,039.03	0.32	0.06
COLORADO	23,200	2,780	73		5.93	8.32	4.57	283.54	2.04	94.58	210.0	0.4	0.02
CONNECTICUT	2,700	324	55		3.72	5.24	8.49	115.04	0.66	65.39	258.39	0	0
DELAWARE	6,060	726	122		8.33	11.73	14.54	257.54	1.49	146.40	678.49	0	0
FLORIDA	2,950	354	60		4.09	5.76	7.14	126.44	0.73	71.88	284.02	0	0
GEORGIA	3,500	420	70		4.80	6.75	8.37	148.24	0.86	84.27	332.89	0	0
HAWAII	250	30	5		0.33	0.46	0.57	10.13	0.06	6.76	22.76	0	0
ILLINOIS	213,350	25,600	1,410		98.68	127.63	130.50	3,667.29	26.48	1,670.46	8,068.70	1.02	0.17
INDIANA	418,400	50,210	1,740		101.47	132.61	82.06	4,046.71	46.70	1,692.71	8,368.86	2.37	0.38
KENTUCKY	35,800	4,300	230		17.17	21.20	21.90	646.77	4.33	296.37	912.54	0.15	0.02
MARYLAND	137,000	16,440	678		34.47	51.24	34.97	1,260.88	16.76	559.22	3,693.22	0.82	0.13
MICHIGAN	193,200	23,180	608		49.37	62.76	39.30	2,361.19	16.97	787.62	1,756.05	1.16	0.19
MINNESOTA	2,400	288	49		3.33	4.69	5.81	103.02	0.59	58.56	231.40	0	0
MISSISSIPPI	850	102	17		1.16	1.63	2.02	35.72	0.21	20.30	80.23	0	0
MISSOURI	11,100	1,330	224		15.28	21.81	26.65	472.16	2.73	268.40	1,060.57	0	0
NEW JERSEY	5,200	624	105		7.20	10.13	12.55	222.34	1.28	126.39	499.43	0	0
NEW YORK	115,100	13,810	294		24.93	24.75	13.96	1,284.73	8.48	389.32	693.82	0.71	0.12
N. CAROLINA	2,450	294	50		3.39	4.77	5.91	104.64	0.60	59.48	235.05	0	0
OHIO	488,900	58,670	3,060		172.09	247.56	211.42	6,895.78	65.61	2,921.44	15,850.60	2.64	0.41
OKLAHOMA	2,800	336	57		3.89	5.47	6.78	120.19	0.69	68.12	269.96	0	0
OREGON	3,450	414	70		4.79	6.74	8.35	147.89	0.85	84.07	332.20	0	0
PENNSYLVANIA	606,900	72,830	3,670		201.04	291.07	235.93	6,807.34	81.56	3,437.57	19,502.20	3.14	0.51
RHODE ISLAND													
S. CAROLINA	4,000	480	81		5.50	7.76	9.60	170.05	0.98	98.66	381.96	0	0
TENNESSEE	1,400	168	28		1.94	2.73	3.38	59.92	0.35	34.06	134.59	0	0
TEXAS	55,000	6,600	884		52.82	78.01	89.29	1,539.84	12.42	834.53	4,497.08	0.09	0.02
UTAH	54,750	6,570	446		17.38	32.06	23.15	379.33	9.80	310.74	2,944.35	0.26	0.04
VIRGINIA	800	96	17		1.13	1.59	1.97	34.88	0.20	19.83	78.35	0	0
WASHINGTON	6,200	744	125		8.52	12.00	14.87	263.37	1.52	149.72	691.59	0	0
W. VIRGINIA	74,850	8,980	147		13.57	11.69	2.95	766.63	5.85	212.21	220.07	0.46	0.07
EPA REGION													
I	2,700	324	55		3.72	5.24	6.49	115.04	0.66	65.39	258.39	0	0
II	120,300	14,434	399		32.13	34.88	26.51	1,507.07	10.76	515.71	1,198.25	0.71	0.12
III	825,600	99,072	4,634		258.64	367.32	290.36	9,117.27	105.86	4,376.23	24,072.33	4.42	0.71
IV	168,150	20,178	987		68.20	87.04	84.54	2,552.07	19.71	1,090.38	4,326.43	0.92	0.14
V	1,316,250	157,948	6,887		424.84	565.25	468.09	16,073.99	158.35	7,130.78	32,375.71	7.09	1.16
VI	58,450	7,014	934		57.63	84.77	97.87	1,887.38	13.27	1,018.96	4,830.71	0.09	0.02
VII	11,100	1,330	224		15.28	21.81	26.65	472.18	2.73	268.40	1,060.57	0	0
VIII	77,950	9,350	519		23.32	38.38	27.72	661.87	11.84	405.33	3,164.35	0.4	0.06
IX	73,600	8,834	564		29.78	45.06	39.30	893.13	11.54	525.27	3,152.79	0.32	0.05
X	9,650	1,158	195		13.31	18.74	23.22	411.26	2.37	233.79	923.79	0	0
NATIONAL TOTALS	2,663,750	319,642	15,378		924.75	1,268.48	1,090.56	33,491.24	335.09	15,829.23	76,353.32	13.96	2.26

*APPROXIMATELY 57% OF TOTAL GENERATED IS BLAST FURNACE DUST OF WHICH ~ 90% IS RECYCLED. APPROXIMATELY 12% OF DUST GENERATED IS FROM ELECTRIC FURNACE AND LAND DISPOSED. ELECTRIC FURNACE DUST IS CONSIDERED POTENTIALLY HAZARDOUS. REMAINING 31% OF DUST IS FROM OPEN HEARTH AND BOF FURNACES. IT IS OPEN DUMPED BUT NOT CONSIDERED HAZARDOUS.

**VALUES FOR CN, F, AND PHENOL ARE TO BE CONSIDERED AS MINIMUM SINCE DATA WERE NOT AVAILABLE FOR THESE CONSTITUENTS FOR ALL TYPES OF DUST INCLUDED IN THE SUMMATIONS.

SOURCE: CALSPAN CORPORATION

Table 7h

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL INDUSTRY TOTAL DUST, 1977 (METRIC TONS)

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS								
					Cr	Cu	F**	Mn	Ni	Pb	Zn	Cn	PHENOL
ALABAMA	124,300	14,920	478	OPEN DUMP OR RECYCLE	29.84	38.84	27.79	1,335.81	12.35	452.87	2,082.95	0.87	0.13
ARIZONA	1,000	120	20		1.39	1.96	2.42	42.96	0.25	24.42	96.48	0	0
ARKANSAS	700	84	14		0.97	1.37	1.70	30.05	0.17	17.08	67.49	0	0
CALIFORNIA	76,700	9,200	672		29.83	45.31	38.63	893.03	11.92	528.27	3,221.37	0.34	0.06
COLORADO	24,600	2,950	77		6.28	6.70	4.85	300.58	3.16	100.27	222.59	0.16	0.02
CONNECTICUT	2,850	342	58		3.95	5.55	6.88	121.94	0.70	69.32	273.90	0	0
DELAWARE	6,400	768	130		8.83	12.44	15.41	272.99	1.58	155.19	613.20	0	0
FLORIDA	3,150	378	64		4.34	6.11	7.56	134.03	0.77	76.19	301.06	0	0
GEORGIA	3,700	444	75		5.09	7.16	8.87	157.14	0.91	88.33	352.97	0	0
HAWAII	250	30	5		0.35	0.49	0.61	10.74	0.61	6.10	24.11	0	0
ILLINOIS	226,200	27,140	1,500		104.49	135.29	138.33	3,887.33	26.09	1,770.69	8,432.82	1.08	0.18
INDIANA	443,500	53,220	1,840		107.55	140.56	86.98	4,289.51	49.60	1,784.27	8,871.10	2.51	0.41
KENTUCKY	37,950	4,550	244		18.20	22.47	23.21	685.58	4.58	314.15	967.29	0.16	0.03
MARYLAND	145,200	17,420	719		36.53	64.32	37.07	1,336.53	17.76	592.77	3,914.81	0.87	0.14
MICHIGAN	204,800	24,580	644		52.33	55.92	40.60	2,502.86	17.89	834.88	1,881.41	1.23	0.20
MINNESOTA	2,550	306	52		3.53	4.87	6.16	109.20	0.63	62.07	245.28	0	0
MISSISSIPPI	900	108	18		1.23	1.72	2.14	37.86	0.22	21.52	85.04	0	0
MISSOURI	11,750	1,410	237		16.20	22.80	28.25	500.49	2.89	284.51	1,124.20	0	0
NEW JERSEY	5,550	666	112		7.63	10.74	13.30	235.68	1.36	133.98	529.40	0	0
NEW YORK	122,000	14,640	311		26.43	26.23	14.80	1,361.81	10.05	412.68	740.75	0.76	0.12
N. CAROLINA	2,600	312	53		3.59	5.05	6.26	110.92	0.64	63.05	249.15	0	0
OHIO	518,200	62,180	3,240		182.48	262.41	224.11	6,249.53	69.55	3,096.73	16,907.84	2.70	0.44
OKLAHOMA	3,000	360	60		4.12	5.80	7.19	127.40	0.74	72.42	286.16	0	0
OREGON	3,700	444	74		5.07	7.14	8.85	156.77	0.91	89.12	352.13	0	0
PENNSYLVANIA	643,300	77,200	3,890		213.10	308.53	250.08	7,215.79	86.45	3,643.82	20,872.33	3.32	0.54
RHODE ISLAND	—	–	–		—	—	—	—	—	—	—	—	—
S. CAROLINA	4,250	510	86		5.83	8.21	10.17	180.25	1.04	102.46	404.87	0	0
TENNESSEE	1,500	180	30		2.06	2.89	3.58	63.51	0.37	36.10	142.66	0	0
TEXAS	58,300	7,000	916		55.99	82.69	94.64	1,631.17	13.17	990.60	4,766.90	0.10	0.02
UTAH	58,000	6,960	473		18.43	34.00	24.54	401.03	10.40	329.40	3,121.00	0.28	0.04
VIRGINIA	850	102	18		1.20	1.68	2.09	36.97	0.21	21.02	83.05	0	0
WASHINGTON	6,550	786	132		9.04	12.72	15.76	279.16	1.61	158.70	627.09	0	0
W. VIRGINIA	79,350	9,520	158		14.38	12.40	3.13	802.03	6.20	224.94	233.28	0.49	0.06
EPA REGION													
I	2,850	342	58		3.95	5.55	6.88	121.94	0.70	69.32	273.90	0	0
II	127,550	15,306	423		34.06	36.97	28.10	1,597.49	11.41	546.66	1,270.15	0.76	0.12
III	875,100	105,010	4,913		274.04	389.37	307.78	9,664.31	112.20	4,637.74	25,516.67	4.68	0.76
IV	179,350	21,402	1,048		70.19	92.26	99.58	2,705.20	20.89	1,165.77	4,586.99	0.98	0.16
V	1,395,250	167,426	7,276		450.31	599.15	496.18	17,038.43	165.74	7,568.64	34,318.25	7.52	1.23
VI	62,000	7,444	990		61.08	89.86	103.53	1,788.62	14.08	1,080.10	5,120.55	0.10	0.02
VII	11,750	1,410	237		16.20	22.80	28.25	500.49	2.89	284.51	1,124.20	0	0
VIII	82,600	9,910	550		24.71	40.70	29.39	701.59	13.56	428.67	3,343.59	0.43	0.06
IX	77,950	9,350	697		31.57	47.76	41.68	848.72	12.78	556.78	3,341.98	0.34	0.06
X	10,250	1,230	206		14.11	19.86	24.61	435.95	2.52	247.82	979.22	0	0
NATIONAL TOTALS	2,823,650	338,830	16,298		980.21	1,344.27	1,155.86	36,500.74	356.77	16,567.02	79,874.48	14.8	2.41

*DISPOSAL PRACTICE FOR 1977 IS EXPECTED TO ESSENTIALLY BE THE SAME AS THE CURRENT PRACTICE, BUT WITH A TREND TOWARD INCREASED USE OF SINTERING OR AGGLOMERATING TO ALLOW RECYCLE.

**VALUES FOR CN, F AND PHENOL ARE TO BE CONSIDERED AS MINIMUM SINCE DATA WERE NOT AVAILABLE FOR THESE CONSTITUENTS FOR ALL TYPES OF DUST INCLUDED IN THE SUMMATIONS.

SOURCE: CALSPAN CORPORATION

Table 7i

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL INDUSTRY TOTAL DUST, 1983 (METRIC TONS)

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS								
					Cr	Cu	Mn	Ni	Pb	Zn	CN**	F**	PHENOL**
ALABAMA	144,200	17,300	564	OPEN DUMP OR RECYCLE	34.63	44.84	1,550.16	14.33	575.62	2,417.01	0.95	32.25	0.15
ARIZONA	1,150	138	24		1.61	2.27	49.84	0.29	28.33	111.95	~0	2.81	~0
ARKANSAS	800	96	17		1.13	1.59	34.87	0.20	19.82	78.32	~0	1.97	~0
CALIFORNIA	89,000	10,680	664		34.61	52.57	1,036.25	13.83	610.87	3,738.00	0.40	44.82	0.06
COLORADO	28,600	3,430	90		7.29	7.78	348.76	2.61	116.35	258.29	0.17	5.63	0.03
CONNECTICUT	3,300	396	67		4.58	6.45	141.49	0.82	80.43	317.82	~0	7.99	~0
DELAWARE	7,450	894	150		10.25	14.43	316.78	1.83	180.07	711.55	~0	17.88	~0
FLORIDA	3,650	438	74		5.03	7.08	155.52	0.90	88.41	349.34	~0	8.78	~0
GEORGIA	4,300	516	87		5.90	8.31	182.34	1.05	103.65	409.58	~0	10.28	~0
HAWAII	300	36	6		0.40	0.57	12.46	0.07	7.08	27.99	~0	0.70	~0
ILLINOIS	262,400	31,490	1,740		121.25	156.99	4,510.77	32.57	2,054.67	7,464.50	1.26	160.51	0.20
INDIANA	514,700	61,760	2,140		124.80	163.11	4,977.45	57.44	2,082.03	10,293.82	2.91	100.93	0.47
KENTUCKY	44,000	5,280	283		21.12	28.07	795.53	5.33	364.54	1,122.42	0.19	26.93	0.03
MARYLAND	168,500	20,220	834		42.39	63.03	1,550.88	20.61	687.84	4,542.66	1.01	43.01	0.16
MICHIGAN	237,700	28,520	747		80.73	64.89	2,904.28	20.87	968.77	2,159.84	1.42	47.11	0.23
MINNESOTA	2,950	354	60		4.10	5.77	126.71	0.73	72.03	284.62	~0	7.15	~0
MISSISSIPPI	1,060	126	21		1.42	2.00	43.93	0.25	24.97	98.68	~0	2.48	~0
MISSOURI	13,650	1,640	276		18.80	26.45	580.76	3.35	330.14	1,304.50	~0	32.78	~0
NEW JERSEY	6,400	768	130		8.85	12.46	273.48	1.58	155.46	614.30	~0	15.44	~0
NEW YORK	141,500	16,980	361		30.67	30.44	1,580.22	11.66	478.87	859.55	0.88	17.17	0.14
N. CAROLINA	3,000	360	61		4.17	5.86	128.71	0.74	73.17	289.11	~0	7.28	~0
OHIO	601,300	72,160	3,760		211.67	304.49	7,251.81	80.70	3,593.37	19,619.24	3.13	260.06	0.61
OKLAHOMA	3,450	414	70		4.78	6.73	147.83	0.85	84.03	332.05	~0	8.34	~0
OREGON	4,250	510	86		5.89	8.29	181.91	1.05	103.41	408.61	~0	10.27	~0
PENNSYLVANIA	746,500	89,580	4,510		247.28	358.01	8,373.03	100.31	4,228.21	23,987.71	3.88	290.19	0.62
S. CAROLINA	4,900	588	99		6.77	9.53	209.16	1.21	118.90	469.81	~0	11.81	~0
TENNESSEE	1,750	210	35		2.39	3.36	73.70	0.43	41.89	165.54	~0	4.16	~0
TEXAS	67,650	8,120	1,060		64.97	96.98	1,892.77	16.26	1,149.47	5,531.41	0.12	109.82	0.02
UTAH	67,350	8,080	549		21.39	39.43	465.35	12.06	382.21	3,621.55	0.32	28.48	0.05
VIRGINIA	1,000	120	20		1.39	1.95	42.80	0.25	24.39	96.37	~0	2.42	~0
WASHINGTON	7,600	912	154		10.48	14.76	323.95	1.87	184.15	727.66	~0	18.28	~0
W. VIRGINIA	92,100	11,050	181		16.69	14.38	930.65	7.19	261.08	270.89	0.57	3.63	0.09
EPA REGION													
I	3,300	396	67		4.58	6.45	141.49	0.82	80.43	317.82	~0	7.99	~0
II	147,900	17,748	491		39.52	42.90	1,853.70	13.24	634.33	1,473.85	0.88	32.61	0.14
III	2,075,550	121,864	5,695		318.0	451.80	11,214.24	130.19	6,381.53	29,608.98	5.44	357.13	0.87
IV	206,850	24,818	1,214		81.43	107.06	3,139.05	24.24	1,341.15	5,321.49	1.14	103.96	0.18
V	1,619,050	194,284	8,447		522.55	696.25	19,771.0	192.31	8,770.87	39,822.12	8.72	575.75	1.41
VI	71,900	8,630	1,147		70.88	104.28	2,075.47	16.33	1,253.32	5,941.78	0.12	120.13	0.02
VII	13,650	1,640	276		18.80	26.45	580.76	3.35	330.14	1,304.50	~0	32.78	~0
VIII	95,950	11,510	639		28.68	47.21	814.11	14.57	498.56	3,879.84	0.49	34.11	0.08
IX	90,450	10,854	694		36.82	55.41	1,098.55	14.19	646.08	3,877.94	0.40	48.33	0.06
X	11,850	1,422	240		16.37	23.05	505.86	2.92	287.56	1,136.27	~0	28.55	~0
NATIONAL TOTALS	3,276,450	393,186	18,910		1,137.43	1,559.85	41,194.23	412.16	19,223.97	92,664.59	17.19	1,341.34	2.78

*DISPOSAL PRACTICE FOR 1983 IS EXPECTED TO ESSENTIALLY BE THE SAME AS THE CURRENT PRACTICE, BUT WITH A TREND TOWARD INCREASED USE OF SINTERING OR AGGLOMERATING TO ALLOW RECYCLE.

**VALUES FOR CN, F AND PHENOL ARE TO BE CONSIDERED AS MINIMUM SINCE DATA WERE NOT AVAILABLE FOR THESE CONSTITUENTS FOR ALL TYPES OF DUST INCLUDED IN THE SUMMATIONS.

SOURCE: CALSPAN CORPORATION

Table 7j

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM THE IRON AND STEEL INDUSTRY TOTAL SCALE, 1974 (METRIC TONS)

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS						OIL & GREASE
					Cr	Cu	Mn	Ni	Pb	Zn	
ALABAMA	196,400	39,280	991.9	RECYCLE OR OPEN DUMP	56.34	78.46	937.47	84.49	16.72	6.07	3,760.08
ARIZONA	3,780	756	19.1		1.09	1.51	18.06	1.63	0.32	0.12	72.82
ARKANSAS	1,380	276	8.8		0.31	0.42	4.91	0.71	0.19	0.04	37.33
CALIFORNIA	185,080	37,020	944.1		52.67	73.27	874.86	80.25	16.13	5.70	3,517.61
COLORADO	56,500	11,300	285.2		16.20	22.56	269.60	24.30	4.81	1.75	1,086.90
CONNECTICUT	10,700	2,140	54.3		3.08	4.29	51.31	4.63	0.92	0.33	206.93
DELAWARE	18,300	3,660	100.6		4.87	6.71	79.70	8.40	1.88	0.56	401.00
FLORIDA	3,340	668	31.1		0.69	0.91	10.57	1.82	0.51	0.09	141.03
GEORGIA	13,800	2,760	69.9		3.97	5.53	66.09	5.96	1.18	0.43	266.44
HAWAII	720	144	6.7		0.15	0.20	2.28	0.39	0.11	0.02	30.42
ILLINOIS	562,200	112,440	2,855.1		160.59	223.49	2,669.40	242.91	48.49	17.35	10,913.10
INDIANA	938,000	187,600	4,842.9		264.45	367.35	4,382.72	410.38	83.95	28.78	18,677.00
KENTUCKY	109,500	21,900	561.1		31.06	43.18	515.51	47.63	9.63	3.37	2,154.88
MARYLAND	256,900	51,380	1,297.3		73.89	102.62	1,226.14	110.51	21.87	7.94	4,943.73
MICHIGAN	468,300	93,660	2,365.1		134.34	187.08	2,235.40	201.47	39.87	14.48	9,013.00
MINNESOTA	5,000	1,000	31.9		1.14	1.53	17.83	2.58	0.68	0.14	135.65
MISSISSIPPI	1,730	346	11.1		0.39	0.53	6.18	0.90	0.24	0.05	47.03
MISSOURI	44,100	8,820	222.7		12.65	17.62	210.49	18.97	3.75	1.36	848.60
NEW JERSEY	15,800	3,160	86.9		4.22	5.81	68.98	7.27	1.63	0.47	346.23
NEW YORK	273,900	54,780	1,383.4		78.58	109.42	1,307.48	117.84	23.32	8.47	5,271.81
N. CAROLINA	2,760	552	25.8		0.57	0.76	8.74	1.51	0.43	0.07	116.72
OHIO	1,150,200	230,040	6,032.6		324.83	451.32	5,385.53	502.34	102.43	35.30	23,362.40
OKLAHOMA	5,830	1,170	37.2		1.33	1.78	20.80	3.01	0.80	0.16	158.26
OREGON	13,800	2,760	69.8		3.96	5.52	65.93	5.94	1.18	0.43	265.81
PENNSYLVANIA	1,416,600	283,320	7,205.1		404.18	562.41	6,716.97	612.74	122.57	43.68	27,563.70
S. CAROLINA	7,440	1,490	45.1		1.71	2.30	26.87	3.82	1.00	0.21	189.66
TENNESSEE	2,910	582	18.6		0.66	0.89	10.37	1.50	0.40	0.08	78.90
TEXAS	183,000	36,600	924.4		52.51	73.12	873.74	78.74	15.58	5.66	3,522.47
UTAH	113,900	22,780	575.1		32.67	45.49	543.54	46.99	9.69	3.52	2,191.48
VIRGINIA	3,260	650	16.5		0.93	1.30	15.55	1.40	0.28	0.10	62.69
WASHINGTON	24,600	4,920	124.2		7.06	9.83	117.41	10.58	2.09	0.76	473.35
W. VIRGINIA	206,100	41,220	984.0		58.88	81.95	978.80	89.07	17.78	6.36	3,687.20
EPA REGION											
I	10,700	2,140	54.3		3.08	4.29	51.31	4.63	0.92	0.33	206.93
II	289,700	57,940	1,470.3		82.80	115.23	1,376.44	125.11	24.95	8.94	5,618.04
III	1,901,160	380,230	9,603.5		542.55	754.99	9,017.16	822.12	164.38	58.63	36,657.82
IV	337,880	67,578	1,764.6		95.39	127.03	1,581.80	147.63	30.11	10.37	6,774.74
V	3,123,700	624,740	16,127.8		885.35	1,230.77	14,890.88	1,358.68	275.42	96.03	62,101.15
VI	190,210	38,046	970.4		54.15	75.32	899.95	82.46	16.57	5.86	3,718.06
VII	44,100	8,820	222.7		12.65	17.62	210.49	18.97	3.75	1.36	848.60
VIII	170,400	34,080	860.3		48.87	68.05	813.14	73.29	14.50	5.27	3,278.36
IX	189,580	37,920	969.9		53.91	74.98	895.20	82.27	16.56	6.84	3,720.86
X	38,400	7,680	194.0		11.02	15.35	183.34	16.52	3.27	1.19	739.16
NATIONAL TOTALS	6,296,830	1,259,174	32,227.8		1,789.77	2,489.16	29,719.21	2,732.68	550.43	193.82	123,863.73

*IT IS ESTIMATED THAT ~ 80 PERCENT OF THE SCALE IS RECYCLED DIRECTLY OR SOLD FOR EVENTUAL RECYCLE. THE REMAINDER IS LAND DISPOSED. OIL CONTENT PREVENTS TOTAL RECYCLE.

SOURCE. CALSPAN CORPORATION

Table 7k

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM THE IRON AND STEEL INDUSTRY TOTAL SCALE, 1977 (METRIC TONS)

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS						OIL & GREASE
					Cr	Cu	Mn	Ni	Pb	Zn	
ALABAMA	208,200	41,640	1,051.4	RECYCLE OR OPEN DUMP	59.72	83 16	993.72	89.56	17.73	8.44	4,006.88
ARIZONA	4,010	802	20.3		1.15	1.60	19.15	1.73	0.34	0.12	77.19
ARKANSAS	1,460	292	8.3		0.33	0.45	5.20	0.78	0.20	0.04	39.57
CALIFORNIA	196,200	39,240	1,000 7		56.83	77.66	927.35	85.06	17.10	6.04	3,834.67
COLORADO	59,900	11,980	302.3		17.17	23.92	285.78	25.76	5.10	1.85	1,152.11
CONNECTICUT	11,400	2,280	57.6		3.27	4.55	54.39	4.90	0.97	0.35	219.35
DELAWARE	19,400	3,880	106.7		5.17	7.12	84.48	8.91	1.99	0.58	425.06
FLORIDA	3,540	708	33.0		0.74	0.97	11.20	1.83	0.54	0.10	148.49
GEORGIA	14,700	2,940	74.1		4.21	5.86	70.05	6.31	1.25	0.45	282.42
HAWAII	760	152	7.1		0 18	0.21	2.42	0.42	0.12	0.02	32.24
ILLINOIS	595,900	119,180	3,026.4		170.22	238.89	2,829.56	257.49	51.40	18.39	11,567.88
INDIANA	994,300	198,860	5,133.5		280.31	389.39	4,645.68	435.00	88.88	30.49	19,797.82
KENTUCKY	116,100	23,220	594.7		32.92	45.78	546.44	50.49	10.21	3.57	2,284.17
MARYLAND	272,300	54,460	1,375.1		78.11	108.77	1,299.71	117.14	23.18	8.42	5,240.35
MICHIGAN	496,400	99,280	2,507.0		142.40	198.31	2,369.52	213.56	42.26	15.35	9,553.78
MINNESOTA	5,300	1,060	33.8		1.21	1.62	18.90	2.74	0.73	0.16	143.79
MISSISSIPPI	1,840	368	11.7		0.42	0.56	6.55	0.95	0.25	0.05	49.85
MISSOURI	46,700	9,340	236.1		13.41	18.67	223.12	20.11	3.98	1.44	898.52
NEW JERSEY	16,800	3,360	92.1		4.47	6.16	73.12	7.71	1.72	0.60	367.00
NEW YORK	290,300	58,060	1,466.4		83.29	115.99	1,385.91	124.91	24.72	8.98	5,588.12
N. CAROLINA	2,930	586	27.3		0.61	0.80	9.27	1.60	0.45	0.08	123.72
OHIO	1,219,200	253,840	6,394.8		344.31	478.40	5,708.66	632.48	108.57	37.41	24,764.14
OKLAHOMA	6,180	1,240	39.5		1 41	1.89	22.05	3.19	0.85	0.17	167.75
OREGON	14,600	2,920	73 9		4.20	5.85	69.89	6.30	1.25	0.45	281.75
PENNSYLVANIA	1,501,600	300,320	7,637.4		428.44	596.16	7,119.99	649.50	129.92	46.30	29,216.89
RHODE ISLAND	NEG.	–	–		–	–	–	–	–	–	–
S. CAROLINA	7,890	1,580	47.8		1.81	2.44	28.48	4.05	1.06	0.22	201.04
TENNESSEE	3,080	616	19.7		0.70	0.84	10.99	1.59	0.42	0.09	83.63
TEXAS	194,000	38,800	979.8		55.66	77.51	928.18	83.47	16.52	6.00	3,733.82
UTAH	120,700	24,140	609.6		34.83	48.22	576.15	51.93	10.28	3.73	2,322.97
VIRGINIA	3,450	690	17.4		0.99	1.38	16.48	1.49	0.29	0.11	66.45
WASHINGTON	26,000	5,200	131.7		7.48	10.42	124 46	11.22	2.22	0.81	501.76
W. VIRGINIA	218,600	43,720	1,043.1		62.42	86.87	2,037.52	94.42	18.85	6.74	3,908.46
EPA REGION											
I	11,400	2,280	57.6		3.27	4.55	54.39	4.90	0.97	0.35	219.35
II	307,100	61,420	1,558.5		87.76	122.15	1,459.03	132.62	26.44	9.48	5,956.12
III	2,016,350	403,070	10,179.7		575.13	800.30	9,558.18	871.46	174.23	62.15	38,857.30
IV	358,280	71,668	1,859.7		101.13	140.51	1,676.70	156.48	31.91	11.00	7,181.20
V	3,311,100	662,220	17,096.5		938 45	1,304.61	15,572.32	1,441.27	291.94	101.79	65,827.21
VI	201,840	40,332	1,028.6		57.40	79.85	953.41	87.41	17.57	6.21	3,941.14
VII	46,700	9,340	238.1		13.41	18.67	223 12	20.11	3.98	1.44	899.52
VIII	180,600	36,120	911.9		61.80	72.14	861.93	77.69	15.38	5.58	3,476.08
IX	200,970	40,194	1,028.1		57.14	79.47	948.92	87.21	17.56	6.18	3,944.10
X	40,600	8,120	205.6		11.68	16.27	194.35	17.52	3.47	1.26	783.51
NATIONAL TOTALS	6,673,740	1,334,754	34,181 3		1,897.17	2,638.52	31,502.35	2,896.67	583.45	205.44	131,083.63

*THE AMOUNT OF SCALE RECYCLED IS EXPECTED TO INCREASE OVER PRESENT AMOUNTS.

SOURCE: CALSPAN CORPORATION

Table 71

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM THE IRON AND STEEL INDUSTRY TOTAL SCALE, 1983 (METRIC TONS)

STATE	TOTAL GENERATED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL* METHOD	CONSTITUENTS						OIL & GREASE
					Cr	Cu	Mn	Ni	Pb	Zn	
ALABAMA	241,600	48,320	1,220.1	RECYCLE OR OPEN DUMP	69.30	96.50	1,153.09	103.93	20.57	7.47	4,649.50
ARIZONA	4,650	930	23.5		1.34	1.86	22.22	2.00	0.40	0.14	89.57
ARKANSAS	1,690	338	10.6		0.39	0.52	6.04	0.87	0.23	0.06	45.91
CALIFORNIA	227,600	45,520	1,161.2		64.79	90.12	1,076.08	98.70	18.34	7.01	4,449.66
COLORADO	69,500	13,900	350.6		19.92	27.75	331.61	29.89	5.91	2.16	1,336.89
CONNECTICUT	13,200	2,640	66.8		3.79	5.28	63.11	5.69	1.13	0.41	254.52
DELAWARE	22,500	4,500	123.8		5.99	8.26	98.03	10.33	2.31	0.67	493.23
FLORIDA	4,110	822	38.3		0.85	1.13	13.00	2.24	0.63	0.11	173.47
GEORGIA	17,000	3,400	86.0		4.89	6.80	81.29	7.33	1.45	0.53	327.72
HAWAII	890	178	8.3		0.18	0.24	2.80	0.48	0.14	0.02	37.41
ILLINOIS	691,500	138,300	3,511.7		197.52	274.69	3,283.36	298.78	59.64	21.33	13,423.11
INDIANA	1,153,800	230,760	5,956.8		325.27	451.83	5,390.75	504.76	103.25	35.38	22,872.20
KENTUCKY	134,700	26,940	690.1		38.21	53.12	634.07	58.58	11.85	4.14	2,650.50
MARYLAND	315,900	63,180	1,595.7		90.64	126.22	1,508.15	135.92	26.90	9.77	6,080.79
MICHIGAN	576,000	115,200	2,909.1		165.24	230.11	2,749.54	247.81	49.04	17.81	11,085.99
MINNESOTA	6,150	1,230	39.3		1.40	1.88	21.93	3.18	0.84	0.17	166.85
MISSISSIPPI	2,130	426	13.6		0.49	0.65	7.60	1.10	0.29	0.06	57.85
MISSOURI	54,200	10,840	273.9		15.56	21.67	258.91	23.33	4.62	1.68	1,043.78
NEW JERSEY	19,500	3,900	106.9		5.19	7.15	84.84	8.94	2.00	0.58	425.86
NEW YORK	336,900	67,380	1,701.6		96.65	134.59	1,608.18	144.94	28.68	10.42	6,484.33
N. CAROLINA	3,400	680	31.7		0.71	0.93	10.76	1.85	0.52	0.09	143.56
OHIO	1,414,700	282,940	7,420.4		399.53	555.12	6,624.20	617.88	125.98	43.41	26,735.75
OKLAHOMA	7,175	1,435	45.8		1.63	2.19	25.59	3.71	0.98	0.20	194.66
OREGON	17,000	3,400	85.8		4.87	6.79	81.10	7.31	1.45	0.53	326.94
PENNSYLVANIA	1,742,400	348,480	8,862.3		497.15	691.77	8,261.87	753.67	150.76	53.73	33,902.74
RHODE ISLAND	NEG.	–	–		–	–	–	–	–	–	–
S. CAROLINA	9,160	1,832	55.5		2.10	2.83	33.05	4.70	1.24	0.26	233.29
TENNESSEE	3,580	716	22.8		0.81	1.09	12.76	1.85	0.49	0.10	97.04
TEXAS	225,100	45,020	1,137.0		64.59	89.84	1,074.70	96.86	19.17	6.96	4,332.64
UTAH	140,000	28,000	707.3		40.17	55.95	668.55	60.25	11.92	4.33	2,695.62
VIRGINIA	4,000	800	20.2		1.15	1.60	19.13	1.72	0.34	0.12	77.11
WASHINGTON	30,300	6,060	152.8		8.68	12.09	144.42	13.02	2.58	0.94	582.23
W. VIRGINIA	253,600	50,720	1,210.3		72.43	100.80	1,203.92	109.56	21.87	7.82	4,535.28
EPA REGION											
I	13,200	2,640	66.8		3.79	5.28	63.11	5.69	1.13	0.41	254.52
II	356,400	71,280	1,808.5		101.84	141.74	1,693.02	153.88	30.68	11.00	6,910.19
III	2,338,400	467,680	11,812.3		667.38	928.65	11,091.10	1,011.20	202.18	72.11	45,089.15
IV	416,680	83,136	2,158.1		117.36	163.05	1,945.62	181.58	37.04	12.76	8,332.93
V	3,842,150	768,430	19,837.3		1,088.96	1,513.83	18,069.78	1,672.41	338.75	118.10	79,383.90
VI	233,965	46,793	1,183.6		86.81	92.65	1,106.33	101.44	20.38	7.21	4,573.21
VII	54,200	10,840	273.9		15.56	21.67	258.91	23.33	4.62	1.68	1,043.78
VIII	209,500	41,900	1,058.1		60.09	83.70	1,000.16	90.14	17.83	6.48	4,032.41
IX	233,140	46,628	1,193.0		68.31	92.22	1,101.10	101.18	20.38	7.17	4,576.64
X	47,300	9,460	238.6		13.65	18.88	225.52	20.33	4.03	1.47	909.17
NATIONAL TOTALS	7,743,835	1,548,787	39,640.2		2,201.43	3,061.67	36,554.65	3,361.18	877.02	238.39	152,105.87

*THE AMOUNT OF SCALE RECYCLED IS EXPECTED TO INCREASE OVER PRESENT AMOUNTS.

SOURCE: CALSPAN CORPORATION

Table 7m

ESTIMATED STATE, REGIONAL, AND NATIONAL WASTE FROM THE IRON AND STEEL INDUSTRY PICKLE LIQUOR, 1974 (METRIC TONS) DRY WEIGHTS*

STATE	TOTAL DISPOSED	TOTAL POT. HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	HAZARDOUS CONSTITUENTS						OIL & GREASE
					Cr	Cu	Mn	Ni	Pb	Zn	
ALABAMA	7,827	7,827	11.41	NEUTRALIZED ON SITE OR BY CONTRACT DISPOSAL SERVICE	0.497	0.288	7.005	0.751	0.043	0.323	2.501
CALIFORNIA	4,321	4,321	6.298		0.274	0.159	3.867	0.415	0.024	0.178	1.380
COLORADO	207	207	0.301		0.013	0.0076	0.185	0.020	0.001	0.0085	0.068
CONNECTICUT	745	745	1.086		0.047	0.027	0.667	0.072	0.004	0.031	0.238
FLORIDA	31	31	0.045		0.0020	0.0011	0.028	0.0030	0.00017	0.0013	0.010
GEORGIA	31	31	0.045		0.0020	0.0011	0.028	0.0030	0.00017	0.0013	0.010
ILLINOIS	12,369	12,369	18.03		0.785	0.455	11.070	1.187	0.068	0.511	3.952
INDIANA	43,369	43,368	63.21		2.754	1.594	38.815	4.163	0.239	1.791	13.856
KENTUCKY	4,667	4,667	6.80		0.296	0.172	4.177	0.448	0.026	0.193	1.491
MARYLAND	5,712	5,712	8.325		0.363	0.210	5.112	0.548	0.031	0.236	1.825
MICHIGAN	9,588	9,588	13.97		0.609	0.352	8.581	0.920	0.053	0.396	3.063
MISSISSIPPI	32	32	0.047		0.0020	0.0012	0.029	0.0031	0.00018	0.0013	0.010
MISSOURI	45	45	0.065		0.0028	0.0016	0.040	0.0043	0.00025	0.0018	0.014
NEW JERSEY	135	135	0.196		0.0086	0.005	0.121	0.013	0.00074	0.0056	0.043
NEW YORK	8,410	8,410	12.26		0.534	0.309	7.527	0.807	0.046	0.347	2.687
OHIO	28,872	28,872	42.08		1.833	1.061	25.84	2.772	0.159	1.192	9.225
PENNSYLVANIA	32,991	32,991	48.085		2.095	1.212	29.526	3.167	0.181	1.362	10.540
RHODE ISLAND	141	141	0.205		0.0089	0.0052	0.126	0.014	0.00077	0.0058	0.045
S. CAROLINA	21	21	0.030		0.0013	0.00076	0.018	0.0020	0.00011	0.00086	0.0066
TENNESSEE	21	21	0.030		0.0013	0.00076	0.018	0.0020	0.00011	0.00086	0.0066
TEXAS	21	21	0.030		0.0013	0.00076	0.018	0.0020	0.00011	0.00086	0.0066
UTAH	2,321	2,321	3.38		0.147	0.085	2.078	0.223	0.013	0.096	0.742
W. VIRGINIA	17,537	17,537	25.56		1.114	0.644	15.696	1.684	0.096	0.724	5.603
EPA REGION											
I	886	886	1.291		0.056	0.032	0.793	0.086	0.0048	0.0368	0.283
II	8,545	8,545	12.456		0.543	0.314	7.648	0.82	0.0467	0.3526	2.73
III	56,240	56,240	81.97		3.572	2.066	50.334	5.399	0.308	2.322	17.968
IV	12,630	12,630	18.437		0.802	0.465	11.303	1.212	0.0697	0.5216	4.035
V	94,197	94,197	137.29		5.981	3.462	84.306	9.042	0.519	3.89	30.096
VI	21	21	0.030		0.0013	0.00076	0.018	0.002	0.0001	0.00086	0.0066
VII	45	45	0.065		0.0028	0.0016	0.04	0.004	0.00025	0.0018	0.014
VIII	2,528	2,528	3.681		0.16	0.0926	2.263	0.243	0.014	0.1045	0.808
IX	4,321	4,321	6.298		0.274	0.159	3.857	0.415	0.027	0.178	1.380
NATIONAL TOTALS	179,411	179,411	261.52		11.391	6.593	160.572	17.223	0.9866	7.408	57.321

*MULTIPLY BY 5.0 TO CONVERT TO APPROXIMATE WET WEIGHTS. MULTIPLY BY 1.1 TO CONVERT TO SHORT TONS.

SOURCE: CALSPAN CORPORATION

Table 7n

ESTIMATED STATE, REGIONAL, AND NATIONAL WASTE FROM THE IRON AND STEEL INDUSTRY PICKLE LIQUOR, 1977 (METRIC TONS), DRY WEIGHTS*

STATE	TOTAL DISPOSED	TOTAL POT. HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	HAZARDOUS CONSTITUENTS Cr	Cu	Mn	Ni	Pb	Zn	OIL & GREASE
ALABAMA	8,297	8,297	12.09	NEUTRALIZED ON SITE	0.527	0.305	7.426	0.796	0.046	0.343	2.651
CALIFORNIA	4,580	4,580	6.68	OR BY CONTRACT	0.291	0.168	4.099	0.440	0.025	0.189	1.463
COLORADO	219	219	0.32	DISPOSAL SERVICE	0.014	0.0081	0.196	0.021	0.0012	0.0091	0.070
CONNECTICUT	790	790	1.15		0.050	0.029	0.707	0.076	0.0043	0.033	0.252
FLORIDA	33	33	0.05		0.0021	0.0012	0.029	0.0032	0.0002	0.0014	0.011
GEORGIA	33	33	0.05		0.0021	0.0012	0.029	0.0032	0.0002	0.0014	0.011
ILLINOIS	13,111	13,111	19.11		0.833	0.482	11.734	1.259	0.072	0.541	4.189
INDIANA	45,971	45,971	67.0		2.919	1.689	41.144	4.413	0.253	1.899	14.687
KENTUCKY	4,947	4,947	7.21		0.314	0.182	4.428	0.475	0.027	0.204	1.581
MARYLAND	6,054	6,054	8.82		0.384	0.222	5.419	0.581	0.033	0.250	1.934
MICHIGAN	10,163	10,163	14.81		0.645	0.373	9.096	0.976	0.056	0.420	3.247
MISSISSIPPI	34	34	0.05		0.0022	0.0012	0.030	0.0033	0.0002	0.0014	0.011
MISSOURI	46	46	0.07		0.003	0.0017	0.043	0.0046	0.0003	0.002	0.015
NEW JERSEY	143	143	0.21		0.0091	0.0052	0.128	0.014	0.0008	0.0059	0.046
NEW YORK	8,915	8,915	12.99		0.566	0.328	7.979	0.856	0.049	0.368	2.848
OHIO	30,604	30,604	44.61		1.943	1.125	27.391	2.938	0.168	1.264	9.778
PENNSYLVANIA	34,970	34,970	50.97		2.221	1.285	31.298	3.357	0.192	1.444	11.173
RHODE ISLAND	149	149	0.22		0.0095	0.0055	0.133	0.014	0.0008	0.0062	0.048
S. CAROLINA	22	22	0.03		0.0014	0.0008	0.020	0.0021	0.0001	0.0009	0.007
TENNESSEE	22	22	0.03		0.0014	0.0008	0.020	0.0021	0.0001	0.0009	0.007
TEXAS	22	22	0.03		0.0014	0.0008	0.020	0.0021	0.0001	0.0009	0.007
UTAH	2,461	2,461	3.59		0.156	0.090	2.202	0.236	0.014	0.102	0.788
W. VIRGINIA	18,589	18,589	27.09		1.180	0.683	16.637	1.785	0.102	0.768	5.939
EPA REGION											
I	939	939	1.37		0.0595	0.0385	0.84	0.09	0.0051	0.039	0.3
II	9,057	9,057	13.2		0.575	0.333	8.107	0.87	0.0498	0.374	2.894
III	59,614	59,614	86.88		3.785	2.19	53.351	5.723	0.327	2.462	19.046
IV	13,387	13,387	19.51		0.850	0.492	11.982	1.282	0.074	0.553	4.279
V	99,848	99,848	145.53		6.34	3.669	89.365	9.586	0.549	4.124	31.901
VI	22	22	0.03		0.0014	0.0008	0.020	0.0021	0.0001	0.0009	0.007
VII	46	46	0.07		0.003	0.0017	0.043	0.0046	0.0003	0.002	0.015
VIII	2,680	2,680	3.91		0.17	0.098	2.398	0.257	0.015	0.111	0.858
IX	4,580	4,580	6.68		0.291	0.168	4.099	0.44	0.025	0.189	1.463
NATIONAL TOTALS	190,173	190,173	277.18		12.075	6.9915	170.208	18.254	1.045	7.855	60.761

*MULTIPLY BY 5.0 TO CONVERT TO APPROXIMATE WET WEIGHTS. MULTIPLY BY 1.1 TO CONVERT TO SHORT TONS.
SOURCE: CALSPAN CORPORATION

Table 7o

ESTIMATED STATE, REGIONAL, AND NATIONAL WASTE FROM THE IRON AND STEEL INDUSTRY PICKLE LIQUOR, 1983 (METRIC TONS), DRY WEIGHTS*

STATE	TOTAL DISPOSED	TOTAL POT. HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	HAZARDOUS CONSTITUENTS						OIL & GREASE
					Cr	Cu	Mn	Ni	Pb	Zn	
ALABAMA	9,627	9,627	14.03	NEUTRALIZE ON SITE	0.611	0.354	8.616	0.924	0.053	0.398	3.076
CALIFORNIA	5,315	5,315	7.75	OR BY CONTRACT	0.337	0.195	4.757	0.510	0.029	0.219	1.698
COLORADO	254	254	0.371	DISPOSAL SERVICE	0.016	0.0093	0.228	0.024	0.0014	0.011	0.081
CONNECTICUT	917	917	1.34		0.058	0.034	0.820	0.088	0.005	0.038	0.293
FLORIDA	38	38	0.056		0.0024	0.0014	0.034	0.0037	0.0002	0.0016	0.012
GEORGIA	38	38	0.056		0.0024	0.0014	0.034	0.0037	0.0002	0.0016	0.012
ILLINOIS	15,213	15,213	22.17		0.966	0.559	13.616	1.460	0.084	0.628	4.861
INDIANA	53,343	53,343	77.75		3.387	1.960	47.742	5.121	0.293	2.203	17.043
KENTUCKY	5,741	5,741	8.37		0.365	0.211	5.138	0.551	0.032	0.237	1.834
MARYLAND	7,025	7,025	10.24		0.446	0.258	6.288	0.674	0.039	0.290	2.245
MICHIGAN	11,793	11,793	17.19		0.749	0.433	10.554	1.132	0.065	0.487	3.768
MISSISSIPPI	39	39	0.057		0.0025	0.0014	0.035	0.0038	0.0002	0.0016	0.013
MISSOURI	55	55	0.08		0.0035	0.002	0.049	0.0053	0.0003	0.0023	0.018
NEW JERSEY	166	166	0.241		0.011	0.0061	0.148	0.016	0.0009	0.0068	0.053
NEW YORK	10,344	10,344	15.08		0.657	0.380	9.258	0.993	0.057	0.427	3.305
OHIO	35,512	35,512	51.76		2.255	1.305	31.784	3.409	0.195	1.467	11.346
PENNSYLVANIA	40,578	40,578	59.14		2.577	1.491	36.318	3.896	0.223	1.676	12.965
RHODE ISLAND	173	173	0.25		0.011	0.0064	0.155	0.017	0.001	0.0071	0.055
S. CAROLINA	25	25	0.037		0.0016	0.0009	0.023	0.002	0.0001	0.0011	0.0081
TENNESSEE	25	25	0.037		0.0016	0.0009	0.023	0.002	0.0001	0.0011	0.0081
TEXAS	25	25	0.037		0.0016	0.0009	0.023	0.002	0.0001	0.0011	0.0081
UTAH	2,855	2,855	4.16		0.181	0.105	2.555	0.274	0.016	0.118	0.912
W. VIRGINIA	21,571	21,571	31.44		1.370	0.793	19.306	2.071	0.119	0.891	6.892
EPA REGION											
I	1,090	1,090	1.59		0.069	0.040	0.975	0.105	0.006	0.045	0.348
II	10,510	10,510	15.32		0.668	0.386	9.406	1.009	0.579	0.434	3.358
III	69,174	69,174	100.82		4.393	2.542	61.912	6.641	0.381	2.857	22.102
IV	15,534	15,534	22.64		0.986	0.571	13.903	1.490	0.086	0.642	4.963
V	115,862	115,862	168.87		7.357	4.257	103.696	11.122	0.637	4.785	37.018
VI	25	25	0.037		0.0016	0.0009	0.023	0.002	0.0001	0.0011	0.0081
VII	55	55	0.08		0.0035	0.002	0.049	0.0053	0.0003	0.0023	0.018
VIII	3,110	3,110	4.53		0.197	0.114	2.783	0.298	0.0174	0.129	0.993
IX	5,315	5,315	7.75		0.337	0.195	4.757	0.510	0.029	0.219	1.698
NATIONAL TOTALS	220,675	220,675	321.64		14.013	8.109	197.504	21.182	1.2145	9.114	70.506

*MULTIPLY BY 5.0 TO CONVERT TO APPROXIMATE WET WEIGHTS. MULTIPLY BY 1.1 TO CONVERT TO SHORT TONS.

SOURCE: CALSPAN CORPORATION

road ballast or building aggregate. It may be stored on the ground for many months or years before use for these purposes. Flue dust contains significant concentration of iron and is normally sent to sinter strand to be agglomerated prior to reprocessing for iron recovery. Sludge from wet emissions control is also sent to the sinter facility for agglomeration prior to reprocessing for iron recovery.

All of the blast furnace residuals (i.e. slag, dust, sludge) are considered non-hazardous. Fluorides may leach to the extent of a few parts per million from these materials which is not considered sufficient to pose an environmental threat.

Basic Oxygen Furnace. Residuals from basic oxygen furnaces include slag, dusts from dry emissions controls, sludges from wet emissions controls and kish from metal pouring. Basic oxygen furnace slag is usually open dumped after recovery of metallics. This practice is adequate since basic oxygen furnace slag is not considered potentially hazardous at the present time.

Dusts and sludges from emissions controls are usually open dumped as is kish. This practice is adequate since none of these wastes are considered potentially hazardous at the present time.

Open Hearth Furnaces. Slag from open hearth furnaces is usually open dumped after processing for recovery of metallics. Open hearth dusts from emissions controls are open dumped and are often wetted down before disposal to prevent blowing. At some steel plants open hearth dusts and BOF dusts are recycled to the sinter. Disposal practices are adequate since these wastes are considered non-hazardous at the present time.

Electric Furnaces. Residuals from electric furnaces include slag, dusts from dry emissions controls and sludge from wet emissions control. Slag is usually open dumped after recovery of metallics. A small amount of slag (approximately 10%) is used as road fill or railroad track ballast. These methods are adequate since electric furnace slag is not considered potentially hazardous.

Dusts from dry emissions control and sludge from wet emissions control can leach potentially hazardous heavy metals as previously discussed. Open dumping of these wastes as currently practiced is environmentally inadequate.

Soaking Pits. Slag is the only waste generated at the soaking pits. It is generally broken into chunks and hauled to open dumps. This practice is adequate since this waste is not considered potentially hazardous.

Mill Sludges. This category of residuals includes sludges from various mill operations at an integrated steel plant including primary mills which produce ingots, slabs and other primary steel shapes, continuous casting mills, hot rolling mills, cold rolling mills, galvanizing mills, and tin plating mills. Sludges from these mills are produced as a result of water pollution control operations including oil and grease removal, flocculation and settling of particulates, and pH adjustment.

All of the above sludges are considered potentially hazardous because of possible leaching of hazardous constituents including chromium, copper, nickel, lead, zinc and oil and grease.

Currently the most prevalent management of the above sludges is open dumping except for tin plating sludges which are put in unlined lagoons. These practices are inadequate because of the danger of toxic heavy metal leaching through permeable soils to groundwater.

Mill Scales. Mill scales containing over 50% iron are generated in primary and hot rolling mills, continuous casting mills, and cold rolling mills. Scales from primary and hot rolling mills and continous casting mills are recycled to the sinter or blast furnace for iron recovery. This practice is environmentally sound since land disposal is precluded.

Scale from cold rolling mills is often highly contaminated with oil which discourages recycle to the sinter because of hydrocarbon emissions in the sinter. Normal disposal is by open dumping. This practice is not environmentally adequate because of the possible movement of oil and grease through permeable soils to groundwaters or surface waters.

Pickle Liquors. Currently the prevalent practice employed by steel plants for handling of waste pickle liquor is the service of outside contract disposal services who generally neutralize the acid before disposal in unlined lagoons. Disposal in unlined lagoons is inadequate if heavy metals leach from the sludge formed from neutralization and percolate through permeable soils to groundwater.

1.3.2 Present Treatment and Disposal Technology (Level I)

Coke Plant. Wastes from coking operations and associated byproduct production which are considered potentially hazardous include waste ammonia liquor, ammonia still lime sludge and decanter tank tar. Treatment of ammonia liquor in a biological treatment plant is adequate since destruction of potentially hazardous constituents (i.e. phenol, cyanide) is achieved. Inputs of these wastes to the biological treatment plant must be sufficiently dilute so as to not interfere with normal biological activity. Deep well disposal of waste ammonia liquor is adequate only when done according to EPA guidelines as stated in EPA Administrator's Decision Statement No. 5 dated February 6, 1973 (Reference 10).

Ammonia still lime sludge and decanter tank tar are presently open dumped. This practice is environmentally inadequate because of the danger of toxics including phenol, ammonia, or cyanide leaching and percolating to ground or surface water.

Electric Furnaces. Residuals from electric furnaces which are considered potentially hazardous include emission control dusts and sludges. Present disposal of dusts and sludges is open dumping. This practice is environmentally inadequate because of the danger of heavy metal leaching through permeable soils to groundwater or surface water.

Mill Sludges. Potentially hazardous sludges are generated from water pollution control operations in primary mills, continuous casting mills, hot rolling mills, cold rolling mills, galvanizing mills and tin plating mills. Present treatment and disposal is open dumping which is environmentally inadequate because of the threat of heavy metal and oil or grease leaching.

Mill Scales. Potentially hazardous mill scales are generated in primary and hot rolling mills, continuous casting mills and cold rolling mills. The scale from all of these operations excepting cold rolling mills is normally recycled to the sinter for iron recovery and is environmentally adequate. Highly oil contaminated scale from cold rolling mills is presently open dumped. This practice is not environmentally adequate.

Pickle Liquor. Present treatment and disposal technology generally consists of disposal by contract disposal companies who neutralize the acid pickle liquor and leave the neutralization sludge in unlined lagoons. Some steel plants dispose of pickle liquor by deep well disposal. The use of unlined lagoons is not environmentally adequate because of the danger of toxic heavy metal leaching through permeable soils to groundwater or surface waters. Deep well disposal is adequate when done in accordance with EPA guidelines.

1.3.3 Best Technology Currently Employed (Level II)

Coke Plant. Level II technology for treatment and disposal of waste ammonia liquor, ammonia still lime sludge and decanter tank tar is the same as Level I and is inadequate except for deep well disposal of pickle liquors which is adequate.

Electric Furnaces. Level II technology for treatment and disposal of potentially hazardous electric furnace dusts and sludges is the same as Level I (i.e. open dumping) and is inadequate.

Mill Sludges. At approximately 5% of the steel plants sludges from primary and hot rolling mills are recycled through the sinter for iron recovery. This precludes land disposal and is therefore environmentally adequate.

Cold rolling mill and galvanizing mill sludges are open dumped which is inadequate for environmental protection.

At some plants tin plating mill water treatment sludge is reprocessed for tin recovery. This is environmentally adequate.

Mill Scales. Level II treatment and disposal technology for mill scales from primary mills , continuous casting mills, hot rolling mills, and cold rolling mills is the same as Level I.

Pickle Liquors. At a few steel plants spent pickling liquor is processed for reclamation of sulfuric acid or hydrochloric acid and reuse in the pickling operations. The iron oxide or iron sulfate residues can be recycled for recovery of iron. This practice is environmentally adequate. Deep well disposal of pickle liquors according to EPA guidelines is adequate.

1.3.4 Technology to Provide Adequate Health and Environmental Protection (Level III)

Coke Plant. Biological treatment of waste ammonia liquor from the byproduct coke plant will detoxify toxic constituents including phenol, cyanide, and ammonia if present in low concentrations. Solvent recovery and ammonia stripping will normally precede biological treatment of ammonia liquor. Deep well disposal of pickle liquors in accordance with EPA guidelines is adequate for environmental protection.

Sealing of permeable soils at dump sites to prevent leaching of phenol, cyanide, or ammonia from lime sludge or decanter tank tar, or collection and treatment of leachate constitutes Level III treatment and disposal technology.

Electric Furnaces. Sealing of permeable soils at dump sites for disposal of sludge or dust from control of emissions from electric furnaces or collection and treatment of leachate will be necessary for adequate environmental protection.

Mill Sludges. If primary or hot rolling mill sludges are not recycled to the sinter, chemical fixation would be required prior to open dumping. Chemical fixation of cold rolling and galvanizing sludges would be required before open dumping.

Metal reclamation from tin plating sludge would qualify as Level III technology. If this sludge is lagoon disposed, the use of lined lagoons would be needed for adequate environmental protection.

Mill Scales. If mill scales are recycled to the sinter adequate environmental protection is assured. If mill scales are open dumped the use of bentonite or other soil sealants would be required to prevent percolation of toxic heavy metals or oil and grease,or collection and treatment of leachate would be necessary.

Pickle Liquor. Processing of spent pickle liquor to reclaim hydrochloric or sulfuric acid and metallic value (i.e. iron),or deep well disposal according to EPA guidelines is Level III technology.

Tables 8a through 8f summarize features of Levels I, II and III treatment and disposal technologies for potentially hazardous wastes from the iron and steel smelting and refining industry.

Table 8A

Treatment and Disposal Technology Levels

Smelting and Refining Category Iron and Steel SIC 3312

Byproduct Coke Plant Wastes

Factor	Level I (Prevalent)	Level II (Best Currently Employed)	Level III (Adequate Health and Environmental Protection)
Physical + Chemical Properties	Ammonia Liquor - dilute ammonia with traces of phenol and cyanide Lime Sludge - predominantly lime with phenols, cyanide, oil and grease, trace metals. Tank Tar - tarry sludge; hydrocarbons with oil and grease, phenol, cyanide traces	Same as I	Same as I
Amount of Waste (kg/MT Product)	Waste Ammonia Liquor - 190 Ammonia Still Lime Sludge - 0.6 Decanter Tank Tar - 4.5	Same as I	Same as I
Factors Affecting Hazardousness	Above wastes contain phenol and cyanide, ammonia and oils and greases, trace metals	Same as I	Same as I
Treatment/ Disposal Technology	Ammonia liquor* - biological treatment Lime Sludge - open dump Decanter tar - open dump	Biological treatment or deep well disposal according to EPA guidelines for lime sludge and decanter tar	Same as for ammonia liquor; ground sealing of disposal area with bentonite or other sealant for lime and decanter tar sludge if significant leaching of phenol, cyanide or ammonia
Estimate of # + % of Plants Using Technology	Ammonia liquor - >90% Lime Sludge - >75% Decanter tar - >75%	Same as I	Ammonia liquor - >90% Lime sludge - 0 Decanter tar - 0

*Included as land disposed waste only because a few plants dispose in deep wells.

Table 8A (cont'd.)

Factor	Level I	Level II	Level III
Adequacy of Technology	Adequate for ammonia liquor; inadequate for lime and tar sludges if significant leaching of phenol, ammonia or cyanide	Same as I	Same as I
Problems and Comments	Ammonia liquor normally is treated without land contact with discharge of treated effluent to receiving stream or sewer. A few plants use deep well disposal.	None	None
Non-Land Environmental Impact	Lime and decanter tank tar sludges could contaminate ground or surface water if leached.	Same as I	None
Compatibility With Existing Facilities	Compatible	Compatible	Compatible
Monitoring & Surveillance Methods	None	None	Groundwater surveillance wells and surface runoff monitoring
Energy Requirements	Negligible	Negligible	Negligible

Table 8B

Treatment and Disposal Technology Levels

Smelting and Refining Category Iron and Steel SIC 3312

ELECTRIC FURNACE DUST

Factor	Level I (Prevalent)	Level II (Best Currently Employed)	Level III (Adequate Health and Enviromental Protection)
Physical + Chemical Properties	Colloidal to silt size particles; iron, silica, lime, traces of heavy metals and fluoride	Same as I.	Same as I
Amount of Waste (kg/MT Product)	15.0	Same as I	Same as I
Factors Affecting Hazardousness	Contain trace heavy metals including Cr, Cu, , Ni, Pb, Zn and fluoride	Same as I	Same as I
Treatment/ Disposal Technology	open dumped	Same as I	Ground sealing at disposal site
Estimate of # + % of Plants Using Technology	>80%	>80%	0

Table 8B-(cont'd.)

Factor	Level I	Level II	Level III
Adequacy of Technology	Inadequate	Same as I	Adequate
Problems and Comments	Significant leaching of lead from electric furnace dust in solubility tests	None	None
Non-Land Environmental Impact	Possible contamination of groundwater or surface water	Same as I	None
Compatibility With Existing Facilities	Compatible	Compatible	Compatible
Monitoring & Surveillance Methods	None	None	Groundwater monitoring Electric furnace dust disposal areas
Energy Requirements	Negligible	Negligible	Negligible

Table 8C

Treatment and Disposal Technology Levels

Smelting and Refining Category Iron and Steel SIC 3312

ELECTRIC FURNACE SLUDGE

Factor	Level I (Prevalent)	Level II (Best Currently Employed)	Level III (Adequate Health and Enviromental Protection)
Physical + Chemical Properties	Colloidal to silt size particles; iron, trace metals, fluorides	Same as I	Same as I
Amount of Waste (kg/MT Product)	Electric furnace sludge - 5.8	Same as I	Same as I
Factors Affecting Hazardousness	Contain traces of heavy metals including Cr, Ni, Pb, Zn, Cu, fluoride	Same as I	Same as I
Treatment/ Disposal Technology	Open Dump	Open Dump	Chemical fixation if leaching of heavy metals from open dumped sludges
Estimate of # + % of Plants Using Technology	>90	>90	0 chemical fixation

Table 8C - (cont'd.)

Factor	Level I	Level II	Level III
Adequacy of Technology	Inadequate	Inadequate	Adequate
Problems and Comments	Significant leaching of Cr, Pb in solubility tests	Same as I	None
Non-Land Environmental Impact	Possible contamination of groundwater and surface water	Same as I	None
Compatibility With Existing Facilities	Compatible	Compatible	Compatible
Monitoring & Surveillance Methods	None	None	Groundwater monitoring wells
Energy Requirements	Negligible	Negligible	Negligible

Table 8D

Treatment and Disposal Technology Levels

Smelting and Refining Category Iron and Steel SIC 3312

PICKLE LIQUORS

Factor	Level I (Prevalent)	Level II (Best Currently Employed)	Level III (Adequate Health and Enviromental Protection)
Physical + Chemical Properties	Dilute sulfuric or hydrochloric acid with dissolved and particulate iron	Iron sulfate or oxide salt residues; acid is 100% regenerated	Same as II for acid regeneration Same as I if not regenerated
Amount of Waste (kg/MT Product)	Cold rolling mills - 22.8 Galvanizing Mills - 5.17	No acid wasted (100% recycle) Residual salts are land dumped only if no market (36.3 kg, $FeSO_4$)	Same as II
Factors Affecting Hazardousness	Acid, trace heavy metals including Cr, Cu, Mn, Ni, Pb, Zn	Same as I	Same as I
Treatment/ Disposal Technology	Outside contract disposal service who neutralize in unlined lagoons	Acid regeneration or deep well disposal according to EPA guidelines	Acid regeneration or neutralization with sludge kept in lined lagoons if heavy metals leach; deep well disposal according to EPA guidelines
Estimate of # + % of Plants Using Technology	∿95%	10	10

Table 8D (cont'd.)

Factor	Level I	Level II	Level III
Adequacy of Technology	Inadequate	Inadequate if land dumped residues leach heavy metals; adequate for acid problem	Adequate
Problems and Comments	None	None	None
Non-Land Environmental Impact	Possible contamination of ground and surface water	Possible contamination of ground and surface water by residual salts if leached of heavy metals	None
Compatibility With Existing Facilities	Compatible	Compatible	Compatible
Monitoring & Surveillance Methods	None	None	Groundwater monitoring, Well and surface runoff monitoring
Energy Requirements	Negligible	Moderate (0.24 kw/MT Steel)	Moderate for acid regeneration, negligible for lined lagoon

Table 8E

Treatment and Disposal Technology Levels

Smelting and Refining Category Iron and Steel SIC 3312

MILL SLUDGES (galvanizing, primary, continuous casting, hot rolling, cold rolling, tin-plating)

Factor	Level I (Prevalent)	Level II (Best Currently Employed)	Level III (Adequate Health and Enviromental Protection)
Physical + Chemical Properties	Mill sludges are colloidal to silt size aggregated particles, high in iron; trace metals, oils and greases	Same as I	Same as I
Amount of Waste (kg/MT Product)	Galvanizing Mill - 10.8 Primary Mill - 1.87 Continuous Casting - 0.104 Hot Rolling Mills - 1.74 Cold Rolling Mills - 0.159 Tin Plating Mill - 0.532	No sludge waste from primary, hot rolling, or tin plating mill if reprocessed; other factors for other mill sludges same as Level I	Same as II
Factors Affecting Hazardousness	Contains trace heavy metals including Cr, Cu, Mn, Ni, Pb, Zn and oil and grease	Same as I	Same as I
Treatment/ Disposal Technology	Open dumped except for tin plating sludges which are lagooned	Primary, continuous casting, & Hot rolling mill- recycle to sinter Cold rolling & galvanizing mill - open dump Tin plating mill-tin reclamation	Primary & hot rolling mill - recycle to sinter or chemical fixation Cold rolling & galvanizing - chemical fixation Tin plating - metal reclamation
Estimate of # + % of Plants Using Technology	90%	Primary & hot rolling - 5% Cold rolling & galvanizing- 90% Tin plating - 20%	Primary & hot rolling - <5% recycle; 0 chemical fixation Cold rolling & galvanizing- 0 chemical fixation Tin plating - ∿20% tin reclamation, 0 lined lagoon

Table 8E-(cont'd.)

Factor	Level I	Level II	Level III
Adequacy of Technology	Inadequate if significant leaching of heavy metals	Adequate if sludges are recycled - otherwise same as I	Adequate
Problems and Comments	None	None	None
Non-Land Environmental Impact	Possible contamination of ground or surface water if leached oil and grease or heavy metals percolate through permeable soils	Same as I	None
Compatibility With Existing Facilities	Compatible	Compatible	Compatible
Monitoring & Surveillance Methods	None	None	Groundwater surveillance wells and surface runoff monitoring
Energy Requirements	Negligible	Negligible	Negligible

Table 8F

Treatment and Disposal Technology Levels

Smelting and Refining Category Iron and Steel SIC 3312

MILL SCALES (Primary mills, continuous casting, hot rolling, cold rolling)

Factor	Level I (Prevalent)	Level II (Best Currently Employed)	Level III (Adequate Health and Enviromental Protection)
Physical + Chemical Properties	Fine sand to small granular size flaky particles - predominantly iron (>60-70%)	Same as I	Same as I
Amount of Waste (kg/MT Product)	Primary Mill - 44.9* Continuous Casting - 8.7* Hot rolling mills - 18.3* Cold rolling mills - 0.052	Same as I	Same as I
Factors Affecting Hazardousness	Contain trace heavy metals including Cr, Cu, Mn, Ni, Pb, Zn, oil and grease	Same as I	Same as I
Treatment/ Disposal Technology	Primary & hot rolling & continuous casting - recycled to sinter or blast furnace Cold rolling mills - open dump	Same as I	Recycle to sinter or ground sealing with bentonite or other sealant if land disposed
Estimate of # + % of Plants Using Technology	>90%	Same as I	0 ground sealing

*These scales are not wasted if recycled to sinter or blast furnace
~80% of total scale is recycled.

Table 8F-(cont'd.)

Factor	Level I	Level II	Level III
Adequacy of Technology	Recycling - adequate; inadequate if land dumped and heavy metal leaching occurs	Same as I	Adequate
Problems and Comments	None	None	None
Non-Land Environmental Impact	Possible contamination of surface or ground water if heavy metals or oils and greases leach	Same as I	None
Compatibility With Existing Facilities	Compatible	Compatible	Compatible
Monitoring & Surveillance Methods	None	None	Groundwater surveillance and surface runoff monitoring
Energy Requirements	Negligible	Negligible	Negligible

1.4 COST ANALYSIS

In the last section various treatment and disposal technologies currently employed or considered for adequate health and environmental protection were described. The costs of implementing this technology for a typical integrated iron and steel mill complex are estimated in this section. Costs of land disposal from individual operations such as steel furnaces and rolling mills are also given. The exemplary plant has an annual capacity of 2,500,000 MT of steel and is assumed to operated 350 days per year. Facilities at the plant include the operations given in Table 4 and generate the wastes listed previously in Table 5. All disposal sites are situated on semi-industrial land.

Dust

Dust results from blast furnace, basic oxygen furnace and electric furnace operations. Dust from the blast furnaces is recycled to the sinter plant. No disposal cost is incurred. The dust from the basic oxygen furnace operations amounts to only 288 MT (222 m^3)/year. It is not considered hazardous.

Electric Furnace Dust. Dust from the electric furnaces considered potentially hazardous (7,500 MT or 4165 m^3/yr) is hauled to an on-site dump. This requires 1 hr/day of front loader and truck time plus 40 hrs/yr of bulldozer time at the dump. The dust is piled to a height of 5 m. The dump area is sized to hold 20 years of waste and extends over 1.7 ha.

Electric Furnace Dust

Capital Cost

Dust Dump	
Survey	$ 1,065
Land	6,725
Equipment	
Truck (12.5%)	3,125
Front Loader (12.5%)	2,500
Bulldozer (2%)	320
Total	$13,735

Annual Cost

Land	$ 675
Construction Amortization	125
Equipment Amortization	945
Equipment Repair and Maintenance	295
Operating Personnel	8,045
Energy	
Fuel	995
Electricity	100
Taxes	170
Insurance	135
Total	$11,485

Sludge

Sludge wastes are generated by all operations except by the electric furnaces (where a dry control system is assumed) and the soaking pits.

Coke Oven Sludge. Ammonia still lime sludge (6,160 MT or 5,135 m^3/yr) is produced at the coke ovens. The sludge is disposed at a dump. One hr/day of frontloader and truck time are needed for loading and transporting the sludge and 50 hrs/yr of bulldozer time at the dump site. The sludge is piled to a height of 5 m. The dump occupies 2.1 hectares and accommodates 20 years of waste sludge.

Coke Oven Sludge (ammonia still lime sludge)

Capital Cost	
Sludge Dump	
Survey	$ 1,315
Land	8,305
Equipment	
Truck (12.5%)	3,125
Front Loader (12.5%)	2,500
Bulldozer (2.5%)	400
Total	$15,645
Annual Cost	
Land	$ 830
Construction Amortization	155
Equipment Amortization	960
Equipment Repair & Maintenance	300
Operating Personnel	8,170
Energy	
Fuel	1,005
Electricity	100
Taxes	210
Insurance	155
Total	$11,885

Primary and Other Hot Rolling Mill Sludge. The primary and other hot rolling mills produce 5739 MT of sludge per year. The scale wastes generated by these operations are recycled to sinter on the blast furnace. However, about 2 percent of the scale, containing oil contaminants, is skimmed off and disposed with the sludge.

The total yearly waste disposed is about 7,750 MT or 4840 m^3. Loading and hauling require 1 hr/day of front loader and truck time, and 50 hrs/yr of bulldozer time is assigned at the dumpe site. The dump occupies 1.9 ha.

Primary and Other Hot Rolling Mill Sludge

Capital Cost	
Sludge Dump	
Survey	$ 1,190
Land	7,515
Equipment	
Truck (12.5%)	3,125
Front Loader (12.5%)	2,500
Bulldozer (2.5%)	400
Total	$14,730

Annual Cost	
Land	$ 750
Construction Amortization	140
Equipment Amortization	960
Equipment Repair & Maintenance	300
Operating Personnel	8,170
Energy	
Fuel	1,005
Electricity	100
Taxes	190
Insurance	145
Total	$11,760

Cold Rolling Mill Sludge. The cold rolling mills produce only 111 MT of sludge annually. For the purpose of costing, the disposal cost of this sludge is combined with that generated by the galvanizing mill.

Tin Plating Mill Sludge. The sludge from the tin plating mill is disposed in a lagoon. The wet sludge (50% solids) produced annually amounts to 1064 MT. The lagoon is sized to hold 20 years of waste. The lagoon characteristics are:

Volume	21,300 m^3	Circumference	390 m
Bottom Width	55 m	Dike volume	5,900 m^3
Top width	67 m	Dike surface	5,540 m^2
Bottom length	110 m	Total width	81 m
Top length	122 m	Total length	136 m
Total depth	3 m	Required area	1.1 ha
Depth of Excavation	.9 m		

Tin Plating Mill Sludge

Capital Cost	
Lagoon	
Site Preparation	
Survey	$ 690
Test Drilling	980
Sample Testing	500
Report Preparation	1,500
Construction	
Excavation and Forming	7,845
Compacting	10,910
Fine Grade Finishing	2,490
Soil Poisoning	485
Transverse Drain Fields	1,500
Land	4,350
Total	$31,250
Annual Cost	
Land	$ 435
Construction Amortization	2,695
Construction Maintenance & Repair	695
Taxes	110
Insurance	315
Total	$ 4,250

Galvanizing Mill Sludge. The sludge produced by the galvanizing mill is combined with that from the cold rolling mill. Also included is the small amount of scale waste (36 MT/yr) from the cold rolling mill. The total waste disposed is 1500 MT/yr. Loading, hauling and diposing on land requires about .25 hrs/day of front loader and truck time and a .4 ha sludge dump.

Galvanizing and Cold Rolling Mill Sludge

Capital Cost	
Sludge Dump	
Survey	$ 250
Land	1,580
Equipment	
Truck (5%)	1,250
Front Loader (5%)	1,000
Total	$ 4,080

Annual Cost	
Land	$ 160
Construction Amortization	30
Equipment Amortization	360
Equipment Repair & Maintenance	115
Operating Personnel	1,890
Energy	
Fuel	240
Electricity	25
Taxes	40
Insurance	40
Total	$ 2,900

Scale

Scale is produced by primary and hot rolling mills and the cold rolling mills. Practically all of the scale of the former is recycled to sinter or blast furnaces. No disposal costs are incurred. Scale from the cold rolling mill is land disposed together with the sludge from that operation. No separate costs are incurred.

Waste Pickle Liquor

Waste pickle liquor results from cold rolling and galvanizing mill operations. The liquor is treated and disposed of by an outside contractor at a cost of $\$10.55/m^3$ ($.04/gal).

No capital costs are incurred. The annual cost is $149,010.

Waste Ammonia Liquor

Waste ammonia liquor is normally not land disposed. It is normally detoxified in a biological treatment plant as a minor flow. Occasionally it is disposed of in deep wells. The associated costs of deep well disposal were not ascertained since no land disposal is considered as Levels I, II and III treatment and disposal technology.

1.4.2 Cost of Best Technology Currently Employed (Level II).

Dust

Dust disposal and associated costs are the same for Level II as Level I.

Sludge

Sludge from the blast furnaces, basic oxygen furnaces and primary and hot rolling mills can be recycled to sinter depending on its composition.

Tin plating mill sludge in some plants has a sufficiently high metal content so that it can be sold to an outside contractor for metal reclamation. We were unable to obtain information on prices paid by reclaimers for the sludge. This treatment method would eliminate the need for the lagoon specified for Level I and its associated costs. Level II treatment for the other sludges is the same as for Level I.

Waste Pickle Liquor

Acid regeneration is the Level II treatment for waste pickle liquor. Reference 2 indicates a cost of $\$13/m^3$ of waste treated. This cost is included as an annual cost. It includes the amortization of capital treatment plant investment. Acid regeneration results in an annual cost of $183,610 which is about a $35,000 increase over the Level I treatment cost.

Incremental changes resulting from the implementation of Level II technology are shown below.

	Capital Cost	Annual Cost
Slag	-	-
Dust	-	-
Sludge	($31,250)	($4,250)
Waste Pickle Liquor	-	34,600
Total	($31,250)	$30,350

( ) = savings engendered by sale of tin plating mill sludge and resultant elimination of sludge lagoon.

1.4.3 Cost of Technology to Provide Adequate Health and Environmental Protection (Level III)

Dust

The soil is sealed at the dump used for storing the dust from the electric furnaces. Collection ditches, pump and piping are provided at the dump site.

Electric Furnace Dust

Capital Cost	
Soil Sealing	$34,000
Collection ditches	1,970
Pump	9,100
Piping	2,210
Total	$47,280

Annual Cost	
Construction Amortization	$ 4,175
Equipment Amortization	1,800
Construction Repair & Maintenance	1,080
Equipment Repair & Maintenance	565
Energy	
Fuel	
Electricity	95
Insurance	475
Total	$ 8,190

Sludge

The soil is sealed at the coke oven sludge dump; collection ditches, pump and piping are installed.

Coke Oven Sludge

Capital Cost	
Soil Sealing	$ 42,000
Collection Ditches	2,195
Pump	9,300
Piping	2,210
Total	$ 55,705

Annual Cost	
Construction Amortization	$ 5,130
Equipment Amortization	1,835
Construction Repair & Maintenance	1,325
Equipment Repair & Maintenance	575
Energy	
Fuel	
Electricity	110
Insurance	560
Total	$ 9,535

The sludges from the primary and other hot rolling mills as well as those from the galvanizing and cold rolling mills are chemically fixed prior to land disposal.

Primary and Other Hot Rolling Mill Sludge

Capital Cost	Not Applicable
Annual Cost	
Chemical Fixation	$63,930
Total	$63,930

Galvanizing and Cold Rolling Mill Sludge

Capital Cost	Not Applicable
Annual Cost	
Chemical Fixation	$13,175
Total	$13,175

Level III for tin plating mill sludge disposal consists either of the sale of the sludge to a metal reclaimer or installing a lagoon liner where the sludge is disposed on land. The former entails no cost to the plant. Costs for the latter are shown below.

Tin Mill Sludge

Capital Cost	
Lagoon Liner	$38,235
Total	$38,235
Annual Cost	
Construction Amortization	$ 4,440
Construction Repair & Maintenance	1,145
Insurance	380
Total	$ 5,965

Waste Pickle Liquor

Level III treatment of waste pickle liquor consists either of acid regeneration or neutralizing the waste by lime treatment, allow for settling of the sludge in a lined lagoon followed by chemical fixation and land disposal of the sludge. Acid regeneration involves no additional costs beyond those listed under Level II treatment. Costs for the other alternative is shown in Table 9.

The total annual waste liquor amounts to 15,100 MT. This results in the formation of 6,285 MT or 4,910 m^3 of sludge. The selected lagoon size is 10,000 m^3 and it assumed that 4,910 m^3 of sludge are dredged annually. The removed sludge is chemically fixed and hauled to a dump site.

A 236 l/min slurry pump is used for dredging. The pump is operated 350 hrs/yr and 400 hours of labor are assigned to its operation. Loading and hauling of the sludge to the dump site requires 265 hrs/yr of front loader and truck time and 50 hrs/yr of bulldozer time at the sludge dump.

TABLE 9. COST OF LEVEL III TREATMENT AND DISPOSAL TECHNOLOGY INTEGRATED STEEL MILL - PICKLE LIQUOR SLUDGE

Capital Cost	
Lagoon	
Site Preparation	
Survey	$ 375
Test Drilling	490
Sample Testing	250
Report Preparation	1,200
Construction	
Excavation and Forming	4,535
Compacting	6,310
Fine Grade Finishing	1,705
Soil Poisoning	345
Transverse Drain Field	855
Lagoon Liner	20,025
Land	2,375
Sludge Dump	
Survey	625
Land	3,955
Equipment	
Slurry Pump	13,730
Flexible Pipe (100 m)	440
Front Loader (15%)	3,000
Truck (15%)	3,750
Bulldozer (2.5%)	400
Total	$ 64,365

TABLE 9 (Continued)

Annual Cost	
Land	635
Construction Amortization	4,270
Equipment Amortization	3,405
Construction Repair and Maintenance	1,015
Equipment Repair and Maintenance	1,065
Operating Personnel	10,110
Energy	
Fuel	775
Electricity	90
Chemical Fixation	64,810
Taxes	160
Insurance	645
Total	$ 86,980
Less Acid Regeneration	(183,610)
Total	($96,930)

(   ) = savings

The lagoon characteristics are:

Volume	10,000 m	Circumference	277 m
Bottom width	36 m	Dike volume	3,410 m^3
Top width	48 m	Dike surface	3,790 m
Bottom length	72 m	Total width	62 m
Top length	84 m	Total length	98 m
Total depth	3 m	Required area	16 ha
Depth of excavation	1.15 m		

The dump is sized to hold 20 years of waste piled to a height of 10 m. It occupies 1.0 ha. The lime treatment facility used to neutralize the waste pickle liquor is considered part of the water treatment system and its cost is not included.

Summary costs for Level I, II and III waste treatments for an integrated steel plant are given in Table 10. Annual costs for Levels I and II disposal of potentially hazardous wastes are estimated as $7,570,000 which represents less than 0.1% of the estimated 1973 sales value. Annual costs for Level III technology (i.e. adequate for environmental protection) are estimated as $12,930,000 or 0.15% of estimated 1973 sales value.

TABLE 10 - COST SUMMARY FOR TREATMENT AND DISPOSAL TECHNOLOGIES, IRON AND STEEL

Annual Production: Model Plant 2,500,000 MT Industry 100,929,000 MT

Waste (Type)	Amount (MT/MT of Production)
Dust	0.003
Sludge	0.007
Pickle Liquor	0.006

Cum. Unit Waste Disposal Costs:

Waste (Type)	Level I $/MT of Waste	Level I $/MT of Prod.	Level II $/MT of Waste	Level II $/MT of Prod.	Level III $/MT of Waste	Level III $/MT of Prod.
Dust						
Capital Cost	$ 1.83	$ 0.005	$ 1.83	$ 0.005	$8.14	$ 0.02
Annual Cost	1.53	0.005	1.53	0.005	2.62	0.008
Sludge						
Capital Cost	3.99	0.03	3.99	0.03	9.69	0.06
Annual Cost	1.87	0.01	1.87	0.01	7.49	0.05
Pickle Liquor						
Capital Cost	--	--	--	--	--	--
Annual Cost	10.55	0.06	13.00	0.07	13.00	0.07
Total Capital Cost	--	$0.04	--	$0.04	--	$0.08
Total Annual Cost	--	0.08	--	0.09	--	0.13

Cum. Industry Waste Disposal Costs ($ Million)

Waste (Type)	Level I Cap.	Level I Ann.	Level II Cap.	Level II Ann.	Level III Cap.	Level III Ann.
Dust	$0.50	$0.50	$0.50	$0.50	$2.02	$0.81
Sludge	3.03	1.01	3.03	1.01	6.06	5.05
Pickle Liquor	--	6.06	--	7.07	--	7.07
Total:	$3.53	$7.57	$3.53	$7.57	$8.08	$12.93

1973 Metal Price: $82.57/MT

Percent Treatment Cost/Price of Metric Ton of Production

Waste (Type)	Level I Cap.	Level I Ann.	Level II Cap.	Level II Ann.	Level III Cap.	Level III Ann.
Dust	0.01%	0.01%	0.01%	0.01%	0.02%	0.01%
Sludge	0.04	0.01	0.04	0.01	0.07	0.06
Pickle Liquor	--	0.07	--	0.08	--	0.08
Total:	0.05%	0.09%	0.05%	0.10%	0.09%	0.15%

2.0 IRON AND STEEL FOUNDRIES

2.1 INDUSTRY CHARACTERIZATION

The three major groupings of ferrous castings are gray and ductile iron castings, malleable iron castings, and steel castings. While specific procedures might vary from foundry to foundry, the overall operations for producting castings of all three types are essentially the same and include metal melting and pouring, casting shakeout and cleaning and finishing.

There are about 2000 foundries in the U.S. producing ferrous castings. There is great variability in plant size with monthly capacities ranging from 20 net tons to over 10,000 net tons.* It is important to note that only about 60 percent of all castings produced in the United States are covered under SIC 332 (Iron and Steel Foundries). The remaining 40 percent are produced under other SIC categories, such as SIC 3714 (Motor Vehicles), SIC 3541 (Machine Tools), etc.

The production data and waste data presented in this report represents only those operations covered under SIC 332 which are within the primary metal smelting and refining industry.

The 1973-74 directory of members of the Gray and Ductile Iron Founders Society, Inc. lists 186 foundries. The monthly average production of these foundries was calculated to be about 1125 MT of finished castings giving an average annual production of 13,500 MT. Using data from "The Metal Casting Industry Census Guide" (1972 Edition, published by Penton Publishing Co., Cleveland, Ohio), the average annual production for all gray and ductile iron foundries (an estimated 1300 to 1500 foundries) was calculated to be about 9,250 MT. Thus, a reasonable capacity figure for a typical gray and ductile iron foundry plant would be about 11,000 net tons per year.

Steel foundries average about 5,440 MT of capacity per year and malleable iron foundries average about 12,700 MT per year.

Table 11 gives state by state, regional, and national shipments of the various type of ferrous castings for 1973. These figures are believed to reflect 1973 capacity. Iron and Steel foundries are concentrated in states heavy in manufacture of iron and steel and automobiles and heavy industrial equipment which are principal consumers of foundry castings.

2.2 WASTE CHARACTERIZATION

This section contains descriptions of production technology at ferrous foundries and the resultant byproducts or wastes which are either recycled directly, reprocessed, or disposed of on land or in lagoons.

* amount of metal smelted for finished castings exceeds net output of castings products.

TABLE 11

STATE, REGIONAL, AND NATIONAL SHIPMENTS OF IRON AND STEEL CASTINGS, 1973*
(METRIC TONS)

State	Gray & Ductile Iron Castings	Malleable Iron Castings	Steel Casting	Total Iron & Steel Castings
Alabama	1,543,121	17,237	87,090	1,647,448
Arizona	0	0	58,060	58,060
California	412,769	0	60,781	473,550
Colorado	98,883	0	5,443	104,326
Connecticut	35,380	8,165	0	43,545
Delaware	0	0	6,350	6,350
Florida	9,072	0	10,886	19,958
Georgia	10,886	0	6,350	17,236
Illinois	1,364,406	118,841	236,775	1,720,022
Indiana	970,688	35,380	72,575	1,078,643
Iowa	368,317	9,072	23,587	400,976
Kansas	10,886	0	59,874	70,760
Kentucky	291,206	0	0	291,206
Lousiana	9,072	0	12,701	21,773
Maryland	72,575	0	6,350	78,925
Massachusetts	59,870	1,814	0	61,684
Michigan	2,597,270	395,533	60,781	3,053,584
Minnesota	170,551	10,886	20,865	202,302
Missouri	63,503	0	49,895	113,398
Nebraska	10,886	0	13,608	24,494
New Jersey	347,452	0	6,350	353,802
New York	822,820	16,329	72,575	911,724
North Carolina	107,048	0	0	107,048
Ohio	2,255,260	128,820	318,422	2,702,502
Oklahoma	34,473	0	10,886	45,359
Oregon	9,979	0	32,659	42,638
Pennsylvania	1,954,980	111,584	221,353	2,287,917
Rhode Island	28,120	3,629	0	31,749

TABLE 11 (cont.)

STATE, REGIONAL, AND NATIONAL SHIPMENTS OF IRON AND STEEL CASTINGS, 1973* (METRIC TONS)

State	Gray & Ductile Iron Castings	Malleable Iron Castings	Steel Castings	Total Iron & Steel Castings
South Carolina	25,401	0	0	25,401
South Dakota	0	0	2,722	2,722
Tennessee	378,296	0	37,195	387,368
Texas	495,323	29,030	42,638	566,991
Utah	196,859	0	9,072	205,931
Vermont	9,980	907	0	10,887
Virginia	162,386	0	5,443	167,829
Washington	9,072	0	26,308	35,380
West Virginia	74,389	1,814	9,979	86,182
Wisconsin	453,592	46,266	130,635	630,493
<u>EPA Region</u>				
I	133,350	14,515	0	147,865
II	1,170,272	16,329	78,925	1,265,526
III	2,264,330	113,398	249,475	2,627,203
IV	2,365,030	17,237	141,521	2,523,788
V	7,811,767	735,726	840,053	9,387,546
VI	538,868	29,030	66,225	634,123
VII	453,592	9,072	146,964	609,628
VIII	295,742	0	17,237	312,979
IX	412,769	0	118,841	531,610
X	19,051	0	58,967	78,018
U.S. Total	15,464,771	935,307	1,718,208	18,118,286

* Believed to Reflect U.S. Production Capacity in 1973

Estimates are given for the quantities of wastes and potentially hazardous constituents thereof which are disposed of on land either in lagoons, landfills or open dumps.

2.2.1 Process Descriptions

While specific procedures might vary from foundry to foundry, the overall operations for producing iron castings, malleable iron castings, and steel castings are essentially the same and include: sand preparation, mold and core making, metal melting and pouring, casting shakeout, and cleaning and finishing. The interrelationship between major operations in a typical foundry is shown in Figure 2. Also shown are the major sources of solid wastes. Although not all foundries practice sand reclamation, its use has become sufficiently widespread in the industry to require its inclusion in Figure 2.

Clay bonded molding sands are prepared by mixing silica sand, organic additives, bentonite clay and water together. Some foundries use olivine, zircon, chromite, biasill or other aggregates instead of silica sand. Carbonaceous material in the amount of 2 to 10 percent is also added to the molding sand as may be required to impart special properties. Materials in this category include finely ground bituminous coal, ground corn flower, fuel oil, and finely ground cellulose material.

The molds are made by packing the molding sand around previously made patterns to form the required shapes. For castings having hollows or recesses, cores are required to complete the mold. Since the cores must be removed after the castings have solidified, the core sands have special properties that facilitate their removal. The desired properties are achieved through the use of special binders, the most common of which are: (1) combinations of vegetable, fish and petroleum oils; (2) phenol formaldehyde resin, (3) sodium silicate; (4) phenolic isocyanate; (5) alkyd isocyanate; and (6) mixtures of urea and furfural alcohols. The first item is generally baked to promote hardening, and items 2 and 6 are generally heat-cured. The difference is that baking is done at the rate of approximately one hour per inch of thickness while curing is done in a matter of 30 to 60 seconds at approximately the same temperature. In the case of sodium silicate binders, hardening is achieved by forcing CO_2 gas through the sand. For the isocyanate binders setting occurs at room temperature through the use of special catalysts. For the urea-furfural alcohol binders, setting is possible at room temperature or higher depending on the type of catalyst used. With the successful use of the newer core binders that do not require high temperatures for setting, it appears that fewer and fewer foundries will continue the practice of core baking.

In addition to special binders, certain other materials are frequently used in preparing core sands. These include: iron oxide, ground corn flour; water soluble compounds of wood sugar; coke pitch; and ground hardwood cellulose. These materials facilitate removal of cores.

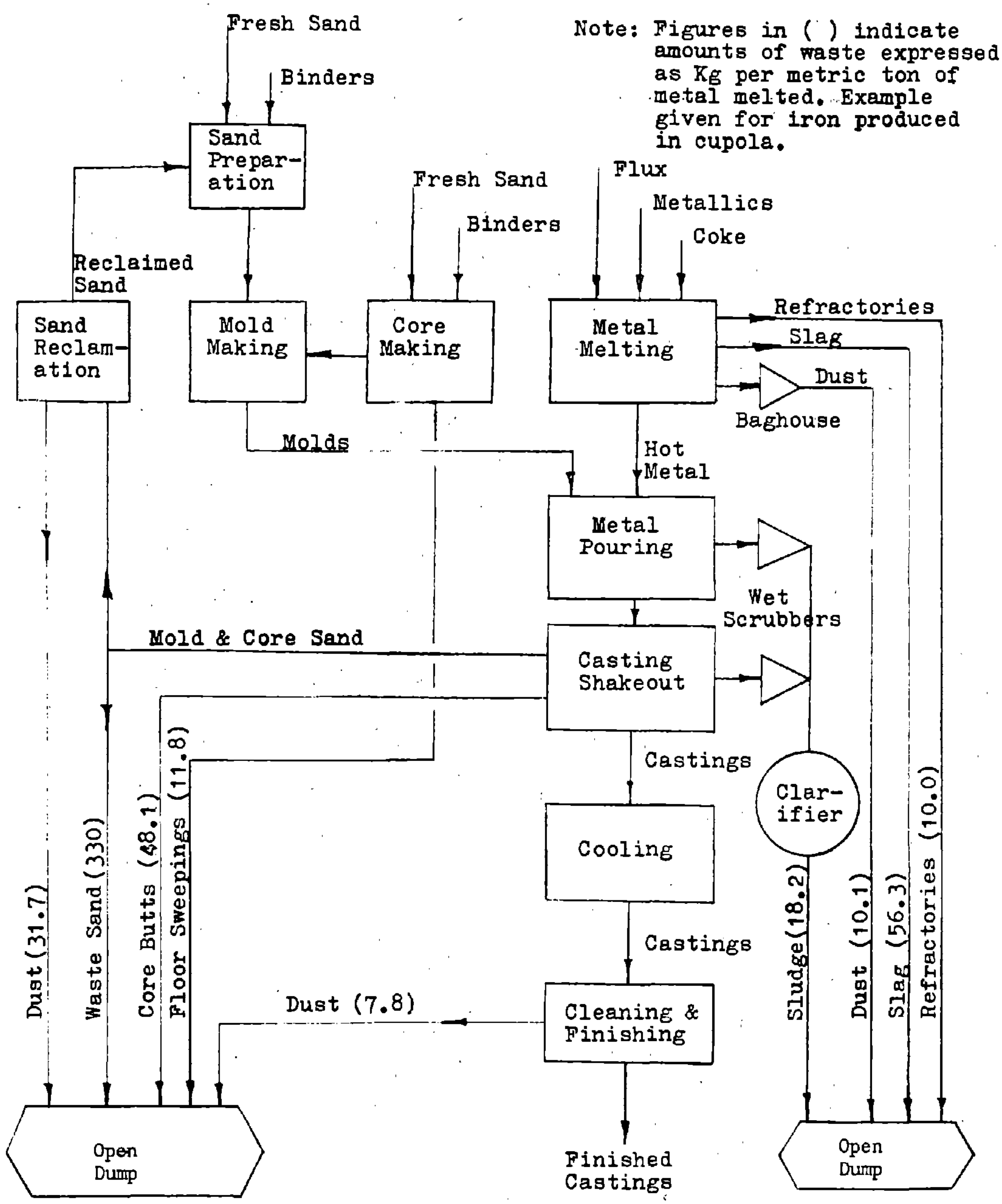

Figure 2 - Foundry Operations

Once the cores are formed and cured, they are integrated with the final molds which are then transferred to the metal pouring area. Molten metal of the desired composition is prepared in one of several different types of commonly used furnaces. Charge materials for the cupola furnace usually consist of a flux material, coke, and metallics. Electric arc or induction furnaces do not require coke. Typical fluxes include limestone ($CaCO_3$), fluorspar (mostly CaF_2), and soda ash ($Na_2C)_3$). The metallic charge consists mainly of external scrap and some internally generated scrap. For producing gray and ductile iron castings, cupolas and electric induction furnaces are the most widely used, with cupolas accounting for an estimated 60 to 65 percent of total production. Reverberatory furnaces account for one percent or less of gray and ductile iron castings. Most malleable iron castings are produced in cupolas and electric induction furnaces, although a number of air furnaces are still in operation. Electric arc furnaces account for almost all of the steel castings produced with electric induction furnaces accounting for probably less than 5 percent.

The molten metal is tapped from the furnaces into ladles and poured into the waiting molds. After the castings have solidified they are separated from the molds in the shakeout area. The separated castings are then cooled prior to cleaning and finishing. Cleaning and finishing operations include shot blasting, chipping and grinding.

Following casting shakeout, the mold and core sands are screened. Larger remnants of undisintegrated cores (core butts) and larger chunks of molding sand are transferred to a disposal area. Most of the molding sand, along with the degraded core sand, proceed directly back to molding sand preparation without going through sand reclamation (i.e., this sand is recycled, rather than being reclaimed). In some foundries a portion of this return sand is bypassed through a reclamation system and then returned to either the core or molding sand mixing operation. In the case of no-bake sands, most of the sand from the shakeout may be returned through the sand reclamation unit before recoating. Excess sand is sent to landfill.

2.2.2 Description of Waste Streams

The major types of solid wastes generated at iron and steel foundries were indicated in Figure 2. The general types of waste generated are essentially independent of the type of metal being cast and the type of furnace in use. On the other hand, metal type and furnace type can affect the quantities of waste produced. The numbers in parentheses in Figure 2 indicate the amounts of waste in each category expressed as kilograms of waste per ton of metal melted. The numbers correspond to an average plant producing iron in a cupola. The values are given on the basis of a ton of metal melted rather than on the basis of a ton of finished castings, because yield factors (weight of finished casting/weight of metal melted) vary depending on the foundry and the type of metal cast. For iron (gray, ductile and malleable) the yield factor is generally in the range of 0.6 to 0.7, while for steel values of 0.5 are common. For the purpose of computing total waste quantities for an average iron foundry, a yield factor of 0.65 would be reasonable. Thus, a typical iron foundry would melt about 11,000/0.65 = 16,900 tons of metal per year (15,300 metric tons/year).

Waste Sand. As stated previously and shown in Figure 2 there are two types of waste sand. One type is the clay bonded molding sand used in interior parts of the mold. Combined production of the two types of waste sand is 330 kg/MT of cast product. Although these sands have different organic additives as described on page 72 the organic fractions are burned and charred during the pouring of molten metal leaving principally sand coated with carbon residues and traces of metal compounds including copper, lead, chromium and zinc. Solubility tests on spent foundry sand as described in Appendix B did not show significant leaching of heavy metals or phenol. For this reason foundry sands are not considered potentially hazardous at this time.

Core Butts. After the metal pouring process most of the sand is devoid of binder and has little aggregation. Quite often portions of the core sand retain its binder. It is removed as large chunks known as core butts and brought to dumping areas. Core butts are generated at a rate of 48.1 kg/MT of casted metal. Although solubility testing on core butts was not conducted it is not expected to leach to a greater extent than spent sand. Core butts are therefore not considered potentially hazardous at this time.

Dust. Dust is generated at a rate of 31.7 kg/MT of foundry product from the sand reclamation process and from baghouuses on metal milling furnaces. Dust will principally be silica oxides and iron oxides with traces of heavy metals including lead, cadmium, copper chromium, nickel, and zinc. Solubility tests on foundry dust as described in Appendix B did not show significant leaching of potentially hazardous metals. For this reason foundry dust is not considered potentially hazardous at this time.

Sludges. Wet scrubbers used to scrub emissions from metal pouring operations produces a wastewater which in turn produces a sludge at a rate of 18.2 kg/MT cast metal product. This sludge will contain iron for the most part along with traces of cadmium, copper, chromium, nickel, lead and zinc. Solubility tests were not conducted on sludges. They would be expected to be of similar composition and nature as furnace dusts however which were studied in solubility tests as described in Appendix B. Since the dusts did not leach significant concentrations of toxic constituents sludge was assumed to be of a similar solubility and therefore is considered as not potentially hazardous at this time.

Slag. Slag from iron and scrap steel furnace smelting is produced at a rate of 56.3 kg/MT of finished iron and steel casting. The gravel size to sand size pieces of slag contains iron, lime and soda ash principally, with small traces of heavy metals including cadmium, copper, chromium, nickel, lead and zinc. Solubility tests as described in Appendix B did not show significant leaching of potentially toxic constituents. For this reason furnace slag from iron and steel foundries is not considered hazardous at this time.

Floorsweepings. Cleanup of floors in core making rooms results in sandy floor sweepings at a rate of 11.8 kg/MT of product. This is assumed similar to other waste sands and therefore non-hazardous at this time. Solubility tests were not conducted on floor sweepings.

Refractories. Broken and weathered brick refractories from metal melting furnaces are generated at a rate of 10 kg/MT of finished castings. These bricks are predominantly highly insoluble fired clay ceramic and are not considered potentially hazardous.

Appendix A gives analyses of iron and steel foundry wastes including sands, dust and slag.

2.2.3 Waste Quantities

Table 12 gives generation factors for the various residuals from iron and steel foundry production as well as concentration factors for potentially hazardous constituents. The waste residual factors given in Table 12 are estimated average values for all foundries in each of the three major foundry categories. In developing the waste factors, consideration was given to the different types of furnaces used in each metal category and to the different types of furnace emission control systems. For example, gray and ductile iron is made in cupola furnaces and electric induction furnaces in the ratio of about 3 to 2. Control for cupola furnace emissions is devided about equally between wet and dry systems, while electric induction furnaces generally require no emission control.

In generating the overall waste factors, the computation of sludges, and dusts and slag accounted for the percentage of castings within a given category made from a specific type of furnace with a specific type of control by weighing the waste factors for specific combinations according to the frequency of their occurrence.

Table 13 presents the amounts of wastes and the amounts of specific potentially hazardous constituents generated annually for an average plant in each of the three major foundry categories. The amounts shown were calculated using the waste factors given in Table 12 and taking the following average annual production figures for finished castings for each type of foundry: (a) gray and ductile iron foundries - 10,000 metric tons, (b) malleable iron foundries - 12,700 metric tons; and (c) steel foundries - 5,400 metric tons.

The quantity of waste generated by ferroalloy plants on a state-by-state basis are given in Table 14 for 1974, 1977, and 1983. The quantities of sludges and dusts are based directly on information derived from a solid waste survey sponsored by the Ferroalloy Association in which the quantities of wastes from furnace emission control were tabulated for each state for each type of ferroalloy. The sludges result from the collection of furnace emissions using wet scrubbing systems. The dusts represent the furnace

TABLE 12

WASTE GENERATION FACTORS, IRON AND STEEL FOUNDRIES, DRY WEIGHTS

Type of Waste	Generation Factor Kg/MT of Finished Casting	Concentration Factors (ppm)							
		Cd	Cu	Cr	Mn	Ni	Pb	Zn	Phenol
<u>Gray & Ductile Iron Foundries</u>									
Slag	62.9	1.0	23.1	36.6	1410	10.0	6.6	14.7	--
Sludge	32.8	2.0	146	47.6	826	5.3	134	423	--
Dust	65.6	>0.7	79.9	60.3	1075	>28	75.5	144.5	--
Sand	600	--	8.3	4.8	52.9	28.1	53.6	6.0	1.1
Refractories	13.8	--	--	--	--	--	--	--	--
<u>Malleable Iron Foundries</u>									
Slag	55.5	1.0	25.4	46.1	1730	10.0	7.4	17.0	--
Sludge	31.9	2.0	146	48.0	749	4.4	133	393	--
Dust	64.7	>0.7	79.3	60.7	1041	>28	74.3	126	
Sand	600	--	8.3	4.8	52.9	28.1	53.6	6.0	1.1
Refractories	13.2	--	--	--	--	--	--	--	--
<u>Steel Foundries</u>									
Slag	122	1.0	52	150	5200	--	16	42	--
Sludge	36.4	2.3	150	50	375	--	130	250	--
Dust	186	>1.4	224	105	2806	>85	187	158	--
Sand	780	--	8.3	4.8	52.9	28.1	53.6	6.0	1.1
Refractories	53.0	--	--	--	--	--	--	--	--

TABLE 13

YEARLY GENERATION OF WASTE RESIDUALS - BY TYPICAL IRON AND STEEL FOUNDRIES, DRY WEIGHTS

Type of Waste	Total Waste Quantity (MT)	Quantity of Potentially Hazardous Constituents (MT)							
		Cd	Cu	Cr	Mn	Ni	Pb	Zn	Phenol
Gray & Ductile Iron Foundries[a)]									
Slag	629	0.0006	0.0145	0.0230	0.8870	0.0063	0.0042	0.0092	--
Sludge	328	0.0007	0.0479	0.0156	0.2710	0.0017	0.0440	0.1390	--
Dust	656	>0.0005	0.0524	0.0396	0.7050	>0.0180	0.0495	0.0948	--
Sand	6000	--	0.0498	0.0288	0.3170	0.1690	0.3220	0.0360	0.0066
Refractories	138	--	--	--	--	--	--	--	--
a) Based on production of 10,000 MT/yr of finished castings, multiply by 1.1 to convert to short tons									
Malleable Iron Foundries[b)]									
Slag	704	0.0007	0.0179	0.0325	1.218	0.0070	0.0052	0.0120	--
Sludge	405	0.0008	0.0591	0.0194	0.3030	0.0018	0.0539	0.1590	--
Dust	822	>0.0006	0.6520	0.0499	0.8560	>0.0230	0.0611	0.1040	--
Sand	7620	--	0.0632	0.0366	0.4030	0.2140	0.4080	0.0457	--
Refractories	168	--	--	--	--	--	--	--	--
b) Based on production of 12,700 MT/yr of finished castings, multiply by 1.1 to convert to short tons									
Steel Foundries[c)]									
Slag	659	0.0007	0.0343	0.0989	3.427	--	0.0105	0.0277	--
Sludge	197	0.0005	0.0296	0.0099	0.0739	--	0.0256	0.0493	--
Dust	1004	>0.0014	0.2250	0.1050	2.817	>0.085	0.188	0.159	--
Sand	4212	--	0.0350	0.0202	0.2230	0.1180	0.2260	0.0253	0.0046
Refractories	286	--	--	--	--	--	--	--	--
c) Based on production of 5400 MT/yr of finished castings, multiply by 1.1 to convert to short tons									

Table 14a

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES TOTAL SLAG, 1974 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	CONSTITUENTS						
					Cd	Cu	Cr	Mn	Ni	Pb	Zn
ALABAMA	122,400	0	0	LANDFILL OR OPEN DUMP	0.122	3.16	5.80	217.7	1.22	0.92	2.12
ARIZONA	7,800				0.008	0.41	1.17	40.7	0.08	0.13	0.33
CALIFORNIA	37,500				0.038	1.10	2.30	84.0	0.38	0.33	0.78
COLORADO	7,800				0.008	0.2	0.37	13.7	0.08	0.06	0.13
CONNECTICUT	3,040				0.003	0.07	0.12	4.5	0.03	0.02	0.06
DELAWARE	860				0.001	0.04	0.13	4.4	0.01	0.01	0.04
FLORIDA	2,110				0.002	0.09	0.24	8.5	0.02	0.03	0.07
GEORGIA	1,630				0.002	0.09	0.16	5.5	0.02	0.02	0.05
ILLINOIS	136,500				0.137	4.09	8.67	316.1	1.37	1.20	2.80
INDIANA	81,000				0.081	2.16	4.09	152.2	0.81	0.63	1.46
IOWA	28,900				0.029	0.78	1.46	54.5	0.29	0.23	0.53
KANSAS	8,850				0.009	0.44	1.24	43.1	0.09	0.13	0.35
KENTUCKY	20,680				0.020	0.48	0.76	29.2	0.20	0.14	0.30
LOUISIANA	2,360				0.002	0.10	0.28	9.8	0.02	0.03	0.08
MARYLAND	6,010				0.006	0.16	0.32	11.7	0.06	0.05	0.11
MASSACHUSETTS	4,370				0.004	0.10	0.16	6.2	0.04	0.03	0.06
MICHIGAN	218,200				0.218	5.32	9.15	347.3	2.18	1.54	3.49
MINNESOTA	15,600				0.016	0.44	0.90	32.9	0.16	0.13	0.31
MISSOURI	11,240				0.011	0.45	1.17	41.3	0.11	0.14	0.35
NEBRASKA	2,600				0.003	0.11	0.30	10.6	0.03	0.03	0.09
NEW JERSEY	25,500				0.026	0.61	1.03	39.3	0.26	0.18	0.40
NEW YORK	69,300				0.070	1.88	3.66	135.2	0.70	0.56	1.29
N. CAROLINA	7,600				0.008	0.18	0.28	10.7	0.08	0.05	0.11
OHIO	211,400				0.211	6.13	12.66	463.7	2.11	1.81	4.30
OKLAHOMA	3,920				0.004	0.13	0.31	11.1	0.04	0.04	0.10
OREGON	5,110				0.005	0.25	0.69	23.9	0.05	0.08	0.20
PENNSYLVANIA	175,900				0.176	4.93	9.87	363.7	1.76	1.45	3.42
RHODE ISLAND	2,230				0.002	0.05	0.08	3.2	0.02	0.01	0.03
S. CAROLINA	1,800				0.002	0.04	0.07	2.5	0.02	0.01	0.03
S. DAKOTA	370				~ 0	0.02	0.05	1.9	~ 0	~ 0	0.02
TENNESSEE	31,880				0.032	0.88	1.73	64.0	0.32	0.26	0.61
TEXAS	42,800				0.043	1.16	2.23	82.8	0.43	0.34	0.79
UTAH	15,200				0.015	0.39	0.70	26.1	0.15	0.11	0.28
VERMONT	770				0.001	0.02	0.03	1.1	0.01	0.01	0.01
VIRGINIA	12,270				0.012	0.30	0.53	20.1	0.12	0.09	0.20
WASHINGTON	4,200				0.004	0.20	0.55	19.3	0.04	0.06	0.16
W. VIRGINIA	6,750				0.007	0.20	0.40	14.7	0.07	0.06	0.14
WISCONSIN	52,800				0.053	1.73	3.95	142.2	0.53	0.52	1.26
EPA REGION											
I	10,410				0.010	0.24	0.39	15.0	0.10	0.07	0.15
II	94,800				0.096	2.49	4.68	174.5	0.96	0.73	1.69
III	201,790				0.202	5.63	11.25	414.6	2.02	1.66	3.91
IV	188,100				0.188	4.89	9.04	338.1	1.88	1.43	3.29
V	715,500				0.718	19.87	39.42	1,454.4	7.18	5.83	13.72
VI	49,080				0.049	1.38	2.82	103.7	0.49	0.41	0.97
VII	52,590				0.052	1.78	4.17	149.5	0.52	0.63	1.32
VIII	23,370				0.023	0.61	1.12	41.7	0.23	0.17	0.41
IX	45,300				0.046	1.51	3.47	124.7	0.46	0.46	1.11
X	9,310				0.009	0.45	1.24	43.2	0.09	0.14	0.38
NATIONAL TOTALS	1,390,250				1.390	38.90	77.60	2,859.4	13.90	11.40	26.90

*FOUNDRY SLAG NOT CONSIDERED HAZARDOUS ON BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B.

SOURCE: CALSPAN CORPORATION

Table 14b

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES TOTAL SLAG, 1977 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	CONSTITUENTS						
					Cd	Cu	Cr	Mn	Ni	Pb	Zn
ALABAMA	135,374	0	0	LANDFILL OR OPEN DUMP	0.135	3.49	6.41	240.8	1.35	1.02	2.34
ARIZONA	8,627				0.009	0.45	1.29	45.0	0.09	0.14	0.36
CALIFORNIA	41,475				0.042	1.2	2.64	92.9	0.42	0.38	0.86
COLORADO	8,627				0.009	0.2	0.41	15.2	0.09	0.07	0.14
CONNECTICUT	3,362				0.003	0.08	0.13	5.0	0.03	0.02	0.06
DELAWARE	951				0.001	0.04	0.14	4.9	0.01	0.01	0.04
FLORIDA	2,334				0.002	0.10	0.26	9.4	0.02	0.03	0.08
GEORGIA	1,803				0.002	0.07	0.18	6.1	0.02	0.02	0.06
ILLINOIS	150,969				0.162	4.52	9.69	349.6	1.52	1.33	3.21
INDIANA	89,586				0.090	2.39	4.62	169.3	0.90	0.70	1.61
IOWA	33,069				0.032	0.86	1.61	60.3	0.32	0.25	0.59
KANSAS	9,788				0.010	0.49	1.37	47.7	0.10	0.14	0.39
KENTUCKY	22,872				0.022	0.53	0.84	32.3	0.22	0.15	0.33
LOUISIANA	2,610				0.002	0.11	0.31	10.8	0.02	0.03	0.09
MARYLAND	6,647				0.007	0.18	0.35	12.9	0.07	0.06	0.12
MASSACHUSETTS	4,833				0.004	0.11	0.18	6.8	0.04	0.03	0.07
MICHIGAN	241,329				0.241	5.88	10.12	384.1	2.41	1.70	3.86
MINNESOTA	17,254				0.018	0.49	1.00	36.4	0.18	0.14	0.34
MISSOURI	12,431				0.012	0.50	1.29	45.7	0.12	0.16	0.39
NEBRASKA	2,876				0.003	0.12	0.33	11.7	0.03	0.03	0.10
NEW JERSEY	28,203				0.028	0.67	1.14	43.5	0.29	0.20	0.44
NEW YORK	76,646				0.077	2.08	4.04	149.5	0.77	0.61	1.43
N. CAROLINA	8,406				0.009	0.20	0.31	11.8	0.09	0.06	0.12
OHIO	233,808				0.233	6.78	14.00	512.8	2.33	2.00	4.76
OKLAHOMA	4,336				0.004	0.14	0.34	12.3	0.04	0.04	0.11
OREGON	5,652				0.006	0.28	0.76	26.4	0.06	0.09	0.22
PENNSYLVANIA	194,545				0.195	5.45	10.92	402.2	1.95	1.60	3.78
RHODE ISLAND	2,466				0.002	0.06	0.09	3.5	0.02	0.01	0.03
S. CAROLINA	1,991				0.002	0.04	0.08	2.8	0.02	0.01	0.03
S. DAKOTA	409				~0	0.02	0.06	2.1	~0	~0	0.02
TENNESSEE	35,259				0.036	0.97	1.91	70.8	0.35	0.29	0.67
TEXAS	47,337				0.048	1.28	2.47	91.6	0.48	0.38	0.87
UTAH	16,811				0.017	0.43	0.77	28.9	0.16	0.12	0.29
VERMONT	852				0.001	0.02	0.03	1.2	0.01	0.01	0.01
VIRGINIA	13,571				0.013	0.33	0.59	22.2	0.13	0.10	0.22
WASHINGTON	4,645				0.004	0.22	0.61	21.3	0.04	0.07	0.18
W. VIRGINIA	7,466				0.008	0.22	0.44	16.2	0.08	0.07	0.15
WISCONSIN	58,397				0.059	1.91	4.37	157.3	0.59	0.58	1.39
EPA REGION											
I	11,513				0.011	0.26	0.43	16.6	0.11	0.08	0.16
II	104,849				0.106	2.75	5.18	193.0	1.06	0.81	1.87
III	223,180				0.223	6.23	12.44	458.5	2.23	1.84	4.32
IV	208,039				0.208	5.41	10.00	373.9	2.08	1.58	3.64
V	791,343				0.792	21.98	43.60	1,608.6	7.92	6.45	15.17
VI	64,282				0.054	1.64	3.12	114.7	0.54	0.45	1.07
VII	58,165				0.058	1.87	4.61	165.3	0.58	0.59	1.46
VIII	25,847				0.026	0.67	1.24	48.1	0.25	0.19	0.45
IX	50,102				0.051	1.87	3.84	137.9	0.51	0.51	1.23
X	10,297				0.010	0.50	1.37	47.8	0.10	0.15	0.40
NATIONAL TOTAL	1,537,616				1.54	43.0	85.8	3,162.5	15.4	12.6	29.8

*FOUNDRY SLAG NOT CONSIDERED HAZAROOUS ON BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B.

SOURCE: CALSPAN CORPORATION

Table 14c

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES TOTAL SLAG, 1983 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	CONSTITUENTS						
					Cd	Cu	Cr	Mn	Ni	Pb	Zn
ALABAMA	166,800	0	0	LANDFILL OR OPEN DUMP	0.166	4.31	7.90	296.7	1.66	1.26	2.89
ARIZONA	10,600				0.011	0.56	1.59	55.5	0.11	0.18	0.45
CALIFORNIA	51,100				0.052	1.50	3.13	114.5	0.52	0.46	1.06
COLORADO	10,600				0.011	0.30	0.50	18.7	0.11	0.08	0.18
CONNECTICUT	4,140				0.004	0.10	0.16	6.1	0.04	0.03	0.07
DELAWARE	1,170				0.001	0.05	0.18	6.0	0.01	0.01	0.06
FLORIDA	2,880				0.003	0.12	0.33	11.8	0.03	0.04	0.10
GEORGIA	2,220				0.003	0.08	0.22	7.5	0.03	0.03	0.07
ILLINOIS	186,100				0.187	5.57	11.82	430.8	1.87	1.64	3.95
INDIANA	110,400				0.110	2.94	5.57	207.4	1.10	0.86	1.99
IOWA	40,800				0.040	1.06	1.99	74.3	0.40	0.31	0.72
KANSAS	12,100				0.012	0.60	1.69	58.7	0.12	0.18	0.48
KENTUCKY	26,190				0.027	0.65	1.04	39.8	0.27	0.19	0.41
LOUISIANA	3,220				0.003	0.14	0.38	13.4	0.03	0.04	0.11
MARYLAND	8,190				0.008	0.22	0.44	15.9	0.08	0.07	0.15
MASSACHUSETTS	5,960				0.005	0.14	0.22	8.4	0.05	0.04	0.08
MICHIGAN	297,400				0.297	7.25	12.47	473.4	2.97	2.10	4.76
MINNESOTA	21,300				0.022	0.60	1.23	44.8	0.22	0.18	0.42
MISSOURI	15,320				0.015	0.61	1.59	56.3	0.15	0.19	0.48
NEBRASKA	3,540				0.004	0.15	0.41	14.4	0.04	0.04	0.12
NEW JERSEY	34,800				0.035	0.83	1.40	53.6	0.35	0.24	0.54
NEW YORK	94,500				0.095	2.56	4.97	184.3	0.95	0.75	1.76
N. CAROLINA	10,400				0.011	0.24	0.38	14.6	0.11	0.07	0.15
OHIO	288,100				0.288	8.36	17.26	632.0	2.88	2.47	5.86
OKLAHOMA	5,340				0.005	0.18	0.42	15.1	0.05	0.05	0.14
OREGON	6,970				0.007	0.34	0.94	32.6	0.07	0.11	0.27
PENNSYLVANIA	239,800				0.240	6.72	13.45	495.7	2.40	1.98	4.66
RHODE ISLAND	3,040				0.003	0.07	0.11	4.4	0.03	0.01	0.04
S. CAROLINA	2,450				0.003	0.05	0.10	3.4	0.03	0.01	0.04
S. DAKOTA	504				~0	0.03	0.07	2.6	~0	~0	0.03
TENNESSEE	43,450				0.044	1.20	2.36	87.2	0.44	0.35	0.83
TEXAS	58,300				0.059	1.58	3.04	112.8	0.59	0.46	1.08
UTAH	20,700				0.020	0.53	0.95	35.6	0.20	0.15	0.35
VERMONT	1,050				0.001	0.03	0.04	1.5	0.01	0.01	0.01
VIRGINIA	16,700				0.016	0.41	0.72	27.4	0.16	0.12	0.27
WASHINGTON	5,730				0.005	0.27	0.75	26.3	0.05	0.08	0.22
W. VIRGINIA	9,200				0.010	0.27	0.54	20.0	0.10	0.08	0.19
WISCONSIN	72,000				0.072	2.36	5.38	193.8	0.72	0.71	1.72
EPA REGION											
I	14,190				0.014	0.33	0.63	20.4	0.14	0.10	0.20
II	129,300				0.131	3.39	5.38	237.8	1.31	1.00	2.30
III	275,060				0.275	7.67	15.33	565.1	2.75	2.26	5.33
IV	256,390				0.256	6.66	12.32	480.8	2.56	1.95	4.48
V	975,300				0.976	27.08	53.73	1,982.3	9.76	7.85	18.70
VI	66,860				0.067	1.89	3.84	141.3	0.67	0.56	0.32
VII	71,760				0.071	2.43	5.66	203.8	0.71	0.72	1.80
VIII	31,804				0.031	0.83	1.53	56.8	0.31	0.23	0.56
IX	61,700				0.063	2.06	4.73	170.0	0.63	0.63	1.51
X	12,700				0.012	0.61	1.69	58.9	0.12	0.18	0.49
NATIONAL TOTAL	1,895,064				1.89	53.0	105.8	3,897.4	18.94	15.5	36.7

*FOUNDRY SLAG NOT CONSIDERED HAZARDOUS ON BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B.

SOURCE: CALSPAN CORPORATION

Table 14d

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES TOTAL SLUDGE, 1974 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	CONSTITUENTS						
					Cd	Cu	Cr	Mn	Ni	Pb	Zn
ALABAMA	61,250	0	0	OPEN DUMP AND LANDFILL	0.12	8.84	2.82	48.88	0.30	8.18	25.28
ARIZONA	2,350				0.01	0.35	0.12	0.88	NA	0.30	0.59
CALIFORNIA	17,750				0.04	2.59	0.85	13.54	0.08	2.36	7.07
COLORADO	3,900				0.01	0.57	0.19	3.11	0.02	0.52	1.60
CONNECTICUT	1,600				0	0.24	0.08	1.31	0.01	0.22	0.67
DELAWARE	250				0	0.04	0.01	0.10	NA	0.03	0.06
FLORIDA	800				0	0.11	0.04	0.44	~0	0.10	0.25
GEORGIA	650				0	0.10	0.03	0.43	~0	0.09	0.23
ILLINOIS	64,450				0.13	9.44	3.09	48.61	0.29	8.59	26.47
INDIANA	40,150				0.08	5.87	1.92	31.76	0.20	5.36	16.44
IOWA	14,900				0.03	2.18	0.71	11.87	0.07	1.99	6.13
KANSAS	2,800				0.01	0.42	0.14	1.24	~0	0.37	0.77
KENTUCKY	10,800				0.02	1.57	0.51	8.90	0.06	1.44	4.56
LOUISIANA	850				0	0.13	0.04	0.47	~0	0.11	0.27
MARYLAND	2,950				0.01	0.43	0.14	2.32	0.01	0.39	1.20
MASSACHUSETTS	2,300				0	0.33	0.11	1.88	0.01	0.31	0.96
MICHIGAN	113,250				0.22	16.52	5.40	91.33	0.67	15.14	47.03
MINNESOTA	7,550				0.02	1.11	0.36	5.83	0.04	1.01	3.04
MISSOURI	4,350				0.01	0.64	0.21	2.70	0.01	0.58	1.50
NEBRASKA	950				~0	0.14	0.05	0.54	~0	0.13	0.31
NEW JERSEY	13,100				0.03	1.91	0.62	10.72	0.07	1.75	5.50
NEW YORK	33,900				0.07	4.97	1.62	26.71	0.16	4.54	13.85
N. CAROLINA	3,950				0.01	0.58	0.20	3.27	0.02	0.53	1.68
OHIO	101,100				0.20	14.79	4.84	77.36	0.46	13.48	40.38
OKLAHOMA	1,700				~0	0.25	0.08	1.22	0.01	0.23	0.65
OREGON	1,700				~0	0.25	0.08	0.80	~0	0.22	0.49
PENNSYLVANIA	85,400				0.17	12.49	4.09	66.23	0.40	11.40	34.45
RHODE ISLAND	1,200				~0	0.17	0.06	0.96	0.01	0.16	0.49
S. CAROLINA	950				~0	0.14	0.04	0.78	0.01	0.13	0.40
S. DAKOTA	100				~0	0.02	0.01	0.04	NA	0.01	0.03
TENNESSEE	15,500				0.03	2.27	0.74	12.13	0.07	2.07	6.30
TEXAS	21,100				0.04	3.09	1.01	16.60	0.10	2.82	8.61
UTAH	7,650				0.02	1.12	0.36	6.16	0.04	1.02	3.17
VERMONT	400				~0	0.06	0.02	0.33	~0	0.05	0.17
VIRGINIA	6,200				0.01	0.91	0.30	5.05	0.03	0.83	2.60
WASHINGTON	1,400				~0	0.21	0.07	0.68	~0	0.18	0.41
W. VIRGINIA	3,200				0.01	0.47	0.16	2.48	0.01	0.43	1.29
WISCONSIN	23,800				0.05	3.49	1.14	17.13	0.10	3.16	8.09
EPA REGION											
I	5,500				~0	0.80	0.27	4.48	0.03	0.74	2.29
II	47,000				0.10	6.88	2.24	37.43	0.23	6.29	19.35
III	98,000				0.20	14.34	4.69	76.18	0.45	13.08	39.80
IV	93,900				0.18	13.71	4.48	74.93	0.46	12.55	38.70
V	350,300				0.70	51.22	16.75	272.02	1.66	46.74	141.45
VI	23,650				0.04	3.47	1.13	18.29	0.11	3.16	9.63
VII	23,000				0.05	3.38	1.11	18.35	0.08	3.07	9.71
VIII	11,650				0.03	1.71	0.56	9.31	0.06	1.55	4.80
IX	20,100				0.05	2.94	0.97	14.42	0.08	2.66	7.66
X	3,100				~0	0.46	0.15	1.48	~0	0.40	0.90
NATIONAL TOTALS	676,200				1.40	98.90	32.40	524.90	3.16	90.2	273.00

*FOUNDRY SLUDGE NOT CONSIDERED HAZARDOUS ON BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B.

SOURCE: CALSPAN CORPORATION

Table 14e

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES TOTAL SLUDGE, 1977 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	CONSTITUENTS						
					Cd	Cu	Cr	Mn	Ni	Pb	Zn
ALABAMA	67,740	0	0	OPEN DUMP AND LANDFILL	0.13	9.89	3.23	54.17	0.33	9.06	27.96
ARIZONA	2,600				0.01	0.39	0.13	0.97	NA	0.33	0.65
CALIFORNIA	19,630				0.04	2.86	0.94	14.98	0.09	2.61	7.82
COLORADO	4,315				0.01	0.63	0.21	3.44	0.02	0.58	1.77
CONNECTICUT	1,770				~0	0.27	0.09	1.45	0.01	0.24	0.74
DELAWARE	280				~0	0.04	0.01	0.11	NA	0.03	0.07
FLORIDA	885				~0	0.12	0.04	0.49	~0	0.11	0.28
GEORGIA	720				~0	0.11	0.03	0.48	~0	0.10	0.25
ILLINOIS	71,280				0.14	10.44	3.42	53.76	0.32	9.50	28.17
INDIANA	44,410				0.09	6.49	2.12	35.13	0.22	5.83	18.18
IOWA	16,480				0.03	2.41	0.79	13.13	0.08	2.20	6.78
KANSAS	3,100				0.01	0.46	0.15	1.37	~0	0.41	0.85
KENTUCKY	11,945				0.02	1.74	0.56	9.84	0.07	1.59	5.04
LOUISIANA	940				~0	0.14	0.04	0.52	~0	0.12	0.30
MARYLAND	3,265				0.01	0.48	0.15	2.57	0.01	0.43	1.33
MASSACHUSETTS	2,545				~0	0.36	0.12	2.08	0.01	0.34	1.06
MICHIGAN	125,260				0.24	18.27	5.97	101.01	0.63	16.74	52.02
MINNESOTA	8,350				0.02	1.23	0.40	6.45	0.04	1.12	3.36
MISSOURI	4,810				0.01	0.71	0.23	2.99	0.01	0.64	1.66
NEBRASKA	1,050				~0	0.15	0.06	0.60	~0	0.14	0.34
NEW JERSEY	14,490				0.03	2.11	0.69	11.86	0.08	1.94	6.08
NEW YORK	37,500				0.08	5.50	1.79	29.54	0.18	5.02	15.32
N. CAROLINA	4,370				0.01	0.64	0.22	3.62	0.02	0.59	1.86
OHIO	111,820				0.22	16.36	5.35	85.56	0.51	14.91	44.66
OKLAHOMA	1,880				~0	0.28	0.09	1.35	0.01	0.25	0.72
OREGON	1,880				~0	0.28	0.09	0.88	~0	0.24	0.54
PENNSYLVANIA	94,450				0.19	13.81	4.52	73.25	0.44	12.61	38.10
RHODE ISLAND	1,330				~0	0.19	0.07	1.06	0.01	0.18	0.54
S. CAROLINA	1,050				~0	0.15	0.04	0.86	0.01	0.14	0.44
S. DAKOTA	110				~0	0.02	0.01	0.04	NA	0.01	0.03
TENNESSEE	17,140				0.03	2.51	0.82	13.42	0.08	2.29	6.97
TEXAS	23,340				0.04	3.42	1.12	18.36	0.11	3.12	9.52
UTAH	8,460				0.02	1.24	0.40	6.81	0.04	1.13	3.51
VERMONT	440				~0	0.07	0.02	0.36	~0	0.06	0.19
VIRGINIA	6,860				0.01	1.01	0.33	5.59	0.03	0.92	2.88
WASHINGTON	1,550				~0	0.23	0.08	0.75	~0	0.20	0.45
W. VIRGINIA	3,540				0.01	0.52	0.17	2.74	0.01	0.48	1.43
WISCONSIN	26,325				0.06	3.86	1.26	18.95	0.11	3.49	10.05
EPA REGION											
I	6,085				~0	0.88	0.30	4.95	0.03	0.82	2.53
II	58,955				0.11	7.61	2.48	41.40	0.25	6.96	21.40
III	108,395				0.22	15.86	5.19	84.26	0.50	14.47	43.80
IV	103,850				0.20	15.16	4.95	82.87	0.51	13.88	42.80
V	387,445				0.77	56.65	18.53	300.85	1.84	51.69	156.44
VI	26,160				0.04	3.84	1.25	20.23	0.12	3.49	10.54
VII	25,440				0.06	3.74	1.23	18.08	0.09	3.40	9.63
VIII	12,885				0.03	1.89	0.62	10.30	0.07	1.71	5.31
IX	22,230				0.06	3.25	1.07	15.95	0.09	2.94	8.47
X	3,430				~0	0.51	0.17	1.64	~0	0.44	1.00
NATIONAL TOTAL	754,875				1.5	109.4	35.8	580.5	3.5	99.6	301.9

*FOUNDRY SLUDGE NOT CONSIDERED HAZARDOUS ON BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B.

SOURCE: CALSPAN CORPORATION

Table 14f

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES TOTAL SLUDGE, 1983 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	CONSTITUENTS Cd	Cu	Cr	Mn	Ni	Pb	Zn
ALABAMA	83,480	0	0	OPEN DUMP AND LANDFILL	0.16	12.19	3.98	66.76	0.41	11.16	34.48
ARIZONA	3,200				0.01	0.48	0.16	1.20	NA	0.41	0.80
CALIFORNIA	24,190				0.05	3.53	1.16	18.46	0.11	3.22	9.64
COLORADO	5,320				0.01	0.78	0.26	4.24	0.03	0.71	2.18
CONNECTICUT	2,180				~0	0.33	0.11	1.79	0.01	0.30	0.91
DELAWARE	340				~0	0.05	0.01	0.14	NA	0.04	0.08
FLORIDA	1,090				~0	0.15	0.05	0.60	~0	0.14	0.34
GEORGIA	890				~0	0.14	0.04	0.59	~0	0.12	0.31
ILLINOIS	87,850				0.18	12.87	4.21	66.26	0.40	11.71	34.72
INDIANA	54,720				0.11	8.00	2.62	43.29	0.27	7.31	22.41
IOWA	20,310				0.04	2.97	0.97	16.18	0.10	2.71	8.36
KANSAS	3,820				0.01	0.57	0.19	1.69	~0	0.50	1.06
KENTUCKY	14,720				0.03	2.14	0.70	12.13	0.08	1.98	6.22
LOUISIANA	1,160				~0	0.18	0.05	0.64	~0	0.15	0.37
MARYLAND	4,020				0.01	0.59	0.19	3.16	0.01	0.53	1.64
MASSACHUSETTS	3,135				~0	0.45	0.15	2.56	0.01	0.42	1.31
MICHIGAN	154,360				0.30	22.52	7.38	124.48	0.78	20.64	64.10
MINNESOTA	10,290				0.03	1.51	0.49	7.95	0.05	1.38	4.14
MISSOURI	5,930				0.01	0.87	0.29	3.68	0.01	0.79	2.04
NEBRASKA	1,295				~0	0.19	0.07	0.74	~0	0.18	0.42
NEW JERSEY	17,860				0.04	2.60	0.85	14.61	0.10	2.39	7.50
NEW YORK	46,210				0.10	6.77	2.21	36.41	0.22	6.19	18.88
N. CAROLINA	5,380				0.01	0.79	0.27	4.48	0.03	0.72	2.28
OHIO	137,800				0.27	20.16	6.60	105.44	0.63	18.37	65.04
OKLAHOMA	2,320				~0	0.34	0.11	1.66	0.01	0.31	0.89
OREGON	2,320				~0	0.34	0.11	1.09	~0	0.30	0.67
PENNSYLVANIA	116,400				0.23	17.02	5.57	90.27	0.55	15.54	46.96
RHODE ISLAND	1,640				~0	0.23	0.08	1.31	0.01	0.22	0.67
S. CAROLINA	1,295				~0	0.19	0.05	1.06	0.01	0.18	0.55
S. DAKOTA	140				~0	0.03	0.01	0.06	NA	0.01	0.04
TENNESSEE	21,130				0.04	3.09	1.01	16.53	0.10	2.82	8.59
TEXAS	28,760				0.05	4.21	1.38	22.63	0.14	3.84	11.74
UTAH	10,430				0.03	1.53	0.49	8.40	0.05	1.39	4.32
VERMONT	545				~0	0.08	0.03	0.45	~0	0.07	0.23
VIRGINIA	8,450				0.01	1.24	0.41	6.88	0.04	1.13	3.54
WASHINGTON	1,910				~0	0.29	0.10	0.93	~0	0.26	0.56
W. VIRGINIA	4,360				0.01	0.64	0.20	3.38	0.01	0.59	1.76
WISCONSIN	32,440				0.07	4.76	1.55	23.35	0.14	4.31	12.39
EPA REGION											
I	7,500				~0	1.09	0.37	6.11	0.04	1.01	3.12
II	64,070				0.14	9.38	3.05	51.02	0.31	8.57	26.37
III	133,570				0.27	19.55	6.39	103.83	0.61	17.83	63.97
IV	127,985				0.25	18.69	6.11	102.13	0.63	17.11	52.75
V	477,460				0.85	69.81	22.83	370.76	2.29	63.71	192.80
VI	32,240				0.05	4.73	1.54	24.83	0.15	4.31	12.99
VII	31,355				0.07	4.61	1.51	22.29	0.11	4.18	11.87
VIII	15,890				0.04	2.33	0.76	12.69	0.08	2.11	6.54
IX	27,390				0.07	4.01	1.32	19.65	0.11	3.63	10.44
X	4,230				~0	0.63	0.20	2.02	~0	0.55	1.23
NATIONAL TOTAL	931,650				1.9	138.8	44.2	715.4	4.3	122.9	372.1

*FOUNDRY SLUDGE NOT CONSIDERED HAZARDOUS ON BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B.

SOURCE: CALSPAN CORPORATION

Table 14g

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES TOTAL DUST, 1974 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS*	DISPOSAL METHOD	CONSTITUENTS						
					Cd	Cu	Cr	Mn	Ni	Pb	Zn
ALABAMA	133,400	0	0	OPEN DUMP AND LANDFILL	0.13	13.64	9.03	174.50	4.46	11.84	19.53
ARIZONA	11,950				0.02	2.71	1.28	33.60	1.00	2.22	1.89
CALIFORNIA	43,300				0.06	5.34	3.22	88.01	1.83	4.57	6.40
COLORADO	6,450				0.01	0.86	0.57	11.02	0.28	0.76	1.24
CONNECTICUT	3,250				~0	0.26	0.20	3.46	0.08	0.24	0.48
DELAWARE	1,300				~0	0.03	0.14	3.67	0.11	0.24	0.21
FLORIDA	2,900				~0	0.56	0.28	7.02	0.20	0.47	0.45
GEORGIA	2,100				~0	0.36	0.20	4.54	0.13	0.30	0.32
ILLINOIS	168,800				0.17	20.06	11.97	254.86	6.89	17.14	23.54
INDIANA	89,450				0.09	9.50	6.18	121.99	3.16	8.26	13.12
IOWA	32,800				0.03	3.39	2.24	43.66	1.12	2.96	4.80
KANSAS	13,150				0.02	2.86	1.36	35.51	1.05	2.35	2.07
KENTUCKY	21,550				0.02	1.77	1.33	23.17	0.55	1.58	3.11
LOUISIANA	3,300				0.01	0.65	0.32	8.07	0.24	0.54	0.51
MARYLAND	6,700				0.01	0.74	0.47	9.45	0.25	0.64	0.98
MASSACHUSETTS	4,550				~0	0.37	0.28	4.90	0.12	0.34	0.66
MICHIGAN	234,500				0.22	21.01	15.01	272.76	6.74	18.65	33.50
MINNESOTA	17,750				0.02	2.08	1.29	26.49	0.70	1.79	2.61
MISSOURI	15,000				0.02	2.72	1.39	33.93	0.98	2.25	2.31
NEBRASKA	3,600				0.01	0.70	0.35	8.74	0.25	0.58	0.56
NEW JERSEY	27,000				0.03	2.41	1.72	31.31	0.77	2.14	3.82
NEW YORK	77,100				0.08	8.48	5.42	108.73	2.84	7.35	11.34
N. CAROLINA	7,900				0.01	0.65	0.49	8.52	0.20	0.68	1.15
OHIO	242,300				0.26	29.34	17.87	373.76	10.00	25.18	35.70
OKLAHOMA	4,800				0.01	0.72	0.40	9.04	0.25	0.60	0.72
OREGON	7,500				0.01	1.59	0.76	19.89	0.58	1.30	1.17
PENNSYLVANIA	198,700				0.21	22.88	14.29	292.35	7.73	19.73	29.20
RHODE ISLAND	2,350				~0	0.19	0.15	2.52	0.06	0.17	0.34
S. CAROLINA	1,900				~0	0.15	0.12	2.02	0.05	0.14	0.27
S. DAKOTA	650				~0	0.13	0.06	1.58	0.05	0.10	0.09
TENNESSEE	35,650				0.04	4.03	2.64	51.62	1.38	3.48	5.26
TEXAS	47,650				0.05	5.17	3.33	66.35	1.73	4.49	6.97
UTAH	16,450				0.02	1.82	1.10	20.91	0.53	1.42	2.40
VERMONT	800				~0	0.07	0.05	0.86	0.02	0.06	0.12
VIRGINIA	13,150				0.01	1.24	0.09	16.07	0.40	1.09	1.91
WASHINGTON	6,100				0.01	1.28	0.62	15.95	0.47	1.06	0.86
W. VIRGINIA	7,700				0.01	0.93	0.57	11.83	0.32	0.80	1.14
WISCONSIN	64,000				0.07	9.13	5.15	116.30	3.20	7.72	9.56
EPA REGION											
I	10,950				~0	0.89	0.68	11.73	0.28	0.81	1.68
II	104,100				0.11	10.89	7.14	140.04	3.61	9.49	15.26
III	227,550				0.24	25.82	15.56	333.37	8.81	22.50	33.44
IV	205,400				0.20	21.06	13.99	271.38	6.95	18.40	30.09
V	806,800				0.83	91.12	57.47	1165.16	30.89	78.74	118.03
VI	55,750				0.07	6.54	4.05	83.48	2.22	6.63	8.20
VII	64,550				0.08	9.67	6.34	121.84	3.40	8.14	9.74
VIII	25,450				0.03	2.60	1.73	33.51	0.86	2.27	3.73
IX	56,250				0.07	6.05	4.60	101.61	2.83	6.79	8.28
X	13,600				0.02	2.87	1.38	35.64	1.05	2.36	2.03
NATIONAL TOTAL	1,589,400				1.7	179.5	111.8	2297.8	60.7	165.1	230.4

*IRON AND STEEL FOUNDRY DUSTS NOT CONSIDERED HAZARDOUS BASED ON SOLUBILITY TESTS BY CALSPAN AND DESCRIBED IN APPENDIX B

SOURCE: CALSPAN CORPORATION

Table 14h

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES TOTAL DUST, 1977 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS*	DISPOSAL METHOD	CONSTITUENTS Cd	Cu	Cr	Mn	Ni	Pb	Zn
ALABAMA	147,500	0	0	LANDFILL OR OPEN DUMP	0.14	14.88	9.89	193.00	4.83	13.10	21.60
ARIZONA	13,200				0.02	3.00	1.42	37.16	1.11	2.46	2.09
CALIFORNIA	47,900				0.06	5.91	3.58	75.22	2.02	5.06	7.08
COLORADO	9,350				0.01	0.84	0.63	12.19	0.31	0.83	1.37
CONNECTICUT	3,600				~0	0.29	0.22	3.82	0.09	0.27	0.61
DELAWARE	1,450				~0	0.03	0.15	4.06	0.12	0.27	0.23
FLORIDA	3,200				~0	0.62	0.31	7.76	0.22	0.52	0.50
GEORGIA	2,300				~0	0.40	0.22	5.02	0.14	0.33	0.35
ILLINOIS	175,600				0.19	22.19	13.24	281.88	7.82	18.96	26.04
INDIANA	98,950				0.10	10.50	6.64	134.92	3.50	9.14	14.61
IOWA	36,300				0.03	3.75	2.48	48.29	1.24	3.27	5.31
KANSAS	14,550				0.02	3.18	1.50	39.27	1.16	2.60	2.29
KENTUCKY	23,850				0.02	1.86	1.47	25.55	0.61	1.76	3.44
LOUISIANA	3,650				0.01	0.72	0.35	8.83	0.27	0.60	0.56
MARYLAND	7,400				0.01	0.82	0.52	10.45	0.28	0.71	1.08
MASSACHUSETTS	5,000				~0	0.41	0.31	5.42	0.13	0.38	0.73
MICHIGAN	259,350				0.24	23.24	16.60	301.67	7.45	20.63	37.06
MINNESOTA	19,650				0.02	2.30	1.43	29.30	0.77	1.99	2.89
MISSOURI	16,600				0.02	3.00	1.54	37.53	1.09	2.49	2.66
NEBRASKA	4,000				0.01	0.77	0.39	9.67	0.28	0.64	0.62
NEW JERSEY	29,900				0.03	2.67	1.90	34.63	0.85	2.37	4.34
NEW YORK	85,300				0.09	9.38	6.99	120.26	3.14	8.13	12.54
N. CAROLINA	8,750				0.01	0.72	0.54	9.42	0.22	0.64	1.27
OHIO	268,000				0.28	32.45	19.76	413.38	11.06	27.85	39.48
OKLAHOMA	5,300				0.01	0.80	0.44	10.00	0.28	0.66	0.80
OREGON	8,300				0.01	1.75	0.84	21.78	0.64	1.44	1.29
PENNSYLVANIA	219,800				0.23	25.31	15.80	323.34	8.55	21.82	32.30
RHODE ISLAND	2,600				~0	0.21	0.17	2.79	0.07	0.19	0.38
S. CAROLINA	2,100				~0	0.17	0.13	2.23	0.06	0.15	0.30
S. DAKOTA	600				~0	0.14	0.07	1.75	0.06	0.11	0.10
TENNESSEE	39,400				0.04	4.46	2.81	67.09	1.50	3.85	5.82
TEXAS	52,700				0.06	5.72	3.68	73.38	1.91	4.97	7.71
UTAH	18,200				0.02	1.79	1.22	23.13	0.59	1.67	2.65
VERMONT	900				~0	0.08	0.06	0.95	0.02	0.07	0.13
VIRGINIA	14,550				0.01	1.37	0.10	17.77	0.44	1.21	2.11
WASHINGTON	6,750				0.01	1.42	0.69	17.64	0.52	1.17	0.96
W. VIRGINIA	8,500				0.01	1.03	0.63	13.08	0.35	0.88	1.26
WISCONSIN	70,800				0.08	10.10	5.70	127.52	3.54	8.54	10.57
EPA REGION											
I	12,100				~0	0.98	0.75	12.98	0.31	0.90	1.76
II	115,150				0.12	12.04	7.90	154.89	3.99	10.50	16.88
III	251,700				0.27	28.56	17.21	368.70	9.74	24.89	36.68
IV	227,200				0.22	23.29	15.47	300.07	7.69	20.35	33.28
V	892,300				0.92	100.78	63.56	1288.67	33.94	87.09	130.54
VI	61,650				0.08	7.23	4.49	92.31	2.46	6.23	9.07
VII	71,400				0.09	10.70	5.91	134.78	3.78	9.00	10.77
VIII	28,150				0.03	2.88	1.91	37.07	0.95	2.51	4.12
IX	61,100				0.08	8.90	4.98	112.38	3.13	7.51	9.17
X	15,000				0.02	3.17	1.53	39.42	1.16	2.61	2.24
NATIONAL TOTAL	1,735,750				1.8	198.5	123.7	2541.3	67.1	171.5	254.8

*IRON AND STEEL FOUNDRY DUSTS NOT CONSIDERED HAZARDOUS BASED ON SOLUBILITY TESTS BY CALSPAN AND DESCRIBED IN APPENDIX B

SOURCE: CALSPAN CORPORATION

Table 14i

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES TOTAL DUST, 1983 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS*	DISPOSAL METHOD	CONSTITUENTS						
					Cd	Cu	Cr	Mn	Ni	Pb	Zn
ALABAMA	181,800	0	0	LANDFILL OR OPEN DUMP	0.18	18.46	12.31	237.84	6.08	18.14	26.62
ARIZONA	16,300				0.03	3.68	1.74	45.80	1.36	3.03	2.58
CALIFORNIA	58,000				0.07	7.28	4.39	92.70	2.49	6.23	8.72
COLORADO	11,500				0.01	1.16	0.78	16.02	0.38	1.02	1.69
CONNECTICUT	4,400				~0	0.35	0.27	4.70	0.11	0.33	0.63
DELAWARE	1,800				~0	0.04	0.19	5.00	0.15	0.33	0.29
FLORIDA	3,860				~0	0.76	0.38	9.67	0.27	0.84	0.61
GEORGIA	2,850				~0	0.49	0.27	6.19	0.18	0.41	0.44
ILLINOIS	216,500				0.23	27.34	16.32	347.37	9.39	23.38	32.09
INDIANA	121,900				0.12	12.85	8.42	166.27	4.31	11.26	17.68
IOWA	44,700				0.04	4.62	3.05	59.51	1.53	4.03	6.54
KANSAS	17,900				0.03	3.90	1.86	48.40	1.43	3.20	2.82
KENTUCKY	29,400				0.03	2.41	1.81	31.58	0.75	2.17	4.24
LOUISIANA	4,500				0.01	0.89	0.44	11.00	0.33	0.74	0.70
MARYLAND	9,100				0.01	1.01	0.64	12.88	0.34	0.87	1.34
MASSACHUSETTS	6,200				~0	0.50	0.38	6.68	0.18	0.46	0.90
MICHIGAN	318,600				0.30	28.64	20.46	371.77	9.19	25.42	45.66
MINNESOTA	24,200				0.03	2.84	1.76	36.11	0.95	2.44	3.56
MISSOURI	20,450				0.03	3.71	1.89	46.25	1.34	3.07	3.15
NEBRASKA	4,900				0.01	0.95	0.48	11.91	0.34	0.79	0.76
NEW JERSEY	36,800				0.04	3.28	2.34	42.68	1.05	2.92	5.34
NEW YORK	105,100				0.11	11.56	7.39	148.20	3.87	10.02	15.16
N. CAROLINA	10,800				0.01	0.89	0.67	11.61	0.27	0.78	1.67
OHIO	330,250				0.35	39.89	24.36	509.43	13.63	34.32	48.66
OKLAHOMA	6,550				0.01	0.98	0.55	12.32	0.34	0.82	0.88
OREGON	10,200				0.01	2.17	1.04	26.84	0.79	1.77	1.58
PENNSYLVANIA	270,800				0.29	31.19	19.48	398.47	10.54	26.89	39.80
RHODE ISLAND	3,200				~0	0.26	0.20	3.43	0.08	0.23	0.46
S. CAROLINA	2,600				~0	0.20	0.16	2.75	0.07	0.18	0.37
S. DAKOTA	750				~0	0.18	0.08	2.15	0.07	0.14	0.12
TENNESSEE	48,600				0.04	5.49	3.46	70.36	1.85	4.74	7.17
TEXAS	64,950				0.07	7.05	4.54	90.44	2.36	6.12	9.50
UTAH	22,400				0.03	2.21	1.50	28.50	0.72	1.94	3.27
VERMONT	1,090				~0	0.10	0.07	1.17	0.03	0.08	0.16
VIRGINIA	17,800				0.01	1.69	0.12	21.90	0.56	1.49	2.60
WASHINGTON	8,300				0.01	1.74	0.85	21.74	0.64	1.44	1.17
W. VIRGINIA	10,500				0.01	1.27	0.78	16.12	0.44	1.09	1.65
WISCONSIN	87,250				0.10	12.44	7.02	157.15	4.36	10.52	13.03
EPA REGION											
I	14,900				~0	1.21	0.93	15.98	0.38	1.10	2.15
II	141,900				0.15	14.84	9.73	190.88	4.92	12.93	20.49
III	310,150				0.33	35.19	21.21	454.37	12.01	30.87	45.58
IV	279,950				0.27	28.70	19.07	369.90	9.47	25.08	41.02
V	1,099,650				1.13	124.20	78.33	1588.10	41.83	107.32	180.88
VI	76,000				0.10	8.91	5.62	113.76	3.03	7.67	11.18
VII	88,000				0.11	13.18	7.28	166.07	4.63	11.09	13.27
VIII	34,700				0.04	3.54	2.38	45.67	1.17	3.09	5.08
IX	75,300				0.10	10.97	6.13	138.50	3.86	9.25	11.30
X	18,560				0.03	3.91	1.88	48.58	1.43	3.22	2.76
NATIONAL TOTAL	2,139,100				2.3	244.7	152.4	3131.8	82.7	211.4	313.7

*IRON AND STEEL FOUNDRY DUSTS NOT CONSIDERED HAZARDOUS BASED ON SOLUBILITY TESTS BY CALSPAN AND DESCRIBED IN APPENDIX B

SOURCE: CALSPAN CORPORATION

Table 14j
ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDARIES TOTAL SAND, 1974 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	CONSTITUENTS						
					Cu	Cr	Mn	Ni	Pb	Zn	PHENOL
ALABAMA	1,131,900	0	0	ALL OPEN DUMP OR LANDFILL	9.38	5.39	59.80	31.75	60.63	6.73	1.21
ARIZONA	50,200				0.42	0.24	2.66	1.41	2.69	0.30	0.05
CALIFORNIA	332,000				2.75	1.58	17.57	9.31	17.78	1.97	0.35
COLORADO	71,600				0.59	0.34	3.79	2.01	3.84	0.43	0.08
CONNECTICUT	29,700				0.25	0.14	1.57	0.83	1.59	0.18	0.03
DELAWARE	5,500				0.05	0.03	0.29	0.15	0.29	0.03	0.01
FLORIDA	15,500				0.13	0.07	0.82	0.44	0.83	0.09	0.02
GEORGIA	12,900				0.11	0.06	0.68	0.36	0.69	0.08	0.01
ILLINOIS	1,211,400				10.04	5.77	64.10	33.98	64.89	7.20	1.30
INDIANA	744,500				6.17	3.54	39.40	20.88	39.88	4.42	0.80
IOWA	276,000				2.23	1.31	14.61	7.74	14.79	1.64	0.30
KANSAS	59,200				0.49	0.28	3.13	1.66	3.17	0.35	0.06
KENTUCKY	197,100				1.63	0.94	10.43	5.53	10.56	1.17	0.21
LOUISIANA	17,100				0.14	0.08	0.91	0.48	0.92	0.10	0.02
MARYLAND	54,600				0.45	0.26	2.89	1.53	2.93	0.32	0.06
MASSACHUSETTS	41,800				0.35	0.20	2.21	1.17	2.24	0.25	0.04
MICHIGAN	2,086,900				17.29	9.93	110.40	58.54	111.80	12.40	2.24
MINNESOTA	141,100				1.17	0.67	7.47	3.96	7.56	0.84	0.15
MISSOURI	86,100				0.71	0.41	4.56	2.42	4.61	0.51	0.09
NEBRASKA	19,100				0.16	0.09	1.01	0.54	1.03	0.11	0.02
NEW JERSEY	240,700				1.99	1.15	12.74	6.75	12.89	1.43	0.26
NEW YORK	631,200				5.23	3.00	33.40	17.70	33.81	3.75	0.67
N. CAROLINA	72,500				0.60	0.35	3.84	2.03	3.88	0.43	0.08
OHIO	1,892,000				15.68	9.00	100.10	53.07	101.30	11.24	2.02
OKLAHOMA	32,700				0.27	0.16	1.73	0.92	1.75	0.19	0.04
OREGON	35,000				0.29	0.17	1.85	0.98	1.88	0.21	0.04
PENNSYLVANIA	1,592,700				13.20	7.58	84.28	44.68	85.32	9.47	1.70
RHODE ISLAND	21,600				0.18	0.10	1.14	0.61	1.16	0.13	0.02
S. CAROLINA	17,200				0.14	0.08	0.91	0.48	0.92	0.10	0.02
S. DAKOTA	2,400				0.02	0.01	0.12	0.07	0.13	0.01	0
TENNESSEE	288,200				2.39	1.37	15.25	8.09	15.44	1.71	0.31
TEXAS	392,400				3.25	1.87	20.77	10.01	21.02	2.33	0.42
UTAH	141,100				1.17	0.67	7.47	3.96	7.56	0.84	0.15
VERMONT	7,400				0.06	0.04	0.39	0.21	0.40	0.04	0.01
VIRGINIA	114,800				0.95	0.55	6.07	3.22	6.14	0.68	0.12
WASHINGTON	28,900				0.24	0.14	1.53	0.81	1.55	0.17	0.03
W. VIRGINIA	60,300				0.50	0.29	3.19	1.69	3.23	0.36	0.06
WISCONSIN	452,300				3.76	2.15	23.84	12.69	24.23	2.69	0.48
EPA REGION											
I	100,500				0.84	0.48	5.31	2.82	5.39	0.60	0.10
II	871,900				7.22	4.16	46.14	24.45	46.70	5.18	0.93
III	1,827,700				15.15	8.71	96.72	51.27	97.91	10.86	1.95
IV	1,735,300				14.38	8.26	91.83	48.68	92.95	10.31	1.86
V	6,528,200				54.10	31.06	354.41	183.12	349.66	38.79	6.99
VI	442,200				3.66	2.11	23.31	11.41	23.69	2.62	0.48
VII	440,400				3.59	2.09	23.31	12.38	23.60	2.61	0.47
VIII	215,100				1.78	1.02	11.38	6.04	11.53	1.28	0.23
IX	382,200				3.17	1.82	20.23	10.72	20.47	2.27	0.40
X	63,900				0.53	0.31	3.38	1.79	3.43	0.38	0.07
NATIONAL TOTAL	12,607,400				104.40	60.00	667.10	352.70	675.30	74.80	13.50

*FOUNDRY SANDS NOT CONSIDERED HAZARDOUS ON BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B.

SOURCE: CALSPAN CORPORATION

Table 14k

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES TOTAL SAND, 1977 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	CONSTITUENTS						
					Cu	Cr	Mn	Ni	Pb	Zn	PHENOL
ALABAMA	1,251,800	0	0	LANDFILL OR OPEN DUMP	10.37	5.96	66.25	35.12	67.08	7.44	1.34
ARIZONA	55,520				0.22	0.27	2.94	1.56	2.98	0.33	0.06
CALIFORNIA	367,200				3.04	1.75	19.43	10.30	19.66	2.18	0.39
COLORADO	79,200				0.65	0.38	4.19	2.22	4.25	0.48	0.09
CONNECTICUT	32,800				0.28	0.16	1.74	0.92	1.76	0.20	0.03
DELAWARE	6,100				0.06	0.03	0.32	0.17	0.32	0.03	0.01
FLORIDA	17,100				0.14	0.08	0.91	0.49	0.92	0.10	0.02
GEORGIA	14,300				0.12	0.07	0.75	0.40	0.76	0.09	0.01
ILLINOIS	1,339,800				11.10	6.38	70.89	37.58	71.77	7.96	1.44
INDIANA	823,400				6.82	3.92	43.58	23.09	44.11	4.89	0.88
IOWA	305,300				2.47	1.45	16.16	8.56	16.36	1.81	0.33
KANSAS	65,500				0.54	0.31	3.46	1.84	3.51	0.39	0.07
KENTUCKY	218,000				1.80	1.04	11.54	6.12	11.68	1.29	0.23
LOUISIANA	19,000				0.15	0.09	1.01	0.53	1.02	0.11	0.02
MARYLAND	60,400				0.50	0.29	3.20	1.69	3.24	0.35	0.07
MASSACHUSETTS	46,200				0.39	0.22	2.44	1.29	2.48	0.28	0.04
MICHIGAN	2,308,100				19.12	10.98	122.10	64.74	123.65	13.71	2.48
MINNESOTA	156,100				1.29	0.74	8.26	4.38	8.36	0.93	0.17
MISSOURI	95,200				0.79	0.45	5.04	2.68	5.10	0.56	0.10
NEBRASKA	21,100				0.18	0.10	1.12	0.60	1.14	0.12	0.02
NEW JERSEY	266,200				2.20	1.27	14.09	7.47	14.26	1.58	0.29
NEW YORK	698,100				5.78	3.32	36.94	19.58	37.39	4.15	0.74
N. CAROLINA	80,200				0.66	0.39	4.25	2.45	4.29	0.48	0.09
OHIO	2,092,500				17.34	9.95	110.61	58.70	112.04	12.43	2.23
OKLAHOMA	36,200				0.30	0.18	1.91	1.02	1.94	0.21	0.04
OREGON	38,700				0.32	0.19	2.05	1.08	2.08	0.23	0.04
PENNSYLVANIA	1,761,600				14.60	8.38	93.21	49.42	94.36	10.47	1.89
RHODE ISLAND	23,900				0.20	0.11	1.26	0.67	1.29	0.14	0.02
S. CAROLINA	19,000				0.15	0.09	1.01	0.53	1.02	0.11	0.02
S. DAKOTA	2,700				0.02	0.01	0.13	0.08	0.14	0.01	~0
TENNESSEE	318,700				2.64	1.52	16.87	8.95	17.08	1.89	0.34
TEXAS	434,000				3.59	2.07	22.97	11.07	23.25	2.58	0.46
UTAH	156,000				1.29	0.74	8.26	4.38	8.36	0.93	0.17
VERMONT	8,200				0.07	0.04	0.43	0.23	0.44	0.04	0.01
VIRGINIA	126,800				1.05	0.60	6.71	3.56	6.79	0.75	0.13
WASHINGTON	32,000				0.27	0.15	1.69	0.90	1.71	0.19	0.03
W. VIRGINIA	66,700				0.55	0.32	3.53	1.87	3.57	0.40	0.07
WISCONSIN	500,200				4.15	2.38	26.48	14.04	27.80	2.98	0.53
EPA REGION											
I	111,100				0.93	0.53	5.87	3.12	5.96	0.66	0.11
II	964,300				7.99	4.59	51.03	27.04	51.65	5.73	1.03
III	2,021,500				16.76	9.63	108.40	56.70	108.29	12.01	2.16
IV	1,919,100				15.90	9.14	101.56	53.84	102.80	11.40	2.06
V	7,220,100				59.83	34.35	382.02	202.53	386.72	42.80	7.73
VI	489,200				4.05	2.33	25.89	12.62	26.20	2.90	0.53
VII	487,100				3.97	2.31	25.78	13.67	26.10	2.89	0.52
VIII	237,800				1.97	1.13	12.59	6.68	12.75	1.42	0.25
IX	422,720				3.51	2.01	22.37	11.86	22.64	2.51	0.44
X	70,700				0.59	0.34	3.74	1.98	3.79	0.42	0.08
NATIONAL TOTAL	13,943,720				115.5	66.4	737.8	390.1	746.9	82.8	14.9

*FOUNDRY SANDS NOT CONSIDERED HAZARDOUS ON BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B.

SOURCE: CALSPAN CORPORATION

Table 14I

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES TOTAL SAND, 1983 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS*	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	CONSTITUENTS						
					Cu	Cr	Mn	Ni	Pb	Zn	PHENOL
ALABAMA	1,542,800	0	0	LANDFILL OR OPEN DUMP	12.78	7.35	81.64	43.28	82.64	9.17	1.65
ARIZONA	68,400				0.57	0.33	3.63	1.92	3.67	0.41	0.07
CALIFORNIA	452,500				3.75	2.15	23.96	12.69	24.23	2.69	0.48
COLORADO	97,600				0.80	0.46	5.17	2.74	5.23	0.59	0.11
CONNECTICUT	40,500				0.34	0.19	2.14	1.13	2.17	0.25	0.04
DELAWARE	7,500				0.07	0.04	0.40	0.20	0.40	0.04	0.01
FLORIDA	21,100				0.18	0.10	1.12	0.60	1.13	0.12	0.03
GEORGIA	17,600				0.15	0.08	0.93	0.49	0.94	0.11	0.01
ILLINOIS	1,651,100				13.68	7.86	87.37	46.31	88.46	9.81	1.77
INDIANA	1,014,800				8.41	4.83	53.70	28.46	63.14	6.02	1.09
IOWA	376,200				3.04	1.79	19.91	10.55	20.16	2.24	0.41
KANSAS	80,700				0.67	0.38	4.27	2.28	4.32	0.48	0.08
KENTUCKY	268,600				2.22	1.28	14.22	7.54	14.39	1.59	0.29
LOUISIANA	23,300				0.19	0.11	1.24	0.65	1.25	0.14	0.03
MARYLAND	74,400				0.61	0.35	3.94	2.09	3.99	0.44	0.08
MASSACHUSETTS	57,000				0.48	0.27	3.01	1.59	3.05	0.34	0.05
MICHIGAN	2,844,400				23.57	13.53	150.48	79.79	152.38	16.90	3.05
MINNESOTA	192,300				1.59	0.91	10.18	5.40	10.30	1.14	0.20
MISSOURI	117,400				0.98	0.56	6.22	3.30	6.28	0.70	0.12
NEBRASKA	26,000				0.22	0.12	1.38	0.74	1.40	0.15	0.03
NEW JERSEY	328,100				2.71	1.57	17.36	9.20	17.57	1.95	0.35
NEW YORK	860,300				7.13	4.10	45.52	24.13	46.08	5.11	0.91
N. CAROLINA	98,800				0.82	0.48	5.23	2.77	5.29	0.58	0.11
OHIO	2,578,800				21.37	12.27	136.44	72.33	138.07	15.32	2.75
OKLAHOMA	44,600				0.37	0.22	2.36	1.25	2.39	0.26	0.05
OREGON	47,700				0.40	0.23	2.52	1.34	2.56	0.29	0.05
PENNSYLVANIA	2,170,800				17.99	10.33	114.87	60.90	116.29	12.91	2.32
RHODE ISLAND	29,400				0.25	0.14	1.55	0.83	1.58	0.18	0.03
S. CAROLINA	23,400				0.19	0.11	1.24	0.65	1.25	0.14	0.03
S. DAKOTA	3,270				0.03	0.01	0.16	0.10	0.18	0.01	0
TENNESSEE	392,800				3.26	1.87	20.79	11.03	21.04	2.33	0.42
TEXAS	534,800				4.43	2.55	28.31	13.64	28.66	3.17	0.57
UTAH	192,300				1.59	0.91	10.18	5.40	10.30	1.14	0.20
VERMONT	10,100				0.08	0.05	0.53	0.29	0.55	0.05	0.01
VIRGINIA	156,200				1.29	0.75	8.27	4.39	8.31	0.93	0.16
WASHINGTON	39,400				0.33	0.19	2.09	1.10	2.11	0.23	0.04
W. VIRGINIA	82,200				0.68	0.40	4.35	2.30	4.40	0.49	0.08
WISCONSIN	616,500				5.11	2.93	32.63	17.30	33.03	3.67	0.65
EPA REGION											
I	137,000				1.14	0.65	7.24	3.84	7.35	0.82	0.14
II	1,188,400				9.84	5.66	62.89	33.39	63.65	7.08	1.27
III	2,491,100				20.65	11.87	131.83	69.88	133.46	14.80	2.66
IV	2,096,500				18.60	11.26	125.16	66.35	126.69	14.05	2.54
V	8,897,900				73.74	42.33	470.79	249.59	476.58	52.87	9.53
VI	602,700				4.99	2.88	31.91	15.55	23.29	3.57	0.65
VII	600,300				4.89	2.85	31.77	16.85	32.17	3.56	0.64
VIII	293,170				2.43	1.39	15.51	8.23	15.72	1.74	0.31
IX	520,900				4.32	2.48	27.57	14.61	27.80	3.09	0.55
X	87,100				0.72	0.42	4.81	2.44	4.68	0.52	0.10
NATIONAL TOTAL	16,915,070				142.3	81.8	909.3	480.7	920.4	102.1	18.4

*FOUNDRY SANDS NOT CONSIDERED HAZARDOUS ON BASIS OF CALSPAN SOLUBILITY TESTS DESCRIBED IN APPENDIX B.

SOURCE: CALSPAN CORPORATION

Table 14m

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES REFRACTORIES, 1974 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS	DISPOSAL METHOD
ALABAMA	29,320	0	ALL DISPOSED OF IN OPEN DUMP OR LANDFILLS
ARIZONA	3,410		
CALIFORNIA	8,880		
COLORADO	1,850		
CONNECTICUT	670		
DELAWARE	370		
FLORIDA	780		
GEORGIA	540		
ILLINOIS	36,910		
INDIANA	19,870		
IOWA	7,240		
KANSAS	3,690		
KENTUCKY	4,520		
LOUISIANA	890		
MARYLAND	1,500		
MASSACHUSETTS	960		
MICHIGAN	49,950		
MINNESOTA	4,040		
MISSOURI	3,920		
NEBRASKA	970		
NEW JERSEY	5,760		
NEW YORK	17,280		
N. CAROLINA	1,660		
OHIO	55,680		
OKLAHOMA	1,170		
OREGON	2,070		
PENNSYLVANIA	45,050		
RHODE ISLAND	490		
S. CAROLINA	390		
S. DAKOTA	160		
TENNESSEE	8,050		
TEXAS	10,640		
UTAH	3,590		
VERMONT	170		
VIRGINIA	2,840		
WASHINGTON	1,690		
W. VIRGINIA	1,770		
WISCONSIN	15,430		
EPA REGION			
I	2,290		
II	23,040		
III	51,530		
IV	45,260		
V	181,880		
VI	12,700		
VII	15,820		
VIII	5,600		
IX	13,390		
X	3,760		
NATIONAL TOTAL	355,270		

SOURCE: CALSPAN CORPORATION

Table 14n

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES REFRACTORIES, 1977 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS	DISPOSAL METHOD
ALABAMA	32,428	0	ALL DISPOSED OF IN OPEN DUMP OR LANDFILL
ARIZONA	3,771		
CALIFORNIA	11,038		
COLORADO	2,046		
CONNECTICUT	741		
DELAWARE	409		
FLORIDA	863		
GEORGIA	597		
ILLINOIS	40,822		
INDIANA	21,978		
IOWA	8,007		
KANSAS	4,081		
KENTUCKY	4,999		
LOUISIANA	984		
MARYLAND	1,658		
MASSACHUSETTS	1,082		
MICHIGAN	55,245		
MINNESOTA	4,468		
MISSOURI	4,336		
NEBRASKA	1,073		
NEW JERSEY	6,371		
NEW YORK	19,112		
N. CAROLINA	1,838		
OHIO	81,582		
OKLAHOMA	1,294		
OREGON	2,289		
PENNSYLVANIA	49,825		
RHODE ISLAND	542		
S. CAROLINA	431		
S. DAKOTA	177		
TENNESSEE	8,903		
TEXAS	11,768		
UTAH	3,971		
VERMONT	188		
VIRGINIA	3,141		
WASHINGTON	1,869		
W. VIRGINIA	1,958		
WISCONSIN	17,066		
EPA REGION			
I	2,533		
II	25,482		
III	56,992		
IV	50,058		
V	201,159		
VI	14,046		
VII	17,497		
VIII	6,194		
IX	14,809		
X	4,159		
NATIONAL TOTAL	392,929		

SOURCE: CALSPAN CORPORATION

Table 14o

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FROM IRON AND STEEL FOUNDRIES REFRACTORIES, 1983 (METRIC TONS)

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS	DISPOSAL METHOD
ALABAMA	39,963	0	ALL DISPOSED OF IN OPEN DUMP OR LANDFILL
ARIZONA	4,648		
CALIFORNIA	13,603		
COLORADO	2,522		
CONNECTICUT	913		
DELAWARE	504		
FLORIDA	1,063		
GEORGIA	736		
ILLINOIS	50,308		
INDIANA	27,083		
IOWA	9,868		
KANSAS	5,029		
KENTUCKY	6,161		
LOUISIANA	1,213		
MARYLAND	2,045		
MASSACHUSETTS	1,308		
MICHIGAN	68,082		
MINNESOTA	5,506		
MISSOURI	5,343		
NEBRASKA	1,322		
NEW JERSEY	7,851		
NEW YORK	23,553		
N. CAROLINA	2,263		
OHIO	75,892		
OKLAHOMA	1,595		
OREGON	2,821		
PENNSYLVANIA	61,403		
RHODE ISLAND	668		
S. CAROLINA	532		
S. DAKOTA	218		
TENNESSEE	10,972		
TEXAS	14,502		
UTAH	4,893		
VERMONT	232		
VIRGINIA	3,871		
WASHINGTON	2,303		
W. VIRGINIA	2,413		
WISCONSIN	21,031		
EPA REGION			
I	3,121		
II	31,403		
III	70,235		
IV	61,689		
V	247,902		
VI	17,310		
VII	21,563		
VIII	7,633		
IX	18,251		
X	5,125		
NATIONAL TOTAL	484,233		

SOURCE: CALSPAN CORPORATION

emissions collected by dry control systems. The amounts of individual constituents were calculated by multiplying the total waste figures by the concentration values derived from laboratory analyses of waste samples collected at several plants.

An alternative approach for compiling sludge and dusts values for each state might be to multiply the waste generation factors given in Table 12 by the production figures on a state-by-state basis. This approach was not used since state production figures were not directly available for each type of ferroalloy and the numbers of plants using each type (wet/dry) of control system was not known.

The waste slag quantities were calculated by multiplying the slag generation factors obtained from plant visits (see Table 12) by the state production figures for each type of ferroalloy as estimated from the sludge and dust values obtained from in the ferroalloy survey and from furnace emission data contained in Reference 7. The sums of the sludge and dust values were divided by the furnace emission factors for each ferroalloy category for each state to obtain production estimates. The state production estimates for each ferroalloy were then summed and compared with published national figures. The individual state figures were then adjusted as appropriate so that the national figures agreed. The slag constituent values for each state were obtained by multiplying the total slag values for each alloy type by the concentration values determined through the analyses of collected slag samples, and summing over all alloys.

2.3 TREATMENT AND DISPOSAL TECHNOLOGY

2.3.1 Current Treatment and Disposal Practices

Slag. Slag which originates from the metal smelting furnaces is open dumped. This practice is considered environmentally adequate at this time in the absence of significant leaching of toxic constituents as ascertained in solubility tests as described in Appendix B.

Waste Sand. Waste sand from cores and molds may either be reclaimed for making new molds or disposed of in open dumps. Open dumping is considered environmentally acceptable at this time in the absence of significant leaching of toxic constituents as ascertained in solubility tests described in Appendix B.

Core Butts. Core butts containing non-degraded sands and binders are also open dumped. Although solubility tests were not conducted on core butts they are not considered potentially hazardous at this time. Solubility testing on core butts is needed to confirm non-leachability.

Sludges. Sludges originating from wet scrubbing of furnace emissions is generally mixed with dry sands, dusts or other dry wastes and open dumped along with these wastes. This practice is considered environmentally adequate at this time in the absence of significant leaching of toxic constituents as ascertained in solubility tests described in Appendix B.

Dusts. Dusts originating from sand reclaiming or control of emissions from furnaces are open dumped. This practice is considered environmentally acceptable at this time in the absence of significant leaching of toxic constituents as ascertained in solubility tests described in Appendix B.

Refractories. The broken, or eroded brick refractories from furnaces are open dumped and are considered non-hazardous. Open dumping is considered environmentally acceptable.

Floor Sweepings. Sweepings from the core making room are principally sand and are not considered potentially hazardous at this time. Solubility tests were not conducted on sweepings but are needed to confirm designation as non-hazardous.

Since all of the wastes from iron and steel foundries are considered non-hazardous at this time Levels I, II and III technology need not be addressed at this time.

2.4 COST ANALYSIS

Because none of the iron and steel foundry wastes have been considered potentially hazardous based on available evidence at this time there are no costs attributable to hazardous waste disposal.

3.0 PRIMARY SMELTING AND REFINING OF FERROALLOYS (SIC 3313)

3.1 INDUSTRY CHARACTERIZATION

Ferroalloy is the generic term for alloys consisting of iron and one or more other metals. Ferroalloys are used in steel production as alloying elements and deoxidants.

The major types of ferroalloys produced are ferromanganese, silicon manganese, ferrosilicon, ferrochrome and silvery iron. The 1972 production of the ferroalloys and percent of total ferroalloy production for that year are as follows: (Reference 6)

Ferromanganese	726,416 MT	32%
Silicomanganese	139,014	6%
Ferrosilicon	763,305	33%
Ferrochrome	319,611	14%
Silvery Iron	147,940	6%
Other	206,294	9%

Total U.S. ferroalloy production in 1971 and 1972 was 2,114,733 and 2,292,153 MT respectively. Production of the above alloys comprises over 90% of the industry. Ferroalloys produced in minor quantities (approximately 9% of total) are ferronickel, ferrophosphorus, ferrotitanium, ferrocolumbian, ferrotungsten and ferromolybdenum.

U.S. producers of ferroalloys are listed in Table 15. Table 16 gives ferroalloy plants by process by state, EPA region and nationally. There is insufficient information available to estimate state by state and regional production capacities. Total value of U.S. ferroalloy shipments in 1973 was $720,542,000 (Ref. 8).

3.2 WASTE CHARACTERIZATION

This section contains descriptions of production technology at ferroalloy plants and the resultant byproducts or wastes which are either recycled directly or disposed of on land. Estimates are given for the quantities of wastes and potentially hazardous constituents thereof which are disposed of on land either in lagoons or open dumps.

3.2.1 Process Descriptions

Because of the common coproduction of ferromanganese and silicomanganese within the same plants and close similarities in production technology these ferroalloys will be treated together. Production of ferrosilicon, ferrochrome, and ferronickel will be dealth with separately.

Ferromanganese and Silicomanganese. The assumed plant has a daily capacity of 236 metric tons (260 short tons) of ferromanganese and 74 metric tons (82 short tons) of silicomanganese. Ferromanganese is produced in two furnaces. The silicomanganese is produced in a single

TABLE 15. PRODUCERS OF FERROALLOYS IN THE UNITED STATES IN 1972

Producer	Plant location	Product [1]	Type of furnace
Agrico Chemical Co.	Pierce, Fla.	FeP	Electric.
Airco Alloys & Carbide	Calvert City, Ky. Charleston, S.C. Mobile, Ala. Niagara Falls, N.Y.	FeCr, FeCrSi, FeMn, FeSi, SiMn.	Do.
Alabama Metallurgical Corp.	Selma, Ala.	FeSi	Do.
Bethlehem Steel Corp.	Johnstown, Pa.	FeMn	Blast.
Chromium Mining & Smelting Co.	Woodstock, Tenn.	FeMn, SiMn, FeCr, FeSi, FeCrSi.	Electric.
Climax Molybdenum Co.	Langeloth, Pa.	FeMo	Aluminothermic.
Diamond Shamrock Corp.	Kingwood, W. Va.	FeMn	Electric.
FMC Corp.	Pocatello, Idaho	FeP	Do.
Foote Mineral Co.	Cambridge, Ohio Graham, W. Va. Keokuk, Iowa Vancoram, Ohio Wenatchee, Wash.	FeB, FeCb, FeTi, FeV, FeCr, FeCrSi, FeSi, silvery iron, other.[2]	Do.
Hanna Furnace Corp.	Buffalo, N.Y.	Silvery iron	Blast.
Hanna Nickel Smelting Co.	Riddle, Oreg.	FeNi	Electric.
Hooker Chemical Corp.	Columbia, Tenn.	FeP	Do.
Interlake Steel Corp.	Beverly, Ohio	FeCr, FeCrSi, FeSi, SiMn.	Do.
Kawecki Chemical Co.	Easton, Pa.	FeCb	Aluminothermic.
Mobil Chemical Co.	Nichols, Fla.	FeP	Electric.
Molybdenum Corp. of America	Washington, Pa.	FeMo, FeW, FeCb, FeB.	Electric and aluminothermic.
Monsanto Chemical Co.	Columbia, Tenn. Soda Springs, Idaho	FeP	Electric.
N L Industries, Inc.	Niagara Falls, N.Y.	FeTi, other [2]	Do.
New Jersey Zinc Co.	Palmerton, Pa.	Spln	Do.
Ohio Ferro-Alloys Corp.	Brilliant, Ohio Philo, Ohio Powhatan, Ohio Tacoma, Wash.	FeCr, FeSi, FeB, FeMn, SiMn, other.[2]	Do.
Reading Alloys	Robesonia, Pa.	FeCb, FeV	Aluminothermic.
Shieldalloy Corp.	Newfield, N.J.	FeV, FeTi, FeB, FeCb, NiCb, CrMo, other.[2]	Do.
Stauffer Chemical Co.	Tarpon Springs, Fla. Mt. Pleasant, Tenn. Silver Bow, Mont.	FeP	Electric.
Tennessee Alloys Corp.	Bridgeport, Ala. Kimball, Tenn.	FeSi	Do.
Tennessee Valley Authority	Muscle Shoals, Ala.	FeP	Do.
Tenn-Tex Alloy Chemical Corp. of Houston.	Houston, Tex.	FeMn, SiMn	Do.
Union Carbide Corp.	Alloy, W. Va. Ashtabula, Ohio Marietta, Ohio Niagara Falls, N.Y. Portland, Oreg. Sheffield, Ala.	FeB, FeCr, FeCrSi, FeCb, FeSi, FeMn, FeTi, FeW, FeV, SiMn, other.[1]	Do.
U.S. Steel Corp.	Clairton, Pa. McKeesport, Pa.	FeMn	Blast.
Woodward Iron Co.	Woodward, Ala. Rockwood, Tenn.	FeSi, FeMn, SiMn	Electric.

[1] CrMo, Chromium molybdenum; FeMn, ferromanganese; Spln, spiegeleisen; SiMn, silicomanganese; FeSi, ferrosilicon; FeP, ferrophosphorus; FeCr, ferrochromium; FeMo, ferromolybdenum; FeNi, ferronickel; FeTi, ferrotitanium; FeW, ferrotungsten; FeV, ferrovanadium; FeB, ferroboron; FeCb, ferrocolumbium; NiCb, nickel columbium; Si, silicon metal.

[2] Includes Alsifer, Simanal, zirconium alloys, ferrosilicon boron, aluminum silicon alloys, and miscellaneous ferroalloys.

Source: Minerals Yearbook, Volume I, U.S. Dept. of Interior, 1972

TABLE 16

STATE, REGIONAL, AND NATIONAL DISTRIBUTION
OF FERROALLOY PLANTS BY PROCESS

State	No. of Plants	Plant Distribution By Process BF	A	E
Alabama	6	0	0	6
Florida	3	0	0	3
Idaho	2	0	0	2
Iowa	1	0	0	1
Kentucky	1	0	0	1
Montana	1	0	0	1
New Jersey	1	0	1	0
New York	4	1	0	3
Ohio	8	0	0	8
Oregon	2	0	0	2
Pennsylvania	8*	3	4	2
South Carolina	1	0	0	1
Tennessee	6	0	0	6
Texas	1	0	0	1
Washington	2	0	0	2
West Virginia	3	0	0	3

Region	No. of Plants	Plant Distribution By Process BF	A	E
1	0	0	0	0
2	5	0	1	3
3	11*	3	4	5
4	17	0	0	17
5	8	0	0	8
6	1	0	0	1
7	1	0	0	1
8	1	0	0	1
9	0	0	0	0
10	6	0	0	6
Nation	50	3	5	42

BF = Blast Furnace
A = Aluminothermic
E = Electric Furnace

*One plant employs both aluminothermic and electric furnace processes furnace. Annual production is given as 81,100 metric tons (89,400 short tons) of ferromanganese and 25,400 metric tons (28,000 short tons) of silicomanganese on the basis of an 11.3 month operating year for each of the three furnaces.

Raw materials for the production of standard ferromanganese (80% Mn and 6.5% C, with the balance mostly iron) consist of manganese ore, coke, mill scale and melted ferromanganese. The input materials are sized, mixed together and introduced into the furnaces directly over the molten bath. An overall flow sheet is shown in Figure 3. The furnaces are of the open submerged-arc type having three vertical Soderberg-type electrodes arranged in a triangle. The ends of the electrodes protrude 5 to 6 feet below the molten bath material. A paste, consisting of coke and pitch, is fed into the electrode shells from the top. As the paste descends, it is baked into a solid mass by the heat of the furnace.

The molten ferromanganese collects at the bottom of the furnace and is tapped into ladles for transfer to a cooling area. Slag is decanted from the top of the ladles, and the product is poured into a cooling bed in layers, a process called layer casting. The solidified product is broken into pieces and sized for sale. The ferromanganese slag is rich in manganese and most of it is used as charge material for silicomanganese production.

The silicomanganese is also made in an open submerged-arc furnace whose general operation is similar to that of the ferromanganese furnaces. The process flow diagram is shown in Figure 3. Input materials for silicomanganese production consist of coal, coke, manganese ore, ferromanganese slag, quartz, mill scale, dolomite, and remelt. The molten silicomanganese is tapped from the furnace into ladles, and the slag is decanted off. The product is cast into layers prior to final sizing. The slag cannot be recycled within the plant so most of it is sold to contractors for use as road fill. Some is sent to an on-site disposal area.

The air emissions for all three furnaces are controlled by wet scrubber systems. The emissions scrubwater from the ferromanganese furnaces with solids amounting to 150.6 kg/MT of product is lime treated and clarified.

Ferrosilicon. There are three major types of ferrosilicon produced in the United States: 75% FeSi, 50% FeSi, and 16-22% FeSi, where the percentages indicate the amount of silicon in the product. The 16-22% FeSi type is commonly called silvery pig iron and accounts for about 20 percent of the total ferrosilicon production.

Most of the ferrosilicon produced in the United States is made in electric submerged-arc furnaces. An average furnace size might be about 15 megawatts with a daily capacity of 37 MT (41 tons) to 65 MT (72 tons), depending on whether the furnace produces 75% FeSi or 50% FeSi. The energy required for 75% FeSi production is about 75% greater than that required for 50% FeSi production. Specifically, the production of 75% FeSi requires only 5.5 mw-hr per MT. Input materials for ferrosilicon production consist of quartzite, scrap steel, coal, and coke.

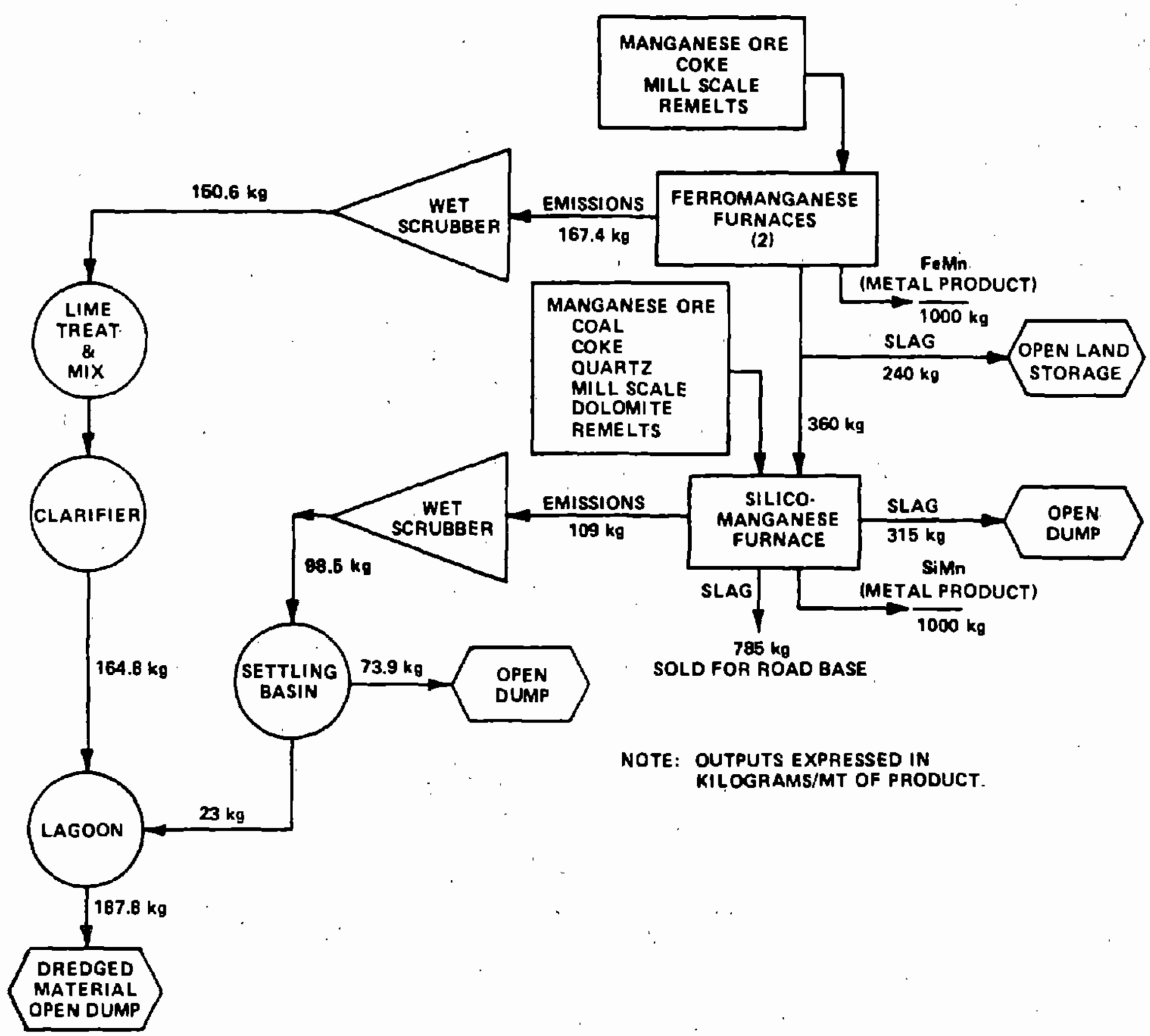

Figure 3 FERROMANGANESE AND SILICOMANGANESE PRODUCTION

Ferrochrome Production. Ferrochrome is made in two grades, high carbon (HC) and low carbon (LC). Most of the ferrochrome produced in the United States is of the high carbon type. Input materials consist of chromium ore, quartzite, limestone, coal and coke. The electrical energy required to produce (HC) ferrochrome averages about 4.6 megawatt-hours per metric ton of product. Furnace emissions average 168 kg of particulates per metric ton of product (335 lb/ton) for either high or low carbon ferrochrome. An average ferrochrome furnace might be rated at 20 megawatts. Thus, the average furnace would produce about 104 metric tons (115 short tons) of ferrochrome per day.

Ferronickel. There is only one ferronickel producing plant in the United States located at Riddle, Oregon. Nickel ore is mined at the top of a mountain and transported to the plant by tram cars.

The plant operates around-the-clock producing approximately 23,600 metric tons (26,000 short tons) of ferronickel (50% Fe, 50% Ni) annually. Reduction of the nickel ore is accomplished by mixing the melted nickel ore with ferrosilicon (48% silicon). The required ferrosilicon is produced in the same plant at the rate of about 20,620 metric tons (22,730 short tons) per year.

The sequence of operations for producing ferronickel consists of ore mining and preparation, melting, reduction, and refining. A flow diagram is presented in Figure 4. The mined ore is first dried and then screened into three fractions. The coarser, low grade rock is diverted to a reject ore pile for possible use in the future if an economical process for nickel extraction can be developed. The ore fraction in the 5/16" to 3/4" range is crushed and temporarily stored. The-5/16" fraction is further screened to remove the fines which are stored separately. The coarser retained ore fractions are calcined and the fines are roasted. The coarse and fine fractions are then transferred to hot ore bins from which they are gravity fed to the furnaces. Ore melting is carried out in four 20,000 KVA electric furnaces. The molten nickel ore is tapped into ladles and vigorously mixed with ferrosilicon which acts as the reducing agent. Mixing is accomplished by transferring the molten mixture back and forth between two ladles. During the reduction process, a fraction of the ferronickel is removed from the ladle at regular intervals and introduced into two small electric furnaces for refining. Other input materials for the refining operations are limestone, dolomite, fluorspar, iron ore, and coarse concentrates from the skull plant.

The skull plant processes slag from the refining furnaces, metal spills and residues from the ladles (called skulls) to produce concentrates of high metal content that are recycled to the refining furnaces and to the ferrosilicon furnace. A hammer mill pulverizes the input materials and the coarser metal-rich fraction is removed magnetically. The finer tailings are slurried with water and piped to a tailings pile.

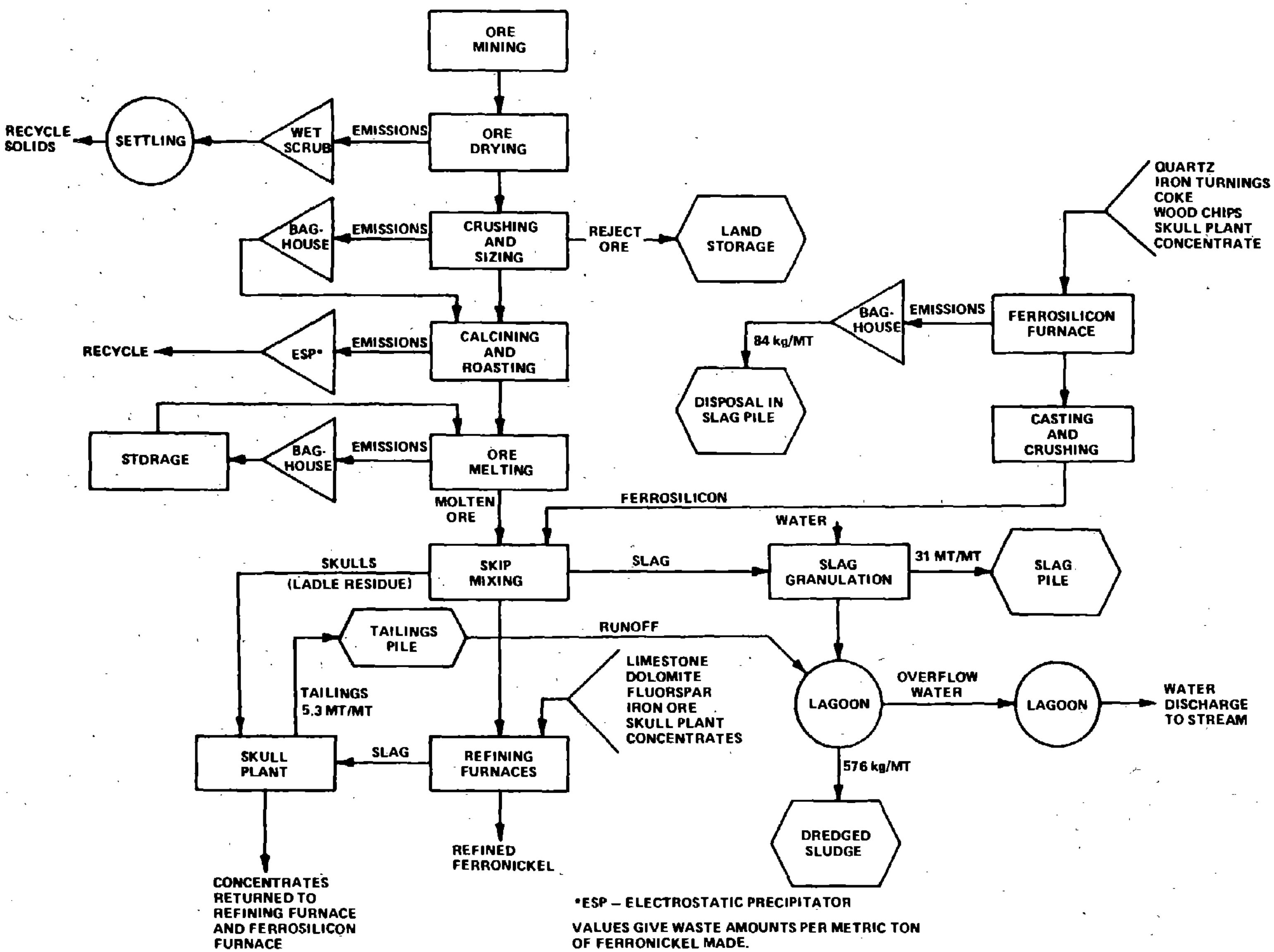

Figure 4 PROCESS AND SOLID WASTE FLOW DIAGRAM FOR FERRONICKEL PRODUCTION

Ferrosilicon is produced in a 15,000 KVA electric furnace with input materials consisting of quartz, iron turnings, coke, wood chips, and skull plant concentrates. All ferrosilicon produced is cast, crushed and used for reduction of the nickel ore.

The molten slag generated during the reduction of the nickel ore is granulated by high pressure water sprays and transferred to the slag pile by conveyor belt. The fines derived from granulation of the slag are carried in the water stream to settling ponds (or lagoons).

3.2.2 Description of Waste Streams

Ferromanganese and Silicomanganese

Slags. A dense vesicular slag is generated from ferromanganese production at a rate of 600 kg/MT ferromanganese product. Approximately 360 kg/MT of the 600 kg/MT generated is used as an input to the silica-manganese furnace. The remaining 240 kg/MT is stored on the ground for possible future use in silicomanganese production.

In the production of silicomanganese a glassy textured slag is generated at a rate of 1100 kg/MT of silicomanganese product. Of this amount approximately 785 kg/MT product is sold for road base with 315 kg/MT product disposed of in open dumps.

Major constituents of ferromanganese and silicomanganese slag are manganese, manganese oxide, silica, alumina, calcium oxide and magnesium oxide. Trace metals in these slags include chromium, copper, lead and zinc.

In solubility tests described in Appendix B there was no leaching of toxic heavy metals at greater than 0.2 ppm from either ferromanganese or silicomanganese slag. For this reason in addition to the dense nature of the slags, ferromanganese and silicomanganese slags are not considered hazardous at this time.

Dusts and Sludges. Depending on whether wet or dry emissions controls are used on furnaces, dusts or sludges are produced. Figure 3 illustrates emissions control residuals using wet scrubbers. Emissions from the ferromanganese furnaces are generated at a rate of 167.4 kg/MT of product. Ninety percent of these emissions or 150.6 kg/MT product are captured in wet scrubbing systems. The scrubber water is lime treated and clarified. Underflow sludge from the clarifier is generated at a dry weight rate of 164.8 kg/MT product and settled in a lagoon.

Emissions from the silico-manganese furnace are generated at a rate of 109 kg/MT silicomanganese product. Ninety percent of the emissions are captured in wet scrubbers as shown in Figure 3 and sent to a settling basin at a rate of 98.5 kg/MT product. Solids are collected in the settling basin, dredged several times per week and trucked to an on-site open dump at a rate of 74 kg/MT product.

Overflow from the settling basin carries 23 kg of dry solids /MT product to the lagoon. Solids from the lagoon are periodically dredged and open dumped at a rate of 187.8 kg/MT of product.

In solubility tests described in Appendix B, dusts and sludges from silicomanganese emissions control leached lead at approximately 1.3 ppm. Ferromanganese dusts leached 110 ppm zinc and 560 ppm lead. For these reasons, along with the fine particulate nature of these wastes,sludges and dust, residuals from ferromanganese and silicomanganese production are considered potentially hazardous at this time.

Ferrosilicon

Dust. The production of ferrosilicon generates no slag. Therefore, control of furnace emissions produces the only significant solid waste. While dry-and-wet emissions control systems are utilized, dry type systems are more prevalent. Furnace emissions average about 450 kg/MT (900 lb/ton) for 75% FeSi and 225 kg/MT (450 lb/ton) for 50% FeSi. Thus, for furnaces controlled by baghouse collection systems the average quantity of collected dry dust will vary between 405 kg/MT product and 202.5 kg/MT product depending on the type of FeSi being made. An overall hooding and capture efficiency of 90 percent is assumed. The collected dusts are trucked to a land disposal area for open dumping.

In solubility tests described in Appendix B there was no leaching of toxic heavy metals greater than 0.3 ppm from ferrosilicon baghouse dust. Sludge would be expected to behave similarly. For this reason dusts and sludges from ferrosilicon production are not considered potentially hazardous at this time.

Ferrochrome

Slag. In ferrochrome production the slag-to-product ratio is estimated to vary from 1.5 to 2.0. Therefore the slag generation factor is approximately 1750 kg/MT of ferrochrome product. The slag occurs in dense 4 to 6 inch diameter clumps and has a vesicular surface. The slag is either open dumped or processed to produce two or more fractions and sold for use in road building.

In solubility tests described in Appendix B, there was insignificant leaching of toxic constituents from ferrochrome slag. This slag is therefore not considered potentially hazardous at this time.

Dust. Available data show that both wet and dry emissions controls systems are used in ferrochrome production. If the furnace emissions are controlled by a dry system 151 kg of dust per MT of ferrochrome product will be collected on the assumption that the overall hooding and collection efficiency is 90%. The collected dust is usually trucked to an on-site dump for final disposal.

In solubility tests described in Appendix B it was found that dusts from ferrochrome production leached over 100 ppm chrome and around 1 ppm lead. For this reason dust from ferrochrome emissions control is considered potentially hazardous at this time.

Sludge. For a wet collection system operating at an overall capture efficiency of 90%, the same weight of particulates would be contained in the scrubber water as were captured by the dry system. The scrubber water would be piped to a settling basin to allow the particulates to settle. An estimated 97% or 146.5 kg/MT product of the solids would be retained in the settling basin. Accumulated bottom sediments in the settling basin would be pumped out or clammed out periodically and dumped on adjacent land areas.

As discussed previously ferrochrome dust released chrome and lead in solubility tests. Sludge would be expected to behave similarly and is therefore considered potentially hazardous at this time.

Ferronickel

Slag. Granulated slag from the reduction operation is generated at a rate of 31 MT/MT production, a very high ratio of waste to product. Accumulation of this slag since the plant began operation in 1954 has produced a huge slag pile covering many acres and extending up to a height of 100 feet or greater. A very small fraction of the slag is purchased by a local contractor for road base.

Solids are carried from the slag granulation operation into a large lagoon (approximately 12 acres) at a rate of 697 kg/MT ferronickel product (see Figure 4). Sludge amounting to 576 kg/MT product is dredged once a year from the lagoon and open dumped on land adjacent to the lagoon. Overflow from the settling lagoon is diverted to a second lagoon which is not dredged.

In solubility tests described in Appendix B zinc leached from slag at 2.0 ppm and lead at 1.0 ppm. The fines from this slag (i.e. sludge) however, did not leach toxic heavy metal constituents beyond 0.3 ppm in the solubility tests. For this reason slag and slag fines (sludge) are not considered hazardous at this time.

Skull Plant Tailings. Tailings from the skull plant as shown in Figure 4 are generated at the high rate of 5.3 MT/MT product. The tailings are piped to the tailings pile at the rate of 360 MT (400 short tons) per day. Water runoff from the tailings pile is diverted to the lagoon which receives slag granulation water. Since the skull plant began operation the skull plant tailings pile has grown to an impressive area and height but is dwarfed by the mountainous slag pile.

In solubility tests described in Appendix B, skull plant tailings leached copper and zinc at approximately 50 ppm. For this reason skull plant tailings are considered potentially hazardous at this time.

Dusts. Dusts collected during ore preparation including drying, crushing, calcining and roasting are fed to the furnaces so no significant solid waste accumulates from control of emissions from these operations.

Dusts from the electric furnace are captured in baghouses and recycled to the furnaces with the exception of dust collected from the ferrosilicon furnace. The ferrosilicon dusts are collected at the rate of 84 kg/MT product, wetted to prevent blowing, and disposed of in the slag pile.

In solubility tests described in Appendix B ferrosilicon furnace dust did not leach any toxic heavy metals greater than 0.3 ppm and is therefore considered non- hazardous.

3.2.3 Waste Quantities

A number of ferroalloy plants were visited and samples of waste residuals obtained for subsequent chemical analyses. These analyses are given in Appendix A. From these analyses and data provided by individual plants on quantities of wastes, waste generation and constituent concentration factors were developed. These factors are given in Table 17. Using the generation and concentration factors in Table 17 the yearly generation of waste residuals from typical plants have been estimated. These estimates are given in Table 18 for typical plants producing the various ferroalloys (FeMn, SiMn, FeSi, FeCr, FeNi). Based on plant capacities, data supplied by individual plants, and chemical analyses of collected samples, estimates of the total quantities of land disposed wastes and potentially hazardous constituents thereof have been made on state by state, EPA regional, and national levels. This data is tabulated in Table 19 for 1974, 1977 and 1983. Estimates for growth in ferroalloy capacity by 1983 is approximately 4%. Inherent error in estimated waste quantities does not warrant meaningful increased 1977 and 1983 projections at this growth rate.

Oregon with only two ferroalloy plants generates the greatest amount of slag and sludge than other states with ferroalloy industries. This is a result of the ferronickel plant which generates very large quantities of waste per unit of product. Ohio which has 8 ferroalloy plants generates the second largest quantity of slag and sludge and the greatest quantity of dusts.

3.3 TREATMENT AND DISPOSAL TECHNOLOGY

3.3.1 Current Treatment and Disposal Practices

Ferromanganese and Silicomanganese

Slag. Slag from the ferromanganese furnace which is not used as charge material in silicomanganese production (approximately 40% of total slag) is stored on land for possible future use. Approximately 30% of residual slag from silicomanganese furnaces which is not able to be sold as road fill is open dumped. Open dumping or sale as roadfill are environmentally adequate since ferromanganese and silicomanganese slags are not considered potentially hazardous at this time.

Table 17

WASTE GENERATION FACTORS - FERROALLOY PRODUCTION, DRY WEIGHTS

TYPE OF WASTE	GENERATION FACTOR Kg/MT	CONCENTRATION FACTORS (ppm)							
		Co	Cr	Cu	Mn	Ni	Pb	V	Zn
FERROMANGANESE									
SLAG	240	–	100	310	525,000	–	10	–	20
SLUDGE	164.8	–	18	50	20,000	–	5,000	–	35,000
SILICOMANGANESE									
SLAG	1,100	–	27	23	70,000	–	20	–	20
SLUDGE	98.5	–	45	82	200,000	–	25,000	–	10,000
FERROSILICON									
SLAG	0	–	–	–	–	–	–	–	–
SLUDGE		–	–	–	–	–	–	–	–
DUST	338	82	160	2,180	1,500	3,250	–	–	1,300
FERROCHROME									
SLAG	1,750	–	3,710	17	290	–	12	–	65
DUST	151	–	3,390	54	7,200	–	300	–	14,000
FERRONICKEL									
SLAG	31,000	104	321	50	1,100	1,850	–	–	100
TAILINGS	5,300	47	380	21	500	1,330	–	–	500
DUST	84	82	160	2,180	1,500	3,250	–	–	1,300
SLUDGE	576	159	2,140	23	2,000	4,100	–	–	125

Table 18

YEARLY GENERATION OF RESIDUALS BY TYPICAL FERROALLOY PLANTS, DRY WEIGHTS

TYPE OF WASTE	TOTAL WASTE QUANTITY (MT)	QUANTITY OF POTENTIALLY HAZARDOUS CONSTITUENTS (MT)						
		Co	Cr	Cu	Mn	Ni	Pb	Zn
FERROMANGANESE[a]								
SLAG	7,200	–	0.72	2.23	3,780	–	0.07	0.14
SLUDGE	4,944	–	0.089	0.247	98.9	–	24.7	173
a) PRODUCTION CAPACITY OF 30,000 MT/YEAR								
SILICOMANGANESE[b]								
SLAG	44,000	–	1.19	1.01	3,080	–	0.088	0.88
SLUDGE	3,940	–	0.177	0.323	788	–	98.5	39.4
b) PRODUCTION CAPACITY OF 40,000 MT/YEAR								
FERROSILICON[c]								
SLAG	0	–	–	–	–	–	–	–
DUST	13,520	1.11	2.16	29.48	20.28	43.94	–	17.58
c) PRODUCTION CAPACITY OF 40,000 MT/YEAR								
FERROCHROME[d]								
SLAG	61,250	–	227	1.04	17.8	–	0.735	3.98
DUST	5,285	–	17.92	0.285	38.1	–	1.586	74.0
d) PRODUCTION CAPACITY OF 35,000 MT/YEAR								
FERRONICKEL[e]								
SLAG	732,000	76	235	37	805	1,350	–	73
TAILINGS	125,000	5.9	48	2.6	62	166	–	62
DUST	1,980	0.16	0.32	4.3	3.0	6.4	–	2.6
SLUDGE	13,600	2.2	29	0.31	27.2	56	–	1.7
e) PRODUCTION CAPACITY OF 23,600 MT/YEAR								

Table 19a

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FOR THE FERROALLOY INDUSTRY TOTAL SLAG – 1974, 1977, 1983 (METRIC TONS)

STATE	TOTAL[a] DISPOSED	TOTAL[b] POTENTIALLY HAZARDOUS	TOTAL[b] HAZARDOUS CONSTITUENTS	DISPOSAL	CONSTITUENTS								
					Cd	Co	Cr	Cu	Mn	Ni	Pb	V	Zn
ALABAMA	27,100	0	0	LAND DISPOSED, SOLD	NA	NA	0.7	0.6	1900	NA	0.5	NA	0.5
KENTUCKY	137,000			LAND DISPOSED, SOLD	NA	NA	353	15	22,700	NA	1.1	NA	7.0
NEW JERSEY	3,200			ON-SITE DISPOSAL, SOME SOLD	NA	NA	P	P	P	P	P	P	P
NEW YORK	8,900			SOLD FOR ROAD CONSTRUCTION	NA	NA	19.1	0.2	5	NA	NA	NA	NA
OHIO	177,500			METAL RECOVERY SOLD, LAND DISPOSED	NA	NA	371	15	23,000	NA	1.5	NA	10.8
OREGON	787,900			LAND DISPOSED, SOLD	NA	1	246	43	9,600	21	0.3	NA	76.5
S. CAROLINA	140,700			PROCESSED TO REMOVE METALS THEN SOLD	NA	NA	522	2.4	41	NA	1.6	NA	9.1
TENNESSEE	65,100			LAND DISPOSED, SOLD	NA	NA	1.8	1.5	4,560	NA	1.3	NA	1.3
TEXAS	17,300			LAND DISPOSED, SOLD	NA	NA	1.7	5.4	9,090	NA	0.2	NA	0.4
W. VIRGINIA	45,700			LAND DISPOSED, SOLD	NA	NA	26.8	0.4	690	NA	0.2	NA	2.0
EPA REGION													
II	12,100				NA	NA	19.1	0.2	5	NA	NA	NA	NA
III	45,700				NA	NA	26.8	0.4	690	NA	0.2	NA	2.0
IV	369,900				NA	NA	877	19.5	29,201	NA	4.5	NA	17.9
V	177,500				NA	NA	371	15	23,000	NA	1.5	NA	10.8
VI	17,300				NA	NA	1.7	5.4	9,090	NA	0.2	NA	0.4
VII	0				0	0	0	0	0	0	0	0	0
X	787,900				NA	1	246	43	9,600	21	0.3	NA	76.5
NATIONAL TOTALS	1,410,400				NA	1	1542	83	71,486	21	6.7	NA	107

a) INCLUDES SLAG SOLD, BUT NOT SLAG USED ON SITE FOR PRODUCING OTHER ALLOYS

b) SLAGS NOT CONSIDERED HAZARDOUS AT THIS TIME AS A RESULT OF SOLUBILITY TESTING CONDUCTED BY CALSPAN AND DESCRIBED IN APPENDIX B.

NA = DATA NOT AVAILABLE P = CONSTITUENT KNOWN TO BE PRESENT, BUT AMOUNT NOT KNOWN.

SOURCE: CALSPAN CORPORATION

Table 19b

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FOR THE FERROALLOY INDUSTRY TOTAL DUST – 1974, 1977, 1983 (METRIC TONS) – DRY AND WET

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	CONSTITUENTS								
					Cd	Co	Cr	Cu	Mn	Ni	Pb	V	Zn
ALABAMA	39,600	0	0	LAND DISPOSED	NA	0.2	0.3	4.5	3.1	6.8	NA	NA	2.7
KENTUCKY	30,700	14,300	1980	LAND DISPOSED	0.6	0.7	249	19.7	1291	28.5	55.2	0.4	408
NEW JERSEY	NA	NA	NA	ON-SITE DUMP	NA	NA	P	P	P	P	P	P	P
NEW YORK	5,900	5,900	8.7	ON-SITE DUMP	NA	NA	0.2	0.3	4.1	NA	NA	NA	4.1
OHIO	104,100	19,500	26		NA	2.3	5.1	60.9	54.1	89.6	NA	NA	48.6
OREGON	2,000	0	0	WETTED AND DUMPED ON SLAG PILE	NA	0.2	0.3	4.3	3.0	6.5	NA	NA	2.6
S. CAROLINA	9,100	9,100	438	LANDFILL	0.9	NA	363	0.5	18.1	NA	9.1	0.6	45.4
TENNESSEE	10,900	10,900	1103	LAND DISPOSED	NA	NA	0.1	0.4	980	NA	35	NA	87
WASHINGTON	15,400	0	0	LAND DISPOSED	NA	0.3	0.6	7.9	5.4	11.8	NA	NA	4.7
W. VIRGINIA	84,400	15,400	178	LAND DISPOSED	NA	1.2	2.5	31.2	174	45.7	5.2	NA	37.1
EPA REGION													
II	5,900	5,900	8.7		NA	NA	0.2	0.3	4.1	NA	NA	NA	4.1
III	84,400	15,400	178		NA	1.2	2.5	31.2	174	45.7	5.2	NA	37.1
IV	90,300	34,300	3520		1.5	0.9	612	25.1	2292	33.3	99.3	0.9	543.1
V	104,100	19,500	26		NA	2.3	5.1	60.9	54.1	89.6	NA	NA	48.6
VI	0	0	0		0	0	0	0	0	0	0	0	0
VII	0	0	0		0	0	0	0	0	0	0	0	0
X	17,400	0	0		NA	0.5	0.9	12.2	8.4	18.3	NA	NA	7.3
NATIONAL TOTALS	302,100	75,100	3730		1.5	4.9	621	130	2533	187	105	0.9	640

NA = DATA NOT AVAILABLE

P = CONSTITUENT KNOWN TO BE PRESENT, BUT AMOUNT NOT KNOWN.

SOURCE: CALSPAN CORPORATION

Table 19c

ESTIMATED STATE, REGIONAL, AND NATIONAL SOLID WASTE FOR THE FERROALLOY INDUSTRY TOTAL SLUDGE – 1974, 1977, 1983 (METRIC TONS) DRY WEIGHT *

STATE	TOTAL DISPOSED	TOTAL POTENTIALLY HAZARDOUS	TOTAL HAZARDOUS CONSTITUENTS	DISPOSAL METHOD	HAZARDOUS CONSTITUENTS								
					Cd	Co	Cr	Cu	Mn	Ni	Pb	V	Zn
ALABAMA	16,600	16,600	561	LAGOONS	NA	1.0	1.9	26.5	426	39.2	14.5	NA	52
IOWA	10,900	10,900	NA	LAGOONS	NA	NA	NA	NA	NA	NA	NA	NA	NA
NEW JERSEY	NA	NA	NA	LAGOONS LINED	NA	NA	P	P	P	P	P	P	P
OHIO	35,800	35,800	2027	LAGOONS	0.5	0.4	219	12	847	16	125	0.3	807
OREGON	142,200	142,200	683	TAILINGS PILE & LAGOON	NA	8.0	77	3.1	163	222	18	NA	192
S. CAROLINA	3,900	3,900	188	LAGOON-DREDGED	0.4	NA	156	0.2	7.8	NA	3.9	0.1	19.5
TENNESSEE	0	0	0	–	0	0	0	0	0	0	0	0	0
TEXAS	3,300	3,300	196	LAGOONS	NA	NA	0.1	0.2	65.3	NA	16.3	NA	114
WASHINGTON	0	0	0	–	0	0	0	0	0	0	0	0	0
W. VIRGINIA	0	0	0	–	0	0	0	0	0	0	0	0	0
EPA REGION													
II	NA	NA	NA		NA	NA	P	P	P	P	P	P	P
III	0	0	0		0	0	0	0	0	0	0	0	0
IV	20,500	20,500	749		0.4	1.0	158	26.7	434	39	18.4	NA	72
V	35,800	35,800	2027		0.5	0.4	219	12	847	16	12.5	0.3	807
VI	3,300	3,300	196		NA	NA	0.1	0.2	65.3	NA	16.3	NA	114
VII	10,900	10,900	NA		NA	NA	NA	NA	NA	NA	NA	NA	NA
X	142,200	142,200	683		NA	8.0	77	3.1	163	222	18	NA	192
NATIONAL TOTALS	212,700	212,700	3,655		0.9	9.0	454	42	1509	277	178	0.3	1185

NA = DATA NOT AVAILABLE

P = CONSTITUENT KNOWN TO BE PRESENT, BUT AMOUNT NOT KNOWN

* TO CONVERT TO APPROXIMATE WET WEIGHTS MULTIPLY BY 2.5

SOURCE: CALSPAN CORPORATION

Sludges and Dusts. At the present time lime treated scrub-water from ferromanganese furnace emissions control and wet scrubber sludge from silicomanganese emissions control is settled in lagoons or settling basins. Settled sediments are periodically dredged and dumped on land. Dusts are either directly dumped on land or wetted before dumping to prevent blowing. The present methods of disposing of sludges or dusts are considered inadequate because of the danger of leaching of lead and zinc.

Ferrosilicon

Dusts and Sludges. Collected dust from ferrosilicon furnaces is usually trucked to on-site open dump areas. Dust is wetted down to prevent blowing from the truck while being transported. If wet emissions control is used a sludge is generated which is open dumped. Open dumping of dust or sludge is environmentally acceptable since they are not considered hazardous at this time.

Ferrochrome

Slag. Electric furnace slag is open dumped or sold for use in road building. These practices are environmentally adequate since solubility tests indicated that ferrochrome furnace slag is non-hazardous at this time.

Dusts and Sludge. Either dusts or scrubber water is generated from emissions control on ferrochrome electric furnaces depending on the method of air pollution control practiced. Dusts are open dumped while scrubber waters are put in unlined lagoons with periodic dredging of settled sediments. Dredged sediments are open dumped. Current practices of dust and sludge disposal are considered inadequate because of the possibility of chrome and lead leaching.

Ferronickel

Slag. Granulated slags from reduction furnaces are presently open dumped. This practice is adequate since ferronickel slag is not considered hazardous at this time.

Skull Plant Tailings. Skull plant tailings are currently open dumped. This practice is not considered adequate because of evidence of zinc and copper leaching at approximately 50 ppm in solubility tests.

Sludges. Sludges result from settling of slag granulation water and skull plant tailing water in an unlined lagoon. The sludges are dredged from the lagoon and open dumped. The sludge from slag granulation is not considered potentially hazardous while that from skull plant tailings is considered potentially hazardous. Since they accumulate in the same lagoon, the entire sludge volume must be considered hazardous at this time and the use of an unlined lagoon as not acceptable.

Dust. The only land disposed dust from ferronickel production is the emission control dust from the associated ferrosilicon furnace. This dust is open dumped on land, an environmentally acceptable practice since ferrosilicon dust is not considered potentially hazardous at this time.

Levels of treatment and disposal technology for those ferroalloy wastes which are considered potentially hazardous are discussed in the following sections.

3.3.2 Present Treatment and Disposal Technology (Level I)

Ferromanganese and Silicomanganese

Sludges and Dust. Lime treated scrubwater from ferromanganese furnace emissions controls and wet scrubber sludge from silicomanganese emissions control is settled in lagoons or settling basins. Settled sediments are dredged and open dumped. Dusts are either open dumped directly or wetted before open dumping. These practices are inadequate because of the possibility of heavy metal leaching and subsequent percolation through permeable soils to groundwater.

Ferrochrome

Dusts and Sludges. Dusts are open dumped and scrubber waters are settled in unlined lagoons with periodic dredging of settled sediments. Dredged sediments are open dumped. These practices are inadequate because of the possibility of heavy metal leaching and subsequent percolation through permeable soils to groundwater.

Ferronickel

Skull Plant Tailings. Skull plant tailings are presently open dumped. This is not adequate since solubility tests indicate leaching of zinc and copper which could percolate through permeable soils to groundwater.

Sludges. Sludges from skull plant tailings water accumulates in a lagoon along with sludge from slag granulation water. Sludge is periodically dredged and open dumped. The lagoon is unlined. The use of an unlined lagoon and open dumping of dredged sludge are considered inadequate because of the danger of heavy metal leaching through permeable soils to groundwater.

3.3.3 Best Technology Currently Employed (Level II)

Ferromanganese and Silicomanganese

Sludges and Dusts. Level II technology is the same as Level I (i.e. open dumping of dust and dredged sludge).

Ferrochrome

Dusts and Sludges. Level II technology is the same as Level I (i.e. open dumping of dust and dredged sludge).

Ferronickel

Skull Plant Tailings. Level II technology is the same as Level I (i.e. open dumping).

Sludges. Level II technology is the same as Level I (i.e. lagoon settling and open dumping of dredged sludge).

3.3.4 Technology To Provide Adequate Health And Environmental Protection (Level III)

Ferromanganese and Silicomanganese

Sludges and Dust. The use of lined lagoons would be required for settling of sludges. Dredged sludges would need chemical fixation before dumping on land to prevent heavy metal leaching. Ground upon which dusts are disposed would require soil sealing to prevent percolation of potentially hazardous constituents.

Ferronickel

Skull Plant Tailings. The ground area for disposal of skull plant tailings would require sealing with bentonite or other sealant to prevent percolation of leachate. Runoff water would be collected and diverted to the lagoon.

Sludges. The lagoon receiving sludge from the skull plant tailings pile and slag granulation would require a lining. Dredged lagoon sediments would be dried and disposed of in sealed soil areas.

Tables 20a through 20e summarize features of Levels I, II and III treatment and disposal technology for those wastes from the ferroalloy industry which are considered potentially hazardous at this time.

3.4 COST ANALYSIS

In the last section, various treatment and disposal technologies currently employed or considered for adequate health and environment protection were described. The costs for implementing this technology for typical plants is considered in this section. Costs are given separately for plants producing ferromanganese and silicomanganese, ferrosilicon, ferrochrome, and ferronickel.

Table 20a

Treatment and Disposal Technology Levels

Smelting and Refining Category Ferromanganese SIC 3313

Sludge

Factor	Level I (Prevalent)	Level II (Best Available)	Level III (Adequate Health and Enviromental Protection)
Physical + Chemical Properties	Colloidal to silt size particles; lime, silica, iron	Same as I	Same as I
Amount of Waste (kg/MT Product)	150.6	Same as I	Same as I
Factors Affecting Hazardousness	Contains trace heavy metals including Cr, Cu, Pb, Zn	Same as I	Same as I
Treatment/ Disposal Technology	Sludge - lagoons with dredged material open dumped	Same as I	Sludge - lines lagoon with chemical fixation of sludge
Estimate of # + % of Plants Using Technology	>75%	>75%	0

Table 20a - (cont'd.)

Factor	Level I	Level II	Level III
Adequacy of Technology	Inadequate	Same as I	Adequate
Problems and Comments	Lead and zinc leached in solubility tests	Same as I	None
Non-Land Environmental Impact	Possible contamination of ground or surface water	Same as I	None
Compatibility With Existing Facilities	Compatible	Compatible	Compatible
Monitoring & Surveillance Methods	None	Same as I	Groundwater and surface runoff monitoring
Energy Requirements	Negligible	Negligible	Negligible

Table 20b

Treatment and Disposal Technology Levels

Smelting and Refining Category Silicomanganese SIC 3313

Scrubber Sludge

Factor	Level I (Prevalent)	Level II (Best Available)	Level III (Adequate Health and Enviromental Protection)
Physical + Chemical Properties	Colloidal to silt size particles; silica, iron, magnesium, manganese	Same as I	Same as I
Amount of Waste (kg/MT Product)	985	Same as I	Same as I
Factors Affecting Hazardousness	Contains trace heavy metals including Cr, Cu, Pb, Zn, Mn	Same as I	Same as I
Treatment/ Disposal Technology	Lagooned with dredged material open dumped	Same as I	Lined lagoons and chemical fixation if heavy metals leached
Estimate of # + % of Plants Using Technology	>75%	>75%	0

Table 20b (Cont.)

Factor	Level I	Level II	Level III
Adequacy of Technology	Inadequate if heavy metals are significantly leached	Same as I	Adequate
Problems and Comments	Lead leached in solubility tests	Same as I	None
Non-Land Environmental Impact	Possible contamination of ground or surface water	Same as I	None
Compatibility With Existing Facilities	Compatible	Compatible	Compatible
Monitoring & Surveillance Methods	None	None	Groundwater surveillance wells, surface runoff monitoring
Energy Requirements	Negligible	Negligible	Negligible

Table 20c

Treatment and Disposal Technology Levels

Smelting and Refining Category Ferrochrome SIC 3313

Dust, Sludge

Factor	Level I (Prevalent)	Level II (Best Available)	Level III (Adequate Health and Enviromental Protection)
Physical + Chemical Properties	Dust-colloidal to silt size particles Sludge-colloidal to silt size particles	Same as I	Same as I
Amount of Waste (kg/MT Product)	Dust - 168 Sludge - 146	Same as I	Same as I
Factors Affecting Hazardousness	Presence of heavy metals including Cr, Cu, Pb, Zn, Mn	Same as I	Same as I
Treatment/ Disposal Technology	Dust - open dumped Sludge - unlined lagoon with dredged sediments dumped on land	Same as I	Dust - land sealing and diversion of runoff if heavy metals leach significantly Sludge - lined lagoons and chemical fixation if heavymetals leach significantly
Estimate of # + % of Plants Using Technology	>75%	>75%	0

*Dust from dry air pollution control system; sludge from wet air pollution control system.

Table 20c (Cont.)

Factor	Level I	Level II	Level III
Adequacy of Technology	Inadequate if heavy metals are significantly leached	Same as I	Adequate
Problems and Comments	Chrome and lead leached from dust in solubility tests	Same as I	None
Non-Land Environmental Impact	Possible contamination of ground or surface water	Same as I	None
Compatibility With Existing Facilities	Compatible	Compatible	Compatible
Monitoring & Surveillance Methods	None	Same as I	Groundwater surveillance wells, surface runoff monitoring
Energy Requirements	Negligible	Negligible	Negligible

Table 20d

Treatment and Disposal Technology Levels

Smelting and Refining Category Ferronickel SIC 3313

Skull Plant Tailings

Factor	Level I (Prevalent)	Level II (Best Available)	Level III (Adequate Health and Enviro-mental Protection)
Physical + Chemical Properties	Sand to gravel size, lime, magnesium, iron, silica	Same as I	Same as I
Amount of Waste (kg/MT Product)	5,300	Same as I	Same as I
Factors Affecting Hazardousness	Presence of heavy metals including Co, Cr, Cu, Zn, Mn, Ni	Same as I	Same as I
Treatment/ Disposal Technology	Open dump	Same as I	Ground sealing and diversion of runoff if heavy metals leached
Estimate of # + % of Plants Using Technology	1 (100%)	1 (100%)	0

Table 20d (Cont.)

Factor	Level I	Level II	Level III
Adequacy of Technology	Inadequate if heavy metals are significantly leached	Same as I	Adequate
Problems and Comments	Copper and zinc leached in solubility tests	Same as I	None
Non-Land Environmental Impact	Possible contamination of ground or surface water	Same as I	None
Compatibility With Existing Facilities	Compatible	Compatible	Compatible
Monitoring & Surveillance Methods	None	Same as I	Groundwater surveillance wells, surface runoff monitoring
Energy Requirements	Negligible	Negligible	Negligible

Table 20e

Treatment and Disposal Technology Levels

Smelting and Refining Category Ferronickel SIC 3313

Sludge from Slag Granulation Water and Skull Tailings Water

Factor	Level I (Prevalent)	Level II (Best Available)	Level III (Adequate Health and Enviro-mental Protection)
Physical + Chemical Properties	Silt to sand size particles; silica, iron	Same as I	Same as I
Amount of Waste (kg/MT Product)	576	Same as I	Same as I
Factors Affecting Hazardousness	Presence of trace metals including Co, Cr, Cu, Zn, Mn, Ni	Same as I	Same as I
Treatment/ Disposal Technology	Unlined lagoon with dredged sludge dumped on land	Same as I	Lined lagoons with sealing of sludge disposal area
Estimate of # + % of Plants Using Technology	1 (100%)	1 (100%)	0

Table 20e (cont'd.)

Factor	Level I	Level II	Level III
Adequacy of Technology	Inadequate if heavy metals are significant leached	Same as I	Adequate
Problems and Comments	Solubility tests indicate that sludge from skull plant tailings will leach copper and zinc	Same as I	None
Non-Land Environmental Impact	Possible contamination of ground or surface water	Same as I	None
Compatibility With Existing Facilities	Compatible	Compatible	Compatible
Monitoring & Surveillance Methods	None	None	Groundwater surveillance wells, surface runoff monitoring
Energy Requirements	Negligible	Negligible	Negligible

3.4.1 Cost of Present Treatment and Disposal Technology (Level I)

Ferromanganese and Silicomanganese. The typical plant produces 81,000 MT of ferromanganese and 25,400 MT of silicomanganese operating about 345 days/year.

Effluents from both operations go to a lagoon. It has a volume of 10,700 m^3 and allows for 4 days of residence. Its design characteristics are:

Volume	10,700 m^3
Bottom width	38 m
Top width	50 m
Bottom length	75 m
Top length	87 m
Total depth	3 m
Depth of excavation	1.15 m
Circumference	286 m
Dike volume	3,546 m^3
Dike surface	3,921 m^2
Total width	63 m
Total length	101 m
Required area	.65 ha

The daily inflow into the lagoon contains 40.6 MT of solids which form about 29 m^3 of sludge. This requires that the lagoon is dredged about 1.9 times/yr assuming that it is dredged when half filled with sludge. This requires about 380 hours of dragline time based on a capacity of 27 m^3/yr of frontloader and truck time. The lagoon is located on semi-industrial land.

Scrubber water from the silicomanganese furnace flows through a concrete-lined settling pit before entering the lagoon. The pit is sized to allow a settling time of 30 minutes. About 38.7 MT of solids are removed weekly from the pit and trucked to the on-site dump. This operation is estimated to require 80 hours of truck and backhoe time/yr.

Capital and annual costs of Level I treatment and disposal technology are given in Table 21.

Ferrochrome. The selected plant produces 62,790 MT of ferrochrome/year operating 345 days. Two types of wastes are generated. One is furnace slag (non-hazardous) which is open dumped or sold for use in road building. The other consists of wastes collected by air emission control systems considered hazardous. Both dry and wet systems are employed for handling the latter waste, and costs are developed for both systems.

TABLE 21

COST OF LEVEL I TREATMENT AND DISPOSAL TECHNOLOGY
FERROALLOYS - FERROMANGANESE AND SILICOMANGANESE

Capital Cost

	Sludge
Lagoon	
Site Preparation	
Survey	$ 375
Test Drilling	490
Sample Testing	250
Report Preparation	1,200
Construction	
Excavation & Forming	4,715
Compacting	6,560
Fine Grading	1,765
Soil Poisoning	355
Transverse Drain Fields	580
Land	2,570
Sump	3,870
Equipment	
Truck (1.1)	8,250
Front Loader (1.1)	6,600
Dragline (20%)	14,000
Bulldozer (30%)	2,305
Dump	
Survey	1,350
Land	8,545
TOTAL	$63,780

TABLE 21 (Cont.)

Annual Cost

		Sludge
Land		$ 1,110
Amortization		
Construction		2,495
Equipment		4,955
Operating Personnel		20,110
Repair and Maintenance		
Construction		535
Equipment		1,560
Energy		
Fuel		2,310
Electricity		230
Taxes		280
Insurance		
(Slag Sale)		640
	TOTAL	$34,225

The dry system results in the collection of 15.7 MT of dust/day with a density of 500 Kg/m^3. The dust is transported to an on-site dump, which requires 2 hrs/day of frontloader and truck time.

In the wet system, the scrubber water is piped to a lagoon. The lagoon, like all other waste disposal facilities is assumed located on semi-industrial land. Inflow into the lagoon is at a rate of 80 l/sec. The lagoon size allows for 4 days detention. Its characteristics are:

Volume	27,650 m^3
Bottom width	63 m
Top width	75 m
Bottom length	126 m
Top length	138 m
Total depth	3 m
Depth of excavation	.85 m
Circumference	438 m
Dike volume	6,872 m^3
Dike surface	6,282 m^2
Total width	90 m
Total length	153 m
Required area	1.4 ha

About 15.2 MT of solids settle in the lagoon daily which form 12.7 m^3 of sludge. Dredging is required only once every three years. On the average, 4,150 m^3 of sludge are dredged annually which represents 220 hours of frontloader and truck time.

The sludge dump is designed to accommodate lagoon sludge dredged over a 20-year period.

Capital and annual costs of Level I treatment and disposal technology are given in Table 22.

Ferrosilicon. Since there are no hazardous wastes believed associated with ferrosilicon production at this time, there are no costs associated with hazardous waste treatment and disposal.

Ferronickel. The model plant produces 23,600 MT of ferronickel operating 365 days/year. Ferrosilicon required for the reduction of nickel is produced in the same plant at a rate of about 20,620 MT/yr. The only wastes associated with ferronickel production which is believed hazardous is skull plant tailings and associated sludge.

Tailings from the skull plant are piped to a tailings pile. Solids accumulate at a rate of about 360 MT/day. The water from the tailings slurry drains into a lagoon which also receives water and solids from slag granulation. The tailings have an estimated density of 1,300 kg/m^3. Thus, about 275 m^3 of solids form daily and 100,375 m^3 annually. The accumulation over a 20-year period amounts to about 2,000,000 m^3. This will require a 7 ha area given that the tailings are built-up to a height of 30 m.

TABLE 22

COST OF LEVEL I TREATMENT AND DISPOSAL TECHNOLOGY

FERROALLOYS - FERROCHROME PLANT - DRY COLLECTION SYSTEM

Capital Cost

	Dust
Equipment	
Truck (35%)	$ 8,750
Front Loader (35%)	7,000
Bulldozer (5%)	1,000
Dump	
Survey	1,380
Land	8,740
TOTAL	$26,870

Annual Cost

	Dust
Land	$ 875
Amortization	
Construction	160
Equipment	2,665
Operating Personnel	16,265
Repair and Maintenance	
Construction	-
Equipment	840
Energy	
Fuel	2,000
Electricity	200
Taxes	220
Insurance	270
TOTAL	$23,495

TABLE 22 (Cont.)

FERROCHROME PLANT - WET COLLECTION SYSTEM

Capital Cost

	Sludge
Lagoon	
Site Preparation	
Survey	$ 875
Test Drilling	980
Sample Testing	500
Report Preparation	1,500
Construction	
Excavation & Forming	9,140
Compacting	12,715
Fine Grading	2,825
Soil Poisoning	545
Transverse Drain Fields	2,070
Land	5,535
Equipment	
Truck (10%)	2,500
Front Loader (10%)	2,000
Bulldozer (1%)	200
Drag Line (10%)	7,000
Dump	
Survey	505
Land	3,230
TOTAL	$52,120

TABLE 22 (Cont.)

Annual Cost

		Sludge
Land		$ 875
Amortization		
Construction		3,670
Equipment		1,860
Operating Personnel		7,145
Repair and Maintenance		
Construction		820
Equipment		585
Energy		
Fuel		820
Electricity		80
Taxes		220
Insurance		520
	TOTAL	$16,595

Solids carried into the settling lagoons accumulate at an estimated rate of 13,600 MT/yr. The sludge formed has a wet density of 1,260 Kg/m^3 and a dry density of 1,390 Kg/m^3. Most of the solids settle in the first of two lagoons (Lagoon A). The overflow from Lagoon A goes to the second lagoon (Lagoon B). The characteristics of the lagoons are:

	Lagoon A	Lagoon B
Volume	80,000 m^3	95,000 m^3
Bottom width	139 m	152 m
Top width	147 m	160 m
Bottom length	278 m	304 m
Top length	286 m	312 m
Circumference	879 m	955 m
Depth	2 m	2 m
Depth of excavation	.25 m	.25 m
Dike volume	9,990 m^3	10,863 m^3
Dike surface	9,893 m^2	10,758 m^2
Total width	160 m	173 m
Total length	299 m	325 m
Required area	4.8 ha	5.6 ha

Lagoon A is dredged once per year at which time about 10,800 m^3 of sludge is removed. This requires about 400 hours of dragline time. The sludge is then deposited on adjacent land. The transport is estimated to require 520 hours of frontloader and truck time annually.

In a dry state, sludge removed amounts to 9,785 m^3/yr or 195,700 m^3 in 20 years. This will require a 2 ha area if the built-up is to 10 m.

All dust except those from the ferrosilicon furnace are recycled. The latter are not considered hazardous and therefore have no hazardous waste disposal costs attributed to their disposal.

Altogether, about 680,000 m^3 of solids are deposited on land each year. This is estimated to require 6,800 hrs of bulldozer time yearly for spreading, shaping and compacting. Capital and annual costs of Level I treatment and disposal technology are given in Table 23.

3.4.2 Cost of Best Technology Currently Employed (Level II)

Ferromanganese and Silicomanganese. Technology and costs for Level II are the same as those for Level I.

Ferrochrome. Technology and costs for Level II are the same as those for Level I.

Ferronickel. Technology and costs for Level II are the same as those for Level I.

TABLE 23

COST OF LEVEL I TREATMENT AND DISPOSAL TECHNOLOGY

FERROALLOYS - FERRONICKEL PLANT

Capital Cost

	Sludge	Tailings
Lagoon A		
Site Preparation		
Survey	$ 3,000	
Test Drilling	900	
Sample Testing	250	
Report Preparation	1,500	
Construction		
Excavation & Forming	13,285	
Compacting	18,480	
Fine Grading	4,450	
Soil Poisoning	1,090	
Transverse Drain Fields	6,625	
Land	8,400	
Lagoon B		
Site Preparation		
Survey	3,500	
Test Drilling	900	
Sample Testing	250	
Report Preparation	1,500	
Construction		
Excavation & Forming	14,450	
Compacting	20,095	
Fine Grading	4,840	
Soil Poisoning	1,185	
Transverse Drain Fields	7,960	
Land	9,800	
Tailing's Dump		
Survey		4,375
Land		12,250
Sludge Dump		
Survey	1,250	
Land	3,500	
Equipment		
Truck (35%)	6,565	
Front Loader (35%)	5,250	
Bulldozer (55%)	545	7,615
Belt Conveyor		
Dragline (20%)	14,000	
TOTAL	$153,390	$24,240

TABLE 23 (Cont.)

Annual Cost

	Sludge	Tailings
Land	$ 2,170	$ 1,225
Amortization		
Construction	12,220	510
Equipment	4,190	1,210
Operating Personnel	16,920	11,565
Repair and Maintenance		
Construction	2,775	-
Equipment	1,320	380
Energy		
Fuel	1,945	915
Electricity	195	90
Taxes	545	305
Insurance	1,535	240
TOTAL	$43,815	$16,440

3.4.3 Cost of Technology to Provide Adequate Health and Environmental Protection (Level III)

Ferromanganese and Silicomanganese. The lagoon is lined and the accumulated sludge is removed by pumping instead of dredging. The sludge is chemically fixed prior to being deposited at the slag dump. The slurry pump is operated about 720 hrs/yr, and 1,000 labor hours are assigned for its operation. The use of the slurry pump eliminates the use of the dragline.

Capital and annual costs are given in Table 24.

Ferrochrome. The lagoon is lined, and the sludge or slurried dust is removed by pumping instead of dredging. The sludge is chemically fixed prior to being deposited at the dump. The dump surface is sealed and collection ditches installed, together with a pump and piping. The slurry pump is operated about 300 hrs/yr and 450 hrs are assigned for its operation. The use of the slurry pump eliminates use of the dragline. Capital and annual costs are given in Table 25.

Ferronickel. Both lagoons are lined and the accumulated sludge is removed from Lagoon A by pumping instead of dredging. The slurry pump used for this purpose is operated about 765 hrs/yr and 1,000 labor hours are assigned for its operation. The use of the slurry pump eliminates the need for the dragline.

The pumped sludge is deposited on a sealed .25 hectare area adjacent to Lagoon A for drying. The runoff is collected in ditches and then flows by gravity into Lagoon B. The dried sludge is then hauled to dump where the ground has been sealed.

The tailings from the skull plant are deposited on sealed ground and collection ditches are constructed at the dump site. The capital and annual costs of Level III treatment and disposal technology are given in Table 26.

Tables 27 through 29 summarize the capital and annual costs for Levels I, II and III treatment and disposal technologies for hazardous land disposed waste from the U.S. ferroalloys industry. Costs are given per metric ton of dry and wet wastes (i.e. sludges) and per metric ton of product. Cumulative total industry costs for each ferroalloy sector to meet Levels I, II and III treatment and disposal technology are also given. Costs for each type of waste and total costs for each ferroalloy sector are also expressed as percentages of product selling prices.

Estimated 1973 annualized industry costs for Levels I and II treatment and disposal technology of potentially hazardous wastes from ferromanganese and silicomanganese production are $250,000 or 0.2% of estimated national sales value. The industry cost of Level III treatment and disposal technology (adequate for environmental protection) is estimated as $1,310,000 or 0.8% of estimated national sales value.

TABLE 24

COST OF LEVEL III TREATMENT AND DISPOSAL TECHNOLOGY

FERROALLOYS - FERROMANGANES AND SILICOMANGANESE PLANT

Capital Cost

		Sludge
Construction		
Lagoon Liner		$21,440
Equipment		
Slurry Pump		13,730
Piping, Flexible		440
(Dragline)		(14,000)
	TOTAL	$21,610

Annual Cost

		Sludge
Land		-
Amortization		
Construction		$ 2,485
Equipment (1)		25
Operating Personnel (1)		4,835
Repair and Maintenance		
Construction		645
Equipment (1)		10
Energy		
Fuel (1)		(435)
Electricity		15
Taxes		-
Insurance (1)		215
Chem. Fixation		134,180
	TOTAL	$141,975

(1) Costs shown are net costs, i.e. costs of new equipment less dragline associated costs which are no longer incurred.

TABLE 25

COST OF LEVEL III TREATMENT AND DISPOSAL TECHNOLOGY

FERROALLOYS - FERROCHROME PLANT

Capital Cost

		Sludge
Construction		
Lagoon Liner		$47,630
Equipment		
Slurry Pump		13,730
Pipe, Flexible		440
(Dragline)		(7,000)
	TOTAL	$54,800

Annual Cost

		Sludge
Land		-
Amortization		
Construction		$ 5,525
Equipment (1)		1,140
Operating Personnel (1)		2,370
Repair and Maintenance		
Construction		1,430
Equipment (1)		360
Energy		
Fuel (1)		(175)
Electricity		10
Taxes		-
Insurances (1)		550
Chem. Fixation		54,780
	TOTAL	$65,990

(1) Costs shown are net costs, i.e. costs of new equipment less dragline associated costs which are no longer incurred.

TABLE 26

COST OF LEVEL III TREATMENT AND DISPOSAL TECHNOLOGY

FERROALLOYS - FERRONICKEL PLANT

Capital Cost

		Sludge	Tailings
Construction			
Lagoon (A) Liner		$180,080	
Lagoon (B) Liner		212,655	
Equipment			
Slurry Pump		13,730	
Piping, Flexible		440	
Sludge Drying Area			
Land Sealing		5,000	
Collection Ditches		760	
Pipe Rigid		1,730	
Dumps			
Survey			
Land			
Land Sealing		40,000	140,000
Collection Ditches		2,145	4,010
Pump and Piping		11,140	18,210
	TOTAL	$453,680	$162,220

TABLE 26 (Cont.)

Annual Cost

	Sludge	Tailings
Land	-	-
Amortization		
Construction	$51,115	$16,705
Equipment	2,075	2,895
Operating Personnel	4,590	-
Repair and Maintenance		
Construction	13,220	4,320
Equipment	650	910
Energy		
Fuel	(455)	-
Electricity	95	325
Taxes	-	-
Insurance	4,535	1,620
TOTAL	$75,825	$26,775

TABLE 27. SUMMARY COSTS - FERROMANGANESE AND SILICOMANGANESE

Annual Production: Model Plant 81,000/25,400 MT Industry 620,977/167,002 MT

Waste (Type)	Amount (MT/MT of Production)
Sludge	0.15 (Avg.)

Cum. Unit Waste Disposal Costs:

Waste (Type)	Level I $/MT of Waste		Level I $/MT of Prod.	Level II $/MT of Waste		Level II $/MT of Prod.	Level III $/MT of Waste		Level III $/MT of Prod.
Sludge	Dry	Wet		Dry	Wet		Dry	Wet	
Capital Cost	$4.00	$1.60	$0.60	$4.00	$1.60	$0.60	$5.36	$2.14	$0.80
Annual Cost	2.15	0.86	0.32	2.15	0.86	0.32	11.06	4.42	1.66
Total Capital Cost	--	--	0.60	--	--	0.60	--	--	0.80
Total Annual Cost	--	--	0.32	--	--	0.32	--	--	1.66

Cum. Industry Waste Disposal Costs ($ Million)

Waste (Type)	Level I Cap.	Level I Ann.	Level II Cap.	Level II Ann.	Level III Cap.	Level III Ann.
Sludge	$0.47	$0.25	$0.47	$0.25	$0.63	$1.31
Total	0.47	0.25	0.47	0.25	0.63	1.31

1973 Metal Price: $199.20/MT (avg.)

Percent Treatment Cost/Price of Metric Ton of Production

Waste (Type)	Level I Cap.	Level I Ann.	Level II Cap.	Level II Ann.	Level III Cap.	Level III Ann.
Sludge	0.3%	0.2%	0.3%	0.2%	0.4%	0.8%
Total	0.3	0.2	0.3	0.2	0.4	0.8

TABLE 28. SUMMARY COSTS - FERROCHROME

Annual Production: Model Plant 62,790 MT Industry 426,846 MT

Waste (Type)	Amount (MT/MT of Production)
Sludge	0.08

Cum. Unit Waste Disposal Costs:

Waste (Type)	Level I $/MT of Waste		Level I $/MT of Prod.	Level II $/MT of Waste		Level II $/MT of Prod.	Level III $/MT of Waste		Level III $/MT of Prod.
Sludge	Dry	Wet		Dry	Wet		Dry	Wet	
Capital Cost	$9.91	$3.96	$0.83	$9.91	$3.96	$0.83	$20.33	$8.13	$1.70
Annual Cost	3.15	1.26	0.26	3.15	1.26	0.26	15.70	6.28	1.32

Cum. Industry Waste Disposal Costs ($ Million)

Waste (Type)	Level I Cap.	Level I Ann.	Level II Cap.	Level II Ann.	Level III Cap.	Level III Ann.
Sludge	$0.35	$0.11	$0.35	$0.11	$0.73	$0.56

1973 Metal Price: $365.20/MT

Percent Treatment Cost/Price of Metric Ton of Production

Waste (Type)	Level I Cap.	Level I Ann.	Level II Cap.	Level II Ann.	Level III Cap.	Level III Ann.
Sludge	0.23%	0.07%	0.23%	0.07%	0.47%	0.36%

TABLE 29. SUMMARY COSTS - FERRONICKEL

Annual Production: Model Plant 23,600 MT Industry 23,600 MT (est.)

Waste (Type)	Amount (MT/MT of Production)
Sludge	0.58
Tailings	5.57

Cum. Unit Waste Disposal Costs:

Waste (Type)	Level I: $/MT of Waste, Dry	Level I: $/MT of Waste, Wet	Level I: $/MT of Prod.	Level II: $/MT of Waste, Dry	Level II: $/MT of Waste, Wet	Level II: $/MT of Prod.	Level III: $/MT of Waste, Dry	Level III: $/MT of Waste, Wet	Level III: $/MT of Prod.
Sludge									
Capital Cost	$11.20	$4.51	$6.50	$11.28	$4.51	$6.50	$44.63	$7.85	$25.72
Annual Cost	3.22	1.29	1.86	3.22	1.29	1.86	8.80	3.52	5.07
Tailings									
Capital Cost	0.18	--	1.03	0.18	--	1.03	1.42	--	7.90
Annual Cost	0.13	--	0.70	0.13	--	0.70	0.33	--	1.83
Total Capital Cost	--	--	7.53	--	--	7.53	--	--	33.62
Total Annual Cost	--	--	2.56	--	--	2.56	--	--	6.90

Cum. Industry Waste Disposal Costs ($ Million)

Waste (Type)	Level I: Cap.	Level I: Ann.	Level II: Cap.	Level II: Ann.	Level III: Cap.	Level III: Ann.
Sludge	$0.15	$0.04	$0.15	$0.04	$0.61	$0.12
Tailings	0.02	0.02	0.02	0.02	0.19	0.04
Total	0.17	0.06	0.17	0.06	0.80	0.16

1973 Metal Price: $1,430/MT (est)

Percent Treatment Cost/Price of Metric Ton of Production

Waste (Type)	Level I: Cap.	Level I: Ann.	Level II: Cap.	Level II: Ann.	Level III: Cap.	Level III: Ann.
Sludge	0.45%	0.13%	0.45%	0.13%	1.80%	0.35%
Tailings	0.07	0.05	0.07	0.05	0.55	0.13
Total	0.52	0.18	0.52	0.18	2.35	0.48

Assuming that wet systems are used for emissions control for ferrochrome production the industry annualized costs for Levels I and II treatment and disposal technology are estimated as $110,000 or 0.07% of estimated national sales. The industry annual cost of Level III technology using wet emissions controls is estimated as $560,000 or 0.36% of 1973 national sales.

The estimated annual cost for Level I and II treatment and disposal technology for potentially hazardous waste from the one United States ferronickel plant is $60,000 or 0.18% of estimated 1973 sales value. Estimated annual costs for Level III treatment and disposal technology are $160,000 or 0.48% of estimated national sales.

4.0 PRIMARY METAL PRODUCTS NOT ELSEWHERE CLASSIFIED (SIC 3399)

This SIC category includes a number of miscellaneous metal products and associated manufacturing processes including production of ferrous and non-ferrous metal powders, metal paste, and ferrous and non-ferrous nails, brads, wire and staples. Table 30 shows the geographic distribution of industries in this SIC category as of 1972.

Brads, nails, tacks, spikes and similar items are manufactured from metal by machining, extrusion and other similar processes. Solid wastes will consist principally of metal turnings, clippings and other metal remnants. These wastes are recovered for scrap and therefore do not constitute a solid or hazardous waste problem.

Metal powders are produced by a variety of processes as summarized in Table 31. The raw materials for production is either solid metal or chemical compounds of metals - generally oxides of metals.

The three predominant practices for powder production are atomization, gaseous reduction and electrolysis. Atomization is the most widely employed method for manufacturing low-melting metal powders, such as tin, lead, zinc, cadmium and aluminum. Atomization consists essentially in forcing a thin stream of molten metal through a small orifice and then bombarding it with a stream of compressed gas, which causes the metal to disintegrate and solidify into finely divided particles. Usually the gas stream is directed through a nozzle, partly submerged in the molten metal, in such a manner as to draw the metal up through the nozzle to the tip. Solidification of the metal occurs instantaneously upon contact with the gas stream. The product is then removed by means of a suction system and collected in baghouses or cyclone dust collectors.

Electrolytic production methods for metal powders consist of electrolytic deposition from solution and electrolytic deposition from fused salts. These methods are most suitable for manufacture of extremely pure powders of a variety of metals including copper, iron, silver, nickel, manganese and chromium.

Gaseous reduction is employed for the manufacture of commercial quantities of iron and copper powders, the most common metal powders, and less common metal powders including nickel, cobalt, tungsten and molybdenum. Hydrogen, carbon monoxide or some other reducing gas is used to reduce metallic compounds, usually oxides, to fine metal powders.

Because either pure metal or metal oxides are used as raw materials for metal powder production there is little waste. Dust, slag or sludge residues contain high metallic content and are reprocessed. Table 32 which summarizes residual disposition for one of the largest metal powder producers in the United States illustrates the dominant practice of residual recycle.

TABLE 30

GEOGRAPHIC DISTRIBUTION OF MISCELLANEOUS PRIMARY METAL PRODUCT MANUFACTURING FIRMS, 1972 (SIC 3399)

Geographic Area	Total No. of Establishments	No. with 20+ Employees	Value of Ind. Shipments
U.S. Total	161	101	$341M
N.E. Region	56	35	153
New England Div.	8	7	25
Connecticut	3	3	9
Middle Atlantic Div.	48	28	128
New York	9	5	9
New Jersey	14	8	63
Pennsylvania	25	15	57
N. Central Region	55	34	91
Ohio	14	9	19
Illinois	10	5	10
S. Region	28	18	64
S. Atlantic Div.	6	3	8
E.S. Central Div.	14	9	37
Tennessee	6	4	17
W.S. Central Div.	8	6	20
W. Region	22	14	33
Mountain Div.	5	4	9
Pacific Div.	17	10	24

Source: Census of Manufacturing 1972

TABLE 31 PRODUCTION OF METAL POWDERS

Raw material	State	Process	Principle involved	Product
Metal	Solid	Machining Bessemer process Screening beaten foil	Tearing	Mg Cu and Al alloys Au, Cu, and alloys
		Stamp mills Hametag impact mills	Severe working	Al, Cu, and alloys Al, Cu, and alloys
		Eddy mills		Fe Cu
		Grinding sponge		Fe
		Grinding Cleavable metals	Fracturing of cleavage planes	Bi, Sb, etc.
		Grinding brittle electrolytic metals	Intercrystalline fracturing	Fe
		Grinding brittle metals made fine by hot wax		Ni-Fe alloys
	Molten	Atomization by air blast or steam	Spraying	Al Pb Pb alloys
		Granulation by stirring	Graining	Al Pb alloys
	Vapor	Condensation at normal or low pressure	Condensation	Zn, Mg
Chemical	Solid	Reduction by hydrogen or other gases at temperatures below melting point	Reduction	W, Mo Ni, Co Fe Fe, Cu
	Solution	Chemical precipitation	Precipitation	Pt, Pd Sn
		Electrodeposition as a powder	Electrolysis	Cu, Fe, etc.
	Gas	Carbonyl process	Thermal decomposition	Fe Ni, Ni-Fe alloys

Source: Treatise on Powder Metallurgy, Vol. I, Interscience Publishers, NY, 1949

TABLE 32 DISPOSITION OF RESIDUALS FROM METAL POWDER PRODUCTION

Type of Powder	Av. Production per year	Process Type	Dust Quantity-Disposition per year	Waste Residue Sludge or Slurry Quantity-Disposition per year	Other Quantity-Dispositio per year
Copper	6500 tons	Electrolytic Deposition	150 tons Reprocessed by Re-Cycle	50 tons Reprocessed by Re-Cycle	Nil
Copper Base Alloy	400 tons	Water Atomization	Nil	2 tons Reprocessed	Slag, 15 tons Reprocessed
Tin	160 tons	Air Atomization	3 tons Reprocessed	Nil	Dross, 8 tons Reprocessed
Solder	150 tons	Air Atomization	3 tons Reprocessed	Nil	Dross, 20 tons Reprocessed

LIST OF REFERENCES

1. Development Document For Proposed Effluent Limitations Guidelines and New Source Performance Standards For the Steel Making Segment of The Iron and Steel Manufacturing Point Source Category, EPA 440/1-73/024, U. S. Environmental Protection Agency, February 1974.

2. Sulfuric Acid and Ferrous Sulfate Recovery From Waste Pickle Liquor, Joseph K. Seyler et. al., EPA-660/2-73-032, January 1974.

3. A Study of Foundry Waste Material, Carmen Santa Maria, M.S. Thesis, University of Wisconsin, 1974.

4. Compilation of Air Pollutant Emission Factors, 2nd Edition, AP-42, U. S. Environmental Protection Agency, 1973.

5. Washington Alert, Published by American Foundrymen's Society, July 1975.

6. Minerals Yearbook 1972, Vol. I, Metals, Minerals and Fuels. Prepared by Staff of the Bureau of Mines, U. S. Government Printing Office, Washington, D. C. 1974.

7. Engineering And Cost Study of The Ferroalloy Industry, EPA-450/2-74-008, March 1974.

8. Minerals Yearbook 1973, Vol. I, Metals, Minerals and Fuels. Prepared by Staff of the Bureau of Mines, U.S. Government Printing Office, Washington, D.C. 1975.

9. Steel Industry Economics and Federal Income Tax Policy, American Iron and Steel Institute, June 1975.

10. EPA Policy On Subsurface Emplacement of Fluids By Well Injection, Administrator's Decision No. 5, February 6, 1973.

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BIBLIOGRAPHIC DATA SHEET	1. Report No. EPA/530/SW-145c.3	2.	3. Recipient's Accession No. PB276171
4. Title and Subtitle Assessment of Industrial Hazardous Waste Practices in the Metal Smelting and Refining Industry (Volume 3)			5. Report Date April, 1977
			6.
7. Author(s) Richard P. Leonard, Robert C. Ziegler, W. Richard Brown, John Y. Yang, Hans G. Reif			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Calspan Corporation Box 235 Buffalo, New York 14221			10. Project/Task/Work Unit No.
			11. Contract/Grant No. EPA No. 68-01-2604
12. Sponsoring Organization Name and Address EPA Hazardous Waste Management Division Office of Solid Waste Waterside Mall Washington, D.C, 20640			13. Type of Report & Period Covered Final May 1974- April 1977
			14.

15. Supplementary Notes

EPA Project Officers - Timothy Fields, Allen Pearce

16. Abstracts

This report covers primary and secondary metal smelting and refining industries. Characteristics of each industry sector, including plant locations, production capacities, and smelting and refining processes, have been identified and described. Land-disposal or stored residuals have been identified and characterized for physical and chemical properties. State, regional, and national estimates have been made of the total quantities of land-disposed or stored residuals and potentially hazardous constituents thereof. Current methods employed by the primary metals industry for the disposal or storage of process and pollution control residuals on land are described. Methods of residual treatment and disposal considered suitable for adequate health and environmental protection have been provided. Finally, the costs incurred by typical plants in each primary smelting and refining category for current and environmentally sound potentially hazardous residual disposal or storage on land have been estimated.

17. Key Words and Document Analysis. 17a. Descriptors

Ferrous Smelting and Refining
Nonferrous Smelting and Refining
Secondary Smelting and Refining
Primary Smelting and Refining
Hazardous Wastes
Slags, Sludges, Dust
Lagoons
Open Dump
Disposal Technology
Leaching
Heavy Metals
Lined Lagoons
Soil Sealing - Bentonite
Sludge Solidification
Cyanide
Floride
Oil and Grease

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	
	20. Security Class (This Page) UNCLASSIFIED	22. Price A08 - A01