# SECTION 5

# DESCRIPTION OF THE INDUSTRY

This section describes the iron and steel industry in the United States. Unless otherwise noted, all estimates included in this section represent 1997 data collected in the U.S. EPA Collection of 1997 Iron and Steel Industry Data (EPA survey). EPA recognizes that the estimates provided in this section do not necessarily reflect the current status of the iron and steel industry in the United States; however, EPA does not have a more recent comprehensive set of data to use to describe the industry.

The United States is the third largest steel producer in the world, accounting for 12 percent of the international steel market. The iron and steel industry in the United States has an annual steel output of approximately 117 million tons per year, and employs nearly 145,000 people (Reference 5-1). Based on estimates from the EPA survey, there are approximately 254 iron and steel sites in the United States; the 254 sites are owned by 115 companies. The types of sites and the manufacturing operations conducted at these sites are described below.

## 5.1 Types of Sites

EPA classified manufacturing facilities in the iron and steel industry into the following three types on the basis of raw material consumption and manufacturing processes: integrated steel mills, non-integrated steel mills, and stand-alone facilities. This section provides a general description of the types of sites, these processes conducted, the number of facilities and locations, the types of steel processed, and the wastewater discharge practices for each type of site. Figure 5-1 is a schematic drawing of the steelmaking, refining, and casting operations that occur at iron and steel facilities. Figure 5-2 shows the various hot forming and finishing operations that steel may undergo to form semi-finished or finished products.

Integrated steel mills produce molten iron in blast furnaces using coke, limestone, beneficiated iron ore, and preheated air as the principal raw materials. Other raw materials used to produce molten iron may include sinter, other iron-bearing materials, oxygen, and alternate sources of carbon. These mills then charge the molten iron (or hot metal) and steel scrap to basic oxygen furnaces (BOFs) to produce molten steel. Depending on final product specifications, the molten steel then undergoes various refining steps prior to casting, hot forming, and finishing operations. Several integrated mills also have cokemaking and sintering plants that produce raw materials for blast furnace operations.

Non-integrated steel mills produce molten steel by melting steel scrap in electric arc furnaces (EAFs). Some non-integrated steel mills also use high-quality iron materials such as pig iron or direct-reduced iron along with scrap. As at integrated mills, the molten steel undergoes various refining, casting, hot forming, and finishing operations.

Stand-alone facilities do not produce molten steel and include certain raw material preparation facilities and steel forming and finishing mills. A number of stand-alone operations produce raw materials for ironmaking and steelmaking (e.g., by-product recovery and non-recovery coke plants, sinter plants, and direct-reduced ironmaking plants). Steel forming and finishing stand-alone mills conduct many of the same hot forming and steel finishing operations conducted at integrated and non-integrated steel mills. The major types of stand-alone facilities are described below:

- Coke plants and sinter plants manufacture feed materials for blast furnaces.

- Direct-reduced ironmaking plants manufacture feed materials for EAFs.

- Hot forming mills receive cast products from integrated and non-integrated steel mills. These facilities perform hot forming operations and, depending on the product, a limited number may perform steel finishing operations.

- Carbon steel finishing mills may perform acid pickling, cold forming and annealing, acid and alkaline cleaning, electroplating, and hot coating on carbon steel products received from other mills. Stand-alone stainless steel finishing mills typically perform acid pickling and descaling and cold forming and annealing operations on stainless steel products received from other mills.

- Pipe and tube mills include:

    — Facilities that manufacture butt-welded or seamless pipe and tube through hot forming operations,

    — Facilities that manufacture pipe and tube using cold forming operations, such as electric resistance welding, and

    — Facilities that receive pipe and tube and perform other operations, such as drawing.

  Only the stand-alone pipe and tube mills that manufacture butt-welded or seamless pipe and tube through hot forming operations, as opposed to those that perform cold forming and drawing operations on pipe and tube , were evaluated as part of the iron and steel industry for the purpose of developing effluent limitations and guidelines. Section 1 provides more detail on the applicability of the iron and steel category.

Table 5-1 presents EPA's national estimates of the numbers of iron and steel sites by type in the United States. There are 20 integrated steel mills that account for approximately 60 percent of domestic annual raw steel production. Approximately 94 non-integrated steel mills account for the remaining 40 percent of domestic annual raw steel production. There are approximately 138 stand-alone facilities. Non-integrated steel mills are the largest group and they outnumber integrated steel mills by more than four to one. Stand-alone finishing facilities form the second largest group, and stand-alone hot forming facilities form the third largest group. This reflects two trends in the industry over the past 25 years: (1) a shift of steel production from older, larger integrated steel mills to newer, smaller non-integrated steel mills, and (2) the emergence of specialized, stand-alone finishing facilities that process semi-finished sheet, strip, bars, and rods obtained from integrated or non-integrated facilities.

Integrated steel mills are located primarily east of the Mississippi River in Illinois, Indiana, Michigan, Ohio, Pennsylvania, West Virginia, Maryland, Kentucky, and Alabama; one integrated steel mill is located in Utah. Figure 5-3 shows the locations of integrated steel mills. Stand-alone coke plants and coke plants at integrated steel mills are located in Illinois, Indiana, Michigan, Ohio, New York, Pennsylvania, Virginia, Kentucky, Alabama, and Utah. Figure 5-4 shows the locations of stand-alone and colocated coke facilities. Non-integrated steel mills are located throughout the continental United States, as are stand-alone hot forming and finishing mills.

Steel produced at integrated and non-integrated steel mills can be classified as carbon steels, alloy steels, and stainless steels. Carbon steels owe their properties to varying concentrations of carbon, with relatively low concentrations of alloying elements (less than 1.65 percent manganese, 0.60 percent silicon, and 0.60 percent copper). Alloy steels contain concentrations of manganese, silicon, or copper greater than those for carbon steels, or other specified alloying elements added to impart unique properties to the steel. Stainless steels are corrosion resistant and heat resistant; the principal alloying elements for stainless steel are chromium, nickel, and silicon. Steel is typically considered stainless steel when the chromium content is 10 percent or greater.

Table 5-2 lists the types of steels manufactured or processed at integrated and non-integrated steel mills and stand-alone hot forming, finishing, and pipe and tube. All integrated steel mills produce carbon steels; some also produce alloy and stainless steels. EPA estimates that 72 non-integrated steel mills, 26 stand-alone hot forming mills, 45 stand-alone finishing mills, and 11 stand-alone pipe and tube mills produce or process carbon steels.

Steel mills discharge process wastewater directly to surface water (direct discharge), to publicly owned treatment works (POTWs) (indirect discharge), both directly and indirectly, or not at all (zero or alternative discharge). Zero and alternative dischargers include sites that do not discharge process wastewater and sites that are completely dry (i.e., do not use water in iron and steel operations). Table 5-3 shows the discharge status of integrated and non-integrated steel mills and stand-alone facilities. A single mill may discharge process wastewater from one operation directly to surface waters and from another operation indirectly to a POTW.

All but one integrated mill discharge directly; two discharge both directly and indirectly. EPA estimates that among the 94 non-integrated steel mills, 46 are direct dischargers, 32 are zero or alternative dischargers, and 19 are indirect dischargers. For the 70 stand-alone finishing mills, EPA estimates 34 indirect dischargers, 28 direct dischargers, and 11 zero or alternative dischargers.

## 5.2 Manufacturing Operations

The following subsections describe the types of manufacturing operations performed at integrated and non-integrated steel mills and stand-alone iron and steel facilities. Table 5-4 lists the various manufacturing operations and EPA's national estimates of the number of sites performing each operation, 1997 production, and 1997 production capacity.

### 5.2.1 Cokemaking

Cokemaking is the manufacture of metallurgical coke from coal. There are two types of coke plants operated in the United States. By-product recovery coke plants recover several chemical by-products from coke oven gas. Non-recovery or heat recovery coke plants do not recover chemical by-products from the coke oven gas; the only by-product is heat, which is used to generate steam and electric power. In 1997, there were 23 by-product recovery coke plants and one non-recovery coke plant located in the United States (one additional non-recovery coke plant started operation after 1997).

Coke is used to reduce iron oxide to metallic iron in both blast furnaces and foundries; coke used for blast furnace operations is called furnace coke, and coke used for foundry operations is called foundry coke. Presently, foundry coke is produced only by by-product coke plants, and furnace coke is produced by both by-product recovery and non-recovery coke plants. Of the 24 coke plants operating in 1997, 19 primarily produce blast furnace coke, 4 primarily produce foundry coke, and 1 routinely produces both. Merchant by-product cokemaking operations provide more than 50 percent of the coke produced to operations, industries, or processes other than ironmaking blast furnaces. Iron and steel by-product cokemaking operations are those other than merchant cokemaking operations.

#### By-Product Recovery Coke Plants

By-product recovery coke plants comprise coal handling and preparation facilities, one or more coke batteries (i.e., groups of 40 or more vertical, slot-type coke ovens located side by side) equipped with coal charging and coke pushing equipment, coke oven gas collection and cleaning facilities, by-product recovery systems, coke quenching stations, and associated air and water pollution control facilities and solid waste processing operations.

Blends of high-, medium-, and low-volatile coals and other carbonaceous materials are pulverized and screened to desired size and charged into the tops of coke ovens with charging machines called larry cars. Different blends of coals are used to produce foundry and furnace coke. The ovens are positive pressure ovens operated on a sequential batch basis. The coal charge is heated in the absence of air to drive off volatile materials and water to leave the carbonaceous residue called coke. The coking time is approximately 16 hours for furnace coke and approximately 28 to 30 hours for foundry coke. Coking temperatures in the ovens range from approximately 1,650 to 2,000°F (Reference 5-2).

When the coking cycle is completed, the oven doors are removed and the incandescent coke is pushed from the oven into a rail car called a coke quench car. Plants usually control air emissions from pushing operations with baghouses or wet scrubbers. The quench car is positioned under a quench station where large volumes of water quench the coke. All coke plants in the United States recycle and evaporate coke quench water, typically to extinction. The coke is then sized and stored for future use. Relatively fine coke particles collected in quench station sumps are called coke breeze. Coke breeze is reused as a charge material for production of foundry coke or for sinter plant operations, or sold for other uses.

Figure 5-5 presents a typical by-product cokemaking process diagram. Processed coke oven gas is ultimately used as a fuel for battery underfiring. Coke oven gas is scrubbed in gas collector mains, which are located on top of the coke battery, with a fluid called flushing liquor to condense tars and moisture derived from the coal. The flushing liquor is processed in tar decanter tanks to separate tar from the flushing liquor stream. Flushing liquor is recycled to the gas collector mains at a high rate. Primary gas coolers and electrostatic precipitators remove additional tar from coke oven gas. Exhausters pull the coke oven gas through the primary coolers and push the gas through the remainder of the by-product recovery plant. Final gas coolers lower the coke oven gas temperature further; the location of the final coolers depend on the types of by-products that are recovered at the plant.

Excess flushing liquor, also called waste ammonia liquor, is rejected from the flushing liquor circuit and is the principal process wastewater stream generated at by-product coke plants. Sludge collected at the bottom of the tar decanters is a listed hazardous waste and is typically mixed with coke breeze and other carbonaceous material and recycled to the coke ovens with the coal charge. The recovered tars are stored in tanks on site and sold as a by-product.

The by-product recovery cokemaking industry uses a variety of chemical processing technologies to recover additional products from coke oven gas and waste ammonia liquor, such as ammonia or ammonia compounds, sulfur and sulfur compounds, naphthalene, crude light oils, and phenols. The following technologies are used:

- *Recovery of ammonia and ammonia compounds*. Ammonia formed during by-product recovery cokemaking is recovered from both coke oven gas and waste ammonia liquor that is condensed from the gas (Reference 5-3). Ammonia is recovered from the waste ammonia liquor through distillation; overhead vapors from the distillation process are combined with the coke oven gas stream for further recovery of ammonia. Ammonia may be scrubbed directly from coke oven gas with sulfuric acid to produce ammonium sulfate crystals. Using the Phosam process, ammonia may also be scrubbed directly from coke oven gas with phosphoric acid and then stripped. The overhead vapor from the stripper is condensed to form an aqueous ammonia feed for a fractionator, where anhydrous ammonia is produced. Ammonia may also be scrubbed from coke oven gas using water; the ammonia-rich water stream is generally sent to an ammonia stripper to produce ammonia vapors. Vapors from the ammonia stripper are typically combined with coke oven gas and can be combusted or destructed, or can be used to generate ammonium sulfate crystals using sulfuric acid or liquid ammonia using the Phosam process.

- *Recovery of sulfur and sulfur compounds.* Desulfurization systems recover elemental sulfur or sulfur compounds from coke oven gas. Techniques to remove sulfur include iron oxide boxes using $Fe_2O_3$ on wood shavings, absorption and desorption with soda ash, Wilputte vacuum carbonate systems, and Claus sulfur recovery systems.

- *Recovery of naphthalene.* Crystals of naphthalene are condensed from the coke oven gas in the final cooler and recovered from the recirculating final cooler wastewater by skimming, filtration, or centrifugation. Naphthalene may be recovered by solidification at temperatures below 74°C (165°F).

- *Recovery of crude light oils.* Crude light oils are scrubbed from coke oven gas with a recirculated wash oil solution. Crude light oil is an unrefined oil rich in benzene, toluene, xylene, and solvent naphthas. The oil is recovered for resale, reused as a solvent to recover phenolic compounds from waste ammonia liquor, or further refined on or off site.

- *Recovery of phenols.* Liquid/liquid extraction with suitable solvents is a common method to remove and recover phenols from waste ammonia liquor. In liquid/liquid extraction, light oil or other suitable solvents extracts phenolic compounds from waste ammonia liquor. The phenolized solvent is separated and extracted with caustic to form sodium phenolate. Because there is not a strong economic incentive, phenol recovery is not commonly performed.

**Non-Recovery Coke Plants**

Non-recovery coke plants carbonize coal in large dome-shaped oven chambers. The single non-recovery coke plant that was in operation in 1997 operates Jewell-Thompson non-recovery coke batteries (Reference 5-4). Coal is charged to the ovens with a conveyor charging machine. Volatile by-products generated during the cokemaking process are contained in the ovens by negative pressure and are thermally destroyed, thus eliminating the need for a by-products recovery plant. Combustion of these volatile components also provides some of the heat for the cokemaking process. Air for combustion enters the ovens above the charge; the temperature in the ovens can be controlled by regulating the flow of air into the ovens. The volatile components are combusted in the sole flues beneath the cokemaking oven floors; additional air may be added to the sole flues to aid combustion. The gas is collected in a common waste heat tunnel above the ovens; the gas may then pass through an afterburner or a scrubber before being discharged to the atmosphere at a temperature of 1,600°F. Heat from the waste gases can be recovered to generate steam for electric power generation or for other uses.

Because non-recovery plants combust all materials evolved from the coal, there are no by-products recovered other than heat in the waste gases and coke breeze. The pushing and quenching operations are similar to those performed at by-product recovery coke plants. Non-recovery cokemaking operations do not generate process wastewater other than boiler blowdown and process storm water, which are typically disposed of by coke quenching.

### 5.2.2 Sintering

Sintering is a beneficiation process in which iron-bearing materials recovered from other iron and steel operations are mixed with iron ore, limestone, and finely divided fuel, such as coke breeze. During iron and steel production operations, blast furnaces, basic oxygen furnaces, continuous casters, and hot forming mills generate large quantities of particulate matter and other solids (e.g., fines, mill scale, flue dust, wastewater sludge). Sintering can recover a large percentage of these iron-rich materials, provided the oil content is low enough to prevent objectionable fumes. Sinter serves as a supplementary raw material for blast furnace operations.

Sinter plants consist of raw material handling facilities and raw material storage bins, a sinter strand (traveling grate combustion device), a mixing drum for each sinter strand, a windbox (draws air through the traveling grate), a discharge end, and a cooling bed for sintered product. The iron-rich materials are mixed in sinter machines and charged to the traveling grate at a depth of approximately one foot. The mixture is ignited, and air is drawn through the bed as it travels toward the discharge end to promote combustion and fusing of the iron-bearing materials. Sinter plants may operate either wet air pollution control systems or dry air pollution control systems. In 1997, seven sites reported that they used wet air pollution control systems to control air emissions from the sintering process, while two sites used dry air pollution control systems.

### 5.2.3 Briquetting

Briquetting is an agglomeration process used to recycle and reuse fine materials recovered from other iron and steel operations that otherwise could not be charged to blast furnaces or steelmaking furnaces. The operation forms materials into discrete shapes of sufficient size, strength, and weight for charging to a subsequent process (e.g., blast furnaces, BOFs). Materials are similar to those charged to sintering operations, although they are usually formed with the use of a binder and do not possess the strength of sintered products (Reference 5-5). Briquetting operations can be performed with or without heating the raw materials, and do not generate process wastewater. EPA estimates that four facilities perform briquetting or similar agglomeration processes.

### 5.2.4 Blast Furnace Ironmaking

Blast furnaces produce molten iron, which is charged to BOFs. The blast furnace has several zones: a crucible-shaped hearth (bottom of the furnace), an intermediate zone called a bosh (between the hearth and the stack), a vertical shaft called the stack (between the bosh and furnace top), and the furnace top, which contains the mechanism for charging the furnace. The hearth and bosh walls are lined with carbon-type refractory blocks, and the stack is lined with high-quality fireclay bricks. To protect these refractory materials from burning out, cooling water circulates through exterior plates, staves, or sprays. Blast furnaces range between 70 and 120 feet in height, with hearth diameters between 20 and 45 feet (Reference 5-6). The rated capacity of blast furnaces ranges from under one million tons per year to over four million tons per year. There are 20 integrated steel mills with blast furnace operations in the United States.

The raw materials charged to the top of the blast furnace include coke, limestone, beneficiated iron ores or iron pellets, scrap, and sinter. Iron pellets, the dominant burden material (material charged to the furnace) in North America, include acid pellets and fluxed pellets, which are typically produced at or near iron ore mine sites. A continuous feed of alternating layers of coke, iron-bearing materials, and limestone are charged to the top of the furnace. Hot blast (preheated air) at temperatures between 1,650 and 2,300°F and injected fuel (e.g., pulverized coal, oil, natural gas) are blown into the bottom of the furnace (top of the hearth) through a bustle pipe and tuyeres (orifices) located around the circumference of the furnace (Reference 5-6). The preheated air reacts with the coke to produce the reducing agent, carbon monoxide. The reducing gases ascend through the furnace to reduce the iron-bearing materials to produce the molten iron and slag. The following chemical equations present a simplified summary of the chemical reactions that occur in a blast furnace:

$$3Fe_2O_3 + H_2 \dashrightarrow 2Fe_3O_4 + H_2O$$
$$3Fe_2O_3 + CO \dashrightarrow 2Fe_3O_4 + CO_2$$

$$Fe_3O_4 + H_2 \dashrightarrow 3FeO + H_2O$$
$$Fe_3O_4 + CO \dashrightarrow 3FeO + CO_2$$

$$FeO + H_2 \dashrightarrow Fe + H_2O$$
$$FeO + CO \dashrightarrow Fe + CO_2$$

$$3Fe + CO \dashrightarrow Fe_3C + H_2O$$
$$3Fe + 2CO \dashrightarrow Fe_3C + CO_2$$

$$CO_2 + C \dashrightarrow 2CO$$
$$H_2O + C \dashrightarrow CO + H_2$$

$$FeO + C \rightarrow Fe + CO$$

$$3Fe + C \rightarrow Fe_3C$$

The molten iron, at approximately 2,800 to 3,000°F, accumulates in the hearth and is tapped at regular intervals into refractory-lined cars for transport to the steelmaking furnaces. Limestone is a fluxing agent that forms fluid slag to dissolve unwanted impurities in the ore. Molten slag, which floats on top of the molten iron, is also tapped and processed for sale as a by-product. Blast furnace slag uses include railroad ballast, aggregate in cement manufacturing, and other construction uses. Wastewater or plant service water is used for slag cooling or quenching. Nineteen of the 20 integrated facilities surveyed use water for slag cooling at blast furnace operations.

The hot blast exits the furnace top as blast furnace flue gas in enclosed piping. A combination of dry dust catchers and high-energy venturi scrubbers clean and cool the gas. Stoves combust the cleaned gas to preheat the incoming air or the cleaned gas is used as fuel elsewhere at integrated mills. Direct contact water is applied in the gas coolers and high-energy scrubbers. All sites operating blast furnaces use wet air gas cleaning systems.

### 5.2.5 Direct-Reduced Ironmaking

Another method of producing iron is through direct reduction. Direct reduction produces relatively pure iron in solid pellet form by reducing iron ore at a temperature below the melting point of the iron produced. Direct-reduced iron (DRI) is produced through the same chemical reactions presented in Section 5.2.4 for blast furnace ironmaking. DRI is used as a substitute for scrap steel in EAF steelmaking to minimize contaminant levels in the melted steel and to allow economic steel production when market prices for scrap steel are high. There were two direct-reduced ironmaking plants in the United States operating in 1997 (an additional direct-reduced ironmaking facility started operation after 1997).

DRI can be produced by several different types of processes (Reference 5-5). DRI may be produced in shaft furnaces or fluidized beds, with the reducing gases generated outside of the reduction furnace. DRI may also be produced in rotary kilns or shaft or hearth furnaces, with the reducing gases generated inside the reduction furnace. Facilities in the United States use the Midrex® process, which produces DRI in a shaft furnace with reducing gases produced outside of the reduction furnace. The Midrex® process is discussed in more detail below.

The Midrex® process equipment consists of three main components: a direct-reduction shaft furnace, a gas reformer, and a cooling-gas system. The direct-reduction shaft furnace is divided into three zones: a preheat zone, a reduction zone, and a cooling zone. Iron ore is charged into the top of the furnace and heated in the preheat zone with ascending gases from the reduction zone. Reformed gas consisting of hydrogen and carbon monoxide, which reduce the iron ore, flows into the reduction zone at a temperature of approximately 875° C; the hydrogen and carbon monoxide are produced in the gas reformers from natural gas and scrubbed reducing furnace top gas using a catalyst. The DRI formed in the reduction zone is cooled in the cooling zone using direct-contact cooling gas. The cooling gas is scrubbed and then recycled. DRI is continuously conveyed from the furnace through seal legs and screened to provide the final product. Direct-reduced ironmaking facilities have wet air pollution control systems to control furnace emissions and emissions from material handling and storage.

### 5.2.6 Steelmaking

Steelmaking in the United States is performed in either BOFs or EAFs. BOF and EAF processes are batch operations with tap-to-tap (batch cycle) times of about 45 minutes for BOFs and in the range of 1 hour to more than 1.5 hours for EAFs. BOFs typically produce high-tonnage carbon steels and EAFs produce low-tonnage carbon, alloy, and stainless steels.

#### Basic Oxygen Furnace (BOF)

The open hearth furnace process for steelmaking was replaced after World War II with the basic oxygen process (BOP). This process involves blowing oxygen through a lance into the top of a pear-shaped vessel. Lime addition to the charge removes phosphorus and sulfur impurities in the form of slag. Compared with the open hearth furnace, which had tap-to-tap times of 12 hours or more, steelmaking using BOP is a much quicker process. In addition, up to 35 percent of the charge could be steel scrap. After its invention, the BOP was modified. In addition to blowing oxygen directly onto the charge, the process involved also blowing burnt lime through the lance with the oxygen. This process allowed refining of pig iron smelted from high-phosphorus ores. Another process modification, developed in Canada and Germany in the mid-1960s, was the bottom-blown steelmaking process. This process used two concentric tuyeres, the outer with hydrocarbon gas and the inner with oxygen. This new process became know as Quelle-BOP (Q-BOP). Both the BOP and Q-BOP process are types of BOF steelmaking used today.

The BOF steelmaking process refines the product of the blast furnace (molten iron), which contains approximately 3.5 to 4.4 percent carbon, $\leq$0.05 percent sulfur, and $\leq$0.04 percent phosphorus. In steelmaking operations, the furnace charge consists of approximately two-thirds molten iron and one-third scrap steel. The furnace melts the charge and refines it by oxidizing silicon, carbon, manganese, phosphorus, and a portion of the iron in the molten bath. Various alloying elements are added to produce different grades of steel. Common alloying elements include aluminum, boron, chromium, copper, magnesium, molybdenum, niobium, nickel, silicon, and vanadium. The BOF allows close control of steel quality and the ability to process a wide range of raw materials.

Vessels used in the BOF process are generally vertical cylinders surmounted by a truncated cone. Typical heat sizes in BOFs range between under 100 tons per heat to over 300 tons per heat. Scrap and molten iron are first placed in the vessel. Oxygen is then injected into the molten bath either through the top of the furnace (top blown), bottom of the furnace (bottom blown), or both (combination blown). A violent reaction occurs immediately, bringing the molten metal and hot gases into intimate contact, causing impurities to burn off quickly. Management of furnace slag processes controls residual sulfur. The slag is separated and removed from the molten steel. Alloys are added to the bath or as the steel is tapped (poured) into ladles. Slag material is charged back to the blast furnace to recover iron or used as railroad ballast. Similar to blast furnaces, BOF manufacturing facilities may use wastewater or plant service water for slag cooling or quenching. Eighteen of the 20 integrated facilities surveyed use water instead of air for slag cooling in BOF operations.

Off-gases from BOFs exit the vessel at temperatures of approximately 3,000°F. This gas contains approximately 90 percent carbon monoxide, 10 percent carbon dioxide, and may also contain ferrous oxide dust. BOF off-gas control systems include three types: semi-wet, wet-open combustion, and wet-suppressed combustion. Semi-wet systems condition furnace off-gases with moisture prior to processing in the electrostatic precipitators or baghouses. Wet-open combustion systems admit excess air to the off-gas collection system, allowing carbon monoxide to combust prior to high-energy wet scrubbing for air pollution control. Wet-suppressed combustion systems do not admit excess air to the off-gas collection system prior to high-energy scrubbing for air pollution control. BOF facilities use water for air pollution control systems designed to treat furnace off-gases prior to release into the atmosphere (Reference 5-6).

**Electric Arc Furnace (EAF)**

The EAF is designed to produce specific grades of steel. The first EAFs developed in the late 1800s and early 1900s could melt approximately one ton per heat. Typical heat sizes in current EAFs range between under one ton per heat to over 350 tons per heat. EPA estimates that 96 sites operate EAFs.

An EAF is a cylindrical vessel with a dish-shaped refractory hearth and three electrodes that lower from the dome-shaped, removable roof. Shell diameters depend on the heat size and range from 8 feet for a 10-ton vessel to 30 feet for a 300-ton vessel. Tar-bonded magnesite bricks form the lining of the furnace. The walls typically contain water-cooled panels that are covered to minimize heat loss. The electrodes may also be equipped with water cooling systems (Reference 5-6).

EAF steelmaking consists of scrap charging, melting, refining, deslagging, and tapping. In addition to scrap steel, the charge may include pig iron, DRI, and alloying elements. As the steel scrap is melted, additional scrap may be added to the furnace. The EAF generates heat by passing an electric current between electrodes through the charge in the furnace. Lime-rich slag removes the steel impurities (e.g., silicon, sulfur, and phosphorus) from the molten steel. Oxygen may be added to the furnace to speed up the steelmaking process. At the end of a heat, the furnace tips forward and the molten steel is poured off. EAFs in the United States are equipped with dry or semi-wet air pollution controls, and none discharge process wastewater.

### 5.2.7 Vacuum Degassing

Vacuum degassing is a refining process in which gases are removed from molten steel prior to casting to produce steel of high metallurgical quality. Vacuum degassing is used to control composition and temperature, remove oxygen (deoxidation) and hydrogen (degassing), decarburize, and otherwise remove impurities from the steel. Vacuum degassers are common at integrated and non-integrated mills that produce carbon, stainless, and certain alloy steels. Vacuum degassers often operate as part of ladle metallurgy stations (discussed in Section 5.2.8), where additional steel refining is conducted. EPA estimates that 44 sites operate vacuum degassing systems.

Steam ejectors create the vacuum for most vacuum degassing units. Gases removed from the molten steel come in contact with the injected steam, thereby contaminating the condensate wastewater. While the molten steel is under vacuum, elements that have a relatively higher vapor pressure volatilize and are present in the gases.

### 5.2.8 Ladle Metallurgy and Secondary Steelmaking

Ladle metallurgy and secondary steelmaking are steel refining operations that molten steels undergo at atmospheric conditions (i.e., no vacuum is applied) prior to casting. The purpose of ladle metallurgy and secondary steelmaking may include controlling gases in the steel, adjusting concentrations of metallic or nonmetallic compounds (alloying), and adjusting physical properties (e.g., temperature).

Common types of ladle metallurgy include argon or nitrogen bubbling and stirring, argon-oxygen decarburization, lance injection, magnetic stirring, and other alloy addition operations. Common types of secondary steelmaking include electroslag refining and other alloy addition operations. None of sites that conduct ladle metallurgy and/or secondary steelmaking reported generating or discharging process wastewater from these operations. EPA estimates that 103 sites use ladle metallurgy and/or secondary steelmaking; some sites may operate more than one type of process. The following table lists the numbers of sites in 1997 performing various types of ladle metallurgy and secondary steelmaking.

**1997 National Estimate for Types of Ladle Metallurgy and Secondary Steelmaking Processes**

| Type of Ladle Metallurgy or Secondary Steelmaking | Number of Sites |
|---|---|
| Argon bubbling | 66 |
| Argon-oxygen decarburization | 16 |
| Electroslag remelting | 10 |
| Lance injection | 19 |

| Type of Ladle Metallurgy or Secondary Steelmaking | Number of Sites |
|---|---|
| Other (a) | 37 |

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Surveys).
(a) Other types of ladle metallurgy include alloy addition, reheating, magnetic stirring, ladle stirring, and carbon addition/adjustment.

### 5.2.9 Casting

Casting converts molten steel into a semi-finished product or shape that is suitable for further processing. There are two main types of casting operations: continuous casting and ingot casting. Molten steel is tapped from the BOF or EAF into ladles large enough to hold an entire heat. The ladles are then processed in ladle metallurgy stations and/or vacuum degassers prior to teeming (pouring) the steel into ingot molds or direct casting it into semi-finished shapes using continuous casters. EPA estimates that 113 sites operate casters.

**Continuous Casting**

Continuous casting is the most efficient and most common method of casting performed at steel mills. In the continuous casting process, molten steel is poured from the ladle into a refractory-lined tundish. The molten metal from the tundish pours through nozzles into an oscillating water-cooled copper mold, where the metal partially solidifies. The copper molds oscillate to prevent the molten steel from sticking to their sides. Lubricants spray into the molds to keep the steel moving through the mold. After passing through the water-cooled molds, the partially solidified product passes into a secondary cooling zone, where sprays of contact water cool the semi-finished product enough to solidify. The product then passes into the cut-off zone where it is cut to the desired length.

Continuous casting machines are configured with either single or multiple strands, which mold molten steel into the desired shapes. The three main types of continuous casters are based on the shape of the cast product: billet, bloom, and slab. Billet casters form squares or rounds between 3 and 7 inches thick and are multiple-strand casters (Reference 5-6); billet casters also form steel for seamless tube production. Bloom casters form sections ranging between 7 by 7 inches and 14.6 by 23.6 inches and are usually three-strand. Slab casters form sections up to 12 inches thick and 100 inches wide, and are usually single- or twin-strands. In addition, casters may form beams that are fed directly to I-beam or H-beam rolling mills. The following table presents continuous casting products and the number of sites casting these products in 1997.

**1997 National Estimate For Types of Continuous Casting Products**

| Type of Cast Product | Number of Sites |
|---|---|
| Slab | 28 |
| Thin slab | 8 |
| Round billet | 6 |
| Rectangular or square billet | 47 |
| Bloom | 12 |
| Other (a) | 7 |

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Surveys).
(a) Other types of cast products include beam blanks and near net-shape products.

### Ingot Casting

Ingot casting involves teeming the molten steel into ingot molds, and then cooling and stripping the ingots out of the molds. The ingots are then heated and rolled into blooms, billets, or slabs during hot forming. Because continuous casting directly forms the molten steel into blooms, billets, or slabs, increasing productivity and conserving energy, continuous casting has replaced most ingot casting operations. Ingot casting is used typically for small, specialty batches and for certain applications for producing plate. Twenty-two sites reported performing ingot casting.

## 5.2.10 Hot Forming

Hot forming is a process in which preheated (typically in the range of 1,800°F), solidified steel is reshaped through a series of forming steps in which mechanical pressure is applied through work rolls (Reference 5-2). Hot formed products have numerous cross-sections, lengths, and tonnages. While several different types of hot forming mills are in operation today, they can be grouped into four types:

- Primary mills;
- Section mills;
- Flat mills (plate, hot strip, and sheet); and
- Pipe and tube mills (seamless and butt-weld).

In general, hot forming primary mills reduce ingots to slabs or blooms, or blooms to billets. Section mills reduce billets to form rod, bar products, structural shapes (e.g., channels, angles), or other forms. Flat mills reduce slabs to plates or strips. Pipe and tube mills form seamless products from round billets and butt-welded products from strips.

Hand chipping, machine chipping, manual scarfing, grinding, milling, and machine scarfing are methods used to remove surface defects from blooms, billets, and slabs prior to hot rolling. Scarfing removes a thin layer of the steel surface by localized melting and oxidation. The process may be done manually (continuously moving an oxyacetylene torch along the length of the product), or by a scarfing machine located near the entry of the hot forming mill.

Flat mills, specifically hot strip mills, are the most common type of hot forming mills at integrated steel mills. Hot rolled strip is formed from a slab, which is heated in one or more furnaces. Scale is removed from the heated slab in a two-high rolling mill with vertical rolls. The rolls loosen the scale, and high-pressure water jets remove the scale. The slab then rolls through four-high roughing stands until it reaches a thickness of approximately 1.2 inches. The slab then passes to the finishing train, where a crop-shear cuts both ends and high-pressure steam jets remove scale. Six or seven four-high finishing stands roll the strip to a thickness between 0.06 and 0.4 inches. Both the roughing and finishing stands are usually arranged in tandem.

Butt-welded pipes and tubes are made from hot rolled strips with square or slightly beveled edges called skelp. The width of skelp corresponds to the circumference of the pipe, while the gauge corresponds to the wall thickness. Skelp is preheated to welding temperature in a reheat furnace and drawn through a die or roll forming a cylindrical shape. The edges are pressed together forming a butt-weld. Seamless pipes and tubes are usually made by a piercing process. The process heats, pierces, and shapes a solid round bar or billet to the desired diameter and wall thickness.

Forging is another type of steel forming where steel shapes are produced by hammering or by processing in a press (Reference 5-7). Forging operations can be conducted on cold, warm, or hot steel. Typically, ingots are forged into billets, flats, or rounds. Types of forging include open die forging, impression die forging, ring rolling, and extrusion. Open die forging is conducted with dies that do not completely confine the steel that is being shaped, and is generally used to shape large parts, such as shafts, sleeves, and disks. Impression die forging is conducted in a die that completely encloses the steel shape that is being formed; impression die forging accounts for the majority of forging production. Ring rolling produces seamless rolled rings in a variety of dimensions. Extrusion is conducted by placing a steel shape in a container and compressing it until the steel travels through an opening to form an extruded product. Secondary forging processes and special techniques, such as drawing, ironing, bending, trimming, coining, and swaging, may also be conducted on steel shapes.

The following table presents the national estimate for types of hot forming operations and the number of sites performing these operations in 1997.

**1997 National Estimate for Hot Forming Operations**

| Hot Forming Operation | Number of Sites |
|---|---|
| Rolling mill | 122 |
| Pipe and tube mill | 6 |
| Forging | 14 |

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Surveys).

The following table presents the national estimate for types of hot forming products and the number of sites producing these products in 1997.

**1997 National Estimate for Hot Forming Products**

| Type of Hot Forming Product | Number of Sites |
|---|---|
| Bar | 67 |
| Beam (a) | 8 |
| Billet | 25 |
| Bloom (a) | 7 |
| Plate | 21 |
| Railroad rail (a) | 4 |
| Reinforcing bar | 25 |
| Rod | 17 |
| Sheet | 11 |
| Slab (a) | 16 |
| Small structural | 23 |
| Strip | 25 |
| Tube and pipe | 21 |
| Other (b) | 44 |

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Surveys).
(a) This estimate does not represent a national estimate of sites producing this product because it is based on data from only the detailed survey. Short surveys did not collect this level of detail on products.
(b) Other hot forming products include various miscellaneous product shapes.

Hot forming mills generally use water for scale breaking, flume flushing, and direct contact cooling. The water often recirculates in cooling water systems. Sites may have multiple hot forming contact water and/or rolling solution systems. Forging wastewater sources are very similar to those for hot forming.

### 5.2.11 Finishing

Steel finishing operations follow hot forming operations; therefore, integrated steel mills and those stand-alone steel finishing mills that receive steel from integrated steel mills are most likely to perform steel finishing operations. Integrated steel mills in the United States principally produce flat-rolled steel products that require finishing, such as hot rolled strip (hot bands), pickled and oiled strip, cold rolled and annealed strip and sheet, hot coated strip (principally zinc and zinc/aluminum), electroplated strip (principally chromium, tin, and zinc), and plates. Several non-integrated steel mills produce flat-rolled products, but most produce bar and bar products and small structural shapes. Non-integrated steel mills are more likely to ship hot rolled products without further surface treatments or finishing.

The type of steel finishing operation is closely related to the type of steel processed. For carbon steels, acid pickling with hydrochloric acid, cold forming and annealing, temper rolling, acid and/or alkaline cleaning, hot coating, and electroplating are performed. For stainless steels, descaling (molten salt bath and electrolytic sodium sulfate); sulfuric, nitric, nitric/hydrofluoric acid and sometimes hydrochloric acid pickling; cold forming and annealing; and temper rolling are likely to be performed. A number of steel finishing mills also perform surface coating of electrical steels.

#### Acid Pickling and Descaling

Acid pickling and descaling operations clean the steel surface prior to further processing (e.g., cold forming, application of protective and decorative coatings). The steel surface must also be cleaned at various production stages to ensure that oxides that form on the surface are not worked into the finished product, causing marring, staining, or other surface imperfections.

The acid pickling process chemically removes oxides and scale from the surface of the steel using water solutions of inorganic acids. While acid pickling is only one of several methods of removing undesirable surface oxides, it is most widely used because of comparatively low operating costs and ease of operation. Carbon steel is usually pickled with hydrochloric acid; stainless steels are pickled with sulfuric, hydrochloric, nitric, and/or hydrofluoric acids. The Agency estimates that 38 of the 69 acid pickling sites use hydrochloric acid, 33 use sulfuric acid, 28 use hydrofluoric acid, and 28 use nitric acid. The pickling process uses various organic chemicals that inhibit the acid from attacking the base metal while permitting it to attack the oxides. Wetting agents improve the effective contact of the acid solution with the metal surface. After the pickling bath, the steel passes through one or more rinse operations.

Finishing mills that conduct pickling operations may regenerate or recover the spent acid by removing the iron; acids can then be reused by the mill. Hydrochloric acid and sulfuric acid are the more commonly regenerated or recovered acids, although stainless steel finishing mills also recover nitric and mixed nitric/hydrofluoric acids.

Two common types of descaling operations are blast cleaning and salt bath descaling. Blast cleaning (mechanical descaling) uses abrasives such as sand, steel, iron grit, or shot to clean the steel surface. The abrasives come in contact with the steel using either a compressed air blast cleaning apparatus or by a rotary-type blasting cleaning machine. Salt bath descaling, a surface treatment operation, processes stainless or alloy steel products in molten salt solutions. This operation uses the physical and chemical properties of molten salt baths to loosen heavy scale from selected stainless and high-alloy steels; the scale is removed in subsequent water-quenching steps. Two processes, oxidizing and reducing, are commonly referred to by the names of proprietary molten salt descaling baths, Kolene® and Hydride®, respectively. Descaling may also be performed using an electrolytic solution of sodium sulfate.

Of the 69 sites operating acid pickling and descaling systems, 41 reported using wet air pollution control, and 14 reported using dry air pollution control. The remaining sites did not report the use of pollution control.

**Cold Forming**

Cold forming involves cold rolling of hot rolled and pickled steels at ambient temperatures to impart desired mechanical and surface properties in the steel. Cold rolling operations reduce the thickness of the steel much less than it is reduced in hot forming operations. Cold rolling imparts hardness to steel. The following table shows common products formed during cold forming.

**1997 National Estimate for Type of Cold Forming Product**

| Type of Cold Forming Product | Number of Sites |
|---|---|
| Plate | 5 |
| Sheet | 21 |
| Strip | 47 |

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Surveys).

Common cold rolling mills in the iron and steel industry include tandem and temper mills. Tandem mills modify steel sheet properties, including strength, surface properties, and thickness. They are typically used in a series of three to five stands. Temper mills slightly improve the finish of steel sheet, such as shiny, dull, or grooved surfaces, and generally do not modify shape or thickness; they primarily improve flatness, alter mechanical properties, and minimize surface disturbances. Temper mills are typically used with only one or two stands (Reference 5-8).

Sendzimir cold rolling mills, commonly referred to as Z-mills, are another type of cold forming operation. Z-mills have various configurations, but generally steel passes through work rolls that are supported and driven by first- and second-intermediate rolls. The mill design allows for quick adjustments to vary the width, thickness, and hardness of the rolled steel. These mills typically use hydraulic fluid or oil emulsions rather than aqueous rolling solutions.

Cold rolling operations generate heat that is dissipated by flooded lubrication systems. These systems use palm oil or synthetic oils that are emulsified in water and directed in jets against the rolls and the steel surface during rolling.

**Surface Treatment and Annealing Operations**

Surface treatment and annealing operations include alkaline cleaning, annealing, hot coating, and electroplating. Facilities performing finishing operations often have a number of these operations on a single line.

Alkaline cleaning removes mineral and animal fats and oils from the steel surface. Caustic, soda ash, alkaline silicates, and phosphates are common alkaline cleaning agents. Passing the steel through alkaline solutions of specified compositions, concentrations, and temperatures is often enough to clean the product; however, for large-scale production or a cleaner product, sites may use electrolytic cleaning. Adding wetting agents to the cleaning bath also facilitates cleaning.

The annealing process heats steel to modify its bulk properties, which makes the steel easier to form and bend. Steel is heated and kept at a designated temperature and then cooled at a designated rate. Through the annealing process, the metal grain size increases, new bonds are formed at the higher temperature, and the steel becomes more ductile. Sites perform annealing through a batch or continuous process; they may follow annealing operations with a water quench to cool the steel for further processing.

Steel coating operations, such as hot coating and electroplating, improve resistance to corrosion or appearance. Hot coating operations involve immersing precleaned steel into molten baths of tin, zinc (hot galvanizing), combinations of lead and tin (terne coating), or combinations of aluminum and zinc (galvalume coating); any associated cleaning or fluxing (used to facilitate metal application) steps prior to immersion; and any post-immersion steps (e.g., chromium passivation). Based on survey responses, the metals used for hot coating operations include zinc, zinc/aluminum alloy, aluminum, chromium, lead, antimony, tin/lead alloy, and zinc/nickel alloy.

Electroplating uses electrodes to deposit a metal coating onto the steel. Historically, electroplating at steel mills was limited to tin and chromium electroplating for food and beverage markets and relatively low-tonnage production of zinc electroplated (electrogalvanized) steel for the automotive market. New coatings consisting of combinations of iron, nickel, and other metals have been developed. Based on survey responses, the metals used for electroplating operations include zinc, chromium, tin, nickel, brass, cobalt, copper, nickel/tin alloy, zinc/nickel alloy, and zinc/iron/aluminum alloy.

EPA estimates that, of the 98 sites performing surface treatment operations, 38 operate wet air pollution control systems and 16 operate dry systems.

## 5.3 References


5-1 American Iron and Steel Institute (AISI). Annual Statistical Report. Washington, DC, 1998.

5-2 U.S. Environmental Protection Agency. Preliminary Study of the Iron and Steel Category: 40 CFR Part 420 Effluent Limitations Guidelines and Standards. EPA 821-R-95-037, Washington, DC, September 1995.

5-3 Association of Iron and Steel Engineers. The Making, Shaping and Treating of Steel (10th edition). ISBN 0-930767-00-4, Pittsburgh, PA, 1985.

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5-5 Association of Iron and Steel Engineers. The Making, Shaping and Treating of Steel (11th edition), Ironmaking Volume. Pittsburgh, PA, 1999.

5-6 Encyclopedia Britannica. Britannica.com. http:\\www.britannica.com, Chicago, IL.

5-7 The Forging Industry Association. The Forging Industry Association's How Are Forgings Produced?. http://www.forging.org/facts/wwhy6.htm, 2000.

5-8 American Iron and Steel Institute. AISI's Everything You Always Wanted to Know About Steel. . . A Glossary of Terms and Concepts. Courtesy of Michelle Applebaum, Managing Director (Summer 1998). Salomon Smith Barney Inc, http://www.steel.org/learning/glossary/, 2000.

## Table 5-1

## 1997 National Estimate of Types of Iron and Steel Sites in the United States

| **Type of Site** | **Total Number of Sites Operating in 1997 (% of Industry Total)** |
|---|---|
| Integrated steel mill with coke plant | 9 (3.5%) |
| Integrated steel mill without coke plant | 11 (4.5%) |
| Stand-alone coke plant | 15 (6.0%) |
| Stand-alone sintering plant | 2 (<1%) |
| Stand-alone direct-reduced ironmaking plant | 1 (<1%) |
| Non-integrated steel mill | 94 (37%) |
| Stand-alone hot forming mill | 39 (15.5%) |
| Stand-alone finishing mill | 70 (28%) |
| Stand-alone pipe and tube mill | 11 (4.5%) |
| **TOTAL (a)** | **254** |

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Surveys).
(a) Columns do not sum to totals because of rounding each number and because two sites are counted as one integrated steel mill.

# Table 5-2

## 1997 National Estimate of Sites Producing or Processing Carbon, Alloy, or Stainless Steel

| Type of Site (a) | Total Number of Sites (a) | Number of Sites Producing Each Type of Steel | | |
|---|---|---|---|---|
| | | Carbon Steel | Stainless Steel | Alloy Steel |
| Integrated steel mill with coke plant | 9 | 9 | 1 | 6 |
| Integrated steel mill without coke plant | 11 | 11 | 2 | 5 |
| Non-integrated steel mill | 94 | 72 | 20 | 58 |
| Stand-alone hot forming mill | 39 | 26 | 10 | 19 |
| Stand-alone finishing mill | 70 | 45 | 24 | 21 |
| Stand-alone pipe and tube mill | 11 | 11 | 0 | 6 |
| **TOTAL** | **234** | **174** | **57** | **115** |

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Surveys).
(a) The sum of the numbers of sites producing each steel type may not equal the total number of sites. Sites may produce more than one steel type.

# Table 5-3

## 1997 National Estimate of Direct, Indirect, and Zero or Alternative Discharging Sites

| Type of Site | Total Number of Sites (a) | Number (%) of Direct Dischargers | Number (%) of Indirect Dischargers | Number (%) of Zero or Alternative Dischargers (b) |
|---|---|---|---|---|
| Integrated steel mill with coke plant | 9 | 8 (89%) | 3 (33%) | 0 (c) |
| Integrated steel mill without coke plant | 11 | 11 (100%) | 0 (c) | 0 (c) |
| Stand-alone coke plant | 15 | 9 (60%) | 5 (33%) | 1 (7%) |
| Stand-alone sintering plant | 2 | 1 (50%) | 0 (c) | 1 (50%) |
| Stand-alone direct-reduced ironmaking plant | 1 | 0 (c) | 1 (100%) | 0 (c) |
| Non-integrated steel mill | 94 | 46 (49%) | 19 (20%) | 32 (34%) |
| Stand-alone hot forming mill | 39 | 22 (56%) | 6 (15%) | 12 (31%) |
| Stand-alone finishing mill | 70 | 28 (40%) | 34 (49%) | 11 (16%) |
| Stand-alone pipe and tube mill | 11 | 8 (72%) | 3 (27%) | 0 (c) |
| **TOTAL (d)** | **254** | **133 (53%)** | **70 (28%)** | **56 (22%)** |

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Surveys).
(a) The sum of direct dischargers, indirect dischargers, and zero dischargers may not equal the total number of sites. Sites may directly and indirectly discharge wastewater from their site.
(b) Zero dischargers include sites that do not discharge process wastewater and sites that are completely dry (i.e., do not use water in iron and steel operations).
(c) Cells with a zero (0) value indicate that none of the survey respondents have the characteristic.
(d) Columns do not sum to totals because of rounding each number and because two sites are counted as one integrated mill.

## Table 5-4

## 1997 National Estimate of Actual Production and Rated Capacity by Manufacturing Operation

| Manufacturing Operation | Total Number of Sites with this Operation | Total 1997 Production (million standard tons) | Total 1997 Rated Capacity (million standard tons) |
|---|---|---|---|
| Cokemaking | 24 | 20.4 | 22.6 |
| Sintering | 9 | 12.4 | 17.9 |
| Blast furnace ironmaking | 20 | 54.5 | 68.6 |
| BOF steelmaking | 20 | 65.9 | 78.3 |
| EAF steelmaking | 96 | 50.8 | 75.8 |
| Vacuum degassing | 44 | 18.0 | 39.1 |
| Ladle metallurgy | 103 | 102 | 157 |
| Casting | 113 | 110 | 142 |
| Hot forming | 153 | 127 | 177 (a) |
| Acid pickling and descaling | 69 | 48.3 | 67.9 (a) |
| Cold forming | 103 | 72.8 | 105 |
| Surface cleaning and coating | 98 | 35.3 | 40.1 |
| Briquetting and other agglomeration process | 4 | 0.319 | 0.731 |
| Direct-reduced ironmaking | 2 | 0.581 | 1.56 |

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Surveys).
(a) This estimate does not represent a national estimate of capacity because it is based on data only from the detailed survey. Production capacity was not requested in the short survey.

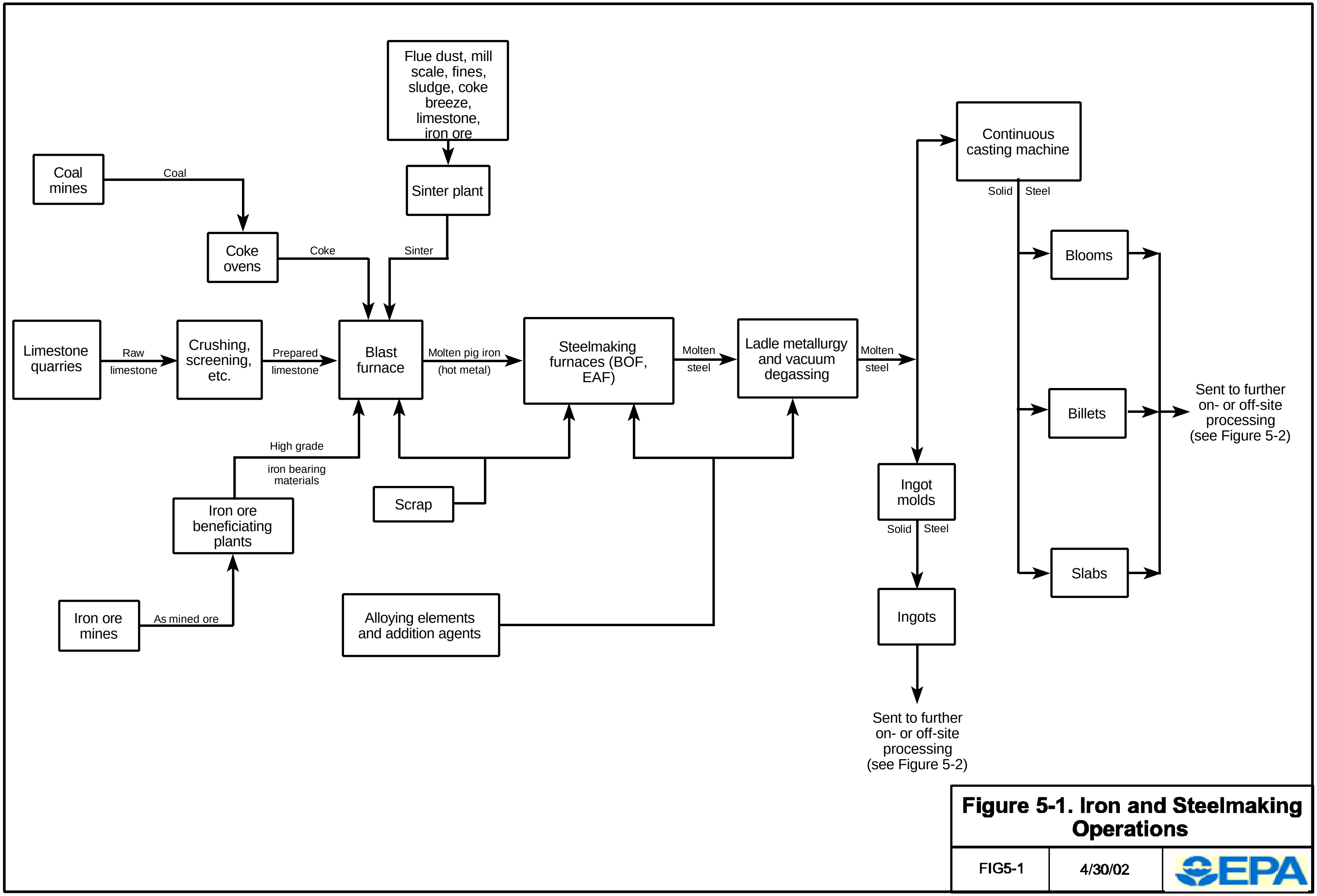



**Figure 5-1. Iron and Steelmaking Operations**

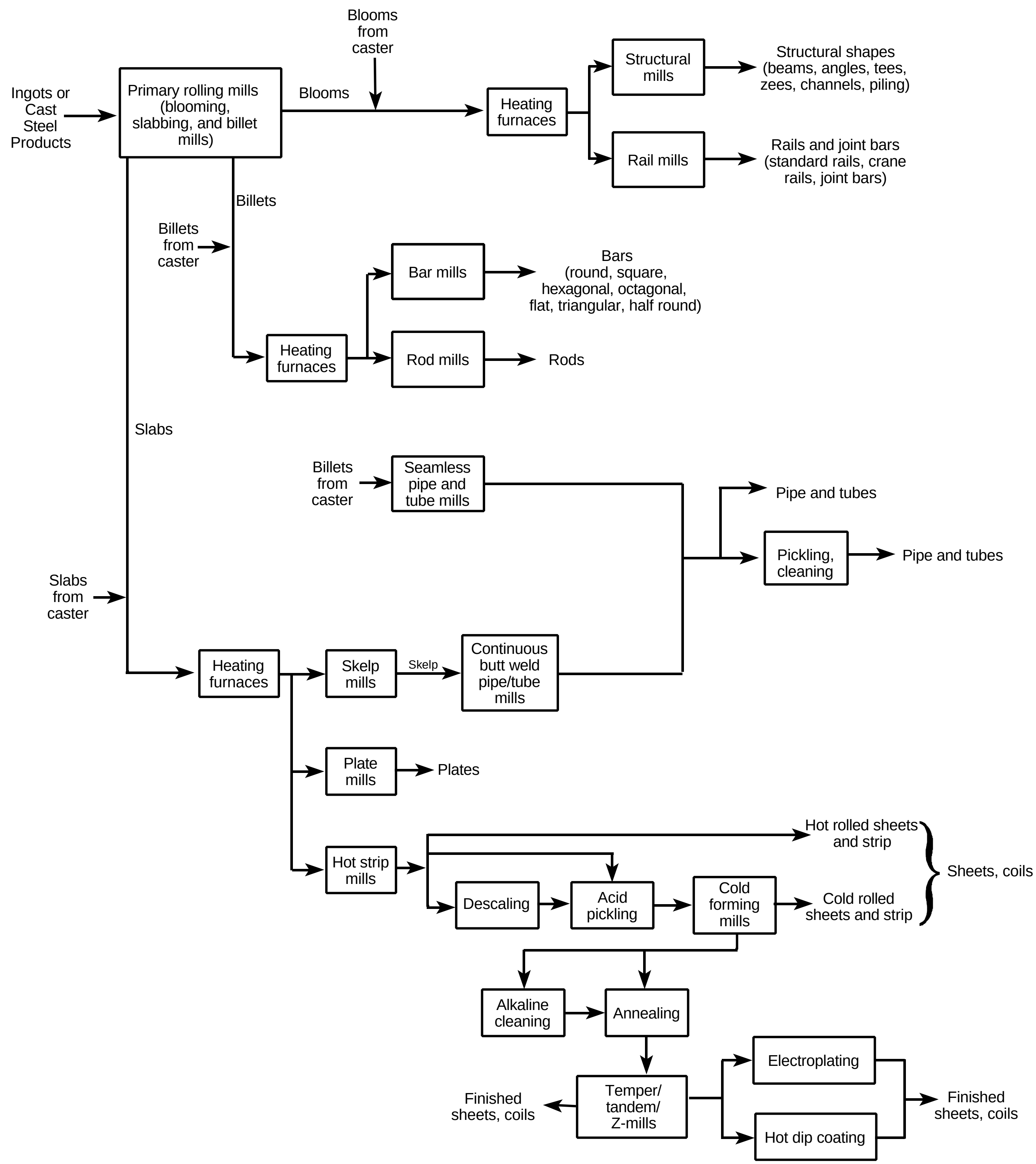
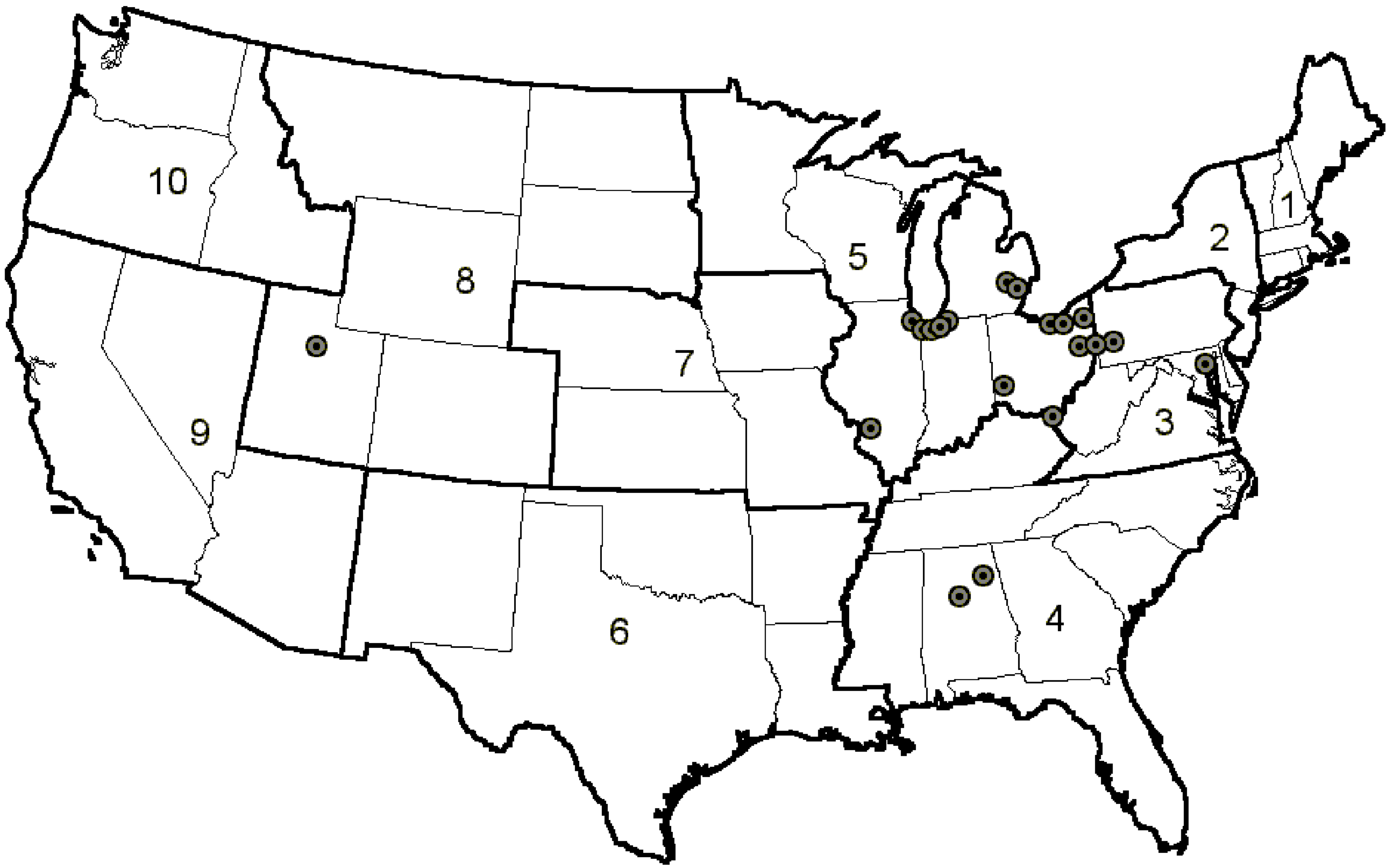



**Figure 5-2. Forming and Finishing Operations**

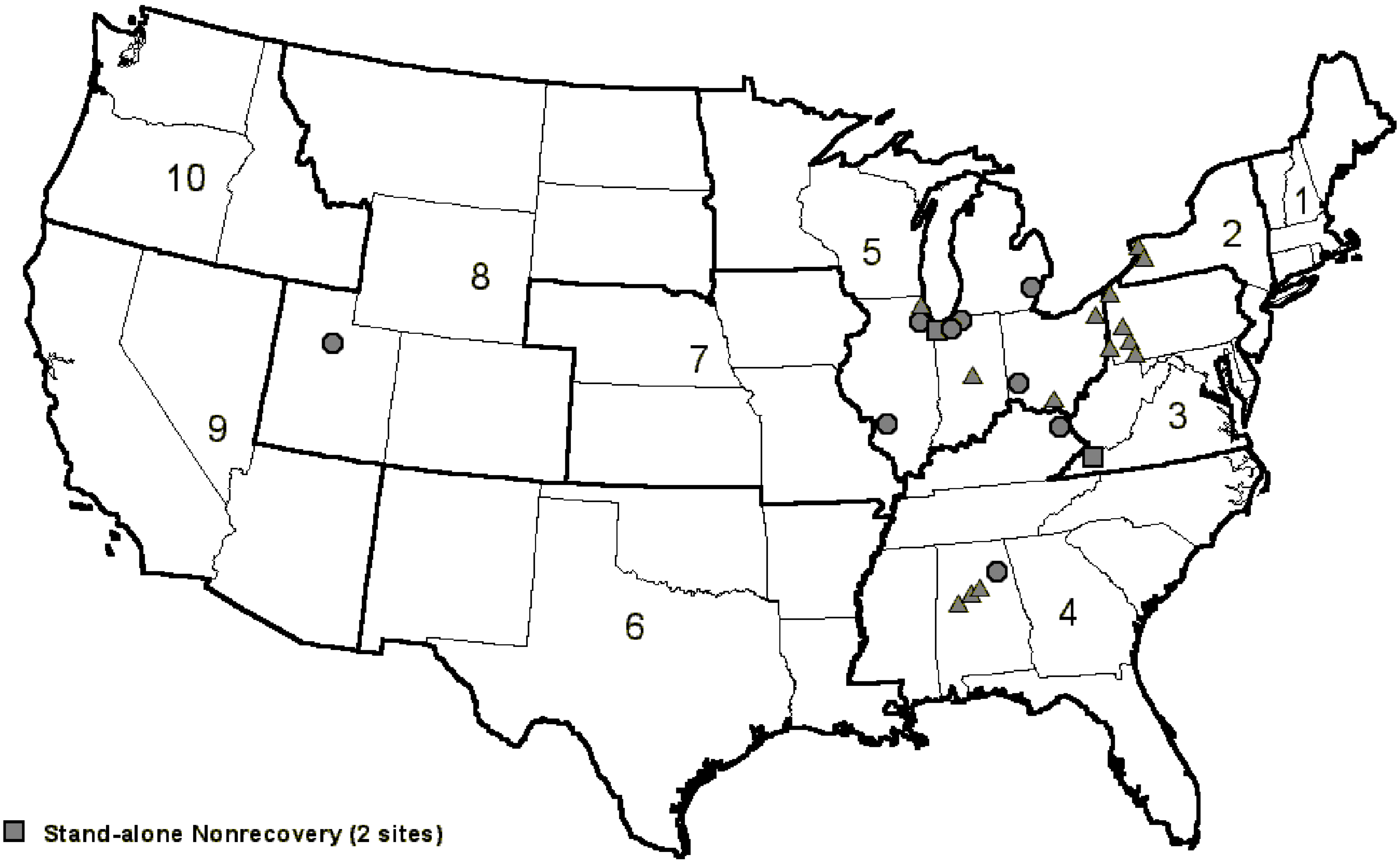
| FIG5_2 | 4/30/02 | EPA |
|---|---|---|

# Figure 5-3.
## Integrated Steel Manufacturing Sites




Smaller stand-alone forming and finishing facilities are generally located near steel manufacturing sites.

# Figure 5-4.
# Cokemaking Sites




■ Stand-alone Nonrecovery (2 sites)

● By-product Recovery Co-located at Integrated Steel Mills (9 sites)

▲ Stand-alone By-product Recovery (14 sites)

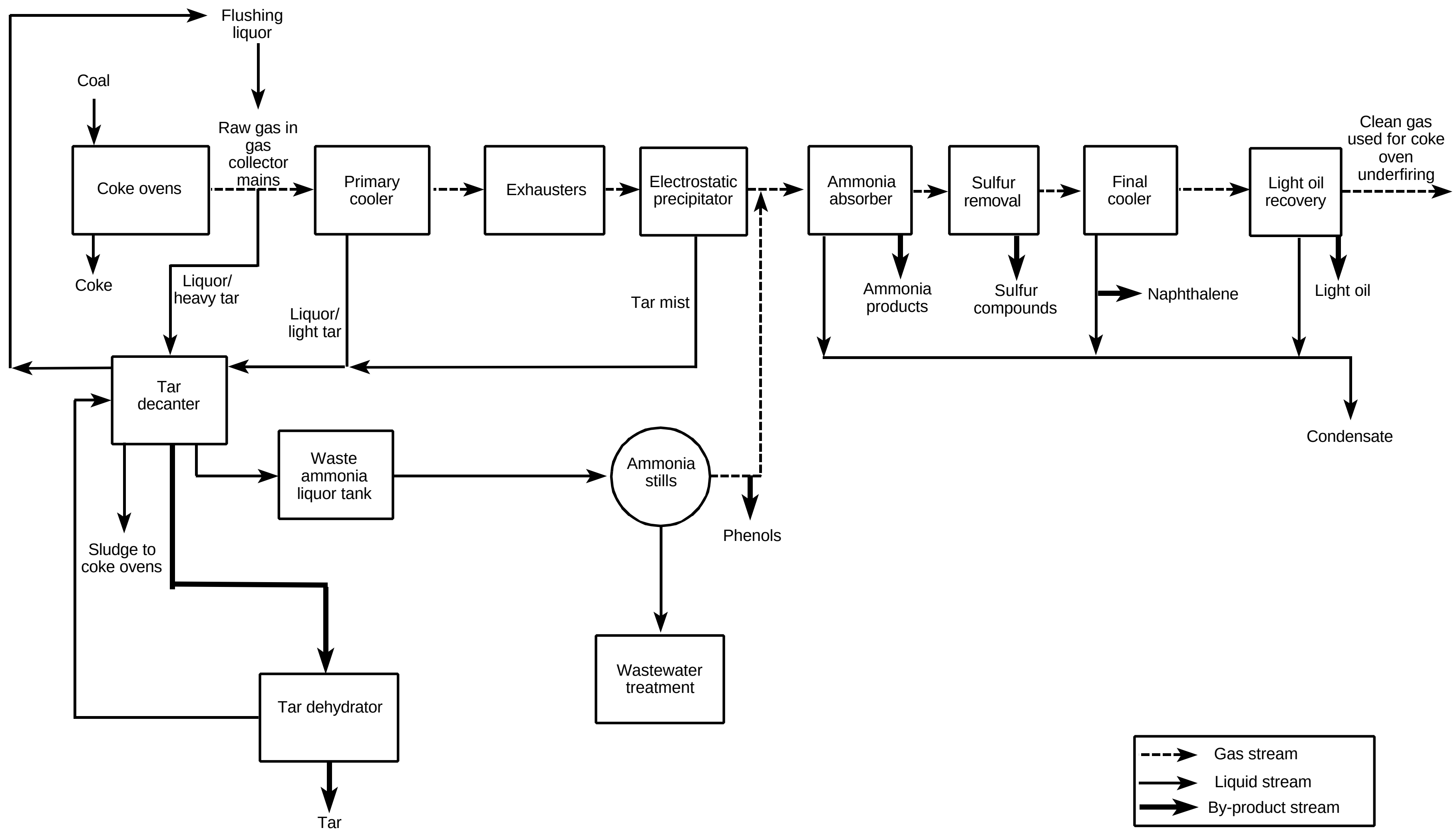



**Figure 5-5. By-Product Recovery Cokemaking Process Diagram**

| FIG5-5 | 4/30/02 | EPA |
|---|---|---|

# SECTION 6

# SUBCATEGORIZATION

This section presents a discussion on subcategorization for today's iron and steel effluent limitations guidelines and standards. Section 6.1 presents background on EPA's subcategorization process and describes the factors EPA evaluated for this rulemaking. Section 6.2 presents information on the proposed subcategorization structure. Section 6.3 presents the final subcategorization analyses, structure, and rational, and describes each of the subcategories and segments.

## 6.1 Subcategorization Factors

The CWA requires EPA, in developing effluent limitations guidelines and standards, to consider a number of different factors (Section 304(b)(2)(b), 33 U.S.C. § 1314 (b)(2)(B)). Among others, these factors include

- Age of equipment and facilities;
- Location;
- Size of site;
- Manufacturing processes employed;
- Wastewater characteristics; and
- Non-water quality environmental impacts.

One way the Agency has taken some of these factors into account is by breaking down categories of industries into separate classes of similar characteristics. This recognizes the major differences among companies within an industry that may reflect, for example, different manufacturing processes or other factors.

EPA considered all the relevant factors in developing the subcategorization structure for the existing iron and steel regulation, which is based on manufacturing operation and/or product produced. In developing today's final rule for the iron and steel industry, EPA reviewed the existing subcategorization structure to determine whether it is still appropriate. EPA used information from industry survey data, EPA site visits, sampling data, and public comments (discussed in Chapter 2) to re-evaluate and consider each of the statutory factors listed above as they affect the current industry.

For both the proposed and final rule, EPA concluded that, like the existing subcategorization structure, the majority of these factors do not support subcategorization. EPA first evaluated the age of facilities with respect to production-normalized wastewater discharge rates (volume of water discharged with respect to production). The comparison between the age of the facilities and the respective process wastewater discharge rates showed no relationships between mill age and the volume of process wastewater discharged. Therefore, the Agency determined that the age of facilities and equipment did not have an impact on wastewater generation or discharge. The Agency's analysis of age versus wastewater discharge rate are located in the administrative record for the rule. (See DCNs IS10357, IS10359, IS10362, and IS10441 of Section 14.1 of the Administrative Record.)

Similarly, the Agency also evaluated age with respect to installing or upgrading wastewater treatment equipment and found that while a site or a plant may have been operating for several decades, manufacturing and treatment system upgrades regularly occur. In certain cases, older sites actually have modern wastewater treatment systems and have demonstrated model BAT treatment. Consequently, the Agency has determined that subcategorization was not warranted on the basis of age. (See DCN IS04614 of Section 5.2 of the Administrative Record.)

The Agency analyzed location of the sites with respect to the amount of process wastewater discharged. While the Agency realizes that facilities located in arid and semi-arid regions of the country have greater opportunity for decreased discharge flow rates due to water loss from evaporation, the flow allowances used to develop the final regulation have been determined to be achievable in any region of the country. Therefore, the Agency determined that location was not a significant criterion for subcategorization. The data from EPA's analysis of location versus wastewater discharge rate are located in the administrative record for this rule. (See DCNs IS10357, IS10359, IS10362, and IS10441 of Section 14.1 of the Administrative Record.)

While larger iron and steel sites discharge greater total volumes of wastewater, the size of a site (e.g., acreage, number of employees) did not have an impact on production-normalized wastewater discharge rates or pollutant concentrations. Consequently, the Agency determined that size was also not a significant factor for subcategorization. (See DCNs IS10357, IS10359, IS10362, and IS10441 of Section 14.1 of the Administrative Record.)

Similarly, EPA evaluated non-water quality impacts, such as solid waste and air emission effects, and determined that non-water quality environmental impacts did not constitute a basis for subcategorization in the final rule. A detailed discussion of non-water quality impacts is presented in Section 15.

Of all the subcategorization criteria, EPA identified manufacturing processes as the most significant factor affecting the final subcategorization structure because it had the greatest impact on wastewater generation and characteristics. In addition, EPA used type of product and wastewater characteristics, including flow rates with respect to production and type of pollutant present, to segment within each subcategory. A detailed discussion of wastewater sources, pollutant loadings, option selection, regulated pollutants, and production-normalized flow rates for each segment is presented in Sections 7, 9, 11, 12, and 13 of this document.

Since many of the elements considered for subcategorization, including statutory factors, have not changed since the 1982 rule, refer to Volume I of the Technical Development for the 1982 regulation (pages 155 to 163, EPA 440/1-82/024, May 1982) for a more detailed review of the above factors.

## 6.2 Proposed Subcategorization

On December 27, 2000, EPA proposed a subcategorization structure that was significantly different from the structure in the 1982 iron and steel rule (see 65 FR 65 FR 81964, 81974-81975). The Agency proposed to revise the subcategorization structure to create seven subcategories of iron and steel facilities based on co-treatment of compatible waste streams. This would have replaced the present structure of 12 subcategories. EPA proposed the following seven subcategories:

| Subpart | Subcategory | Segment |
|---|---|---|
| Subpart A | Cokemaking Subcategory | By-Product Recovery<br>Non-Recovery |
| Subpart B | Ironmaking Subcategory | Blast Furnace<br>Sintering |
| Subpart C | Steelmaking Subcategory | |
| Subpart D | Integrated and Stand-Alone Hot Forming Mills Subcategory | Carbon and Alloy<br>Stainless |
| Subpart E | Non-Integrated Steelmaking and Hot Forming Operations Subcategory | Carbon and Alloy<br>Stainless |
| Subpart F | Steel Finishing Subcategory | Carbon and Alloy<br>Stainless |
| Subpart G | Other Operations Subcategory | Direct-Reduced Ironmaking<br>Forging<br>Briquetting |

The Agency proposed to consolidate sintering and ironmaking into a single "ironmaking subcategory." Additionally, the Agency consolidated steelmaking processes combining basic oxygen furnace (BOF), vacuum degassing, and continuous casting into the "steelmaking subcategory." The Agency also attempted to separate integrated mills hot forming operations from non-integrated mills operations (electric arc furnace steelmaking, vacuum degassing, continuous casting, and hot forming). Unlike the 1982 rule, EPA proposed to consolidate operations such as salt bath descaling, acid pickling, and other finishing operations into a single "steel finishing subcategory." In addition, one new subcategory, "other operations subcategory," has been created to regulate direct-reduced ironmaking, briquetting, and forging.

In addition to the revised subcategory structure, EPA proposed segmentation changes in the proposed cokemaking, ironmaking (sintering), integrated steelmaking, integrated and stand-alone hot forming, non-integrated steelmaking and hot forming, and finishing subcategories. First, EPA proposed to combine two 1982 segments in the cokemaking subcategory, "iron and steel" and "merchant," into a single "by-product recovery" segment because differences in wastewater flow rates observed in the 1982 rulemaking are no longer apparent within the current population of by-product coke plants. In addition to combining all by-product recovery cokemaking operations into one segment, the Agency also proposed a new "non-recovery" segment to accommodate the two non-recovery coke plants. Second, for the proposed integrated and stand-alone hot forming subcategory, the non-integrated steelmaking and hot forming subcategory, and the steel finishing subcategory, EPA proposed segmenting based on whether facilities primarily make stainless or carbon/alloy steels.

The Agency proposed this subcategorization structure to reflect not only the modern state of the industry, in terms of both process and wastewater management, but also the experience that the Agency and other regulatory entities have gained from implementing the 1982 iron and steel effluent limitations guidelines and standards. EPA also expected that the revised subcategorization structure would simplify the regulatory process and reflect co-treatment of compatible wastewaters, which is currently practiced by the industry. As a result, many of the proposed subcategories would have included various operations that are regulated under different segments or subcategories in the 1982 rule.

Table 6-1 presents a comparison of the 1982 subcategorization structure and the structure EPA proposed on December 27, 2000. For a detailed discussion of the proposed subcategorization, see Section 6 of the Development Document for the Proposed Iron and Steel Manufacturing Point Source Category, EPA 831-B-00-011, December 2000.

## 6.3 Final Subcategorization

While EPA did not receive any comments specific to the proposed subcategorization structure, the Agency did receive a number of comments on the change in segmentation for the cokemaking subcategory. The comments opposed EPA's proposal to drop the segmentation of "iron and steel" and "merchant" coke plants; however, the comments agree with EPA's assessment that production process and wastewaters from these types of plants coke plants are similar. The Agency also evaluated potential economic differences among these plants in order to see whether they justified retaining the 1982 segmentation. Although some difference in facility size was observed, EPA did not find substantial differences in profitability or other factors that might affect economic achievability. Some commenters also expressed confusion regarding the segmentation of stainless and carbon/alloy steels.

Following proposal, the Agency re-evaluated the economic conditions and technology bases of the proposed rule. The Agency decided to promulgate new or revised limits for only three subcategories (cokemaking, sintering, and other operations), and for segments within two others (ironmaking and steelmaking). These decisions similarly affected the final subcategorization structure. Due to the small number of subcategories affected by today's rule, the Agency has decided to retain the 1982 subcategory structure with the addition of an "other operations subcategory." As a result, the final rule covers the following 13 subcategories:

| Subcategory | Description |
|---|---|
| Subcategory A | Cokemaking (includes by-product recovery and non-recovery operations) |
| Subcategory B | Sintering (includes wet and dry air pollution control operations |
| Subcategory C | Ironmaking |
| Subcategory D | Steelmaking (includes basic oxygen furnace and electric arc furnace operations) |
| Subcategory E | Vacuum degassing |
| Subcategory F | Continuous casting |
| Subcategory G | Hot forming |
| Subcategory H | Salt bath descaling |
| Subcategory I | Acid pickling |
| Subcategory J | Cold forming |
| Subcategory K | Alkaline cleaning |
| Subcategory L | Hot coating |
| Subcategory M | Other operations (includes forging, direct-reduced ironmaking, and briquetting operations) |

For the cokemaking subcategory, this final rule combines the "iron and steel" and "merchant" segments into a newly-created "by-product recovery" cokemaking segment for most regulatory purposes, although EPA is retaining the "iron and steel" and "merchant" segments for purposes of reflecting the existing BPT/BCT limitations. EPA is also creating a new cokemaking segment for non-recovery operations and a new sintering segment for dry air pollution control systems. Because the promulgated rule makes no change to subcategorization for the steelmaking, hot forming, vacuum degassing, casting, or various finishing operations, the segmentation for these operations in the 1982 rule remains applicable. Finally, the Agency is creating a new subcategory, the "other operations subcategory." The complete final subcategorization structure is presented in Table 6-2. A detailed discussion of each subcategory, in the structure of the 2000 proposal follows.

### 6.3.1 Proposed Subpart A: Cokemaking

Cokemaking turns carbon in raw coal into metallurgical coke, which is subsequently used in the ironmaking process. There are two types of cokemaking operations: by-product recovery and non-recovery. In by-product coke plants, metallurgical coke is produced by distilling coal in refractory-lined, slot-type ovens at high temperatures in the absence of air. In non-recovery coke plants, coal is made into coke in negative pressure, higher temperature coke ovens.

In by-product coke operations, the moisture and volatile components generated from the coal distillation process are collected and processed to recover by-products, such as crude coal tars, light crude oil, etc. Non-recovery cokemaking facilities use higher temperature ovens which destroy volatile organics, and they do not recover any by-products.

In by-product recovery coke plants, wastewater such as waste ammonia liquor is generated from moisture contained in the coal charge to the coke ovens, and some wastewater is generated from the by-product recovery operations. The non-recovery coke plants, on the other hand, do not generate process wastewater other than boiler blowdown and process storm water, which are typically disposed of by coke quenching.

The 1982 regulation segmented by-product recovery cokemaking into "iron and steel" and "merchant" coke plants. "Iron and steel" cokemaking was defined at 420.11(d) and "merchant" cokemaking was defined at 420.11(c). The term "iron and steel" means those by-product recovery cokemaking operations other than merchant cokemaking operations. "Merchant" means those by-product recovery cokemaking operations which provide more than fifty percent of the coke produced to operations, industries, or processes other than iron making blast furnaces associated with steel production. The proposed subdivision was created to reflect different wastewater volume generation rates between coke plants located at integrated steel plants and at merchant coke plants.

In December 2000, EPA proposed to combine the iron and steel and merchant cokemaking segments into a single segment: by-product recovery cokemaking. EPA proposed this change because its analyses showed that wastewater generation and characteristics, and pollution prevention and wastewater treatment technology effectiveness for the two segments were similar. In 1982, EPA determined that the model flow rates for "iron and steel" coke plants and merchant coke plants, including control water, were 153 gpt and 170 gpt, respectively. However, EPA did not observe these differences in wastewater generation rates when analyzing the current survey data.

Comments opposed EPA's proposal to drop the segmentation on the basis of "iron and steel" and "merchant" coke plants based on economic considerations. However, the comments agreed with EPA's assessment that production process and wastewaters characteristics and flow rates from merchant coke plants are similar to those from the integrated "iron and steel" facilities. The Agency evaluated potential economic differences between "merchant" and "iron and steel" facilities and found no substantial differences in profitability or other factors which might affect economic achievability, although some difference in facility size was observed. This facility size was not significant and not considered adequate for subcategorization. (See DCN IS11044 of Section 15.1.4, and DCN IS10362 of Section 14.1, of the Administrative Record.)

Consequently, for the cokemaking subcategory, today's rule combines the "iron and steel" and "merchant" segments into a newly-created "by-product recovery" cokemaking segment for most regulatory purposes, although EPA is retaining the "iron and steel" and "merchant" segments for purposes of reflecting the existing BPT limitations. EPA concluded that this was appropriate because the production processes, wastewater characteristics, wastewater flow rates, and economic impacts from all by-product recovery cokemaking operations, including merchant facilities, are similar.

The non-recovery cokemaking segment includes non-recovery cokemaking processes that have either existed for many years or are currently emerging in the industry. Other than low-volume boiler blowdown and process area storm water, non-recovery cokemaking processes do not generate wastewater like the by-product recovery processes do. This major difference in wastewater flow necessitated the segmentation of this subcategory.

### 6.3.2 Proposed Subpart B: Ironmaking

In ironmaking, blast furnaces are used to produce molten iron, which makes up about two-thirds of the charge to basic oxygen steelmaking furnaces. The raw materials charged to the top of the blast furnace include coke, limestone, refined iron ores, and sinter. Preheated air is blown into the bottom of the furnace and exits the furnace top as blast furnace gas in enclosed piping. The off-gas is cleaned and cooled in a combination of dry dust catchers and high-energy venturi scrubbers. Direct contact water used in the gas coolers and high-energy scrubbers comprises nearly all of the wastewater from ironmaking blast furnace operations.

Sinter plants upgrade the iron content of ores and recover iron from a mixture of wastewater treatment sludges, mill scale from integrated steel mills, and fine coke particles (also known as coke breeze) from cokemaking operations. In sinter plants, the iron source mixture is combined with limestone and charged to a furnace. Sinter of suitable size and weight is formed for charging to the blast furnace. Wastewaters are generated from wet air pollution control devices on the wind box and discharge ends of the sinter furnace. No process wastewater is generated by dry air pollution control systems.

The 1982 regulation distinguished sintering and blast furnace operations as two separate subcategories, sintering and ironmaking, respectively. In 2000, EPA proposed to combine these two subcategories together into a single “ironmaking” subcategory. EPA proposed this change because survey responses indicated that facilities with both operations generate wastewater with similar characteristics and tended to co-mingle these wastewaters before treatment[1]. However, EPA concluded that it was still appropriate to distinguish between the two in terms of model system flow rates and manufacturing process, and proposed to divide the ironmaking subcategory into the sintering and blast furnace segments. The Agency proposed to further divide the sintering segment due to differences in wastewater generation, as discussed below.

Sinter facilities use two types of air pollution control systems to treat air emissions from sinter plants: wet and dry. Sinter plants that operate dry air pollution controls do

[1]An exception is that EPA found dioxins and furans in wastestreams from sinter operations with wet air pollution control systems and in blast furnace wastewaters cotreated with sintering wastewaters. No measurable dioxins and furans were found in treated blast furnace wastewater only.

not generate process wastewater. Data from the surveys indicate that approximately a third of these plants employ dry air pollution controls. EPA proposed to establish a segment for sintering plants with dry air pollution control and designate the discharge requirements to be zero discharge of pollutants.

In response to comments received on the proposal, EPA generally concluded it was not appropriate to revise the existing limitations and standards for the proposed ironmaking subcategory (with the exception of codifying an ammonia waiver). Consequently, EPA is similarly retaining the existing subcategorization structure for sintering and ironmaking. However, EPA did not receive any comments opposing the segmentation of sintering on the basis of air pollution control systems. Therefore, the final rule creates two segments the sintering subcategory: dry air pollution control and wet air pollution control.

### 6.3.3 Proposed Subpart C: Integrated Steelmaking

The 1982 iron and steel regulation included separate subcategories for steelmaking, vacuum degassing, continuous casting, and hot forming. In 2000, EPA proposed a revised subcategorization structure that recognized the differences between integrated and non-integrated steelmaking facilities. The Agency proposed segregating steelmaking operations at integrated plants and non-integrated plants to simplify the structure of the regulation and because different wastewater generation rates were observed between integrated and non-integrated plants. This proposed structure included combining certain operations at integrated facilities from the existing steelmaking, vacuum degassing, and continuous casting operations into an "integrated steelmaking subcategory." The following provides a general description of each of these operations.

BOFs are one of two types of furnaces used in steelmaking in the United States[2]. They are typically used for high tonnage production of carbon steels at integrated mills. Integrated steel mills use BOFs to refine a metallic charge consisting of approximately two-thirds molten iron and one-third steel scrap. Facilities use three types of air pollution control systems to treat furnace off-gases from BOF steelmaking operations: semi-wet air pollution controls, wet-open combustion air pollution controls, and wet-suppressed combustion air pollution controls. Each type of air pollution control system operates in a different manner and generates different wastewater flow rates. However, the wastewater characteristics are similar. Twenty-four BOF shops are operated at 20 integrated steel plants and one non-integrated steel plant. Of the 24 BOF shops, eight use semi-wet air pollution control systems, eight use wet-open combustion air pollution control systems, seven use wet-suppressed combustion air pollution control systems, and one uses a combination wet-open/wet-suppressed combustion air pollution control system.

Vacuum degassing is a batch process where molten steel is subjected to a vacuum for composition control, temperature control, deoxidation, degassing, decarburization, and the removal of impurities from the steel. Oxygen and hydrogen are the principal gases removed

[2]The other type is an electric arc furnace (EAF), which is typically used to produce low-tonnage carbon, alloy, and stainless steels at non-integrated mills.

from the steel. In most degassing systems, the vacuum is provided by barometric condensers; thus, direct contact between the gases and the barometric water occurs.

Likewise, ladle metallurgy is also a batch process where molten steel is refined in addition to, or in place of, vacuum degassing. These operations include argon bubbling, argon-oxygen decarburization (AOD), electroslag remelting (ESR), and lance injection. These additional refining operations do not generate any process water.

Casting is generally a continuous process where molten steel is shaped while cooling into semi-finished shapes after the vacuum degassing and/or ladle metallurgy processes. The continuous casting machine includes a receiving vessel for molten steel, water-cooled molds, secondary cooling water sprays, containment rolls, oxygen-acetylene torches for cutoff, and a runout table. Wastewater is generated by a direct contact water system used for spray cooling and for flume flushing to transport scale from below the caster runout table. The other main casting operation type is ingot casting, in which molten steel is poured into ingot molds.

Under the proposed structure, wastewaters from basic oxygen furnace operations were included with wastewaters from vacuum degassing operations and continuous casting operations to make up the “integrated steelmaking subcategory.” Hot forming operations that took place either at integrated mills or were not associated directly with steelmaking operations were to be covered by the “integrated and stand-alone hot forming subcategory.” Wastewaters from electric arc furnaces were included with wastewaters from vacuum degassing operations, continuous casting operations and hot forming operations to make up the “non-integrated steelmaking and hot forming subcategory.” This proposed subcategory is discussed in more detail in Section 6.3.5 below.

After considering comments to the proposal and conducting a thorough re-evaluation of the costs, pollutant reductions, and economic achievability of the proposed subcategorization structure, EPA, for the most part, is not promulgating new effluent limitations guidelines and standards for the proposed “integrated steelmaking subcategory.” (EPA is promulgating a provision for one segment whereby permit writers or pretreatment control authorities can establish alternative limitations on a best professional judgement basis.) Therefore, EPA is not adopting the proposed subcategorization structure. Changing the subcategorization structure only made sense when EPA believed it would promulgate new limits and standards for the new subcategory. Consequently, this final rule maintains the current subcategorization structure in regards to steelmaking, vacuum degassing, and continuous casting.

However, EPA is revising the segments of the 1982 steelmaking subcategory so that they cover the following operations:

- Electric arc furnace steelmaking - semi-wet;
- BOF steelmaking - wet-suppressed combustion (retained);

- BOF steelmaking - wet-open combustion, and electric arc furnace steelmaking-wet; and

- BOF steelmaking - semi-wet.

### 6.3.4 Proposed Subpart D: Integrated and Stand-Alone Hot Forming

Hot forming is a process that heats ingots, blooms, billets, slabs, or rounds to rolling temperatures so that the products will form under mechanical pressure into semi-finished shapes for further hot or cold rolling or as finished shapes. Process water is used for scale breaking, flume flushing, and direct contact cooling.

Integrated and stand-alone hot forming operations include hot forming processes at integrated steel plants and stand-alone hot forming mills. Four different types of hot forming mills are operated at integrated and stand-alone facilities: flat mills (hot strip and sheet mills and plate mills), primary mills (slabbing and blooming mills), section mills (bar and rod mills), and hot formed pipe and tube mills. The existing regulation segregates the hot forming subcategory into four different segments based on differences in flow rates: primary mills, section mills, flat mills, and pipe and tube mills.

The proposed integrated and stand-alone hot forming subcategory includes hot forming processes that takes place at integrated mills or at locations that were not associated directly with steelmaking operations (stand-alone hot forming mills). EPA proposed two segments, carbon and alloy steel and stainless steel, for this subcategory because of differences in pollutants present in the wastewater and because facilities typically combine these types of wastewaters together for treatment.

However, for today's final rule, EPA has not adopted limits and standards for the proposed "integrated and stand-alone hot forming subcategory." Therefore, EPA is not adopting the proposed subcategorization structure. Changing the subcategorization structure only made sense when EPA believed it would promulgate new limits and standards for the new subcategory. Consequently, the final rule maintains the existing hot forming subcategory.

### 6.3.5 Proposed Subpart E: Non-Integrated Steelmaking and Hot Forming

As explained in Section 6.3.3 above, in 2000, EPA proposed a revised subcategorization structure that recognized the differences between integrated and non-integrated steelmaking facilities. The Agency proposed segregating steelmaking operations at integrated plants and non-integrated plants to simplify the structure of the regulation and because different wastewater generation rates were observed between integrated and non-integrated plants. This proposed structure included combining certain operations at non-integrated facilities from the existing steelmaking, vacuum degassing, continuous casting, and hot forming subcategories into a "non-integrated steelmaking and hot forming subcategory." The following provides a general description of non-integrated steelmaking. Section 6.6.3 provides descriptions of the other operations included in this subcategory.

Non-integrated steelmaking in this proposed subcategory is achieved with the use of electric arc furnaces (EAF). EAFs melt and refine a metallic charge of scrap steel to produce low tonnage carbon, alloy, and stainless steels at non-integrated mills. In addition, most mills operate EAFs with dry air cleaning systems, which produce no process wastewater discharges. There are a small number of wet and semi-wet systems.

Departing from the structure of the 1982 regulation, EPA proposed the non-integrated steelmaking and hot forming subcategory as a means to simplify the regulatory structure by grouping the basic steelmaking (electric arc furnace, vacuum degassing, and continuous casting) and forming operations performed at non-integrated plants under one subcategory. EPA proposed to combine these operations into one subcategory because of similar wastewater pollutant characteristics and the potential for cotreatment of these wastewaters. Substantially lower wastewater flow rates are demonstrated at non-integrated facilities, due to their lower water application rates, use of high-rate water recycle systems, and good water management practices.

As in the integrated and stand-alone hot forming subcategory, EPA proposed two segments, carbon and alloy steel and stainless steel, in this subcategory due to differences in wastewater pollutant characteristics. The Agency believed this approach would be helpful in simplifying the existing regulation was appropriate because of the similar wastewater characteristics, demonstrated flows, and treatment systems applied at these mills. For additional details of the proposed subcategorization structure and rational, see Section 6 of the Development Document for the Proposed Iron and Steel Manufacturing Point Source Category, EPA 831-B-00-011, December 2000.

For today's final rule, EPA has not adopted limits and standards for the proposed "non-integrated steelmaking and hot forming subcategory." Therefore, EPA is not adopting the proposed subcategorization structure. Changing the subcategorization structure only made sense when EPA believed it would promulgate new limits and standards for the new subcategory. Consequently, the final rule maintains the existing subcategorization structure in regards to steelmaking, vacuum degassing, and continuous casting.

### 6.3.6 Proposed Subpart F: Steel Finishing

Since extensive cotreatment of steel finishing wastewaters is currently practiced by the industry, the Agency proposed to simplify the regulatory structure for steel finishing operations by combining them into a single subcategory, steel finishing, because of the compatibility of wastewaters for treatment. The proposed steel finishing subcategory included salt bath and ESS descaling, acid pickling, cold forming, alkaline cleaning, continuous annealing, hot coating, and electroplating at integrated, non-integrated, and stand-alone facilities. EPA proposed to divide this subcategory into carbon and alloy steel and stainless steel segments to reflect variations in the wastewater pollutant characteristics and flow rates. The following provides a general description of the operations included in the proposed steel finishing subcategory and additional information on the proposed structure and EPA's rational is located in

Section 6 of the Development Document for the Proposed Iron and Steel Manufacturing Point Source Category, EPA 831-B-00-011, December 2000.

Salt bath descaling is the oxidizing and reducing using molten salt baths to remove heavy scale from specialty and high-alloy steels. Process wastewaters originate from quenching and rinsing operations conducted after processing in the molten salt baths. Electrolytic sodium sulfate (ESS) descaling is performed on stainless steels for essentially the same purposes as salt bath descaling.

Acid pickling is the use of acid solutions of various acids to remove oxide scale from the surfaces of semi-finished products prior to further processing by cold rolling, cold drawing, and subsequent cleaning and coating operations. Process wastewaters include spent pickling acids, rinse waters, and pickling line fume scrubber water.

Cold forming is the shaping of metal products conducted on hot rolled and pickled steels at ambient temperatures to impart desired mechanical and surface properties in the steel. Process wastewater characteristics result from using synthetic or animal-fat based rolling solutions, many of which are proprietary.

Hot coating is a process where pre-cleaned steel is immersed into baths of molten metal. Hot coating is typically used to improve resistance to corrosion, and for some products, to improve appearance and ability to hold paint. Wastewaters result principally from cleaning operations prior to the molten bath.

For today's final rule, EPA has not adopted limits and standards for the proposed "steel finishing subcategory." Therefore, EPA is not adopting the proposed subcategorization structure. Changing the subcategorization structure only made sense when EPA believed it would promulgate new limits and standards for the new subcategory. Consequently, the final rule maintains the existing subcategorization structure in regards to salt bath descaling, acid pickling, cold forming, alkaline cleaning, and hot coating.

### 6.3.7 Proposed Subpart G: Other Operations

In 2000, EPA proposed to create a new subcategory, the "other operations subcategory," which included the following operations: direct-reduced ironmaking, forging, and briquetting. These manufacturing operations are not covered by the existing rule, but are directly related to iron and steel production and are performed at iron and steel sites.

The direct-reduced ironmaking (DRI) process produces relatively pure iron by reducing iron ore in a furnace below the melting point of the iron produced. DRI is used as a substitute for scrap steel in the non-integrated steelmaking process to minimize contaminant levels in the melted steel and to allow economic steel production when market prices for scrap are high. Process wastewaters are generated from air pollution control devices, but contain insignificant toxic pollutants.

The briquetting process of agglomeration forms materials into discrete shapes of sufficient size, strength, and weight so that the material can serve as feed for subsequent processes. Briquetting does not generate process wastewater.

Forging is a hot forming operation in which a metal piece is shaped by hammering or by processing in a hydraulic press. Process wastewaters are generated from direct contact cooling water, but contain insignificant toxic pollutants.

As explained in its proposal, the Agency determined that it was appropriate to segment this subcategory on the basis of manufacturing operation. Therefore, the Agency proposed to segment the subcategory into DRI, forging and briquetting.

The Agency received no comments on the proposed subcategorization structure and determined it was appropriate to establish limits for this subcategory. Consequently, the final rule includes this additional subcategory for "other operations."

## Table 6-1

## Subcategory Comparison of the 1982 and Proposed Regulations

<table>
<tr><th>1982 Regulation</th><th colspan="2">Proposed Regulation</th></tr>
<tr><td>A. Cokemaking</td><td colspan="2">A. Cokemaking</td></tr>
<tr><td>B. Sintering</td><td colspan="2" rowspan="2">B. Ironmaking</td></tr>
<tr><td>C. Ironmaking</td></tr>
<tr><td>D. Steelmaking</td><td rowspan="3">C. Integrated Steelmaking</td><td rowspan="4">E. Non-Integrated Steelmaking and Hot Forming</td></tr>
<tr><td>E. Vacuum Degassing</td></tr>
<tr><td>F. Continuous Casting</td></tr>
<tr><td>G. Hot Forming</td><td>D. Integrated and Stand-Alone Hot Forming</td></tr>
<tr><td>H. Salt Bath Descaling</td><td colspan="2" rowspan="5">F. Steel Finishing</td></tr>
<tr><td>I. Acid Pickling</td></tr>
<tr><td>J. Cold Forming</td></tr>
<tr><td>K. Alkaline Cleaning</td></tr>
<tr><td>L. Hot Coating</td></tr>
<tr><td></td><td colspan="2">G. Other Operations</td></tr>
</table>

## Table 6-2

## Final Subcategorization

| Subcategory | | Segment | Manufacturing Process |
|---|---|---|---|
| A | Cokemaking | By-Product Recovery | --- |
| | | Non-Recovery | --- |
| B | Sintering | Dry Air Pollution Control | --- |
| | | Wet Air Pollution Control | --- |
| C | Ironmaking | Iron Blast Furnace | --- |
| D | Steelmaking | Basic Oxygen Furnace | Semi-Wet |
| | | | Wet-Suppressed Combustion |
| | | | Wet-Open Combustion |
| | | Electric Arc Furnace | Semi-Wet |
| | | | Wet |
| E | Vacuum Degassing | --- | --- |
| F | Continuous Casting | --- | --- |
| G | Hot Forming | Primary | Carbon and Specialty Mills Without Scarfers |
| | | | Carbon and Specialty Mills With Scarfers |
| | | Section | Carbon Mills |
| | | | Specialty Mills |
| | | Flat | Hot Strip and Sheet Mills |
| | | | Carbon Plate Mills |
| | | | Specialty Plate Mills |
| | | Pipe & Tube Mills | --- |

## Table 6-2 (Continued)

| Subcategory | | Segment | Manufacturing Process |
|---|---|---|---|
| H | Salt Bath Descaling | Oxidizing | Batch: Sheet, Plate |
| | | | Batch: Rod, Wire, Bar |
| | | | Batch: Pipe, Tube |
| | | | Continuous |
| | | Reducing | Batch |
| | | | Continuous |
| I | Acid Pickling | Sulfuric Acid | Rod, Wire, Coil |
| | | | Bar, Billet, Bloom |
| | | | Strip, Sheet, Plate |
| | | | Pipe, Tube, Other |
| | | | Fume Scrubber |
| | | Hydrochloric Acid | Rod, Wire, Coil |
| | | | Strip, Sheet, Plate |
| | | | Pipe, Tube, Other |
| | | | Fume Scrubber |
| | | | Acid Regeneration |
| | | Combination Acid | Rod, Wire, Coil |
| | | | Bar, Billet, Bloom |
| | | | Strip, Sheet, Plate - Continuous |
| | | | Strip, Sheet, Plate - Batch |
| | | | Pipe, Tube, Other |
| | | | Fume Scrubber |

## Table 6-2 (Continued)

| Subcategory | | Segment | Manufacturing Process |
|---|---|---|---|
| J | Cold Forming | Cold Rolling | Recirculation: Single Stand |
| | | | Recirculation: Multi Stand |
| | | | Combination |
| | | | Direct Application: Single Stand |
| | | | Direct Application: Multi Stand |
| | | Cold Worked Pipe & Tube | Water Solutions |
| | | | Oil Solutions |
| K | Alkaline Cleaning | Batch | --- |
| | | Continuous | --- |
| L | Hot Coating | Galvanizing, Terne and Other Metal Coatings | Strip, Sheet, and Miscellaneous Products |
| | | | Wire Products and Fasteners |
| | | Fume Scrubbers | --- |
| M | Other Operations | Direct Iron Reduction | --- |
| | | Forging | --- |
| | | Briquetting | --- |