12.5.1 Steel Minimills

12.5.1.1 General

The U.S. steel industry produced about 106 million tons of raw steel in 2006, and approximately 93 "minimills" that recycle ferrous scrap metal accounted for 57 percent of the total U.S. steel production. The production of steel in minimills has increased dramatically over the past 30 years. Minimills accounted for 10 percent of the national steel production in 1970, 30 to 40 percent in the 1980s, 40 to 50 percent in the 1990s, and (as noted) 57 percent in 2006. The growth has been attributed in part to an expansion in the types and quality of steel products that minimills can produce, including heavy structural shapes, rail, plate, specialty bar, hot rolled, cold rolled, galvanized, and stainless flat rolled products.

Minimills produce a variety of steel products that vary in their carbon content and in the amount and composition of alloying elements. Most of the steel produced in minimills is carbon steel used in the manufacture of construction materials, automobiles, appliances, and other applications. Approximately 4 percent (about 2 million tons) is specialty and stainless steel. Stainless and alloy steels contain less carbon and zinc and more chromium, manganese, and nickel than carbon steels. Typical stainless steel grades contain 12 to 28 percent chromium and 4 to 25 percent nickel.

Minimills are the largest recyclers in the United States. Recycled iron and steel scrap nationwide in 2004 included 25 percent “home scrap” (from current operations at the plant), 26 percent “prompt scrap” (from plants manufacturing steel products), and 49 percent post-consumer scrap. The primary source of post-consumer scrap is the automobile, and in 2004, the steel industry recycled 14.2 million tons of iron and steel scrap from 14 million vehicles.

12.5.1.2 Process Description

In a minimill, scrap metal is melted and refined in an electric arc furnace (EAF) to make steel products. Generally, molten steel is produced in an EAF and then tapped from the EAF to a ladle. The molten steel is then usually further refined with the addition of alloys. Semi-finished product is then produced using continuous casting or ingot casting. Multiple finishing processes may then be used to produce finished steel products. A general flow diagram for a minimill is presented in Figure 12.5-1.

The amount, type, age, and operation of equipment used in minimills varies widely. Some facilities operate one or more small EAFs and have relatively low production volume of finished goods. Other facilities operate multiple EAFs, Argon Oxygen Decarburization (AOD) and other refining processes, casters and product finishing lines. Some facilities produce steel in a narrow composition range; other facilities produce a wide variety of types and metallurgies of steel products. Some facilities can recycle only certain types of ferrous scrap, other facilities produce products that can be made utilizing scrap metal from a variety of sources. All of these factors

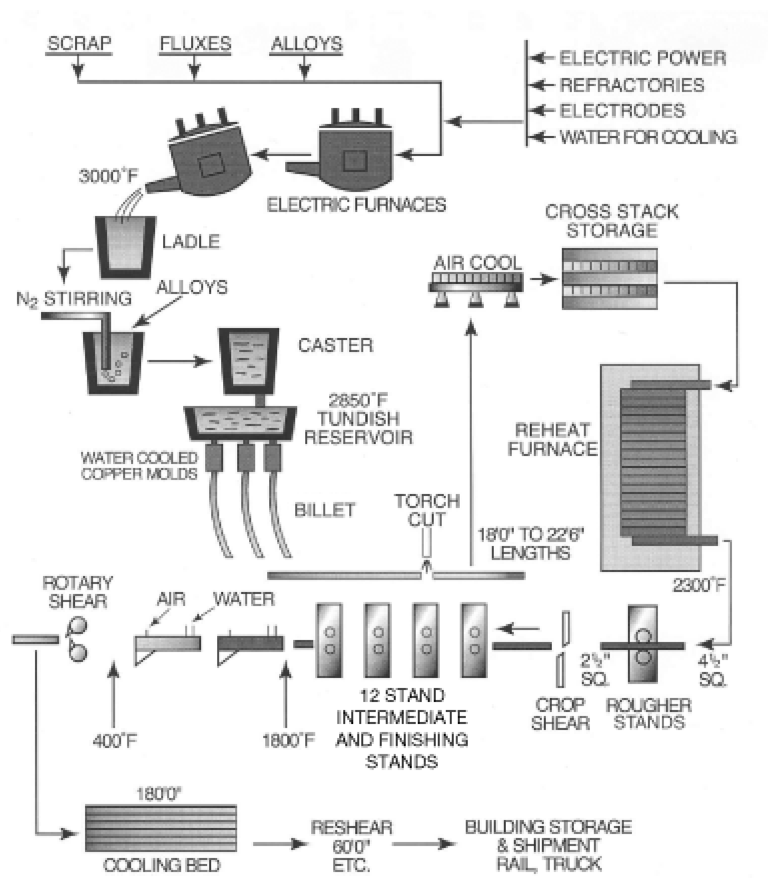

Figure 12.5-1. General Flow Diagram of a Steel Minimill

affect the quantity and characteristics of emissions. Please see the discussion in section 12.5.1.3.1 regarding emission variability.

12.5.1.2.1 Electric Arc Furnace

The input material for an EAF is typically nearly 100 percent ferrous scrap. An EAF is a cylindrical, refractory-lined container. Carbon electrodes can be raised and lowered through openings in the furnace roof. With electrodes retracted, the furnace roof can be rotated aside to permit scrap metal to be placed ("charged") into the EAF by overhead crane. Some furnaces are charged through a shaft or continuously charged from a conveyor without the removal of the furnace roof. Electric current generates heat between the electrodes and through the scrap to melt the scrap.

The production of steel in an EAF is a batch process. Stages include charging, melting, refining, slagging, and tapping. During the charging stage, scrap metal is introduced into the EAF. The charge can also include carbon and lime, a fluxing agent. Direct reduced iron (DRI) or other iron-bearing material can supplement the scrap metal used as charge material.

After the charging stage, the next step is the melting phase, during which electrical energy is supplied to the furnace interior. Oxy-fuel burners and oxygen lances may also be used to supply chemical energy. Oxy-fuel burners, which burn natural gas and oxygen, use convection and flame radiation to transfer heat to the scrap metal. During oxygen lancing, oxygen is injected directly into the molten steel; exothermic reactions with the iron and other components provide additional energy to assist in the melting of the scrap and removal of excess carbon. Alloying elements may be added to achieve the desired composition.

Refining of the molten steel can occur simultaneously with melting, especially in EAF operations where oxygen is introduced throughout the batch. During the refining process, substances that are incompatible with iron and steel are separated out by forming a layer of slag on top of the molten metal. Chemically, the slag layer consists primarily of oxides of calcium, iron, silicon, phosphorus, sulfur, aluminum, magnesium, and manganese in complexes of calcium silicates, aluminosilicates and aluminoferrite. The slag is typically removed by tipping the furnace backwards and pouring the molten slag out through a slag door[1], at which point the slag is further processed (*i.e.*, cooled, cured, and sized) into a product.

After completion of the batch, the tap hole is opened, and the steel is poured from the EAF into a ladle for transfer to the next operation.

12.5.1.2.2 Argon Oxygen Decarburization

Argon oxygen decarburization (AOD) is a process used to further refine the steel outside the EAF during the production of certain stainless and specialty steels. In the AOD process, steel from the EAF is transferred into an AOD vessel and gaseous mixtures containing argon and oxygen or nitrogen are blown into the vessel to reduce the carbon content of the steel. Argon assists the carbon removal by increasing the affinity of carbon for oxygen.[3]

12.5.1.2.3 Ladle Metallurgy

After initial melting and refining of the steel in the EAF, molten steel is often further refined in a ladle metallurgy process. There are numerous ladle metallurgy processes including ladle temperature control, composition control, deoxidation, degassing, cleanliness control, and others.[3] Alloys may be added to the molten steel to produce the desired metallurgy.[4] Electric arc heating is generally used in the final refining process.

12.5.1.2.4 Casting and Finishing

Most steel follows one of two major routes to final processing. The most common finishing method is continuous casting. In this process, a ladle with molten steel is lifted to the top of a continuous caster, where it flows into a reservoir (called a tundish) and then into the molds of the continuous casting machine. As the steel passes through the molds and is cooled, a thin skin forms on the outside of the steel. Various designs of the casters shape the steel as it continues to flow. The steel is shaped into semi-finished products such as blooms, billets, or slabs.

Another finishing route, which is not used as frequently as continuous casting, is ingot casting. Molten steel is poured from the ladle into an ingot mold, where it cools and begins to solidify. The molds are stripped away, and the ingots are transported to a soaking pit or reheat furnace where they are heated to a uniform temperature. The ingots are shaped by rolling into semi-finished products, usually blooms, billets, slabs, or by forging.

The semi-finished products may be further processed by a number of different steps, such as annealing, hot forming, cold rolling, pickling, galvanizing, coating, or painting. Some of these steps require additional heating or reheating. The additional heating or reheating is accomplished using furnaces usually fired with natural gas. The furnaces are custom designed for the type of steel, the dimensions of the semi-finished steel pieces, and the desired temperature.

12.5.1.3 Emissions and Controls

12.5.1.3.1 Electric Arc Furnace

The operations which generate emissions during the EAF steelmaking process are charging scrap, melting and refining, removing slag, and tapping steel. These processes produce metal dusts and gaseous products. The amount and composition of the particulate matter (PM) emitted can vary depending on the scrap composition and types and amounts of furnace additives such as fluxes that are added to aid in slag formation. Iron or iron oxides are the primary component of the PM. In addition, zinc, chromium, nickel, lead, cadmium, and other metals (and the oxides of the metals) may also be present in the PM. Gaseous pollutants, such as NO_X and CO, may also be emitted in amounts that depend on the equipment and operating practices.

Emissions from EAFs are generally captured using direct shell evacuation supplemented with a canopy hood located above the EAF. In general, the captured gases and particulate from the EAF are routed to baghouses for PM control. Some minimills have a common baghouse through which emissions from the EAF as well as emissions from the ladle metallurgy process and/or continuous caster are ducted and subsequently controlled.

This section also includes information on mercury (Hg) emissions from EAF sources, which were used to calculate a mercury emission factor. Due to recent developments after collection of the mercury data, we believe mercury emissions from EAFs will be lower than those estimated using this emissions factor. On August 11, 2006, EPA announced a national program aimed at addressing the primary source of mercury emissions from EAF steel mills. The National Vehicle Mercury Switch Recovery Program (NVMSRP) is designed to remove mercury-containing light switches from scrap vehicles before the vehicles are flattened, shredded, and sent to EAF steel mills for recycling into new steel products. Together with existing state mercury switch recovery efforts, this program is expected to reduce mercury air emissions from EAFs used in steel making by approximately 50 percent over the next 15 years. The program was codified as a compliance option for the mercury requirements in a December 2007 EPA final rule promulgating national emission standards for hazard air pollutants (NESHAP) for EAF steelmaking facilities.

12.5.1.3.2 Argon Oxygen Decarburization

The AOD vessel is a potential source of emissions of several pollutants, including PM, CO, and NO_X. A baghouse may be used to control particulate emissions from the AOD vessel.

12.5.1.3.3 Ladle Metallurgy

Emission sources in the ladle metallurgy process include the ladle furnace and the ladle heater. At some facilities, a roof canopy hood or a side draft hood is used to capture the emissions, which are then vented to a baghouse (which may be the same baghouse used for EAF emissions).

12.5.1.3.4 Casting and Finishing

At some facilities, fugitive particulate emissions may be generated at the caster and emitted through a roof monitor. Control devices are generally not employed for these processes. Other potential sources of emissions, especially NO_X and CO, include reheat furnaces, annealing furnaces, and other furnaces used in the finishing processes. Low NO_X burners, ultra-low NO_X burners, flue gas recirculation, or selective catalytic reduction (SCR) are being used on some of these furnaces to control emissions of NO_X.

12.5.1.4 Emission Factors

Emissions data for PM, NO_X, CO, SO_2, lead, VOC, arsenic, beryllium, cadmium, chromium, mercury, manganese, nickel, and fluoride were gathered for several of the emission sources at minimills. The emission factors are presented in Tables 12.5-1 through 12.5-9 and are in units of pounds per ton (lb/ton) of steel produced. Where possible, the values have been rounded to two significant figures; however, in some cases, the data on which the emission factors were based contained only one significant figure.

12.5.1.4.1 Variability

Minimills exhibit significant variability in product mix, configuration, and production processes, all of which contribute to the type and rate of emissions. For minimills, the primary variables include the following:

(1) *Product Type*: Minimills manufacture a wide range of products, including high carbon steel, low carbon steels, stainless steel, specialty alloy steels, leaded steels, *etc*. Production of this wide range of products requires different feedstocks, different steel melting and refining equipment, and different melting and refining practices.

(2) *Furnace Type, Size, and Power*: EAFs used throughout the country are highly variable in their type, size, and power. Some minimills utilize direct current (DC) electricity while others utilize alternate current (AC) electricity. There is wide variability in terms of the amount of steel produced per heat or batch: some EAFs produce 10-15 tons of steel per heat, while others produce over 100 tons. The rate at which electrical power (megawatts) is utilized and the amount of chemical energy applied to melt and refine the steel also vary widely.

(3) *Furnace Design*: Furnace design is critical, particularly with regard to PM emissions. For example, furnaces that have the fourth hole duct work coming directly off the side of the furnace with no bends typically pick up considerably more dust, which then must be filtered at the baghouse. In comparison, furnaces with a “goose neck” design do not collect as much dust.

(4) *Type of Scrap/Raw Material Inputs*: Different grades of scrap metal and the type and amount of other raw materials will produce different types of emissions with different levels of various constituents. The raw materials used depend on the type of steel being produced, scrap availability in the area, and other operational factors. Even when producing

a similar product, raw material inputs will vary from mill to mill depending on material availability and cost.

(5) *Scrap Feed Practices*: Scrap metal is usually fed to an EAF by adding one to four bucket loads of materials per batch; however, some EAFs are equipped with continuous scrap feed through a conveyor or via a shaft to allow scrap preheating. With traditional batch processes, the furnaces are equipped with a roof that swings to allow for scrap feed; fugitive emissions are released each time the roof is opened. In contrast, shaft fed furnaces do not require a swing roof, which results in greater capture of emissions directly from the furnace – the result is fewer "fugitive" emissions but greater emissions from the baghouse (due to the higher volume of emissions that are captured).

(6) *Slag Practices*: Slag production is a vital step in the steelmaking process. The more carbon that is used during the steel- and slag-making process, the more emissions that result. The type of carbon used also can make a difference (*e.g.*, petroleum coke, anthracite coal, or metallurgical coke).

Differences in these variables lead to wide-ranging emission rates across facilities within the industry. Emissions from ladle metallurgy furnace (LMF) operations are influenced by the same variables as EAFs, in addition to factors such as whether the LMF has a side draft hood, whether the building is enclosed, and whether emissions go to a separate baghouse or one that collects combined emissions from the EAF and LMF. For these reasons, it is common for two LMFs at the same facility to produce different levels of emissions.

Reheat furnaces also are subject to significant variability in emissions. One reason for this is the type of burners employed (*e.g.*, low NO_X, ultra-low NO_X). In addition, there are other major factors that influence emissions from reheat furnaces. For example, the physical size of the reheat furnace and the type of product (*e.g.*, rod, bar, beam, plate) manufactured by the facility influence emissions. Some products require large doors to allow the product to be inserted into and ultimately extracted from the reheat furnace. The larger door openings typically will result in greater emissions of various pollutants. The configuration of burners (*i.e.,* the number, location and relative firing rate) within the furnace also has an effect on emissions and is dictated by the product being manufactured.

This inherent site- and process-specific variability affects emissions of all of the pollutants addressed in this chapter of the AP-42 section for minimills, including condensable and filterable PM, NO_X, CO, SO_2, lead, and VOCs. In addition, emissions of the other two pollutants included in this AP-42 section, fluoride and beryllium – which is not as commonly found in minimill emissions – would be similarly influenced by these variables, particularly the type of product being manufactured.

These factors that affect variability should be considered when using the emission factors in this section, particularly when applied to estimate emissions from an individual source.

12.5.1.5 Changes from October 2008 Update

- Added process auxiliary equipment that were omitted from the October 2008 version.

- Specific changes to auxiliary process equipment emission factors. Changes are explained in the background report, chapter 5 (http://www.epa.gov/ttn/chief/ap42/ch12/bgdocs/b12s0501.pdf):
    - Filterable PM Emission Factors
        - Reheat furnace, natural gas-fired, (SCC 3-04-003-14) Uncontrolled
        - Cold reversing mill, (SCC 3-04-003-30) Controlled by high efficiency mist eliminator
    - NO_X Emission Factors
        - Ladle metallurgy station, (SCC 3-04-003-17) Uncontrolled
        - Tunnel furnace, (SCC 3-04-003-02) Uncontrolled
    - CO Emission Factors
        - Ladle metallurgy station, (SCC 3-04-003-17) Uncontrolled
        - Reheat furnace, natural gas-fired, (SCC 3-04-003-14) Uncontrolled

12.5.1-1. FILTERABLE PM EMISSION FACTORS FOR MINIMILLS

Source	EMISSION FACTOR RATING	Emission Factor	Unit[a]
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Charging, melting, slagging, tapping, ladle transfer to ladle furnace, ladle preheater, alloy addition to ladle furnace, ladle furnace melting, continuous casting Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	B	2.0E-2	lb/ton
Metallized briquetter (SCC 3-04-003-19) Controlled by wet scrubber	E	1.5E-1	lb/ton
Reheat furnace, natural gas-fired (SCC 3-04-003-14) Uncontrolled	E	3.2E-2 3.5E-3	lb/ton lb/MMBtu
Cold reversing mill (SCC 3-04-003-30) Controlled by high efficiency mist eliminator	E	1.9E-2	lb/ton
Billet cutting torches, natural gas-fired (SCC 3-04-003-60) Uncontrolled	E	3.2E-2	lb/ton
Ladle metallurgy station (SCC 3-04-003-17) Controlled by baghouse	E	3.4E-3	lb/ton
Ladle heating and transfer and continuous casting (SCC 3-04-003-17) Uncontrolled	E	1.2E-1	lb/ton

[a] Unit of lb/ton is lb/ton of steel produced.
Unit of lb/MMBtu is calculated based on MMBtu/hr heat input.

12.5.1-2. CONDENSABLE PM EMISSION FACTORS FOR MINIMILLS

Source	EMISSION FACTOR RATING	Emission Factor	Unit[a]
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Charging, melting, slagging, tapping, ladle transfer to ladle furnace, ladle preheater, alloy addition to ladle furnace, ladle furnace melting, continuous casting Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	C	2.9E-2 Non carbon condensable	lb/ton
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Charging, melting, slagging, tapping, ladle transfer to ladle furnace, ladle preheater, alloy addition to ladle furnace, ladle furnace melting, continuous casting Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	C	1.0E-2 Carbon containing condensable	lb/ton
Reheat furnace, natural gas-fired (SCC 3-04-003-14) Uncontrolled	E	9.3E-3	lb/MMBtu
Ladle metallurgy station (SCC 3-04-003-17) Controlled by baghouse	E	1.1E-2 Non carbon condensable	lb/ton
Ladle metallurgy station (SCC 3-04-003-17) Controlled by baghouse	E	1.3E-1 Carbon containing condensable	lb/ton

[a] Unit of lb/ton is lb/ton of steel produced.
Unit of lb/MMBtu is calculated based on MMBtu/hr heat input.

12.5.1-3. TOTAL PM (FILTERABLE + CONDENSABLE) EMISSION FACTORS FOR MINIMILLS

Source	EMISSION FACTOR RATING	Emission Factor	Unit[a]
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Charging, melting, slagging, tapping, ladle transfer to ladle furnace, ladle preheater, alloy addition to ladle furnace, ladle furnace melting, continuous casting Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	C	5.9E-2	lb/ton
Reheat furnace, natural gas-fired (SCC 3-04-003-14) Uncontrolled	E	1.3E-2	lb/MMBtu
Ladle metallurgy station (SCC 3-04-003-17) Controlled by baghouse	E	1.4E-1	lb/ton

[a] Unit of lb/ton is lb/ton of steel produced.
Unit of lb/MMBtu is calculated based on MMBtu/hr heat input.

12.5.1-4. NO_X EMISSION FACTORS FOR MINIMILLS

Source	EMISSION FACTOR RATING	Emission Factor	Unit[a]
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Charging, melting, slagging, tapping, ladle transfer to ladle furnace, ladle preheater, alloy addition to ladle furnace, ladle furnace melting, continuous casting Uncontrolled	B	2.2E-1	lb/ton
Ladle metallurgical station (SCC 3-04-003-17) Uncontrolled	E	2.4E-2	lb/ton
Reheat furnace, natural gas-fired (SCC 3-04-003-14) Controlled by low NOx burners	E	1.9E-1	lb/MMBtu
Reheat furnace, natural gas-fired (SCC 3-04-003-14) Controlled by low NO_X burners and flue gas recirculation	E	1.7E-1	lb/MMBtu
Reheat furnace, natural gas-fired (SCC 3-04-003-14) Controlled by SCR	E	8.5E-2	lb/MMBtu
Annealing furnace, natural gas-fired (SCC 3-04-003-05) Uncontrolled	E	2.6E-1	lb/MMBtu
Annealing furnace, natural gas-fired (SCC 3-04-003-05) Controlled by low NO_X burners	E	8.5E-2	lb/MMBtu
Direct reduced iron reformer (SCC 3-04-003-20) Uncontrolled	E	9.6E-1	lb/ton

12.5.1-4. NO_X EMISSION FACTORS FOR MINIMILLS (continued)

Source	EMISSION FACTOR RATING	Emission Factor	Unit[a]
Tunnel furnace, natural gas-fired (SCC 3-04-003-02) Controlled by low NO_X burners	E	7.6E-2	lb/MMBtu

[a] Unit of lb/ton is lb/ton of steel produced.
Unit of lb/MMBtu is calculated based on MMBtu/hr heat input.

12.5.1-5. CO EMISSION FACTORS FOR MINIMILLS

Source	EMISSION FACTOR RATING	Emission Factor	Unit[a]
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Charging, melting, slagging, tapping, ladle transfer to ladle furnace, ladle preheater, alloy addition to ladle furnace, ladle furnace melting, continuous casting Uncontrolled	B	1.8	lb/ton
Ladle Metallurgical Station (SCC 3-04-003-17) Uncontrolled	E	2.5E-2	lb/ton
Reheat Furnace, natural gas-fired (SCC 3-04-003-14) Uncontrolled	E	1.3E-3	lb/MMBtu
Annealing furnace, natural gas-fired (SCC 3-04-003-05) Uncontrolled	E	1.8E-3	lb/ton

[a] Unit of lb/ton is lb/ton of steel produced.
Unit of lb/MMBtu is calculated based on MMBtu/hr heat input.

12.5.1-6. SO_2 EMISSION FACTORS FOR MINIMILLS

Source	EMISSION FACTOR RATING	Emission Factor	Unit[a]
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Charging, melting, slagging, tapping, ladle transfer to ladle furnace, ladle preheater, alloy addition to ladle furnace, ladle furnace melting, continuous casting Uncontrolled	C	2.0E-1	lb/ton
Ladle Metallurgical Station (SCC 3-04-003-17) Uncontrolled	E	3.5E-2	lb/ton
Direct Reduced Iron Reformer (SCC 3-04-003-20) Controlled by scrubber	E	4.8E-2	lb/ton

[a] Unit of lb/ton is lb/ton of steel produced.

12.5.1-7. LEAD EMISSION FACTORS FOR MINIMILLS

Source	EMISSION FACTOR RATING	Emission Factor	Unit[a]
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Charging, melting, slagging, tapping, ladle transfer to ladle furnace, ladle preheater, alloy addition to ladle furnace, ladle furnace melting, continuous casting Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	C	5.6E-4	lb/ton

[a] Unit of lb/ton is lb/ton of steel produced.

12.5.1-8. VOC EMISSION FACTORS FOR MINIMILLS

Source	EMISSION FACTOR RATING	Emission Factor	Unit[a]
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Charging, melting, slagging, tapping, ladle transfer to ladle furnace, ladle preheater, alloy addition to ladle furnace, ladle furnace melting, continuous casting Uncontrolled	C	2.3E-2	lb/ton
Ladle Metallurgical Station (SCC 3-04-003-17) Uncontrolled	E	3.3E-3	lb/ton
Reheat Furnace, natural gas-fired (SCC 3-04-003-14) Uncontrolled	E	3.0E-4	lb/MMBtu

[a] Unit of lb/ton is lb/ton of steel produced.
Unit of lb/MMBtu is calculated based on MMBtu/hr heat input.

12.5.1-9. OTHER EMISSION FACTORS FOR MINIMILLS

Source	Pollutant	EMISSION FACTOR RATING	Emission Factor	Unit[a]
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	Arsenic	E	6.2E-06	lb/ton
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	Beryllium	D	2.8E-07	lb/ton
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	Cadmium	E	5.0E-06	lb/ton
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	Chromium	E	3.5E-06	lb/ton
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Uncontrolled	Mercury	D	1.1E-04	lb/ton

[a] Unit of lb/ton is lb/ton of steel produced.

12.5.1-9. OTHER EMISSION FACTORS FOR MINIMILLS (Continued)

Source	Pollutant	EMISSION FACTOR RATING	Emission Factor	Unit[a]
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	Manganese	E	3.0E-04	lb/ton
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	Nickel	E	5.5E-06	lb/ton
Electric arc furnace, ladle metallurgy, and melt shop (SCC 3-04-003-04) Controlled by direct shell evacuation and roof canopy hood exhausted to baghouse	Fluoride	D	5.9E-2	lb/ton

[a] Unit of lb/ton is lb/ton of steel produced.

References for Section 12.5.1

1. Jeremy Jones, Nupro Corporation, Electric Arc Furnace Steelmaking, American Iron and Steel Institute website, http://www.steel.org/learning/howmade/eaf.htm.

2. Everything You Always Wanted to Know About Steel . . . A Glossary of Terms and Concepts, Summer 1998, Courtesy of Michelle Applebaum, Managing Director, Saloman Smith Barney, Inc., American Iron and Steel Institute website: http://www.steel.org/learning/glossary/glossary.htm.

3. Alternative Control Techniques Document – NOx Emissions from Iron and Steel Mills, EPA 453/R-94-065, U.S. Environmental Protection Agency, September 1994.

4. Douglas W. Freitag, Opportunities for Advanced Ceramics to Meet the Needs of the Industries of the Future - Chapter Five: Steel Industry, U.S. Advanced Ceramics Association, September 1998.