

Mini Steel Mills

Industry Description and Practices

Mini steel mills normally use the electric arc furnace (EAF) to produce steel from returned steel, scrap, and direct reduced iron. EAF is a batch process with a cycle time of about two to three hours. Since the process uses scrap metal instead of molten iron, coke-making and iron-making operations are eliminated. EAFs can economically serve small, local markets.

Further processing of steel can include continuous casting, hot rolling and forming, cold rolling, wire drawing, coating, and pickling. The *continuous casting* process bypasses several steps of the conventional ingot teeming process by casting steel directly into semifinished shapes. The casting, rolling, and steel finishing processes are also used in iron and steel manufacturing.

Hot steel is transformed in size and shape through a series of *hot rolling* and *forming* steps to manufacture semifinished and finished steel products. The hot rolling process consists of slab-heating (as well as billet and bloom), rolling, and forming operations. Several types of hot forming mills (primary, section, flat, pipe and tube, wire, rebar, and profile) manufacture a variety of steel products.

For the manufacture of a very thin strip or a strip with a high-quality finish, *cold rolling* must follow the hot rolling operations. Lubricants emulsified in water are usually used to achieve high surface quality and to prevent overheating of the product.

Wire drawing includes heat treatment of rods, cleaning, and sometimes coating. Water, oil, or lead baths are used for cooling and to impart desired features.

To prepare the steel for cold rolling or drawing, *acid pickling* is performed to chemically remove oxides and scale from the surface of the

steel through use of inorganic acid water solutions. Mixed acids (nitric and hydrofluoric) are used for stainless steel pickling; sulfuric or hydrochloric acid is used for other steels. Other methods for removing scale include salt pickling, electrolytic pickling, and blasting; blasting is environmentally desirable, where feasible.

Waste Characteristics

EAFs produce metal dusts, slag, and gaseous emissions. The primary hazardous components of EAF dust are zinc, lead, and cadmium; nickel and chromium are present when stainless steels are manufactured. The composition of EAF dust can vary greatly, depending on scrap composition and furnace additives. EAF dust usually has a zinc content of more than 15%, with a range of 5–35%. Other metals present in EAF dust include lead (2–7%), cadmium (generally 0.1–0.2% but can be up to 2.5% where stainless steel cases of nickel-cadmium batteries are melted), chromium (up to 15%), and nickel (up to 4%). Generally, an EAF produces 10 kilograms of dust per metric ton (kg/t) of steel, with a range of 5–30 kg/t, depending on factors such as furnace characteristics and scrap quality. Major pollutants present in the air emissions include particulates (1,000 milligrams per normal cubic meter, mg/Nm³), nitrogen oxides from cutting, scarfing, and pickling operations, and acid fumes (3,000 mg/Nm³) from pickling operations. Both nitrogen oxides and acid fumes vary with steel quality.

Mini mills generate up to 80 cubic meters of wastewater per metric ton (m³/t) of steel product. Untreated wastewaters contain high levels of total suspended solids (up to 3,000 milligrams per liter, mg/l), copper (up to 170 mg/l), lead (10 mg/l), total chromium (3,500 mg/l), hexavalent chromium (200 mg/l), nickel (4,600

mg/l), and oil and grease (130 mg/l). Chrome and nickel concentrations result mainly from pickling operations. The characteristics of the wastewater depend on the type of steel, the forming and finishing operations, and the quality of scrap used as feed to the process.

Solid wastes, excluding EAF dust and wastewater treatment sludges, are generated at a rate of 20 kg/t of steel product. Sludges and scale from acid pickling, especially in stainless steel manufacturing, contain heavy metals such as chromium (up to 700 mg/kg), lead (up to 700 mg/kg), and nickel (400 mg/kg). These levels may be even higher for some stainless steels.

Pollution Prevention and Control

The following pollution prevention measures should be considered:

- Locate EAFs in enclosed buildings.
- Improve feed quality by using selected scrap to reduce the release of pollutants to the environment.
- Use dry dust collection methods such as fabric filters.

Replace ingot teeming with continuous casting. Use continuous casting for semifinished and finished products wherever feasible. In some cases, continuous charging may be feasible and effective for controlling dust emissions.

- Use bottom tapping of EAFs to prevent dust emissions.
- Control water consumption by proper design of spray nozzles and cooling water systems.
- Segregate wastewaters containing lubricating oils from other wastewater streams and remove oil.
- Recycle mill scale to the sinter plant in an integrated steel plant.
- Use acid-free methods (mechanical methods such as blasting) for descaling, where feasible.
- In the pickling process, use countercurrent flow of rinse water; use indirect methods for heating and pickling baths.
- Use closed-loop systems for pickling; regenerate and recover acids from spent pickling liquor using resin bed, retorting, or other regeneration methods such as vacuum crystallization of sulfuric acid baths.

- Use electrochemical methods in combination with pickling to lower acid consumption.
- Reduce nitrogen oxide (NO_x) emissions by use of natural gas as fuel, use low-NO_x burners, and use hydrogen peroxide and urea in stainless steel pickling baths.
- Recycle slags and other residuals from manufacturing operations for use in construction and other industries.
- Recover zinc from EAF dust containing more than 15% total zinc; recycle EAF dust to the extent feasible.

Target Pollution Loads

High water use is associated with cooling. Recycle wastewaters to reduce the discharge rate to less than 5 m³/t of steel produced, including indirect cooling waters.

The recommended pollution prevention measures can achieve the target levels.

Treatment Technologies

Air Emissions

Dust emission control technologies include cyclones, baghouses, and electrostatic precipitators (ESPs). Scrubbers are used to control acid mists. Fugitive emissions from charging and tapping of EAFs should be controlled by locating the EAF in an enclosed building or using hoods and by evacuating the dust to dust arrestment equipment to achieve an emissions level of less than 0.25 kg/t.

Wastewater Treatment

Spent pickle liquor containing hydrochloric acid is treated by spraying it into a roasting chamber and scrubbing the vapors. If hexavalent chrome is present in salt pickling or electrolytic pickling baths, it can be reduced with a sulfide reagent, iron salts, or other reducing agents. The remaining wastewaters are typically treated using oil-water separation flotation, precipitation, chemical flocculation, sedimentation/parallel plate separation/hydrocycloning, and filtration. Methods such as ultrafiltration may be used for oil emulsions. For continuous casting and cold rolling, oil should be less than 5 g/t and total

suspended solids less than 10 g/t. For hot rolling, the corresponding values are 10 g/t and 50 g/t, respectively.

Emissions Guidelines

Emissions levels for the design and operation of each project must be established through the environmental assessment (EA) process on the basis of country legislation and the *Pollution Prevention and Abatement Handbook*, as applied to local conditions. The emissions levels selected must be justified in the EA and acceptable to the World Bank Group.

The guidelines given below present emissions levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance. Any deviations from these levels must be described in the World Bank Group project documentation. The emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems.

The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is unacceptable.

All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

Air Emissions

Air emissions of particulate matter (PM) should be less than 20 mg/Nm³ where toxic metals are present and less than 50 mg/Nm³ in other cases. This would correspond to total dust emissions of less than 1 kg/t of steel. Sulfur oxides should be less than 2,000 mg/Nm³ and nitrogen oxides, less than 750 mg/Nm³.

Liquid Effluents

For mini steel mills, the effluent levels presented in Table 1 should be achieved.

Sludges from wastewater treatment and steel finishing operations should be disposed of in a secure landfill after chrome reduction and stabilization. Levels of heavy metals in the leachates should be less than those presented for liquid

Table 1. Effluents from Mini Steel Mills

(milligrams per liter, except for pH and temperature)

Parameter	Maximum value
pH	6–9
TSS	50
Oil and grease	10
Cadmium	0.1
Chromium	
Hexavalent	0.1
Total	0.5
Copper	0.5
Lead	0.1
Nickel	0.5
Temperature increase	≤ 3°C ^a

a. The effluent should result in a temperature increase of no more than 3° C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 meters from the point of discharge.

effluents. Solid wastes such as slag, dust, and scale should be sent for metals recovery or recycled to the extent feasible.

Ambient Noise

Noise abatement measures should achieve either the levels given below or a maximum increase in background levels of 3 decibels (measured on the A scale) [dB(A)]. Measurements are to be taken at noise receptors located outside the project property boundary.

Receptor	Maximum allowable log equivalent (hourly measurements), in dB(A)	
	Day (07:00–22:00)	Night (22:00–07:00)
Residential, institutional, educational	55	45
Industrial, commercial	70	70

Monitoring and Reporting

Stack air emissions should be monitored continuously for PM, using an opacity meter (for an opacity level of less than 10%) or a dust detector.

Wastewater discharges should be monitored daily for the parameters listed in Table 1 except

for metals, which should be monitored at least weekly or whenever there are process changes.

Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. A baseline data set should be developed for fugitive emissions, and periodic review (once every three years) of such emissions should be performed. Records of monitoring results should be kept in an acceptable format. The results should be reported to the responsible authorities and relevant parties, as required.

Key Issues

The key production and control practices that will lead to compliance with emissions guidelines can be summarized as follows:

- Replace ingot teeming with continuous casting.
- Locate EAFs in enclosed buildings or install dry dust collection systems such as bag filters.

- Use countercurrent flow of rinse water in acid pickling.
- Regenerate and reuse acid from spent pickle liquor or sell pickle liquor for use as a wastewater treatment reagent.
- Recycle at least 90% of the wastewater.
- Use hydrogen peroxide or urea to reduce nitrogen oxide emissions from nitric and hydrofluoric acid pickling baths.

Sources

British Steel Consultants. 1993. "Research Study, International Steel Industry." Prepared for the International Finance Corporation, Washington, D.C.

Paris Commission. 1991. *Secondary Iron and Steel Production: An Overview of Technologies and Emission Standards Used in the PARCOM Countries.*

World Bank. 1996 "Pollution Prevention and Abatement: Mini Steel Mills." Draft Technical Background Document. Environment Department, Washington, D.C.