**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 or iron making operations are eliminated. These operations are discussed in separate documents. Electric arc furnaces (EAFs) can serve smaller, 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 semi-finished 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 semi-finished 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 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, and sulfuric or hydrochloric acid is used for other steels. Other methods to remove scale include salt pickling, electrolytic pickling, and blasting which is environmentally desirable, where feasible.

**Waste Characteristics**

EAF produces 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), but its composition can vary greatly depending on the scrap composition and furnace additives. EAF dust from a majority of the furnaces have a zinc content in excess of 15 percent (with a range of 5 to 35 percent). Other metals present in the EAF dust include: lead (2 to 7 percent); cadmium (generally 0.1 to 0.2 percent but can be up to 2.5 percent where stainless cases of nickel-cadmium batteries are melted); chromium (up to 15 percent); and nickel (up to 4 percent). Generally, EAF produces 10 kilograms (kg) (with a range of 5 to 30 kg depending on factors such as the furnace characteristics and scrap quality) of dust per metric ton of steel. 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; nitrogen operations, and acid fumes (3,000 mg/Nm$^3$) from pickling operations. Both nitrogen oxides and acid fumes vary with the steel quality.

Mini mills generate up to 80 m$^3$ of wastewater per metric ton 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 mostly result from pickling operations. The characteristics of the wastewater will depend on the type of steel, 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 stainless steel) 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 enclosed buildings
- Improve feed quality - use 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 semi-finished 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 (i.e., mechanical methods) for descaling (for example, blasting) where feasible.
- In the pickling process, use countercurrent flow of rinse water. Use indirect method 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 ($\text{NO}_x$) emissions by use of natural gas as fuel, use low $\text{NO}_x$ burners, and use hydrogen peroxide and urea in stainless steel pickling baths (containing nitric and hydrofluoric acids).
- Recycle and re-use slags and other residuals from the manufacturing operations in construction and other industries.
- Recover zinc from EAF dust containing more than 15 percent total zinc. Recycle EAF dust to the extent feasible.

**Target Pollution Loads**

The recommended pollution prevention measures can achieve the following target levels:

**Wastewaters**

Recycle wastewaters to reduce the discharge rate to less than 5 m$^3$/t of steel produced including indirect cooling waters. High water use is associated with cooling.

**Treatment Technologies**

**Air Emissions**

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

**Wastewater Treatment**

Spent pickle liquor containing hydrochloric acid is treated by spraying into a roasting chamber and scrubbing the vapors. If hexavalent chrome is present in salt pickling or electrolytical pickling baths, it can be reduced with a sulfide reagent, iron salts, or other reducing agents. 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 and total suspended solids should be less than 5 g/t and 10 g/t; and for hot rolling, the corresponding values are 10 g/t and 50 grams per metric ton (g/t), respectively.

**Emissions Guidelines**

Emission levels for the design and operation of each project must be established through the Environmental Assessment (EA) process, based on country legislation and the *Pollution Prevention and Abatement Handbook* as applied to local conditions. The emission levels selected must be justified in the EA and acceptable to MIGA.

The following guidelines present emission levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance, including MIGA guarantees; any deviations from these levels must be described in the project documentation.

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 below 20 mg/Nm³ where toxic metals are present and 50 mg/Nm³ in other cases. This would correspond to a total dust emission of less than 1 kg/t of steel. SO₂ should be 2000 mg/ Nm³ and NOₓ should be controlled to less than 750 mg/ Nm³.

**Liquid Effluents**

For mini steel mills, the following effluent levels should be achieved:

*Effluents from the Mini Steel Mill*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>milligrams per liter (mg/L)</td>
</tr>
<tr>
<td>pH</td>
<td>6 - 9</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>50</td>
</tr>
<tr>
<td>Oil and grease</td>
<td>10</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.1</td>
</tr>
<tr>
<td>Chromium (hexavalent)</td>
<td>0.1</td>
</tr>
<tr>
<td>Chromium (total)</td>
<td>0.5</td>
</tr>
<tr>
<td>Copper</td>
<td>0.5</td>
</tr>
<tr>
<td>Lead</td>
<td>0.1</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.5</td>
</tr>
<tr>
<td>Temperature increase</td>
<td>less than or equal to 3°C</td>
</tr>
</tbody>
</table>

The effluent should result in a temperature increase of no more than 3 degrees Celsius at the edge of the zone where initial mixing and dilution takes place. Where the zone is not defined, use 100 meters from the point of discharge. Solid wastes such as slag, dust, and scale should be sent for recovery or recycled to the extent feasible.

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 effluents.

**Ambient Noise**

Noise abatement measures should achieve either the following levels or a maximum
increase in background levels of 3 dB(A). Measurements are to be taken at noise receptors located outside the project property boundary.

Ambient Noise

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Maximum Allowable $L_{eq}$ (hourly), in dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential; institutional; educational</td>
<td>55</td>
</tr>
<tr>
<td>Industrial; commercial</td>
<td>70</td>
</tr>
</tbody>
</table>

The emission guidelines given here can be consistently achieved by well-designed, well-operated and well-maintained pollution control systems.

Monitoring and Reporting

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

Wastewater discharges should be monitored daily for the above-mentioned parameters except metals, which should be monitored at least on a weekly basis or when 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 base line data set should be developed for fugitive emissions and periodic review of (once every three years) such emissions be performed. Records of monitoring results should be kept in an acceptable format. These should be reported to the responsible authorities and relevant parties, as required, and provided to MIGA if requested.

Key Issues

The following box summarizes the key production and control practices that will lead to compliance with emission guidelines:

- 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 wastewater treatment reagent.
- Recycle at least 90 percent of the wastewater.
- Use hydrogen peroxide or urea to reduce NOx emissions from nitric and hydrofluoric acid pickling baths.

Further Information

The following are suggested as sources of additional information (these sources are provided for guidance and are not intended to be comprehensive):