Foundries

Industry Description and Practices

In foundries, molten metals are cast into objects of desired shapes. Castings of iron, steel, light metals (such as aluminum), and heavy metals (such as copper and zinc) are made in units that may be independent or part of a production line. Auto manufacturing facilities usually have foundries within their production facilities or as ancillaries. The main production steps include:

- Preparation of raw materials
- Metal melting
- Preparation of molds
- Casting
- Finishing (which includes fettling and tumbling).

Electric induction furnaces are used to melt iron and other metals. However, large car-component foundries and some small foundries melt iron in gas or coke-fired cupola furnaces and use induction furnaces for aluminum components of engine blocks. Melting capacities of cupola furnaces generally range from 3 to 25 metric tons per hour (t/hr). Induction furnaces are also used in zinc, copper, and brass foundries. Electric arc furnaces are usually used in stainless steel and sometimes in copper foundries. Flame ovens, which burn fossil fuels, are often used for melting nonferrous metals. The casting process usually employs nonreusable molds of green sand, which consists of sand, soot, and clay (or water glass). The sand in each half of the mold is packed around a model, which is then removed. The two halves of the mold are joined, and the complete mold is filled with molten metal, using ladles or other pouring devices. Large foundries often have pouring furnaces with automatically controlled pouring. The mold contains channels for introducing and distributing the metal—a "gating system." For hollow casting, the mold is fitted with a core. Cores must be extremely durable, and so strong bonding agents are used for the core, as well as for the molds themselves. These bonding agents are usually organic resins, but inorganic ones are also used. Plastic binders are being used for the manufacture of high-quality products. Sand cores and chemically bonded sand molds are often treated with water-based or spirit-based blacking to improve surface characteristics. Aluminum and magnesium, as well as copper and zinc alloys, are frequently die-cast or gravity-cast in reusable steel molds. Die casting involves the injection of metal under high pressure by a plunger into a steel die. Centrifugal casting methods are used for pipes.

Finishing processes such as fettling involves the removal from the casting of the gating system, fins (burrs), and sometimes feeders. This is accomplished by cutting, blasting, grinding, and chiseling. Small items are usually ground by tumbling, carried out in a rotating or vibrating drum, usually with the addition of water, which may have surfactants added to it.

Waste Characteristics

Emissions of particulate matter (PM) from the melting and treatment of molten metal, as well as from mold manufacture, shakeout, cleaning and after-treatment, is generally of greatest concern. PM may contain metals that may be toxic. Oil mists are released from the lubrication of metals. Odor and alcohol vapor (from surface treatment of alcohol-based blacking) and emissions of other volatile organic compounds (VOCs) are also of concern. Care must be exercised when handling halogenated organics, including aluminum scrap contaminated with chlorinated organics, polyvinyl chloride (PVC) scrap and turnings with chlorinated cutting oil, as dioxins may be emitted during melting operations.

Oil and suspended solids are released into process effluents, and treatment is warranted before their discharge. Wet scrubbers release wastewaters that may contain metals. Wastewater from tumbling may contain metals and surfactants. Cooling waters, used in amounts of up to 20 cubic meters per metric ton, may contain oil and some chemicals for the control of algae and corrosion.

Sand molding creates large quantities of waste sand. Other wastes include slag (300–500 kilograms per metric ton, kg / t, of metal), collected particulate matter, sludges from separators used in wastewater treatment, and spent oils and chemicals. Discarded refractory lining is another waste produced.

The primary hazardous components of collected dust are zinc, lead, and cadmium, but its composition can vary greatly depending on scrap composition and furnace additives. (Nickel and chromium are present when stainless steel scrap is used.) Generally, foundries produce 10 kg of dust per ton of molten metal, with a range of 5–30 kg / t, depending on factors such as scrap quality. However, induction furnaces (with emissions of 3 kg / t of molten metal) and flame ovens tend to have lower air emissions than cupolas and electric arc furnaces (EAF). Major pollutants present in the air emissions include particulates of the order of 1,000 milligrams per normal cubic meter (mg / Nm^3).

Foundries can generate up to 20 cubic meters of wastewater per metric ton of molten metal when cooling water, scrubber water, and process water are not regulated. Untreated wastewaters may contain high levels of total suspended solids, copper (0.9 milligrams per liter, mg / l), lead (2.5 mg / l), total chromium (2.5 mg / l), hexavalent chromium, nickel (0.25 mg / l), and oil and grease. The characteristics of the wastewater will depend on the type of metal and the quality of scrap used as feed to the process.

Solid wastes (excluding dust) are generated at a rate of 300–500 kg / t of molten metal. Sludges and scale may contain heavy metals such as chromium, lead, and nickel.

Pollution Prevention and Control

The following pollution prevention measures should be considered:

- Prefer induction furnaces to cupola furnaces.
- Replace the cold-box method for core manufacture, where feasible.
- Improve feed quality: use selected and clean scrap to reduce the release of pollutants to the environment. Preheat scrap, with afterburning of exhaust gases. Store scrap under cover to avoid contamination of stormwater.
- Provide hoods for cupolas or doghouse enclosures for EAFs and induction furnaces.
- Use dry dust collection methods such as fabric filters instead of scrubbers.
- Use continuous casting for semifinished and finished products wherever feasible.
- Store chemicals and other materials in such a way that spills, if any, can be collected.
- Control water consumption by recirculating cooling water after treatment.
- Use closed-loop systems in scrubbers where the latter are necessary.
- Reduce nitrogen oxide (NO_x) emissions by use of natural gas as fuel, use low-NO_x burners.
- Reclaim sand after removing binders.

Pollution Reduction Targets

The recommended pollution prevention measures can achieve the target levels given below.

Air Emissions

Recover metals from collected dust. The target value for PM from furnaces and die casting machinery is not to exceed 0.5 kg / t of molten metal (after controls). The oil aerosol should not exceed 5 mg / Nm^3.

Wastewaters

Recycle wastewaters, if any. Avoid allowing contamination of stormwater with oil; oil in stormwater is not to exceed 5 mg / l.

Solid Wastes

Reclaim sand used in molding.

Treatment Technologies

Air Emissions

Dust emission control technologies include cyclones, scrubbers (with recirculating water), baghouses, and electrostatic precipitators (ESPs). Scrubbers are also used to control mists, acidic gases, and amines. Gas flame is used for incineration of gas from core manufacture. Target values for emissions passing through a fabric filter are normally around 10 mg/Nm3 (dry). Emissions of PM from furnaces (including casting machines used for die casting) should not exceed 0.1–0.3 kg/t of molten metal, depending on the nature of the PM and the melting capacity of the plant. At small iron foundries, a somewhat higher emission factor may be acceptable, while in large heavy-metal foundries, efforts should be made to achieve a target value lower than 0.1 kg PM per metric ton. Odors may be eliminated by using bioscrubbers.

Wastewater Treatment

Recirculate tumbling water by sedimentation or centrifuging followed by filtering (using sand filters or ultrafilters); separate oil from surface water. In the very rare cases in which scrubbers are used, recirculate water and adjust its pH to precipitate metals. Precipitate metals in wastewater by using lime or sodium hydroxide. Cooling waters should be recirculated, and polluted stormwater should be treated before discharge.

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 PM should be below 20 mg/Nm^3 where toxic metals are present and 50 mg/Nm^3 in other cases. This would correspond to total dust emissions of less than 0.5 kg/t of molten metal.

Liquid Effluents

For foundries, the effluent levels presented in Table 1 should be achieved.

Sludges from wastewater treatment operations should be disposed of in a secure landfill after stabilization.

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

Table 1. Effluents from Foundries
(milligrams per liter, except for pH and temperature)

Parameter	*Maximum value*
pH	6–9
TSS	50
Oil and grease	10
Copper	0.5
Zinc	2
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.

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

Air emissions should be monitored continuously for PM using an opacity meter (for an opacity level of less than 10%).

Wastewater discharges should be monitored daily for the parameters listed in this guideline, except for metals, which may be monitored monthly 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. 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 requirements can be summarized as follows:

- Use continuous casting, where feasible.
- Give preference to the use of induction furnaces, where appropriate.
- Use doghouse enclosures for furnaces and dry dust collection systems such as bag filters.
- Recycle at least 90% of the wastewater.
- Reclaim molding sand after the removal of binders

Sources

Freeman, H. M. 1995. *Industrial Pollution Prevention Handbook.* New York: McGraw-Hill.

Swedish Environmental Protection Agency. 1991. "Informs on Foundries-Industry Fact Sheet." SNV 91-620-9377 0 / 91-03 / 500ex. Solna.