Final Draft BAT Guidance Note on Best Available Techniques for Ferrous Metal Foundries

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1. INTRODUCTION

1.1 GENERAL

This Guidance Note is one of a series issued by the Environmental Protection Agency (EPA), which provides guidance on the determination of Best Available Techniques (BAT) in relation to:

– applicants seeking integrated Pollution Prevention and Control (IPPC) licenses under Part IV of the Environmental Protection Agency Acts, 1992 and 2011,
– existing Integrated Pollution Control (IPC) Licensees, whose licence is to be reviewed under the Environmental Protection Agency Acts, 1992 and 2011,
– applicants seeking Waste Licenses under Part V of the Waste Management Acts 1996 to 2011,
– existing Waste Licensees, whose licence is to be reviewed under Waste Management Acts 1996 to 2011.

This Guidance Note shall not be construed as negating the installation/facility statutory obligations or requirements under any other enactments or regulations.

1.2 BAT GUIDANCE NOTE STRUCTURE

This Guidance Note has been structured as follows:

Section	Details
1	Introduction
2	Interpretation of BAT
3	Sector Covered by this Guidance Note
4	Process Description, Risk to the Environment and Control Techniques
5	Best Available Techniques
6	BAT Associated Emission Levels
7	Compliance Monitoring

Where relevant, references are made to other detailed guidance; such as the reference documents (BREF) published by the European Commission, Agency Guidance Notes for Noise in Relation to Scheduled Activities, and the determination of BAT should be made giving regard to these.

The information contained in this Guidance Note is intended for use as a tool to assist in determining BAT for the specified activities.

2. INTERPRETATION OF BAT

2.1 STATUS OF THIS GUIDANCE NOTE

This Guidance Note will be periodically reviewed and updated as required to reflect any changes in legislation and in order to incorporate advances as they arise.

Techniques identified in this Guidance Notes are considered to be current best practice at the time of writing. The EPA encourages the development and introduction of new and innovative technologies and techniques, which meet BAT criteria and look for continuous improvement in the overall environmental performance of the sectors activities as part of sustainable development.

2.2 INTERPRETATION OF BAT

The concept of BAT was introduced as a key principle in the IPPC Directive, 1996/61/EC. This Directive has been incorporated into Irish law by the Protection of the Environment Act 2003. To meet the requirements of this Directive, relevant Sections of the Environmental Protection Agency Act 1992 and the Waste Management Act 1996 have been amended to replace BATNEEC (Best Available Technology Not Entailing Excessive Costs) with BAT.

Best available techniques (BAT) is defined in Section 5 of the Environmental Protection Agency Acts, 1992 and 2011, and Section 5(2) of the Waste Management Acts 1996 to 2011 as the "most effective and advanced stage in the development of an activity and its methods of operation, which indicate the practical suitability of particular techniques for providing, in principle, the basis for emission limit values designed to prevent or eliminate or where that is not practicable, generally to reduce an emission and its impacts on the environment as a whole" where:

B ***'best'*** in relation to techniques means the most effective in achieving a high general level of protection of the environment as a whole.

A ***'available techniques'*** means those techniques developed on a scale which allows implementation in the relevant class of activity under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced within the State, as long as they are reasonably accessible to the person carrying on the activity.

T ***'techniques'*** includes both the technology used and the way in which the installation is designed, built, managed, maintained, operated and decommissioned.

The range of BAT associated emission level values specified in Section 6 indicate those that are achievable through the use of a combination of the process techniques and abatement technologies specified as BAT in Section 5. The licensee must demonstrate to the satisfaction of the Agency, during the licensing process, that the installation/facility will be operated in such a way that all the appropriate preventative measures are taken against pollution through the application of BAT and justify the application of other than the most stringent ELV in the range.

At the installation/facility level the most appropriate techniques will depend on local factors. A local assessment of the costs and benefits of available options may be needed to establish the best option. The choice may be justified on the basis of:

- the technical characteristics of the installation/facility;
- the geographical location of the installation/facility;
- local environmental considerations;
- the economic and technical viability of upgrading existing installation/facility;

The overall objective of ensuring a high level of protection for the environment as a whole will often involve making a judgment between different types of environmental impact, and these judgements will often be influenced by local considerations. On the other hand, the obligation to ensure a high level of environmental protection, including the minimisation of long-distance or transboundary pollution, implies that the most appropriate techniques cannot be set on the basis of purely local considerations.

The guidance issued in this Note in respect of the use of any technology, technique or standard does not preclude the use of any other similar technology, technique or standard that may achieve the required emission standards and is demonstrated to the Agency to satisfy the requirement of BAT.

2.3 BAT HIERARCHY

In the identification of BAT, emphasis is placed on pollution prevention techniques rather than end-of-pipe treatment.

The IPPC Directive 2008/1/EC and the Environmental Protection Agency Acts 1992 and 2011 (Section 5(3)), require the determination of BAT to consider in particular the following, having regard to the likely costs and advantages of measures and to the principles of precaution and prevention:

(i) the use of low-waste technology,

(ii) the use of less hazardous substances,

(iii) the furthering of recovery and recycling of substances generated and used in the process and of waste, where appropriate,

(iv) comparable processes, facilities or methods of operation, which have been tried with success on an industrial scale,

(v) technological advances and changes in scientific knowledge and understanding,

(vi) the nature, effects and volume of the emissions concerned,

(vii) the commissioning dates for new or existing activities,

(viii) the length of time needed to introduce the best available techniques,

(ix) the consumption and nature of raw materials (including water) used in the process and their energy efficiency,

(x) the need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it,

(xi) the need to prevent accidents and to minimize the consequences for the environment, and

(xii) the information published by the Commission of the European Communities pursuant to any exchange of information between Member States and the industries concerned on best available techniques, associated monitoring, and developments in them, or by international organisations, and such other matters as may be prescribed.

3. SECTOR COVERED BY THIS GUIDANCE NOTE

This Guidance Note covers the following activities under First Schedule of the Environmental Protection Agency Acts 1992 and 2007:

3.3.1 The operation of a ferrous metal foundry where production exceeds 20 tonnes per day class, and

3.3.2 The production, recovery, processing or use of ferrous metals in foundries having melting installations with a total capacity exceeding 5 tonnes, not included in class 3.3.1

4. PROCESS DESCRIPTION, RISKS TO THE ENVIRONMENT AND CONTROL TECHNIQUES

(Note: any reference to BREF in this document means the reference document on *Best Available Techniques in the Smitheries and Foundries Industry*, published by the European Commission, May 2005).

4.1 Process Description

The general production sequence in ferrous metal foundries is described herein.

4.1.1 Preparation

Ferrous foundries use pig iron ferrous alloy additives and selected iron and steel scrap as starting materials along with runners from castings and off-spec product which is recycled. All returns are self-generated at the foundry. The various qualities of metal feeds are stored in separate areas in order to allow the controlled feeding of the melting furnace. Sand and binders for the lost moulds are normally delivered in bulk, in bags or by tanker.

4.1.2 Charging

The metal charged in the melting furnace is carefully selected and weighed to ensure the correct composition.

Scrap steel can be melted in an arc furnace or an electric induction furnace. Arc furnaces are capable of using low cost scrap charges since refining takes place in the furnace. They are limited in the grades of low carbon stainless steel that they can make.

The coreless induction furnace can be used for melting but not refining, so carefully selected steel charges have to be used. The steel charges have to have the ‘correct’ chemical composition i.e., that corresponding to the required composition of the melt; hence steel scrap is mainly used, as any type of steel can be melted.

Charging can be done manually, by a lifting magnet, bucket skips or vibrating conveyor. The method used is dependant on capacity. (See BREF Section 2.3).

4.1.3 Melting

There are a number of different furnace types; cupola, electric, arc, coreless induction and rotary. The type of metal to be melted determines which furnace may or may not be used. Electric induction furnaces are gaining market preference over cupola furnaces for the melting of iron. Induction furnaces are more commonly used than electric furnaces for the melting of steel. This type of furnace is used at the only ferrous metal foundry in Ireland at time of writing. (See BREF Section 2.4).

4.1.3.1 Induction Furnaces

An Induction Furnace (IF) operates by utilising a strong magnetic field created by passing an electric current though a coil wrapped around the furnace. The magnetic field creates a voltage across and subsequently an electric current through the metal to be melted. An induction furnace is suitable for melting steel and cast iron as there is no contact between the charge and the energy carrier. (See BREF Section 2.4.3)

There are two types of induction furnaces, a coreless IF and a channel IF. The coreless IF is capable of melting and holding metals. The channel IF is capable of holding metals and is often combined with a melting furnace such as a cupola furnace.

4.1.3.2 Coreless IF

The coreless (IF) is a batch-melting furnace. It contains a water-cooled copper coil, the inside of which is internally refractory lined. The outside is insulated and enclosed in a steel shell.

When metals are melted in this type of furnace, slag rises to the surface. The top of the furnace is open for both charging and deslagging operations. (See BREF Section 2.4.3.1).

The following diagram of a coreless induction furnace has been taken directly from the BREF, Figure 2.13.

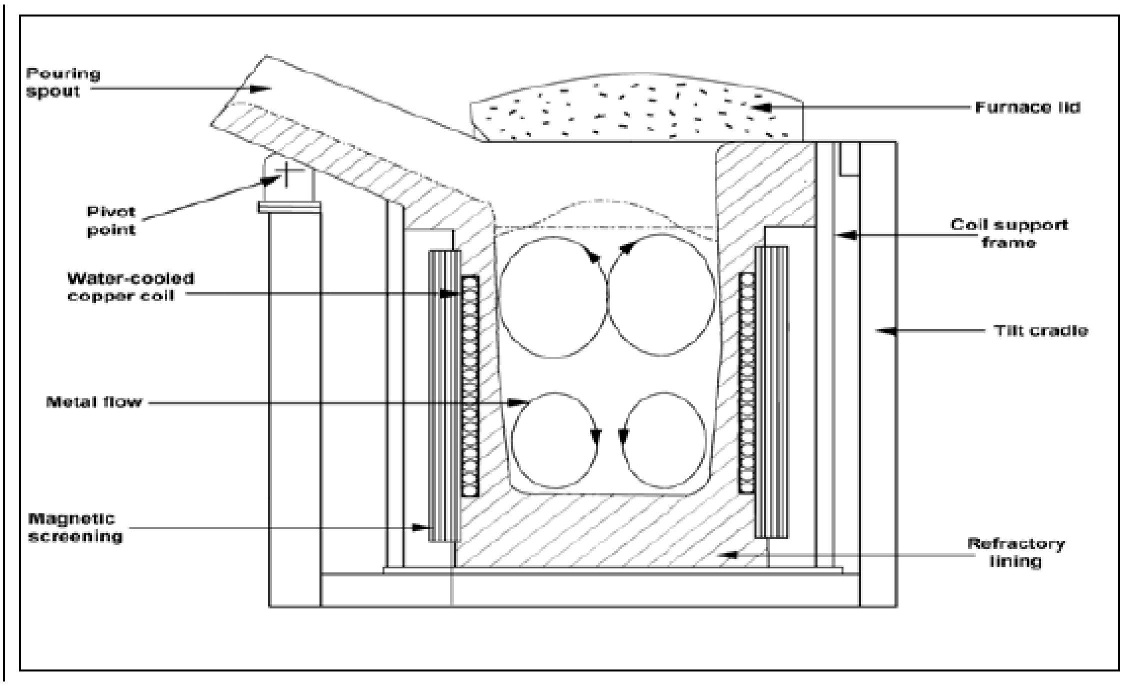

Figure 4.1: General arrangement for coreless induction furnace (Source: BREF)

Water cooling systems are essential for operation of the coreless induction furnace. Cooling protects the coil and the insulation from thermal damage. Several types of cooling system are available.

Induction furnaces are excellent melting units, but in general they are less efficient holders.

The advantages and disadvantages of an IF are as listed in the BREF Sections 2.4.3.1.3 and 2.4.3.1.4.

Since no coal or fuel is burned in the induction furnace and no refining procedures are executed, the emissions depend only on the composition and cleanliness of the charged material.

Two major categories of emissions can be distinguished:

- Charge Cleanliness
  - rust
  - dirt
  - foundry sand
  - paint
  - oil
  - galvanised or soldered metal

  } give rise to emissions of dust and fumes (organic or metallic)
- Chemical Reactions at high temperatures. This can give rise to metallurgical fume due to oxidation.

Additionally, the refractory lining (acid SO_2 based, neutral Al_2O_3 based, or basic MgO based) may add a small amount of dust particles to the emission.

4.1.4 Deslagging

Slag consisting of rust and other impurities rises to the top of the melting furnace. The slag is removed from the furnace by pouring or raking other impurities that may be caused by deoxidation.

Deoxidation of melting steel is required in order to ensure a good casting quality without defects due to oxidation. Aluminium is the most popular, being the most powerful. It is added in the form of a stick or a wire to the melting metal to preferentially bind oxygen. Oxygen dissolves in liquid steel and results in porosity. Aluminium oxide is produced and is insoluble in the melt and mixes with the slag.

During melting, some elements in the melt oxidise and are lost to the slag.

The addition of alloying elements can introduce impurities. The melt is homogenised to reduce the formation of oxides and to cause impurities to coagulate and rise to the melt surface as slag.

4.1.5 Mould and Core Production - Lost Moulds

Foundries can be defined by the type of melting and casting that is employed.

Foundries melt ferrous or non-ferrous metals and alloys, and reshape them into products using moulds. The moulds that cast the molten metal are defined as lost or permanent moulds. Lost moulds are single use moulds. They are specifically made for each casting and are destroyed after pouring. The moulds are generally made out of sand and are chemically bounded, clay-bounded or even unbounded. (See BREF Section 2.5).

Permanent moulds are-multi use moulds. They are used for gravity and low-pressure casting, pressure die-casting and centrifugal casting. Typically these moulds are metallic.

A lost mould, specifically the green sand method) is used for casting in Ireland currently.

4.1.5.1 Raw Materials

The raw materials required for the preparation of moulds include:

- Refractory Sands
- Binders and other chemicals

There are four types of sand that are used to make the refractory materials. The physical and chemical properties of the refractory materials affects the characteristics of the mould material.

4.1.5.2 Refractory Sands (See BREF Section 2.5.1.1)

The four types of sand used are:

- Silica sand
- Chromite sand
- Zircon sand
- Olivine sand

Silica sand is most commonly used. It is currently used in Ireland to make green sand moulds. Silica sand is composed of the mineral quartz SiO_2 which is more or less pure and clean depending on its origin. Silica expands due to heat, therefore additives are added to reduce movement of the mould during pouring and cooling. A green sand mould is made of silica sand mixed with a binding material (a natural clay, bentonite), coal dust and water.

4.1.5.3 Binding Materials and Other Chemicals (See BREF Section 2.5.1.2)

Binding materials include; bentonite, resins, coal dust, cereal binders and iron oxide.

Bentonite is used as the binder in green sand moulds. The main features of bentonite in green sand are their high dry strength, good tolerance to water content variation, high resistance to burn-out and their improved high temperature durability. The bentonite maintains the mould shape during pouring and cooling.

Resins are chemical binders. They are mixed with the foundry sand until all grains are coated with a thin film. They then harden, developing mould strength.

Coal dust is added to green sand for cast iron moulding. It improves the casting surface finish and shake out properties. It creates an inert atmosphere in the mould cavity during pouring, through the combustion of organic compounds, which in turn reduces slag formation.

Coal dust is not used for steel castings due to carbon pick up. Cereal binders are used instead.

Coal dust has the potential to generate environmental impacts:

- Generation of black sticky dust during handling
- May contain or generate polycyclic aromatic hydrocarbons (PAHs) during pouring

There are replacements to coal dust. Blends of high volatile, high lustrous carbon materials blended with clays. Generally they produce less fume during casting, although some coal dust replacements will generate more PAH in the sand.

Cereal binders are used mainly in steel foundries to increase the strength and toughness of the green sand.

Iron oxide is used mainly in the production of core sand to reduce the formation of veins.

Following preparation of the mould there is a methodology to fill it to ensure that the molten metal pours into the mould without defects in casting, without slag and produces a high quality casting. This is referred to as running, grating, feeding and filtration.

4.1.5.4 Sand Preparation (See BREF Section 2.5.2)

Green sand moulds can be reconditioned for multiple re-use. This is a major advantage to this type of mould. It requires some bleed and top-up of the sand system on a daily basis in order to maintain the specification of sand required for the manufacture of the mould.

Sand usually contains metallic elements, pouring drops, pieces of spruce or small parts of casing. These have to be removed usually by a magnetic iron separator or/and eddy current separators. The sand is usually kept cool in a fluidised bed to avoid any loss of moisture by evaporation. The fluidised bed also allows the sand to be debusted by removing excessive amounts of fines. The sand is then screened to remove the remaining lumps and stored before mixing with the required amount of additives, say clay, water, etc., to prepare the green sand for re-use.

4.1.5.5 Green Sand Moulding

The mixture is made up of about 85-95% silica sand, 5-10% bentonite slag, 3-9% coal dust and 2-5% water.

Green sand has a number of advantages over other casting methods. These include:

- Handles the most diverse range of products of any casting method
- Very close tolerances can be obtained
- Short mould manufacture time
- Ideally suited to a mechanised process

Moulds can be created manually or mechanically. Machine moulding is more widespread. Moulding includes ramming the sand, followed by separating the pattern from the compacted sand.

Moulding may also be carried out using unbonded sand. This is known as the V-process.

4.1.5.6 Core Making with Chemically-Bonded Sand

To produce cavities within the casting negative forms are used to produce cores. Cores are physically different from moulds. Chemical binding systems are mainly used, usually silica sand with strong chemical binders.

The sand and binder mix has to be hardened to withstand the strong forces which occur when molten metal fills the mould. Hardening can be done by cold-setting process, gas-hardening process or hot curing processes. Further details of these processes may be found in Sections 2.5.6.1 of the BREF note for foundries, Section 2.5.6.2.

4.1.5.7 Coating of Chemically-Bonded Sand Moulds and Cores

As previously mentioned, there are often refractory linings in the mould to ensure a high quality coasting. The lining minimises interactions that may occur between the mould, core and metal during pouring.

The coatings come as a ready-to-use product or as a mess to dilute with water.

4.1.6 Mould and Production- Permanent Moulds

(See BREF Section 2.5.8)
The molten metal is poured into the moulds. After pouring, the metal cools to solidify and is then removed from the mould for further cooling.

The metal is poured into the mould using a ladle. The ladle is pre-heated by gas. There are three types of ladles:

- Lip pour ladles (used to pour small steel castings)
- Teapot ladles
- Bottom pour ladles

Further details of the advantages of each method are included in the BREF.

Once filled, the moulds are moved along the moulding line onto the cooling line. The metal should be cool enough to provide sufficient strength to the casting during shake-out. This is referred to as solidification (1st cooling). The moulds are broken down by shake-out by placing the mould on a vibrating gate. The casting remains on the grate and the sand falls through (for reprocessing).

In many cases the casting and sand is subjected to controlled cooling. This is carried out in rotary drums, or on oscillating conveyor troughs. Airflow or fine water jets can be used to increase the cooling effect.

4.1.7 Casting in Lost Moulds

There are four phases in this process:

- Pouring
- Solidification
- Shake-out
- Casting cooling

Further details are included in Section 2.6.1 of the BREF.

4.1.8 Casting in Permanent Moulds

There are four types of casting methods for permanent moulds:

- Gravity and low-pressure die-casting
- High-pressure die-casting
- Centrifugal casting
- Continuous casting

Further details are included in Section 2.2.6 of the BREF.

4.1.9 Finishing and Post Casting Operations

There are several operations that may need to take place post casting including:

- Removal of the running system
- Removal of residual moulding-sand from the surface and core remains in the casting cavities
- Removal of pouring burrs
- Repair of casting errors
- Preparation of the casting for mechanical post-treatment, assembly, thermal treatment, coating, etc.

See BREF Section 2.7.

In the Irish context, the following finishing operations are carried out:

4.1.9.1 Knock-Out

The sand mould and product casting are knocked out from the mould flask. The used sand is collected on a conveyor and conveyed back to the sand preparation system. The casting is transferred for finishing and fettling.

4.1.9.2 Finishing/Fettling

Runners are removed from the casting and recycled as foundry returns. The casting is conveyed to a shot-blast machine where flash and adhering sand are removed. It is then moved to a fettling area where some castings are finished by grinding to remove burrs (point where mould and core pieces join).

The coarse dust (sand and metal flakes) that is generated by blasting is collected together with the grit. It is dedusted, magnetically separated and sieved. The fine fraction is removed from the exhaust air, together with the coarse fraction, using a bag filter.

In Ireland, the costing is then conveyed for assembling on pallets.

Further steps take place in some foundries:

- Welding to join castings
- Heat treatment (annealing and hardening)

Further details of this are included in Section 2.8 of the BREF.

4.2 RISKS TO THE ENVIRONMENT

The BREF Section 3.2 lists typical melting furnace properties and emission data. Relevant data to the Irish situation has been extracted from Table 3.1 of the BREF to form Table 4.1 on the following page.

Table 4.1: Typical Induction Furnace Properties and Emission for Cast Iron Production

Energy Source	Electricity
Thermal Efficiency (%)	50-60
Primary Thermal Efficiency (%)	15-20
kWh/tonne Metal Charge	520-800
Batch/Continuous	Batch
Production Rate (tonnes/h)	Not applicable
Furnace capacity (tonnes)	0.01-30
Meltdown time (h)	1-2
Refining ability	No
Capital Cost	High
Slag Production (kg/tonne metal charge)	10-20
Dust Production (kg/tonne metal charge)	0.06-1
Waste gas emission	**(kg/tonne metal charge)**
CO_2	Depending on power generation
CO	n.a.
SO_2	Minor
NOx	n.a.

Emission from Furnaces

4.2.1.1 Coreless Induction Furnace

Input	Output
– Ferrous metals	– Metal alloy
– Alloying metals	– Dust
– Carburising agents	– Organic and metallic fumes
– Energy (electric)	– CO
– Cooling water	– Slag
	– Refractory waste

4.2.1.2 Particulates

See BREF Section 3.2.4.1.2, with specific reference to the production of cast iron.

4.2.1.3 Waste Gases

See BREF Section 3.2.4.1.3.

4.2.1.4 Slag

See BREF Section 3.2.4.1.4.

4.2.1.5 Other Types of Furnaces (for ferrous metals)

The BREF gives details of current Emission and Consumption levels for:

- Cupola Furnaces
- Electric Arc Furnaces
- Channel Induction Furnaces
- Rotary Furnaces,

Sections 3.2.2, 3.2.3, 3.2.4.2 and 3.2.5 respectively.

4.2.2 Emissions from Preparation of Moulds

During mixing of sand, and chemicals if required, there may be emissions of gaseous or volatile reaction products and excess reagents. Table 3.3.5 of the BREF note on foundries lists the environmental impacts of binder systems.

In Ireland, green sand moulds are used. This does not require chemical binders and therefore does not have as significant an environmental impact as some other methods. The section on green sand has been copied from Table 3.35 of the BREF to make Table 4.2.

Table 4.2: Environmental Impacts of Green Sand Mould

System name and binder constituents	Setting method and relative energy requirement	Emissions to air during mixing and setting	Other environmental impacts
GREEN SAND Clay Coal dust or substitute Water	Pressure-low	Particulate matter – no significant emission to the environment	Sand spillage around conveyors needs to be avoided to reduce the likelihood of fugitive emissions. Abatement from the mixing process is not essential (the process is usually self-contained with displaced air vented to the foundry)

Emissions values and emission factors for dust emissions from moulding shops after exhaust cleaning are taken from the BREF in Table 4.3.

Table 4.3: Emissions values and emission factors for dust emissions from moulding shops after exhaust cleaning

	Concentration mg/Nm^3			Emission factor (g/tonne)*		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Bagfilter	3.4	0.4	12.1	24.4	0.5	108.3
Wet Scrubber	5.2	3.6	6.7	6.2	4.0	8.0
Wet Venturi System	9.6	8.5	10.9	34.2	30.1	39.9
* Units g/tonne good casting Number of data points: bag filter: 33: wet scrubber: 4: wet venture: 3. Source: BREF Table 3.36.						

All exhaust cleaning systems attain a level < 15 mg/Nm^3.

Examples of dust emissions and particle sizes for green sand mould and core making are shown in Table 4.4.

Table 4.4: Example (German) dust emissions and particle size for green sand mould and core-making

Activity	Off-gas volume (Nm^3/h)	Gas cleaning equipment	Total dust (mg/m2)	PM10 (%)	PM2.5 (%)	PM1 (%)
Sand preparation	25,600	Bag filter	0.3			
Green sand preparation	24,400	Fume hood, bag filter	0.7	88	38	
Sand preparation	70,400	ESP	22-28.3	79	18	
Core shop	4670 (dry)	Amine washer	0.7	98	47-62	
Moulding shop	52,300 (dry)	Bag filter	0.7	95-97	50-60	2-5
Finishing	22,000 (dry)	Bag filter	5.3	100	45-48	9

Source: BREF note for Foundries (Table 3.37)

Green sand moulding:

Input
- Sand
- Bonding clay, e.g., bentonite
- Coal dust
- Water

Output
- Green sand moulds
- Dust (silica fines, partially burnt off clay, unburned coal dust and ash)

For the inputs and outputs of moulding with unbounded sand (v-process) or chemically bonded sand refer to BREF Sections 3.9.3 and 3.9.4.

4.2.3 Emissions from Casting

Emissions from lost moulds, e.g., green sand are summarised as:

Input
- Finished moulds
- Molten metal

Output
- Castings
- Used sand
- Combustion products (from preheating of pouring ladles)
- Organic pollutants from pyrolysis and thermal degradation of binder blackening moulds, etc., (phenol formaldehyde, amine, hydrogen cyanide, PAH, benzene, VOC
- Odour
- Waste from exhaust air cleaning dry/sludge)
- Dust from shake-out

Gases are generated from pre-heating the pouring ladles with gas (usually natural). The maximum emissions occur only 10 minutes or more after pouring.

The main emissions to air during casting are listed in Table 4.5.

Table 4.5 Environmental Impact upon pouring, shake-out and cooling

Systems name and binder constituents	Emissions to air during casting	Comments
GREEN SAND Clay Coal dust or substitute Water	Particulate matter - soot from coal burning Carbon monoxide and carbon dioxide Benzene Touluene Xylene	Potential odour (may be associated with the sulphur content of the coal)

Source: BREF Table 3.45

The emission factors during pouring, cooling and shake-out for a mixed sand system have been determined through an intensive measurement programme in two automotive foundries in Mexico. The foundries under study produced iron castings, using green sand moulds and chemically bonded sand cores. (The Irish experience is of iron casting using green sand moulds).

The emission factors are very process-specific and vary according to compositional changes in mould and core, or process parameters. The BREF has included the information gathered as a graph, see BREF Figure 3.6. It was not reproduced here as the quality would be diminished.

The data shows that the highest emissions occur during shake-out and only minor emissions during pouring. The major metal emissions include manganese, lead, nickel, copper, and chromium, with manganese and lead having the greatest concentrations.

Figure 3.7 of the BREF is a graphical representation of emission levels for particular matter upon pouring, cooling and shake-out for a green sand iron foundry. See BREF Section 3.10 Figure 3.7.

Sand-to-liquid metal ratios (BREF Section 3.10.1.2):
The sand-to-liquid metal ratio is important. Too much sand increases costs. The BREF Section 3.10.3.2 examines average ratio of between 5:1 and 10:1. However, the ratios vary widely across foundries.

Metal yield (BREF Section 3.10.1.3):
The metal yield is the ratio of the amount of metal melted to the weight of finished good castings.
Metal yields have an important bearing on the quality of the finished product and the economies of sand use.

Used foundry sand (BREF Section 3.10.1.4):
The BREF note examined a review and study of foundry waste sand in Finland. Results showed that the contents of metallic and organic harmful compounds in used foundry sand are normally low, however they are generally higher in green sand compared to chemically-bounded sands.

4.2.4 Emissions from Finishing/Fettling

4.2.4.1 Shot-blasting

Shot blasting has the potential to generate dust. There are four main types of control:

- Bag filter
- Wet filtration
- Wet multi-cyclone
- Wet venture system (least effective system)

See BREF Section 3.11.2 for a review of data on dust emission levels from shot blasting with these control techniques.

4.2.4.2 Fettling

The emission of dust from fettling is largely dependant on the amount of finishing needed and thus the type of casting made. Table 3.5.5 of the BREF shows results from a review of Italian foundries comparing dust emissions from fettling with one of 3 control techniques:

- Bag filter
- Wet multi-cyclone
- Wet venture system

Emissions from slide grinding (aluminium casting) and finishing operations in steel foundries and heat treatment are detailed in the BREF, Sections 3.11.1, 3.11.4. 3.11. These techniques are not in use in Ireland currently.

4.2.5 Wastewater

Wastewater generation in foundries is generally low. The production – specific wastewater quantity averages 0.5 m^3/t good castings. The main sources of generation of wastewater are from:

- Dust removal
- Waste gas treatment systems
    - melting shop
    - moulding material preparation
    - reclamation during cleaning
- Core production
- Wet scrubbers used for dedusting
- Wet sand generation (only two plants in Europe)
- Run-off from scrap storage area and site drainage
- Sand preparation
- Vibratory finishing (not applicable to current Irish operations)
- Cupola shell cooling (not applicable to current Irish operations)
- Cooling baths for (die) castings (not applicable to current to Irish operations)

In the Irish context, there is no wastewater from the preparation of green sand or from cooling of the IF as it is a closed loop system. The IF is placed in concrete bunds to capture any spillages. Surface water generated from traffic, the substation, the extraction and melting plants is discharged to surface water via an oil and grit interceptor.

4.2.6 Environmental Liabilities, Restoration and Aftercare

A key element to understanding and managing environmental risk at an installation is the carrying out of an environmental liabilities risk assessment for known and unknown liabilities (including aftercare), and the financial provision for same. Regard should be had to the Environmental Liabilities Directive 2004/35/EC and consideration should be given to the EPA guidance on Environmental Liability Risk Assessment, Residuals Management Plans and Financial Provision.

Restoration is a process that will return a site to a condition suitable for the selected afteruse. Restoration includes measures such as soil spreading, final landform construction, landscaping works and aftercare. Aftercare involves any measures that are necessary to be taken in relation to the installation for the purposes of preventing environmental pollution following the cessation of the licensable activity at the site. The length of this aftercare period will vary from site to site and the licence holder remains responsible for the aftercare until the Agency accepts the surrender of a licence.

4.3 CONTROL TECHNIQUES

4.3.1 Raw Material Handling and Storage

The following materials may be delivered to the foundry, stored and subsequently handled:

- Sand (and sand reclamation)
- Scrap metal
- Refractories
- Binders
- Coal dust

The main control issues for these relate to the potential for fugitive emissions including dust, emissions to surface water, noise (delivery) and spillages/accidents.

4.3.1.1 Control techniques - Handling and Storage of Raw Materials

See BREF Section 4.1

Dusty materials should be stored to prevent windblown dust. Storage should include covered containers, silos, sealed bags, under cover, etc. Handling and transport of dusty materials should be carried out so as to minimise emissions to air.

Good housekeeping is essential to minimise dust from raw material storage and handling. All spillages should be cleared up immediately. Water should be used when cleaning up dust. Specific handling requirements should be put in place for the handling of coal dust.

The scrap storage area should be designed and managed to mitigate potential impacts of storage. These include:

- A covered storage area to mitigate rainwater infiltration and subsequent contaminated surface water run-off

- Place scrap on a cement hardstanding to prevent rusting of scrap and to prevent entrainment of soil or dirt
- Scrap should be stored carefully according to composition to facilitate correct charging.
- If the scrap is not stored indoors or if scrap arrives on site wet, then a drainage network will be required in the storage slab to prevent pollution of soil or groundwater and to convey water away from scrap to prevent rusting.

Scrap metal should be as clean as possible. The cleaner it is (particularly for IF) the more economic and environmentally friendly the process will be.

Bentonite does not have the potential to cause environmental impacts at storage and handling stage. Correct storage under cover will keep it in good condition and prevent negative economic impacts.

Non-metal compounds such as sand, lime, iron, oxides, manganese oxide and basic oxides (e.g., MgO from nodular iron returns) in combination with silicon refractory (acid) will be taken up by the slag. The greater the quantity of slag, the greater the inefficiency of the process. The negative impacts of slag to the process include:

- Diminishing lifetime of furnace and ladle lining
- Consumes part of the melting energy as the removal of slag requires a higher temperature to keep the slag in a liquid state

Ensuring the scrap metal is as clean as possible will reduce the amount of slag and dust that require disposal. Energy consumption will also be reduced. The BREF note comments that if foundries only accept clean scrap then this will open the market for dirty scrap through the provision of cleaning facilities, therefore increasing recycling levels of scrap metal.

The reduction of slag and dust reduces the quantities of waste for disposal from the facility.

4.3.1.2 Internal Recycling of Scrap Ferrous Metal

Poor casings, knock-off of feeders and runners are recycled back through the foundry if possible. In some instances, this may not be possible, for example due to the amount of dissolved gas in steel foundries, high silicon levels where nodular base iron melting takes places, lead or bismuth levels in grey or nodular iron. If there has been a pollution incident the returns (internal scrap) must not be recycled.

4.3.1.3 Recycling of used Containers

If raw materials are delivered in containers such as drums, pallets, etc., consideration should be given to returning them to the supplier for recycling.

4.3.1.4 Management Techniques for Storage and Handling Raw Materials

Good management practice includes the techniques to optimise use of raw materials and minimise their impact by selection. For BAT the operator needs to demonstrate measures taken to reduce the use of chemicals and other materials, to use where possible, materials with lower risks to the environment and to understand the fate of by-products and contaminants.

As previously discussed, clean scrap should be used to reduce furnace emissions and sand used should be free from excessive fines. All raw materials should be reviewed annually to assess their potential impact and compare with alternatives available.

4.3.2 Melting

The types of furnaces used for melting ferrous materials are:

- Cupola (iron only)
- Rotary
- Electric arc
- Induction

There is an induction furnace (IF) in Ireland. It has gained popularity over the cupola furnace for melting iron.

A summary of the function of an IF has been included previously.

The control techniques for operating an IF with greatest efficiency through shorter melt time and reduced downtime are listed in Section 4.2.3.1 of the BREF and are summarised below:

- Optimisation of feedstock condition (clean scrap metal)
- Close furnace lid (to reduce oxidation and energy loss)
- Restrict holding to a minimum
- Operate at maximum power input level (improved energy efficiency)
- Avoid excess temperature and unnecessary superheating (energy efficiently)
- Optimise high temperature melts for slag removal-good balance (energy efficiency)
- Prevent slag build up (energy efficiency and product quality)
- Trickle the oxygen injection
- Minimise and control the refractory wall lining

Good energy management of coreless IF melting operations will lead to savings in the quantity of electricity used per tonne of iron processed.

The BREF note compares furnace types to choose the best method for melting irons. This is in Table 4.14 and Section 4.2.5 of the BREF. To summarise the IF may be considered above cupola. An IF is in use in Ireland. Table 4.14 is replicated below as Table 4.6. Control techniques for each of the other types of furnace are detailed in the BREF in sections 4.2.1, 4.2.2, 4.2.4, 4.2.6 and 4.2.7.

Table 4.6 Comparison of Melting Equipment for Cast Iron

<table>
<tr><th colspan="2">CRITERION</th><th colspan="6">ONLY GREY CAST IRON</th><th>GREY + MODULAR</th><th colspan="3">ONLY NODULAR CAST IRON</th><th>ONLY MALLEABLE CAST IRON</th></tr>
<tr><th colspan="2">Type of Product</th><th>Counter Weights</th><th>Sewer castings, pipes, urban furniture</th><th colspan="2">Enamelled castings, heating appliances</th><th colspan="2">Mechanical Parts</th><th>Mechanical parts</th><th>Sewer castings, pipes, urban furniture</th><th colspan="2">Mechanical parts</th><th>Mechanical parts</th></tr>
<tr><th colspan="2">Size of series</th><th>Medium to large</th><th>All</th><th colspan="2">Medium to large</th><th>Batch to small</th><th>Medium to large</th><th>All</th><th>All</th><th>Batch to small</th><th>Medium to large</th><th>Medium to large</th></tr>
<tr><td rowspan="3">Cupola</td><td>Cold blast</td><td>++</td><td>++
(<10 – 15 t/h)</td><td colspan="3">++
(< 10 – 15 t/h)</td><td colspan="2">++
(< 10 – 15 t/h)</td><td></td><td>(+)</td><td></td><td></td></tr>
<tr><td>Hot blast</td><td>+</td><td>++
(> 10 – 115 t/h)</td><td colspan="2">++
(> 10 – 15 t/h)</td><td>0</td><td colspan="2">++
(> 10 – 15 t/h)</td><td>++
(>10 – 15 t/h)</td><td>0</td><td colspan="2">+
(>10 – 15 t/h)</td></tr>
<tr><td>Cokeless</td><td></td><td colspan="2"></td><td></td><td>0</td><td>+</td><td></td><td>+</td><td>0</td><td>+</td><td></td></tr>
<tr><td colspan="2">Induction</td><td></td><td colspan="2">+</td><td>+</td><td>+</td><td>++</td><td>++</td><td>+</td><td>++</td><td>++</td><td>++</td></tr>
<tr><td colspan="2">Rotary furnace</td><td>(+) batch</td><td colspan="2"></td><td></td><td>++</td><td>+</td><td>++</td><td>(+) batch or small series</td><td>++</td><td></td><td>++</td></tr>
<tr><td colspan="13">++: technically more adapted;
+: technically adapted
(+): adapted in some cases
0: not adapted</td></tr>
</table>

4.3.3 Fume, Flue-gas and Exhaust Air Capture and Treatment

4.3.3.1 General Principles

There are a number of processes in a foundry that have the potential to produce dust, fumes and other gases. Control techniques include prevention, minimisation, collection and abatement.

Techniques for control include:

- Furnace sealing (possibility dependant on furnace type)
- Fugitive emission collection
- Point source collection

The BREF note Section 4.5.1 displays the results of a survey of air emissions from ferrous foundry stages. It is taken from UK guidance. The summary of results is replicated as Table 4.7. Not all of the sources and releases are applicable to the current Irish situation.

Table 4.7: Survey of Air Emissions from Different Ferrous Metal Foundries

SOURCE	Raw material storage and handling	Furnace operations	Desulphurisation of molten iron	Nodularisation	Preparation of cores and moulds	Casting	Shake-out, reclamation	Fettling, dressing and of castings finishing
RELEASES								
Oxides of sulphur		X	X		X	X	X	
Oxides of nitrogen		X			X	X	X	
Carbon dioxide		X	X	X	X	X	X	
Carbon monoxide		X	X	X	X	X	X	
Hydrogen sulphide					X	X	X	
Ammonia					X	X	X	
Oxides of iron		X	X	X		X	X	X
Alkali metal compounds		X	X					
Alkaline-earth metal compounds		X	X	X		X		
Metal oxide particulates		X	X	X		X	X	X
Non-metallic particulates	X	X	X		X	X	X	X
Metallic iron		X						X
Hydrogen cyanide					X			
Sulphur			X					
Amines/amides					X	X		
Dioxins		X						
Volatile organic compounds		X			X	X	X	
Acid vapours		X			X	X		
Noise		X			X		X	X

Substances include their compounds, except where separate reference to the compound is made.
Releases to air may also be released to land or water, depending upon the abatement technology employed, e.g., via collected dusts, sludges or liquors.
Some releases are specific to a particular binder system

4.3.3.2 Reduction of Fugitive Emissions (See BREF Section 4.5.1.1)

Fugitive emissions occur when emissions from specific process sources are not collected. Process-related emission sources are those when gases and fumes escape from the process and are released into the working area and then the surrounding environment. Hoods are used to prevent and minimise these emissions by being placed as close as possible to the source. Other fugitive emissions are generated from the following:

- Storage areas (e.g., bays, stockpiles, heaps)
- The loading and unloading of transport containers
- Transferences of material from one vessel to another (e.g., furnace, ladle, silos)
- The mixing and curing of chemical binders (inorganic and organic chemical emissions) (Not applicable to current Irish situation)
- Mould coatings (solvents)
- Conveyor systems for moving material around
- Pipework and ductwork systems (e.g., pumps, valves, flanges, catchpots, drains, inspection hatches, etc.); these type of emissions are discussed in detail in the LVOC-BREF[1]
- Poor building containment and extraction
- Bypass of abatement equipment (to air or water)
- An accidental loss of containment from a plant or equipment failure, including leakages, e.g., from the sand reclamation plant
- Spills

In order to minimise fugitive dust emissions, the following techniques may be employed:

- The covering of skips and vessels
- The avoidance of outdoor or uncovered stockpiles
- Where outdoor stockpiles are unavoidable, using sprays, binders, stockpile management techniques, windbreaks, etc.
- Cleaning wheels and roads (i.e., avoiding the transfer of pollution to water and wind)
- Using closed conveyors, pneumatic conveying (although note the higher energy needs), and minimising drops
- Vacuum cleaning of the moulding and casting shop in sand moulding foundries, with the exception of areas where the sand has a technical or safety-related function, e.g., the pouring area, and with the exception of hand-moulding jobbing foundries
- Keeping outside doors shut, e.g., using an automatic shutter system or flaps
- Carrying out good housekeeping, i.e., ensuring that regular inspections are carried out by responsible and delegated staff as a practice of good housekeeping and keeping up-to-date records.

Fugitive emissions to water may arise from subsurface structures or defective surfacing. These types of fugitive emissions can be minimised by the following actions:

[1] European IPPC Bureau., Reference Document on Best Available Techniques on Emissions from Large Volume Organic Chemical Industry, European Commission (2002)

- Establishing and recording the sources, direction, and destination of all installation drains
- Identifying and recording all subsurface sumps and storage vessels
- Carrying out routine programmed inspections
- Having an inspection and maintenance programme of impervious surfaces and containment kerbs
- Being able to justify where operational areas have not been equipped with:
  - an impervious surface
  - spill containment kerbs
  - sealed construction joints
  - connection to a sealed drainage system.

The European IPPC Bureau has noted that fugitive emissions to the environment can be much more significant than collected and abated emissions. Therefore their control is critical. Limiting fugitive emissions will limit the overall odour and dust emissions in the close vicinity of the plant.

4.3.3.3 Use of a Multi-flue Stack

See BREF Section 4.5.1.2
Multi-flue stacks are used to replace a number of chimneys for hot emissions.

4.3.3.4 Abatement Techniques

See BREF Section 4.5.1.3

Collected off-gases can be cleaned with wet and dry systems. The appropriate treatment is based on the composition, flow and conditions of the off-gas system. The following techniques are used:

- Dust and particle removal
  - cyclones
  - fabric or bag filters
  - wet scrubbers
- Gas scrubbing systems (SO_2, Cl, amine removal)
  - wet scrubber towers, venture scrubbers and disintegrators
- Oil mist separators
  - wet electrostatic precipitators
- CO and organics removal
  - post combustion
  - biofilter

Dust and particle removal can be carried with both wet and dry systems.

The advantage of a dry system is that the dust remains dry and can be re-used. No pollution is transferred to other media as is the case for wet systems. Wet scrubber systems results in a wastewater and a sludge. Wastewater needs to be treated and the sludge needs to be disposed of. Bag filters are inefficient for gaseous compounds because the compounds are not absorbed onto the filter surface.

Dust and particle removal systems are described as follows:

4.3.3.5 Cyclones

If the right measures are taken (i.e., heat resistant steel, refractory lining) a cyclone filter may be used for dedusting hot flue-gases (500 – 600 ºC). The efficiency is too low to achieve emission levels in the 20 mg/Nm³ range. The cyclone is mainly used as a spark separator in front of a bag filter. Cyclones are used as a pretreatment step to other abatement systems.

4.3.3.6 Multicyclones

The separation efficiency of a cyclone increases with decreasing diameter. The use of a parallel series of small cyclones allows the separation of small dust particles, without a sharp increase in the pressure drop over the cleaning equipment.

Bag filter

This type of separator is widely applied in various parts of the foundry process, due to its good efficiency and low emission values. It can achieve good efficiencies in controlling the fine particulate matter found in melting operations. Sub-micron particles such as metallic oxides may be separated as well. For proper operation, the following measures need to be taken: flue-gas cooling (T = 130 - 160ºC) and separation of sparks (using a cyclone). The post combustion of organic material (to reduce the fire risk) may be applied for an off-gas with a high VOC content. Post combustion as a "firewall" for bag filter protection has been reported in some cases for off-gas from the unpacking of drums. This technique is not applied in general; instead waste gas streams with high dust loads are mixed with gas streams with increased VOC contents to prevent the filter and the exhaust ducts from becoming sticky.

4.3.3.7 High temperature filter systems (using a ceramic filter medium)

These are available on the market but not currently applied in the foundry industry.

4.3.3.8 Electrostatic Precipitators (ESP)

These are not widely applied for foundry flue-gas dedusting, due to their sensitivity to gas flow, gas temperature and humidity; they are only suitable for continuous melting regimes. They also incur a considerable explosion risk, due to the high gas volume they contain. The removal of dust to reduce this risk requires frequent cleaning, and therefore might incur economic problems. The main field of application for electrostatic precipitators in foundries is oil/mist removal from pressure die-casting exhaust gases. Die casting is not currently used in Ireland.

Wet dedusting systems, such as venturi and disintegrators, are applied in melting flue-gas treatment. Scrubber towers are used for dedusting of non-melting off-gas. Compared to dry systems the wet systems have the following disadvantages: higher energy consumption, higher maintenance (corrosion, bacteria), and they result in waste water and a sludge for disposal.

Advantages are the capture of water-soluble compounds (such as SO_2, chlorides), quick cooling, which prevents dioxin reformation, low investment costs, and less restriction on input temperature.

- Venturi scrubbers:

  Water is sprayed into the gases as they pass through a venturi. The acceleration of the gas flow in the venturi throat causes an intensive mixing of both media. The dust particles are damped, making them heavier, so that they can be separated in a cyclone or other system placed downstream. If the gas flow drops, the venturi throat is adjusted to maintain the collection efficiency.

- Disintegrators:

These so-called dynamic scrubbers consist of concentric rotor and stator mounted pins through which the gas stream is driven by means of a fan placed downstream or by fan blades at the outer end of the rotor. Water injected into the centre of the rotor, is broken into fine droplets by the pins and dispersed in the gas stream. The wet particles impinge on the stator walls and are collected at the bottom of the disintegrator. The system works efficiently when the gas flow is reduced.

Section 4.5.1.3 of the BREF compares the properties of wet and dry systems in a table (Table 4.32), it has been replicated below.

Table 4.8 Properties of Wet and Dry Abatement Systems for Foundries

Abatement Technique	Dry Systems		Wet Systems	
	Multi-cyclone	Bag Filter	Venturi	Disintegrator
Dust emission level*	100 – 200 mg/Nm³	<5 – 20 mg/Nm³	<20 – 150 mg/Nm³	<20 – 150 mg/Nm³
Investment cost	Low	High	Low	Medium
Energy consumption	Low	Low-medium	High	High
Advantages/reason for choice	Applicable for pre-cleaning of gases prior to other methods	Good performance for suitable dusts if well monitored. The potential to recycle dust to the process	Partial SO_2 - capture Low risk of *de novo* synthesis	Compact installation Low risk of *de novo* synthesis
Disadvantages	Low efficiency when there is a disturbed flow pattern (dust blocking of distributor). limited efficiency for fine particles	Fire risk, large volume, blocking upon condensation	Wet sludge, waste water treatment, a loss of efficiency with wearing	Higher energy use, wearing, wet sludge, waste water treatment
* Values from operational practice, that can be maintained throughout the service life of the installation				

4.3.3.9 Dioxin Prevention and Abatement

See BREF Section 4.5.1.4

Dioxins are relevant for thermal systems that have metals present.

4.3.3.10 Odour Abatement

See BREF Section 4.5.1.5

The potential odour impacts may arise when the foundry uses organic binders. In Ireland the mould method uses clay bound sands so odour from binders is not an issue.

The most common odour source complaint from organic binders is phenolic breakdown products because products such as cresols and xylenols have low odour detection thresholds. The use of inorganic binders has been successful in mitigating the impact.

Odour may also be generated from casting, cooling and shake-out, where odours form the process mix with large volumes of air. Collection and treatment of this air is difficult.

No totally effective proven method of eliminating foundry odour is currently available. The best approach is to ensure good ventilation and a rate of air change that ensures emissions are quickly and efficiently dispersed to atmosphere. See BREF Sections 4.3.3.7, 4.5.8.5, 4.5.8.4 and 4.5.8.6.

4.3.3.11 Cupola furnaces

This type of furnace is not in use in Ireland currently. See BREF Section 4.5.2.4, 4.5.2.2 and 4.5.2.3.

Blow down occurs in cupola furnaces at the end of the melting campaign because there is no longer charge material cooling it down and the temperature on the stack gradually rises. CO will burn automatically in contact with O_2. The off-gas collection and treatment system therefore has to be able to cope with temperatures of up to 1200ºC.

There are two collection systems in use for top gas:

- Above charge-hole off-take
- Below charge off-take

Following collection the gases may need cooling for dust abatement. There are several methods for cooling the gases:

- Tube coolers
- Forced air/gas heat exchanger
- Saturation with water

4.3.3.12 Dedusting

Wet Scrubber Systems
- Low capital costs
- Low maintenance costs
- High energy input
- Sludge removal (difficult)
- Treatment of scrubber wastewater required
- Venturi of disintegrators

Dry Collection Systems
- Higher capital cost
- Better control of inlet conditions
- Lower energy input
- Dry dust can be recycled
- Multi-cyclones, bag filters or electrostatic precipitators

4.3.3.13 Post Combustion

Waste gases are combusted to optimise heat recovery and provide cleaner exhaust gas. Heat is chemically bonded as CO and burning it releases CO_2 and H_2O. The heat generated can be recovered using a heat exchanger. A post combustion chamber is installed normally after a cupola. The type of unit varies according to process composition. The following types exist:

- Hot blast cupola with a recuperator and wet scrubber
- Hot blast cupola with a recuperator and a bag filter

Post combustion chambers limit the emissions of CO and eliminate the majority of organic compounds.

4.3.3.14 Electric Arc Furnace (EAF)

There is no EAF in Ireland currently. See BREF Section 4.5.3.

Off-gas Collection Particulate matter from an EAF is very fine and difficult to capture. There are several methods of doing so (with various advantages and disadvantages).

The methods are:

- Roof mounted hoods
- Side draught hoods

- Canopy hoods
- Direct furnace or “fourth-hole” evacuation
- Partial furnace enclosure
- Total furnace enclosure

Exhaust Gas Cleaning:
Again due to the small particle size, the exhaust gas cleaners have to be highly efficient. Fabric filters are most commonly used for dedusting.

4.3.3.15 Induction Furnace

See BREF Section 4.5.4.

The capture of smoke and dust is the most difficult problem to solve when installing an off-gas collection system on a coreless induction furnace, since there is no exhaust shaft. Several methods have been developed in the past decade, each with advantages and disadvantages.

- General ventilation of the workplace:

  A combination of wall mounted louvres and roof mounted ventilators situated over the furnace platform are used to increase the natural convection of smoke and fumes, and to direct them outside. Even with baffles suspended from the roof and using high extraction rates the efficiency is often poor and easily disturbed by draughts.

- Canopy hood extraction:

  Since lower placed hoods will interfere with crane charging systems, larger hoods have to be installed above the charger. This creates a large gap between the furnace and the extraction system, making it difficult to control the rising smoke and dust, even when using high extraction rates. Cross-draughts can seriously distort the collection efficiency of the system. These disadvantages make the use of these collection systems unattractive. Swing aside hoods: These hoods are more efficient when used in conjunction with vibrating feeders. Cut-outs in the hood can facilitate charging. During tapping, the hood is swung over the ladle, allowing efficient fume extraction.

- Side-draught hoods:

  Placing the extraction hood beside the furnace offers the advantage of good furnace accessibility and no interference with the charging systems. Due to the high buoyancy of the exhaust gases, large extraction rates are achieved, therefore giving good efficiency, especially when the hood is placed outside the furnace platform. In this case extraction control is poor during tapping. Attachment to the furnace platform overcomes this problem but may interfere with charging operations. The efficiency can be improved by installing airjets at the opposite side of the hood to blow the dust and fumes into the hood. Unfortunately, this facility does not work if there are any interferences in the airstream, which is the case during charging.

- Lip extraction:

  A suction ring is placed on top of the furnace and arranged so that it moves with the furnace during deslagging or tapping operations. This system does not interfere with the charging operations. With the lid closed, lip extraction offers very good control, since it is as near to the emission source as possible and involves the lowest extraction rates. The fumes do not pass through the breathing zone of the furnace operators. However, the extraction control decreases significantly when the furnace lid is opened, for instance during charging. The design of this extraction equipment has been subjected to many studies. Suppliers offer solutions to overcome some of the disadvantages.

- Cover extraction:

  The gas is exhausted through the furnace cover. This method is very effective. It is used by the majority of furnace producers. Exhaustion is managed according to furnace regime: melting, charging, and pouring. Attention has to be paid to the material used for hoods and ducts since the gases may be at high temperatures when the intake of the collection system is positioned close to the furnace. The heating required by radiation or convection from the molten metal bath needs to be taken into account in the design stage. Proper maintenance in combination with heat-sensors reduces the risk of fire. Again scrap cleanliness plays an important role. When the scrap contains organic matter, collected gas temperatures may rise due to the combustion of the material, thus requiring the use of heat resistant steel or even refractory linings. Oily deposits, formed by condensation of oil vapour in the ductwork, accumulate dust and can present a fire hazard if not removed regularly. When using clean scrap, a mild steel construction is adequate and does not need accessibility for cleaning.

Though the use of specific capture systems such as side-draught hoods, movable extraction hoods and partial housing of the furnace, a capture efficiency of more than 95% is possible.

4.3.3.16 Exhaust Gas Cleaning

Fabric filters are most commonly used to trap the small particles. They are favoured above electrostatic filters as they suit better the wide fluctuations in gas temperature and particulate condensation of the exhaust gases.

Oil is a potential problem in scrap as it can clog the filters and is a potential fire hazard. To overcome this, the filters have to be changed far more regularly than if clean scrap was used to keep up the required extraction rate. If oil vapour is likely to burn in the ductwork, it must be ensured that there is enough time for combustion before it reaches the filter housing. If the gas temperature were to exceed the design temperature of the fabric, cooling of the gas would be required.

If wet scrubbers are required, they need to be venturi to handle the carbonaceous and metallurgic smoke that contains very small particles. Exhaust flowrates are kept low by using exhaust capture systems with the least entraining of ambient air.

Corrosion can occur (though not normally) if sulphur gets into the system. This leads to absorption of SO_2 in the scrubber leading to acidification of water and therefore corrosion of equipment.

Flue-gas cleaning is applied in most ferrous foundries with an IF.

4.3.3.17 Rotary Furnace

There is no rotary furnace in Ireland. See BREF Section 4.5.5.

Off-gas collection and waste gas cleaning:
Bag filters are most commonly used for dedusting but wet systems can be used too. The temperature of the exhaust gases from a rotary furnace are too high for dedusting so it must be cooled beforehand. This is done by diluting with ambient air in a controlled manner. An afterbrurner allows the reduction of organic carbon emissions and combustible particles.

4.3.3.18 Metal Treatment-Air Emissions

See BREF Section 4.5.7.1.

For details of nodularisation, see BREF Section 4.5.7.2.

4.3.3.19 Mould and Core Making

Table 4.20 of the BREF Section 4.3.2 compares the technical properties of various mould types. Green sand compares favourably to chemically bonded sand, low pressure and gravity die-casting and high pressure die-casting. The green sand method is used in Ireland. Control techniques for other mould making processes are discussed in Sections 4.3.3, 4.3.4 and 4.5.8.

Green sand (clay-bonded sand) is prepared using vacuum mixing and cooling. The sand is mixed under reduced pressure which results in cooling by the controlled vaporisation of water. The sand mixer is sealed to facilitate the vacuum. This is shown in Figure 4.2.

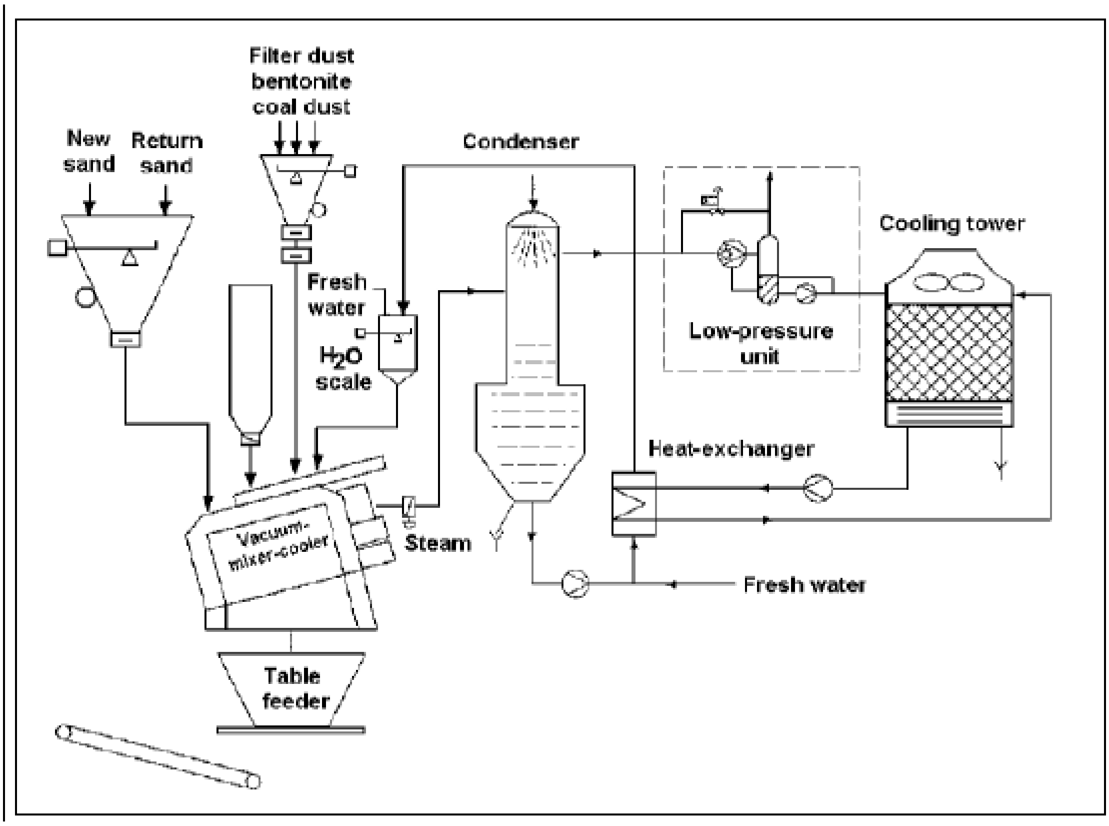

Figure 4.2 Moulding – sand preparation plant with vacuum mixer-cooler
Source: BREF Section 4.3.2

The use of steam leads to quick activation of the bentonite and therefore optimal compressive strength for the bonded sand.

Water is added:

- To moisten the return sand
- To cool the sand by vaporisation

All the water added is used up by the sand, there is no wastewater generated at this point.

4.3.3.20 Potential Impacts

- Dust from mixing (only a few of the different green sand preparation stages can cause significant dust generation, namely the vibrating screen, dedusting and cooling process stages)
- Sand spillages

- Coal dust spillages
- Fumes from mixing
- Dust from core making

4.3.3.21 Control Techniques

Air Extraction or Vacuum Mixing:
Air is drawn off the mixer and is directed to a centralised dedusting unit. This draws off potential dust and fumes. There are two types of deduster systems, wet and dry. The wet system is being widely replaced by the dry system. The wet system produces a wastewater and a sludge fraction. With the dry system, dust can be collected and disposed of more easily. The dry system needs to be managed to prevent clogging due to condensation.

Good management and housekeeping will mitigate any potential impacts of sand and coal dust spillages.

Less air is drawn-off with this method of mould preparation than others, leading to reduced off-gas volume and amount of dust for disposal. This system is more energy efficient than other methods.

Exhaust capture from core making:
The type of emissions are dependant on the type of binder and hardener used. Chemical binders will produce an exhaust gas with a mixture of organic solvents. Further details of emissions and control techniques for core making are included in the BREF Section 4.5.8.

4.3.3.22 Casting/Cooling/Shake-Out

See BREF Section 4.5.9

4.3.3.23 Potential Impacts

- Particulate matter
- Carbon monoxide
- Carbon dioxide
- Benzene
- Toluene
- Xylene
- Potential odour may be associated with sulphur content of the coal

4.3.3.24 Control Techniques

The emissions from casting/cooling and shake-out are captured for treatment. Extraction of air around the pouring zone is critical. Extraction ventilators or extractor surfaces should be fitted as close to the moulds as possible. The best control of emissions from shake-out is when it is performed in enclosed units. This achieves good emission levels with relatively low ventilation rates. Extraction may also be directed around the shaker of under the shake in the sand box.

Extraction drums or tube drums are increasingly being used instead of the usual shakers as they are better at collecting emissions, but they have the disadvantage of possible odour emissions.

In plants where clay-bonded sand moulds are shaken out, steam emissions may be significant. This can lead to obstructions in the duct work if the temperature drops below the dew point or freezing point due to a combination of dust and stream. Hot air injected into the ducts will mitigate this.

Off gas cleaning may be performed using a biofilter to treat odourous gases, mainly consisting of VOCs from casting off-gas. The use of biofilters is not valid as a stand alone technique for VOCs.

4.3.4 Finishing/Post Casting

See BREF Section 4.5.10

Emissions from fettling and shot blasting and finishing activities should be contained where necessary. Shotblasting requires housing. Dust emissions are captured within the housing and subjected to wet washing and dry filters to decontaminate. Standard noise protection should be employed if the process generates noise.

4.3.5 Wastewater prevention and treatment

See BREF Section 4.6

Measures to prevent the generation of wastewater include:

- Dry dedusting systems
- Biofilters or biological waste gas scrubbers (for biodegradable contaminants)

These are both applicable to the Irish situation. For foundries that produce wastewater there are a number of other techniques to reduce generation.

The method employed in the current Irish situation is to direct surface water through an oil and grit interceptor. Surface water is collected from the traffo, the substation and the extraction and melting plants. The oil interceptor generates a residue for disposal.

4.3.6 Energy Efficiency

See BREF Section 4.7

Foundries are significant users of energy. The greatest proportion of energy is used in melting and holding the metal in a molten state. This document highlights a number of controls to increase energy efficiency in the process. Improved energy efficiency is one of the main environmental benefits. Ladle pre-heating is important for energy efficiency. Improved energy efficiency can be obtained through heat recover and heat transfer.

4.3.7 Waste Heat Utilisation (Induction Furnace)

IF use significant quantities of electricity. A significant proportion (20-30%) of that electricity is converted into waste heat from the cooling system.

Cooling is used to:

- Cool the induction coil to protect it from electrical losses
- Protect the coil from heat conducted through the furnace lining from the molten metal

Heat recovery from the cooling system is not even contemplated by most furnace operators for the following reasons:

- The priority is the cooling system and it is essential that it does not fail.

- The heat recovered is low grade
- Users need to be close by (distance wise)
- Heat must be used at time its produced
- May not produce enough heat in winter for heating space or water and may produce too much in summer

Further details of waste heat utilisation in IF and cupola furnaces are discussed in Section 4.7.2 and 2.7.2 of the BREF.

4.3.8 Sand Regeneration

See BREF Section 4.8

Green sand can be easily re-conditioned after use and even shows better technical characteristics than new sand. The process is called Primary Regeneration and involves:

- Breaking down sand from moulds and cores
- Screening the sand
- Removing tramp metal
- Separating and removing fines and runners
- Cooling
- Storage for reblending with new sand

The main primary regeneration techniques are vibration, rotating drum or shot blasting. For green sands, simple mechanical systems are sufficient.

Secondary regeneration is carried out to remove residual binder. Foundries that use secondary regeneration have virtually removed the need for new sand. This is mainly for chemically bound sands. The main techniques are more aggressive than for primary regeneration:

- Vibration
  - Shook on grid or screen
  - Sand goes to treatment,residuals for disposal
- Drum
  - Drum breaks up sand
  - Sand goes through screens for treatment
  - Oversize and residual go for disposal
- Shot blast
  - Mould loaded into shot blast machine
  - Shot blast disintegrates mould
  - Sand goes for treatment
  - Shot for disposal
  - Not very common method

Cooling of the regenerated sand is required because heat has transferred from the casting to the sand. There are two methods of cooling:

- evaporate coolers with turbulent and fluidised beds
- vibrating transporters of revolving drums (cooling occurs simultaneously to shake-out)

See BREF Section 4.8.2. The BREF also addresses cost benefits of primary regeneration.

Sand Regeneration:
Advantages:

- Reduces raw material consumption
- Reduces disposal costs
- Reduces costs

Disadvantages:

- Increases electricity consumption
- Dust emissions can be recycled to collect the binder compounds

For a green sand monosystem, regeneration rates of 98% may be achieved.

4.3.9 Wastes for Disposal

4.3.9.1 Sand

Used sand and undersized sand has the potential for re-use in:

- Construction industry
- Building materials industry
- Landfill construction

See BREF Section 4.8.13.

4.3.9.2 Dust and Solid Residues

Residues may include:

- Slag
- Dust from raw materials
- Dust from melting
- Dust from casting
- Dust from fettling
- Refractory waste
- General inert industrial waste

Wastes should be recovered wherever possible. Table 4.6.7 of the BREF note details pre-treatment requirements for re-use of solid residues.

4.3.10 Noise Reduction

4.3.10.1 Potential Noise Impacts:

- Scrap handling (including delivery)
- Other raw material handling (including delivery)
- Furnace charging

- Fans and motors
- Knock-out/shake-out
- Finishing/post casting
- Transport and handling (tipping, loading, transfer, etc.)

4.3.10.2 Control Techniques

Overall reduction of noise levels involves developing a noise reduction plan. For this, noise surveys and modelling may be required. The noise reduction plan should include all measures to reduce and control noise, such as the measures proposed in the following table. This table has been replicated from the UK Guidance for Ferrous Metal Foundries, Defra, 2005.

Table 4.9 Noise Mitigation Measures

Operation	Control Measure
Scrap Deliveries	– Scrap storage in enclosed area – Minimising deliveries at night* – Minimise the drop height for scrap deliveries
Scrap Handling and charging	– Develop storage systems to avoid double handing – Minimising charging height – Use screens and barriers to conceal noise sources
Site Vehicle Movements	– Using vehicles with "directional and localised sound" for reverse alarms to concentrate noise at the area of immediate danger – Replacing diesel powered forklift trucks with electric powered – Minimising vehicle movements at night
Knock-out/Shake-out	– Acoustic screens and enclosures* – Fitting silencers to avoid noise travelling along ducting – Selection of less noisy engineering equipment
Fans, pumps and motors	– Acoustic screens, enclosures and baffles – Fitting silencers to avoid noise travelling along ducting – Selection of less noisy engineering equipment
Grinding, fettling and shot blasting	– Acoustic screens and enclosures* – Selection of less noisy engineering equipment
General	– Fitting noise reducing flaps to outside doors – Maintaining a closed doors policy – Improving sound insulation of buildings – Holes and openings closed off (use mechanical where necessary)
	– Enclose foundry operations within buildings

* Noise mitigation measures that are likely to be needed in most cases
Source: Defra 2005

4.3.11 Decommissioning

See BREF Section 4.11.

Information discussed includes:

- Designing in for decommissioning for proposed facilities
- Improving identified problems at existing facilities
- Developing and maintaining a site plan

4.3.12 Environmental Management

See BREF Section 4.12.

The best environmental performance is usually achieved by the installation of the best technology and its operation in the most effective and efficient manner.

An Environmental Management System (EMS) should be operated at the installation. This should address design, construction, operation, maintenance, and decommissioning. The EMS can be standardised or customised.

An EMS will typically ensure the continuous improvement of the overall environmental performance of the foundry.

5. BEST AVAILABLE TECHNIQUES

5.1 INTRODUCTION

The foundry industry is diverse and the applicable elements of BAT to a specific foundry need to be selected according to the type of activity.

A foundry is a melting shop and a casting shop. The BREF distinguishes between melting of ferrous or non-ferrous metals and casting in either lost or permanent moulds. This BAT note refers to Ferrous Metal Foundries. There is one ferrous metal foundry in Ireland and it casts using lost moulds. BAT will be presented here for ferrous metal foundries casting with lost moulds.

5.2 GENERIC PREVENTATIVE MEASURES

There are generic elements of BAT that apply to all foundries. These include:

- Material flows
- Finishing of castings
- Noise
- Wastewater
- Environmental management
- Decommissioning and aftercare

5.2.1 Material flows

The material flow through the foundry is critical to the minimisation of raw material use, and recovery and recycling of materials, residue and waste are essential to BAT. BAT therefore is to optimise the management and control of internal flows.

BAT for material flow is:

- Apply storage and handling methods for raw materials, recycled and recovered materials, waste and residues. Further details on Storage BAT are included in the BREF note on Storage[2], and in Section 4.3 Control Techniques – Raw Materials Storage and Handling of this document. BAT is the development of an impermeable hardstanding area to store scrap metal. It should have a drainage, collection and treatment system. A roof can eliminate this requirement.
- Store residue and waste types separately to allow re-use, recycling and disposal.
- Use bulk or recyclable containers if applicable.
- Improve metal yield using simulation models and management and operation procedures.
- Optimise material flows using simulation models and management and operation procedures.
- Implement good practice measures for molten metal transfer and ladle handling.

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[2] European IPPC Bureau, Reference Document on Best Available Techniques on Emissions from Storage, European Commission (2003)

5.2.2 Finishing of Castings

BAT is to collect and treat the off-gas using a wet or dry system.
The BAT associated emissions level for dust is 5-20 mg/Nm^3. Refer to Section 4.3 Control Techniques – Finishing/Post Casting of this document for further details on the techniques for off-gas collection and exhaust air cleaning. For Heat Treatment BAT, refer to BREF Section 5.1 (Finishing of Castings).

5.2.3 Noise Reduction BAT

- Develop and implement a noise reduction strategy, with general and source specific measures
- Use enclosure systems for high-noise unit operations such as shake-out
- Use additional measures as described in Section 4.10 of the BREF note for Foundries according to local conditions.

5.2.4 Wastewater BAT

- Separate wastewaters on site by compositional and pollutant load
- Collect surface water run-off for discharge via oil interceptors to surface water
- Maximise internal recycling of process water
- Maximise multiple use of treated wastewater if applicable
- Apply wastewater treatment for scrubbing water and other wastewater flows as discussed in BREF Sections 4.6.2 and 4.6.3.

5.2.5 Reduction of Fugitive Emissions BAT

- Avoid outdoor or uncovered stockpiles
- If avoidable use sprays, binders, stockpile management techniques, windbreaks, etc., on outdoor stockpiles
- Cover skips and vessels
- Vacuum clean the moulding and casting shop in sand moulding foundries in accordance with Section 4.5.1.1 of the BREF
- Clean wheels on rods
- Keep outside doors shut
- Carry out regular housekeeping
- Manage and control possible sources of fugitive emissions to water.

Additional fugitive emissions may arise from the incomplete evacuation of exhaust dust from contained sources. BAT is to minimise these fugitive emissions by optimising capture and cleaning, taking into account the associated emission levels. Optimisation involves one or more of the following, giving preference to the collection of fume nearest the source:

- Design of hooding and ducting to capture fume arising from the hot metal, furnace charging, slag transfer and tapping
- Applying furnace enclosures to prevent the release of fume losses into the atmosphere
- Applying roofline collection (last resort due to high energy demand)

5.2.6 Environmental Management BAT

A number of environmental management techniques are determined as BAT. Refer to BREF Section 5.1 for information that should be incorporated in an EMS.

5.3 BAT FOR MELTING

Steel is melted in either an:

- Electric arc furnace (AF)
- Induction furnace

The choice is based on technical criteria. The EAF can melt lower grades of scrap because of its ability to refine the scrap. However it requires flue-gas capture and cleaning systems.

Cast iron is melted in either a:

- Cupola furnace
- Rotary furnace
- Induction furnace (IF)
- Electric arc furnace (EAF)

The choice is based on economic and technical criteria.

The IF is used in Ireland.

5.3.1 BAT for the operation of an IF

- Melt clean scrap avoid or remove rust, dirt and sand
- Store metal by composition and type for charging to allow for use of optimum size and density of charge
- Use medium frequency power
- Evaluate the possibility of waste heat recovery
- Use a hood, lip extraction or cover extraction on each IF to capture off-gas and to maximise off-gas collection during the full working cycle. Refer to Section 4.3.1 Control Techniques for fume, flue-gas and exhaust air capture and treatment of this document.
- Use dry flu-gas cleaning taking into account the BAT associated emission levels. Refer to Section 4.3.1 of this guidance.
- Keep dust emissions below 0.2 kg/tonne molten iron

5.3.2 BAT for the operation of Cupola Furnace

See BREF Section 5.2

5.3.3 BAT for the operation of an EAF

See BREF Section 5.2

5.3.4 BAT for the operation of a Rotary Furnace

See BREF Section 5.2

5.3.5 BAT for Ferrous Metal Treatment

See BREF Section 5.2

5.4 BAT FOR CASTING

See BREF Section 5.4

5.4.1 Lost Mould Casting

Lost mould casting involves:

- Moulding
  - production of green sand moulds
  - production of chemically bonded sand moulds
- Cove making
- Pouring
- Cooling
- Shake-out

5.4.1.1 Green Sand Moulding BAT

See BREF Section 5.4

Green sand is prepared using:

- Sand (usually silica sand)
- Clay binder (bentonite)
- Carbonaceous binder (coal dust)

It is prepared in:

- Atmospheric (more common) conditions
- Under vacuum (sand capacity needs to be higher than 60t/h)

For green sand preparation BAT is:

- To enclose all the unit operations of the plant and to dedust the exhaust gas (BAT associated emission levels in Section 6). Dust may be re-used or recycled back into sand preparation. For further details see Section 4.3.3 Prevention and Control Techniques – Fumes, flue-gas and exhaust air capture and treatment – mould and core making of this document
- Apply primary regeneration. A regeneration ratio of 98% is associated with the use of BAT (greensand monosystems). For systems with a high degree of incompatible cores the BAT-associated regeneration ratio is 90-94%.

5.4.1.2 Chemically-Bonded Sand Moulding and Core-Making

(Not currently used in Ireland). This is a brief summary of the BAT. See BREF Section 5.4. There are various types of binder in use and are all determined as BAT. If applied according to good practice measures (emission control).

BAT is to:

- Minimise binder and resin consumption
- Minimise sand loss
- For series production involving frequent changes of production parameters with high production throughout; apply the electronic storage of parameters

- Capture exhaust gas from the area where cores are prepared, handled and held prior to dispatch
- Use water based coatings for refractory coating in foundries producing medium and large series
- Use alcohol based coatings for big or complex moulds and cores, water glass bonded sands, in magnesium casing and in production of manganese steel with MgO – coating
- Use water or alcohol based coatings in small scale foundries and large-scale jobbing foundries
- Amine-hardened urethane-bonded (cold-box) core production
- Regenerate or re-use sand

Alternative moulding methods and inorganic binders are considered to have a promising potential for the minimisation of the environmental impact of moulding and casing operations. Refer to Sections 4.3.4 and 6.5 of the BREF note for foundries for further information on alternative methods and inorganic binders.

5.4.2 Permanent Mould Casting

Permanent moulds are not used currently in Ireland. See BREF Section 5.5.

6. BAT ASSOCIATED EMISSION LEVELS

The following emission levels are associated to the BAT measures described in the previous sections.

6.1 EMISSION LEVELS FOR DISCHARGES TO AIR

All associated emission levels are quoted as an average over the practicable measuring period. Whenever continuous monitoring is practicable, a daily average value is used. Emissions to air are based on standard conditions, i.e., 273K, 101.3K pa and dry gas.

Table 6.1: Emission to Air Associated with the Use of BAT Measures Described in the Previous Sections

Parameter	Emission Level
Dust (1)	5-20 mg/Nm^3
PCDD/PCDF	$\leq$ 0.1 ng TEQ/Nm^3

(1) The emission level of dust depends on the dust components, such as heavy metals, dioxins and its mass flow.

Table 6.2: Emissions to Air Associated with the Use of BAT for the Cupola Melting of Ferrous metals

Type	Parameter	Emission Level (mg/Nm^3)
Hot Blast	CO	20-100
	SO_2	20-100
	NO_x	10-200
Cold Blast	SO_2	100-400
	NO_x	20-70
	NM-VOC	10-20
Cokeless	NO_x	160-400

Table 6.3: Emissions to Air associated with the use of BAT for the EAF Melting of Ferrous Metals

Parameter	Emission Level Mg/Nm^3
SO_2	70-130
NO_x	50-250
CO	20-30

Table 6.4: Emissions to Air associated with the use of BAT for Moulding and Casting using Lost Moulds

Emission Source	Parameter	Emission Level Mg/Nm^3
General	Dust	5-20
Core Shop	Amine	5
Regeneration Units	SO_2	120
	NO_x	150

6.2 EMISSION LEVELS FOR DISCHARGES TO WATER

The following table (Table 6.5) sets out emission levels that are achievable using BAT for wastewater treatment. However establishing emission limit values within a licence for direct discharges to surface water from wastewater treatment plant and storm water discharges must ensure that the quality of the receiving water is not impaired or that the current Environmental Quality Standards (EQS) are not exceeded.

Compliance with the Water Framework Directive (2000/60/EC) is required where relevant.

Table 6.5: BAT Associated Emission Levels for Direct Discharges to Surface Water*

Constituent Group or Parameter	Emission Level	Percentage Reduction [3]
pH	6 - 9	-
Toxicity [1]	1 TU	
BOD_5 [4]	25mg/l	>91 - 99%
COD	100 - 500mg/l	>75%
Suspended Solids	10 - 35mg/l	
Total Ammonia (as N) [4]	5 mg/l	
Total Phosphorus (as P) [4]	2mg/l	>80%
Oils Fats and Greases	10mg/l	
Mineral Oil (from interceptor)	20mg/l	
Mineral Oil (from biological treatment)	1.0mg/l	
Phenols [5]		
Cadmium [5, 6]		
Mercury [5, 6]		
Metals [5, 6]		
Organohalogens [5]		
Priority Substances (as per Water Framework Directive) [5]		
Cyanides [5]		
Other [5, 7]		

* All values refer to daily averages based on a 24-hour flow proportional composite sample, except where stated to the contrary and for pH, which refers to continuous values. Levels apply to effluent prior to dilution by uncontaminated streams, e.g., storm water, cooling water, etc.

* Temperature measured downstream of a point of thermal discharge must not exceed the unaffected temperature by more than 1.5°C in salmonid waters and 3°C in cyprinid waters (Freshwater Fish Directive 79/659/EEC).

Note 1: The number of toxic units (TU) = 100/x hour EC/LC50 in percentage vol/vol so that higher TU values reflect greater levels of toxicity. For test regimes where species death is not easily detected, immobilisation is considered equivalent to death.

Note 2: Total Nitrogen means the sum of Kjeldahl Nitrogen, Nitrate-N and Nitrite-N.

Note 3: Reduction in relation to influent load.

Note 4: Limits will depend on the sensitivity of the receiving waterbody.

Note 5: BAT associated emissions levels are highly dependent on production process, wastewater matrix and treatment. These parameters shall be considered on a site-specific basis when setting emission limit values and shall include consideration of the European Communities Environmental Objectives (Surface Waters) Regulations, 2009, S.I. No. 272 of 2009, and other applicable legislation.

Note 6: PARCOM recommendation 92/4 applies to a wastewater emission from the electroplating industry discharging to water or public sewer. Where the sum of metals specified in combined is < 200g/day prior to treatment, their emission level values may be increased fourfold. Applies to activities other than printed circuit board manufacture. Applies to wastewater streams specially treated (PARCOM).

Note 7: Any relevant polluting substances as specified in Schedule to S.I. No. 394 of 2004: EPA (Licensing)(Amendment) Regulations, 2004.

6.3 EMISSION LEVELS FOR DISCHARGES TO SEWER

All discharges to sewer are subject to approval from the relevant Water Services Authority. Compliance with the Water Framework Directive (2000/60/EC) is required, where relevant.

7. COMPLIANCE MONITORING

The most common parameters measured in the ferrous metal foundaries are particulates, metals, sulphur dioxide, VOCs, dioxins, nitrogen oxides and carbon monoxide.

Gas flow should be measured or otherwise determined to relate concentrations to mass releases. Temperature and pressure must be measured and recorded to relate measurements to reference conditions and water vapour content must be measured where it is likely to exceed 3% unless the measuring techniques used provide results on a dry basis.

The methods proposed for monitoring the emissions from these sectors are set out below. Licence requirements may vary from those stated below due to site location considerations, and scale of the operation.

7.1 MONITORING OF EMISSIONS TO AIR

- Stack sampling periodically, as required by licence, taking account of the nature, magnitude and variability of the emission and the reliability of the control techniques.
- Continuous monitoring on main emissions where technically feasible (e.g., Particulates).
- Monitor solvent / VOC usage by annual mass balance reports and use to determine fugitive emissions.
- Annual monitoring of boiler stack emissions for SOx, NOx, CO and particulates, as required by the licence, taking account of the nature, magnitude and variability of the emission and the reliability of the controls.
- Monitoring of boiler combustion efficiency in accordance with the manufacturer's instructions at a frequency determined by the Agency.
- Periodic monitoring for other parameters as determined by the Agency.
- Periodic visual and olfactory assessment of releases should be undertaken where appropriate, to ensure that all final releases to air are essentially colourless, free from persistent mist or fume and from droplets.

7.2 MONITORING OF AQUEOUS EMISSIONS

- For uncontaminated cooling waters, continuous monitoring of temperature and flow.
- Establish existing conditions prior to start-up, of key emission constituents, and salient flora and fauna.
- Daily, or where deemed necessary, continuous monitoring of flow and volume. Continuous monitoring of pH. Monitoring of other relevant parameters as deemed necessary by the Agency (such as BOD, COD, metals, etc.), taking account of the nature, magnitude and variability of the emission and the reliability of the control techniques.
- Monitoring of influent and effluent from the wastewater treatment plant to establish percentage BOD reduction and an early warning of any difficulties in the wastewater treatment plant, or unusual loads.

- The potential for the treated effluent to have tainting and toxic effects should be assessed and if necessary measured by established laboratory techniques.
- Periodic biodegradability checks where appropriate on effluents to municipal waste treatment plants, both prior to start-up and thereafter.

7.3 MONITORING OF EMISSIONS TO GROUNDWATER

There should be no direct emissions to groundwater, including during extraction and treatment of groundwater.

7.4 MONITORING OF SOLID WASTE

- The recording in a register of the types, quantities, date and manner of disposal/recovery of all wastes.
- Leachate testing of sludges and other material as appropriate being sent for landfilling.
- Annual waste minimisation report showing efforts made to reduce specific consumption together with material balance and fate of all waste materials.

Appendix 1

PRINCIPAL REFERENCES

1. EUROPEAN COMMISION

1. BREF 2001, European Commission. Reference Document on Best Available Techniques in the Ferrous Metals Processing Industry.
2. BREF 2001, European Commission. Reference Document on Best Available Techniques on the production of Iron and Steel.
3. BREF 2004, European Commission IPPC Reference Document on BAT in the Smitheries and Foundries Industry.
4. BREF 2001, European Commission. Reference Document on Best Available Techniques in the Non Ferrous Metals Industry.

2. LEGISLATION

1. Environment Protection Agency Act, 1992
2. Protection of the Environment Act 2003
3. Local Government (Water Pollution) Act 1977
4. Council Directive 80/68/EEC on the protection of groundwater against pollution caused by certain dangerous substances. (OJ L20, 26/01/80). [amended by 85/208/EC (OJ L89, 29/03/85); 87/144/EC (OJ L57, 27/02/87); 2000/60/EC (OJ L 327, 22/12/00)]
5. Protection of Groundwater Regulations 1999 (SI 41/1999)
6. Local Government (Water Pollution) (Amendment) Regulations 1999 (SI 42/1999)
7. European Communities (Quality of Salmonid Waters) Regulations, 1988 (SI 293/1988)
8. European Communities (Quality of Surface Water Intended for the Abstraction of drinking Water) Regulations, 1989 (SI 294/1989)
9. Local Government (Water Pollution) Act 1990
10. Environment Protection Agency Act, 1992 (Urban Waste Water Treatment) Regulations, 1994. SI 419/1994
11. Council Directive 78/659/EEC on the quality of fresh waters needing protection or improvement in order to support fish life. (OJ L327, 22/12/00)
12. Water Quality (Dangerous Substances) Regulations, 2001. S.I. No. 12/2001
13. Air Pollution Act 1987
14. Air Pollution (Air Quality Standards) Regulations, 2002 (S.I. No. 271/2002 – replaces S.I. No. 244/1987) European Community (1996) Council Directive 96/62/EC on ambient air quality assessment and management (OJ: L296/55/96) & Daughter Directives 1999/30/EC and 2000/69/EC
15. European Community (1991). Council Directive 91/689/EEC on hazardous waste (OJ L377, 31/12/91)

16. Waste Management Acts, 1996 to 2011
17. European Community (1999). Council Directive 1999/31/EC on the landfill of waste (OJ L182, 16/7/99)
18. European Communities (Amendment of Waste Management (Licensing) Regulations 2002), S.I. No. 337/2002.
19. European Community (1996). Council Directive 2008/1/EC concerning integrated pollution prevention and control. (OJ L257, 10/10/96)
20. Wildlife Act 1976 and Wildlife (Amendment) Act 2000, and Regulations made there under European Communities (Natural Habitats) Regulations, 1997(S.I. No. 94/1997) & Amendments
21. European Communities (Conservation of Wildbirds) Amendment Regulations, 1997 (S.I. No. 210/1997)
22. DIRECTIVE 2004/107/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air

3. EPA PUBLICATIONS

1. EPA (Environmental Protection Agency) 2004 Guidance Note on Storage and Transfer of Materials for Scheduled Activities
2. EPA (Environmental Protection Agency) 2006 Guidance on Environmental Liability, Risk Assessment, Residual Management Plans and Financial Provision
3. EPA Guidance Note on Energy Efficiency Auditing July 2003
4. EPA (Environmental Protection Agency) 2006 Guidance Notes for Noise in Relation to Scheduled Activities
5. EPA (Environmental Protection Agency) 1996 Integrated Pollution Control BATNEEC
6. Guidance Note for the Chemical Sector
7. EPA (Environmental Protection Agency) 2001 Parameters for Water Quality,
8. Interpretation and Standards
9. EPA (Environmental Protection Agency) Parameters for Water Quality Objectives and Standards 2001.
10. EPA (Environmental Protection Agency) 1997 Environmental Quality Objectives and Environmental Quality Standards - the aquatic environment, a discussion document.
11. BATNEEC Guidance Note, Class 3.1, Production of Iron and Steel
12. Integrated Pollution Prevention and Control (IPPC). Best Available Technique Reference
13. BAT Document on the production of Iron and Steel

4. OTHER REFERENCES

1. Integrated Pollution Prevention and Control (IPPC). UK Secretary of State's Guidance for A2 Activities in the Iron and Steel Sector IPPC SG4

2. IPPC S202 Technical Guidance for Iron and Steel and the production of Carbon and Graphite

Appendix 2

GLOSSARY OF TERMS AND ABBREVIATIONS

Baseline monitoring: monitoring in and around the location of a proposed facility so as to establish background environmental conditions prior to any development of the proposed facility.

Biochemical oxygen demand (BOD): is a measure of the rate at which micro-organisms use dissolved oxygen in the bacterial breakdown of organic matter (food) under aerobic conditions. The BOD, test indicates the organic strength of a wastewater and is determined by measuring the dissolved oxygen concentration before and after the incubation of a sample at 20ºC for five days in the dark. An inhibitor may be added to prevent nitrification from occurring.

Borehole: a shaft installed for the monitoring of and/or the extraction of groundwater. Established by placing a casing and well screen into the boring.

Chemical oxygen demand (COD): is a measure of the amount of oxygen consumed from a chemical oxidising agent under controlled conditions. The COD is generally greater than the BOD as the chemical agent will often oxidise more compounds than is possible under biological conditions.

Direct discharge: introduction into groundwater of substances in Lists I or II without percolation through the ground or subsoil.

Decommissioning: works carried out on a facility or to allow planned afteruse.

Effluent: a liquid, which flows from a process or system.

Emission: as defined in the EPA Acts, 1992 to 2011.

Groundwater: water, which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil.

Indirect discharge: introduction into groundwater of substances in Lists I or II after percolation through the ground or subsoil.

List I/II substances: substances referred to in the EU Directives on Dangerous Substances (76/464/EEC) and Groundwater Directives (2006/11/EC) and (80/68/EEC) and amendments.

Receiving water: a body of water, flowing or otherwise, such as a stream, river, lake, estuary or sea, into which water or wastewater is discharged.

Total organic carbon (TOC): mass concentration of carbon present in the organic matter, which is dissolved or suspended in water.

Trigger level: is a value which when encountered requires certain actions to be taken.

Appendix 2

GLOSSARY OF TERMS AND ABBREVIATIONS

BAT	Best Available Techniques
BATNEEC	Best Available Techniques Not Entailing Excessive Cost
BREF	BAT reference - sector notes being produced by the European Commission
°C	Degree Celsius
CO	Carbon monoxide
CO_2	Carbon dioxide
DMEA	Dimethylethylamine
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
ELV	Emission Limit Value
EMP	Environmental Management Programme
EMS	Environmental Management System
EPA	Environmental Protection Agency
EQO	Environmental Quality Objective
EQS	Environmental Quality Standard
IPC	Integrated Pollution Control; as established by the EPA Act of 1992.
IPPC	Integrated Pollution Prevention and Control
mg	Milligram
Iron and Steel BREF	Reference Document on Best Available Techniques on the production of Iron and Steel, published by the European Commission 2001
Nm^3	Normal cubic metre (101.3 kPa, 273 K)
NOx	Nitrogen Oxides
POE	Protection of the Environment Act 2003
TEA	Triethylamine
US EPA	United States Environmental Protection Agency
WMA	Waste Management Act
VOC	Volatile Organic Compounds