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COMMISSION IMPLEMENTING DECISION (EU) 2024/2974

of 29 November 2024

establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the smitheries and foundries industry

(notified under document C(2024) 8322)

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) ([1]), and in particular Article 13(5) thereof,

Whereas:

(1) Best available techniques (BAT) conclusions are the reference for setting permit conditions for installations covered by Chapter II of Directive 2010/75/EU and competent authorities should set emission limit values which ensure that, under normal operating conditions, emissions do not exceed the emission levels associated with the best available techniques as laid down in the BAT conclusions.

(2) In accordance with Article 13(4) of Directive 2010/75/EU, the forum composed of representatives of Member States, the industries concerned and non-governmental organisations promoting environmental protection, established by Commission Decision of 16 May 2011 ([2]), provided the Commission on 29 April 2024 with its opinion on the proposed content of the BAT reference document for the smitheries and foundries industry. That opinion is publicly available ([3]).

(3) The BAT conclusions set out in the Annex to this Decision take into account the opinion of the forum on the proposed content of the BAT reference document. They contain the key elements of the BAT reference document.

(4) The measures provided for in this Decision are in accordance with the opinion of the Committee established by Article 75(1) of Directive 2010/75/EU,

HAS ADOPTED THIS DECISION:

Article 1

The best available techniques (BAT) conclusions for the smitheries and foundries industry, as set out in the Annex, are adopted.

([1]) OJ L 334, 17.12.2010, p. 17.
([2]) Commission Decision of 16 May 2011 establishing a forum for the exchange of information pursuant to Article 13 of Directive 2010/75/EU on industrial emissions (OJ C 146, 17.5.2011, p. 3).
([3]) https://circabc.europa.eu/ui/group/06f33a94-9829-4eee-b187-21bb783a0fbf/library/c66a71e9-ce56-47bb-9bba-6d9c79649eee?p=1&n=10&sort=created_DESC.

Article 2

This Decision is addressed to the Member States.

Done at Brussels, 29 November 2024.

For the Commission
Maroš ŠEFČOVIČ
Member of the Commission

ANNEX

1. **Best available techniques (BAT) conclusions for the smitheries and foundries industry**

SCOPE

These BAT conclusions concern the following activities specified in Annex I to Directive 2010/75/EU:

2.3. Processing of ferrous metals:

(b) operation of smitheries with hammers the energy of which exceeds 50 kilojoules per hammer, where the calorific power used exceeds 20 MW.

2.4. Operation of ferrous metal foundries with a production capacity exceeding 20 tonnes per day.

2.5. Processing of non-ferrous metals:

(b) melting, including the alloyage, of non-ferrous metals, including recovered products, and operation of non-ferrous metal foundries, with a melting capacity exceeding 4 tonnes per day for lead and cadmium or 20 tonnes per day for all other metals.

6.11. Independently operated treatment of waste water not covered by Directive 91/271/EEC ([1]), provided that the main pollutant load originates from the activities covered by these BAT conclusions.

These BAT conclusions also cover the following:

— Ferrous metal foundries employing continuous casting processes for the production of grey or nodular iron castings at or near their final shape.

— Non-ferrous metal foundries using alloyed ingots, scrap, recovered products or liquid metal for the production of castings at or near their final shape.

— The combined treatment of waste water from different origins, provided that the main pollutant load originates from the activities covered by these BAT conclusions and that the waste water treatment is not covered by Directive 91/271/EEC ([1]).

— The coating of moulds and cores in ferrous and non-ferrous metal foundries.

— The storage, transfer and handling of materials, including the storage and handling of scrap and sand in foundries.

— Combustion processes directly associated with the activities covered by these BAT conclusions provided that the gaseous products of combustion are put into direct contact with material (such as direct feedstock heating or direct feedstock drying).

These BAT conclusions do not cover the following:

— The continuous casting of iron and/or steel (i.e. to produce thin slabs, thin strips, and sheets). This is covered by the BAT conclusions for Iron and Steel Production (IS).

— The production of semi-finished non-ferrous metal products requiring further forming. This is covered by the BAT conclusions for the Non-Ferrous Metals Industries (NFM).

— The coating of castings. This may be covered by the BAT conclusions for the Surface Treatment Using Organic Solvents including Wood and Wood Products Preservation with Chemicals.

— Forging presses.

— Waste water from indirect cooling systems. This may be covered by the BAT conclusions for Industrial Cooling Systems (ICS).

([1]) Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (OJ L 135, 30.5.1991, p. 40).

— Rolling mills. This is covered by the BAT conclusions for the Ferrous Metals Processing Industry (FMP).

— On-site combustion plants generating hot gases that are not used for direct contact heating, drying or any other treatment of objects or materials. These may be covered by the BAT conclusions for Large Combustion Plants (LCP) or by Directive (EU) 2015/2193 of the European Parliament and of the Council [2].

Other BAT conclusions and reference documents which could be relevant for the activities covered by these BAT conclusions are the following:

— Surface Treatment of Metals and Plastics (STM);

— Waste Treatment (WT);

— Monitoring of Emissions to Air and Water from IED Installations (ROM);

— Economics and Cross-Media Effects (ECM);

— Emissions from Storage (EFS);

— Energy Efficiency (ENE).

These BAT conclusions apply without prejudice to other relevant legislation, e.g. on the registration, evaluation, authorisation and restriction of chemicals (REACH), on classification, labelling and packaging of substances and mixtures (CLP).

[2] Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants (OJ L 313, 28.11.2015, p. 1).

DEFINITIONS

For the purposes of these BAT conclusions, the following definitions apply:

General terms	
Term used	Definition
Casting	A metal workpiece, produced using a casting process, which is ejected or released out of a mould.
Casting process	Pouring molten metal into the cavity of a mould. The molten metal is subsequently allowed to solidify.
Centrifugal casting	Molten metal is poured into a preheated rotating mould, placed either vertically or horizontally depending on the product shape. After pouring, the mould rotates around its central axis creating a centrifugal force which displaces the molten metal towards the periphery, forcing it to deposit on the walls of the mould.
Channelled emissions	Emissions of pollutants into the environment through any kind of duct, pipe, stack, etc.
Clean scrap	Scrap metal which meets at least all of the following characteristics: — free of non-metallic impurities; — free of galvanised, primed or painted scrap parts; — free of oil and grease; — free of explosive can material; — free of tool steels, stainless steels or chrome-alloyed steels, except for steel foundries; — for iron and steel foundries, free of non-ferrous metal scrap parts. Free means that residual impurities are present at such a low level that they do not adversely affect the environmental performance (e.g. increased TVOC, PCDD/F and/or heavy metal emissions) and the operation/safety of the plant.
Cold-setting processes	Curing processes for moulds and cores where the sand binder hardens at ambient temperature. Curing begins immediately after the last component of the sand binder formulation is introduced in the mix.
Continuous casting	Molten metal is poured into a water-cooled die that is open at the bottom or at the side. Through intensive cooling, the outside of the metal product solidifies while it is slowly pulled out of the mould. Subsequently, the product (e.g. bars, tubes, profiles) is cut to the desired product length.
Continuous measurement	Measurement using an automated measuring system permanently installed on site.
Core-making	Production of cores which can be solid or hollow. Cores are inserted into the mould to provide the internal cavities or part of the external shape of the casting before the mould halves are joined.
Diffuse emissions	Non-channelled emissions to air. Diffuse emissions include both fugitive and non-fugitive emissions.
Direct discharge	Discharge to a receiving water body without further downstream waste water treatment.
Dross	Solid substances formed during the melting or holding of metal at the surface of the molten metal, e.g. by oxidation with air.
Existing plant	A plant that is not a new plant.
Feedstock	Any metal input in the smitheries production process.

General terms	
Term used	Definition
Finishing	In foundries, this includes a number of mechanical operations carried out after the casting process including deburring, abrasive cutting, chiselling, needling, fettling, slide grinding, shot blasting and welding. In smitheries, this includes fettling, deburring, machining, cutting and chipping.
Flue-gas	The exhaust gas exiting a combustion unit.
Forging	A deformation and metal-shaping process using heating and hammers (e.g. pneumatic, steam-driven, mechanical, electrical, hydraulic).
Full mould process	Moulding technique using a foam pattern made of expanded polymers (e.g. expanded polystyrene) incorporated in chemically bonded sand. The foam pattern is lost upon pouring. This process is generally used for large castings.
Gas-hardening processes	Curing processes for cores where a catalyst or hardener is injected in a gaseous form into the core box.
Gravity die-casting	Molten metal is poured directly from a ladle into a die under gravity. After solidification, the die is opened and the metal workpiece is released.
Green sand	Mixture of sand, clay (e.g. bentonite) and additives (e.g. coal dust, cereal binders) used for mould making.
Hazardous substances	Hazardous substances as defined in point 18 of Article 3 of Directive 2010/75/EU.
Heat treatment	A thermal process where castings (in foundries) or workpieces (in smitheries) are heated below their melting point to improve their physical properties.
High-pressure die-casting	Molten metal is forced under pressure into a sealed mould cavity. It is held in place by a powerful compressive power until the metal solidifies. After solidification, the die is opened and the metal workpiece is released.
Hot-curing processes	Curing processes for cores or moulds where the sand binder hardens into a heated core box or a heated pattern, both made of metal or wood.
Indirect discharge	A discharge that is not a direct discharge.
Internal scrap	Internal scrap consists of gates, risers, defective castings, and other metal pieces generated within the installation.
Ladle preheating	Ladles used to transfer molten metal from a melting furnace to the casting process are preheated to a controlled temperature in order to dry the ladle after preparation, to minimise thermal shock and refractory wear during pouring and to reduce temperature losses of the molten metal.
Liquid metal output	The amount of liquid metal produced in the melting furnaces.
Lost foam casting	Foam patterns of the parts to be cast, made of expanded polymers (e.g. expanded polystyrene), are produced using automated moulding machines and assembled together into clusters. The clusters are subsequently incorporated in unbonded sand. Upon pouring, the molten metal causes the pyrolysis of the expanded polystyrene and fills the emptied space.

General terms	
Term used	Definition
Low-pressure die-casting	Molten metal is transferred from an airtight furnace through a riser tube into a metal die. The molten metal is pushed upwards into the die under low gas pressure. After solidification, the gas pressure is released allowing the still-molten metal in the riser tube to fall back into the furnace, the die is opened and the casting is released.
Major plant upgrade	A major change in the design or technology of a plant with major adjustments or replacements of the process and/or abatement technique(s) and associated equipment.
Mass flow	The mass of a given substance or parameter which is emitted over a defined period of time.
Metal melting	The production of ferrous or non-ferrous molten metal using furnaces. This also includes melting of, for example, scrap generated on site and heat conservation of molten metal in holding furnaces.
Moulding	Making of a mould into which the molten metal will be poured. This also includes the making of patterns.
Natural sand	Mixture composed of silica sand (e.g. 85 %), clay (e.g. 15 %) and water. Generally, no other additives are added to the mixture.
New plant	A plant first permitted at the site of the installation following the publication of these BAT conclusions or a complete replacement of a plant following the publication of these BAT conclusions.
Nodular iron	Cast iron with carbon in a nodular/spheroidal shape, commonly referred to as ductile iron.
Nodularisation	Treatment of molten cast iron with magnesium or with a rare-earth element to change the carbon particles into a nodular/spheroidal shape.
Periodic measurement	Measurement at specified time intervals using manual or automated methods.
Heating/reheating	A succession of thermal process steps used to raise the temperature of the feedstock before hammering.
Process chemicals	Substances and/or mixtures as defined in Article 3 of Regulation (EC) No 1907/2006 and used in the process(es). Process chemicals may contain hazardous substances and/or substances of very high concern.
Refining of steel	Steel treatment process to remove carbon (decarburisation) from pig iron (primary refining) followed by removal of impurities.
Residue	Substance or object generated by the activities covered by the scope of these BAT conclusions as waste or by-product.
Sand reuse	The process of reusing sand in a foundry after sand reconditioning or reclamation.
Sand reconditioning	Any mechanical operation carried out at the installation to reuse green and/or natural sand. This includes screening, removing tramp metal, separating and removing fines and oversized agglomerates. The sand is then cooled and sent for storage/reuse.
Sand reclamation	Any mechanical and/or thermal operation carried out at the installation to reuse chemically bonded sand or mixed sand. This includes an initial mechanical step (e.g. crushing, screening) followed by mechanical (e.g. grinding wheel, impact drum) and/or thermal (e.g. fluidised bed, rotary furnaces) processes in order to remove the residual binders.
Sensitive receptors	Areas which need special protection, such as: — residential areas; — areas where human activities are carried out (e.g. neighbouring workplaces, schools, day-care centres, recreational areas, hospitals or nursing homes).
Slag	Liquid substances that do not dissolve in liquid metal but separate easily from them and form a separate layer on the liquid metal because of their lower density. Slag is formed by the oxidation of non-metallic elements that are present in the metal charge.
Substances of very high concern	Substances meeting the criteria mentioned in Article 57 and included in the Candidate List of Substances of Very High Concern, according to the REACH Regulation ((EC) No 1907/2006 ([1])).

General terms	
Term used	Definition
Surface run-off water	Water from precipitation that flows over land or impervious surfaces, such as paved streets, storage areas and rooftops, and does not soak into the ground.
Treatment of molten metal	Refining operations in aluminium melting processes which include degassing, grain refining, and fluxing. Degassing (i.e. removal of dissolved hydrogen using nitrogen) is often combined with cleaning (i.e. removal of alkali or alkaline earth metal such as Ca) using Cl_2 gas.
Valid hourly (or half-hourly) average	An hourly (or half-hourly) average is considered valid when there is no maintenance or malfunction of the automated measuring system.

([1]) Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ L 396, 30.12.2006, p. 1).

Pollutants and parameters	
Term used	Definition
Amines	Collective term for derivatives of ammonia in which one or more of the hydrogen atoms has been replaced by an alkyl or aryl group.
AOX	Adsorbable organically bound halogens, expressed as Cl, include adsorbable organically bound chlorine, bromine and iodine.
As	The sum of arsenic and its compounds, dissolved or bound to particles, expressed as As.
B[a]P	Benzo[a]pyrene.
BOD_5	Biochemical oxygen demand. Amount of oxygen needed for the biochemical oxidation of organic and/or inorganic matter in 5 (BOD_5) days.
Cd	The sum of cadmium and its compounds, dissolved or bound to particles, expressed as Cd.
Cl_2	Elemental chlorine.
CO	Carbon monoxide.
COD	Chemical oxygen demand. Amount of oxygen needed for the total chemical oxidation of the organic matter to carbon dioxide using dichromate. COD is an indicator for the mass concentration of organic compounds.
Cr	The sum of chromium and its compounds, dissolved or bound to particles, expressed as Cr.
Cu	The sum of copper and its compounds, dissolved or bound to particles, expressed as Cu.
Dust	Total particulate matter (in air).
Fe	The sum of iron and its compounds, dissolved or bound to particles, expressed as Fe.
HCl	Hydrogen chloride.
HF	Hydrogen fluoride.
Hg	The sum of mercury and its compounds, dissolved or bound to particles, expressed as Hg.
HOI	Hydrocarbon oil index. The sum of compounds extractable with a hydrocarbon solvent (including long-chain or branched aliphatic, alicyclic, aromatic or alkyl-substituted aromatic hydrocarbons).
Mg	Magnesium.
MgO	Magnesium oxide.
MgS	Magnesium sulphide.
$MgSO_4$	Magnesium sulphate.
Ni	The sum of nickel and its compounds, dissolved or bound to particles, expressed as Ni.
NO_X	The sum of nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as NO_2.
PCDD/F	Polychlorinated dibenzo-p-dioxins/furans.
Phenol index	The sum of phenolic compounds, expressed as phenol concentration and measured according to EN ISO 14402.

Pollutants and parameters	
Term used	Definition
Pb	The sum of lead and its compounds, dissolved or bound to particles, expressed as Pb (in water). The sum of lead and its compounds, expressed as Pb (in air).
SO_2	Sulphur dioxide.
TOC	Total organic carbon, expressed as C (in water), includes all organic compounds.
TSS	Total suspended solids. Mass concentration of all suspended solids (in water), measured via filtration through glass fibre filters and gravimetry.
Total nitrogen (TN)	Total nitrogen, expressed as N, includes free ammonia and ammonium nitrogen (NH4-N), nitrite nitrogen (NO2-N), nitrate nitrogen (NO3-N) and organically bound nitrogen.
TVOC	Total volatile organic carbon, expressed as C (in air).
VOC	Volatile organic compound as defined in Article 3(45) of Directive 2010/75/EU.
Zn	The sum of zinc and its compounds, dissolved or bound to particles, expressed as Zn.

ACRONYMS

For the purposes of these BAT conclusions, the following acronyms apply.

Acronym	Definition
CBC	Cold blast cupola
CMS	Chemicals management system
CMR	Carcinogenic, mutagenic or toxic for reproduction.
CMR 1A	CMR substance of category 1A as defined in Regulation (EC) No 1272/2008 as amended, i.e. carrying the hazard statements H340, H350, H360.
CMR 1B	CMR substance of category 1B as defined in Regulation (EC) No 1272/2008 as amended, i.e. carrying the hazard statements H340, H350, H360.
CMR 2	CMR 2 CMR substance of category 2 as defined in Regulation (EC) No 1272/2008 as amended, i.e. carrying the hazard statements H341, H351, H361.
DMEA	N,N-Dimethylethylamine
EAF	Electric arc furnace
EMS	Environmental management system
ESP	Electrostatic precipitator
HBC	Hot blast cupola
HPDC	High-pressure die-casting
NFM	Non-ferrous metal
OME	Operational material efficiency
OTNOC	Other than normal operating conditions
TEA	Triethylamine

GENERAL CONSIDERATIONS

Best available techniques

The techniques listed and described in these BAT conclusions are neither prescriptive nor exhaustive. Other techniques may be used that ensure at least an equivalent level of environmental protection.

Unless otherwise stated, the BAT conclusions are generally applicable.

Emission levels associated with the best available techniques (BAT-AELs) and indicative emission levels for emissions to air

In foundries, the BAT-AELs and indicative emission levels for emissions to air given in these BAT conclusions refer to concentrations (mass of emitted substances per volume of waste gas) under the following standard conditions: dry gas at a temperature of 273,15 K and a pressure of 101,3 kPa, without correction to a reference oxygen level, and expressed in the unit mg/Nm^3 or ng WHO-TEQ/Nm^3.

In smitheries, the BAT-AEL and indicative emission level for emissions to air given in these BAT conclusions refer to concentrations (mass of emitted substances per volume of waste gas) under the following standard conditions: dry gas at a temperature of 273,15 K and a pressure of 101,3 kPa, corrected at a reference oxygen level of 3 dry vol-% and expressed in the unit mg/Nm^3.

The equation for calculating the emission concentration at the reference oxygen level is:

$$E_R = \frac{21 - O_R}{21 - O_M} \times E_M$$

where: E_R: emission concentration at the reference oxygen level O_R;

O_R: reference oxygen level in vol-%;

E_M: measured emission concentration;

O_M: measured oxygen level in vol-%.

For averaging periods of BAT-AELs and indicative emission levels for channelled emissions to air, the following definitions apply:

Type of measurement	Averaging period	Definition
Continuous	Daily average	Average over a period of 1 day based on valid hourly or half-hourly averages.
Periodic	Average over the sampling period	Average value of three consecutive samplings/measurements of at least 30 minutes each ([1]).

([1]) For any parameter where, due to sampling or analytical limitations and/or due to operational conditions (e.g. batch processes), a 30-minute sampling/measurement and/or an average of three consecutive samplings/measurements is inappropriate, a more representative sampling/measurement procedure may be employed. For PCDD/F, one sampling period of 6 to 8 hours is used.

When the waste gases of two or more sources (e.g. furnaces) are discharged through a common stack, the BAT-AELs apply to the combined discharge from the stack.

For the purpose of calculating the mass flows in relation to BAT 12, where waste gases with similar characteristics, e.g. containing the same (type of) substances/parameters, and discharged through two or more separate stacks could, in the judgement of the competent authority, be discharged through a common stack, these stacks shall be considered as a single stack.

Emission levels associated with the best available techniques (BAT-AELs) for emissions to water

The BAT-AELs for emissions to water given in these BAT conclusions refer to concentrations (mass of emitted substances per volume of water), expressed in mg/l.

Averaging periods associated with the BAT-AELs refer to either of the following two cases:

— In the case of continuous discharge, daily average values, i.e. 24-hour flow-proportional composite samples.

— In the case of batch discharge, average values over the release duration taken as flow-proportional composite samples, or, provided that the effluent is appropriately mixed and homogeneous, a spot sample taken before discharge.

Time-proportional composite samples can be used provided that sufficient flow stability is demonstrated. Alternatively, spot samples may be taken, provided that the effluent is appropriately mixed and homogeneous.

The BAT-AELs apply at the point where the emission leaves the installation.

Other environmental performance levels associated with the best available techniques (BAT-AEPLs) and indicative levels

BAT-AEPLs for specific energy consumption (foundries)

The BAT-AEPLs for specific energy consumption refer to yearly averages calculated using the following equation:

$$\text{specific energy consumption} = \frac{\text{energy consumption rate}}{\text{activity rate}}$$

where:

energy consumption rate:	total amount of heat (generated from primary energy sources) and electricity consumed by the relevant process(es) (melting and holding, ladle preheating) in foundries, expressed in kWh/year; and
activity rate:	total amount of liquid metal output, expressed in t/year.

The energy consumption rate corresponds to the total amount of heat (generated from primary energy sources) and electricity consumed by all furnaces in the relevant process(es): melting and holding, ladle preheating.

Indicative levels for specific energy consumption (smitheries)

The indicative levels for specific energy consumption refer to yearly averages calculated using the following equation:

$$\text{specific energy consumption} = \frac{\text{energy consumption rate}}{\text{activity rate}}$$

where:

energy consumption rate:	total amount of heat (generated from primary energy sources) and electricity consumed by the plant in smitheries, expressed in kWh/year; and
activity rate:	total amount of feedstock, expressed in t/year.

BAT-AEPLs for specific water consumption (foundries)

The BAT-AEPLs for specific water consumption refer to yearly averages calculated using the following equation:

$$\text{specific water consumption} = \frac{\text{water consumption rate}}{\text{activity rate}}$$

where:

water consumption rate:	total amount of water consumed by the plant excluding: — recycled and reused water, and — cooling water used in once-through cooling systems, and — water for domestic-type usage, expressed in m^3/year; and
activity rate:	total amount of liquid metal output, expressed in t/year.

BAT-AEPLs for specific amount of waste sent for disposal (foundries)

The BAT-AEPLs for specific amount of waste sent for disposal refer to yearly averages calculated using the following equation:

$$\text{specific amount of waste sent for disposal} = \frac{\text{waste disposal rate}}{\text{activity rate}}$$

where:

waste disposal rate:	total amount of *waste* sent for disposal, expressed in kg/year; and
activity rate:	total amount of liquid metal output, expressed in t/year.

Indicative levels for operational material efficiency (OME) (foundries)

The indicative levels for OME refer to yearly averages expressed as a percentage and calculated using the following equation:

$$\text{operational material efficiency (OME)} = \frac{\text{good casting rate}}{\text{activity rate}} \times 100$$

where:

good casting rate:	total amount of final castings produced at the installation without defects, expressed in t/year; and
activity rate:	total amount of liquid metal output, expressed in t/year.

BAT-AEPLs for sand reuse (foundries)

The BAT-AEPLs for sand reuse refer to yearly averages expressed as a percentage and calculated using the following equation:

$$\text{sand reuse ratio} = \frac{\text{amount of reused sand}}{\text{total amount of sand used}} \times 100$$

where:

amount of reused sand:	total amount of reused sand, originating from reconditioning or reclamation, expressed in t/year; and
total amount of sand used:	total amount of sand used, expressed in t/year.

1.1. *General BAT conclusions*

1.1.1. Overall environmental performance

BAT 1. In order to improve the overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS) that incorporates all of the following features:

(i) commitment, leadership, and accountability of the management, including senior management, for the implementation of an effective EMS;

(ii) an analysis that includes the determination of the organisation’s context, the identification of the needs and expectations of interested parties, the identification of characteristics of the installation that are associated with possible risks for the environment as well as of the applicable legal requirements relating to the environment and human health;

(iii) development of an environmental policy that includes the continuous improvement of the environmental performance of the installation;

(iv) establishing objectives and performance indicators in relation to significant environmental aspects, including safeguarding compliance with applicable legal requirements;

(v) planning and implementing the necessary procedures and actions (including corrective and preventive actions where needed), to achieve the environmental objectives and avoid environmental risks;

(vi) determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed;

(vii) ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g. by providing information and training);

(viii) internal and external communication;

(ix) fostering employee involvement in good environmental management practices;

(x) establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records;

(xi) effective operational planning and process control;

(xii) implementation of appropriate maintenance programmes;

(xiii) emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations;

(xiv) when (re)designing a (new) installation or a part thereof, consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning;

(xv) implementation of a monitoring and measurement programme; if necessary, information can be found in the Reference Report on Monitoring of Emissions to Air and Water from IED Installations;

(xvi) application of sectoral benchmarking on a regular basis;

(xvii) periodic independent (as far as practicable) internal auditing and periodic independent external auditing in order to assess the environmental performance and to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;

(xviii) evaluation of causes of nonconformities, implementation of corrective actions in response to nonconformities, review of the effectiveness of corrective actions, and determination of whether similar nonconformities exist or could potentially occur;

(xix) periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness;

(xx) following and taking into account the development of cleaner techniques.

Specifically for the smitheries and foundries industry, BAT is also to incorporate the following features in the EMS:

(xxi) an inventory of inputs and outputs (see BAT 2);

(xxii) a chemicals management system (see BAT 3);

(xxiii) a plan for the prevention and control of leaks and spillages (see BAT 4 (a));

(xxiv) an OTNOC management plan (see BAT 5);

(xxv) an energy efficiency plan and audits (see BAT 7 (a));

(xxvi) a water management plan and audits (see BAT 35 (a));

(xxvii) a noise and/or vibration management plan (see BAT 8);

(xxviii) a residues management plan (see BAT 10);

(xxix) an odour management plan for foundries (see BAT 32).

Note

Regulation (EC) No 1221/2009 establishes the European Union eco-management and audit scheme (EMAS), which is an example of an EMS consistent with this BAT.

Applicability

The level of detail and the degree of formalisation of the EMS will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

BAT 2. In order to improve the overall environmental performance, BAT is to establish, maintain and regularly review (including when a significant change occurs) an inventory of inputs and outputs, as part of the EMS (see BAT 1), that incorporates all of the following features:

(i) information about the production processes, including:

(a) simplified process flow sheets that show the origin of the emissions to air, water and soil;

(b) descriptions of process-integrated techniques and waste water/waste gas treatment techniques to prevent or reduce emissions, including their performance (e.g. abatement efficiency);

(ii) information about the quantity and characteristics of raw materials (e.g. scrap, feedstock, sand) and fuels (e.g. coke) used;

(iii) information about water consumption and usage (e.g. flow diagrams and water mass balances);

(iv) information about energy consumption and usage;

(v) information about the characteristics of the waste water streams, such as:

(a) average values and variability of flow, pH, temperature and conductivity;

(b) average concentration and mass flow values of relevant substances/parameters (e.g. total suspended solids, TOC or COD, hydrocarbon oil index, metals) and their variability;

(vi) information about the quantity and characteristics of the process chemicals used:

(a) the identity and the characteristics of process chemicals, including properties with adverse effects on the environment and/or human health;

(b) the quantities of process chemicals used and the location of their use;

(vii) information about the characteristics of the waste gas streams, such as:

(a) average values and variability of flow and temperature;

(b) average concentration and mass flow values of relevant substances (e.g. dust, NO_X, SO_2, CO, metals) and their variability;

(c) presence of other substances that may affect the waste gas treatment system (e.g. oxygen, nitrogen, water vapour) or installation safety;

(d) presence of substances classified as CMR 1A, CMR 1B or CMR 2; the presence of such substances may for example be assessed according to the criteria of Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP);

(viii) information about the quantity and characteristics of residues generated.

Applicability

The level of detail and the degree of formalisation of the inventory will generally be related to the nature, scale and complexity of the plant, and the range of environmental impacts it may have.

BAT 3. In order to improve the overall environmental performance, BAT is to elaborate and implement a chemicals management system (CMS), as part of the EMS (see BAT 1), that incorporates all of the following features:

(i) A policy to reduce the consumption of and risks associated with process chemicals, including a procurement policy to select less harmful process chemicals and their suppliers with the aim of minimising the use of and risks associated with hazardous substances and substances of very high concern as well as to avoid the procurement of an excess amount of process chemicals. The selection of process chemicals is based on:

(a) the comparative analysis of their bioeliminability/biodegradability, eco-toxicity and potential to be released into the environment in order to reduce emissions to the environment;

(b) the characterisation of the risks associated with the process chemicals, based on the chemicals' hazards classification, pathways through the plant, potential release and level of exposure;

(c) the potential for recovery and reuse (see BAT 17 (f));

(d) the regular (e.g. annual) analysis of the potential for substitution with the aim to identify potentially new available and safer alternatives to the use of hazardous substances and substances of very high concern; this may be achieved by changing process(es) or using other process chemicals with no or lower environmental impacts (see BAT 11 for foundries);

(e) the anticipatory monitoring of regulatory changes related to hazardous substances and substances of very high concern, and the safeguarding of compliance with applicable legal requirements.

The inventory of process chemicals (see BAT 2 (vi)) may be used to provide and keep the information needed for the selection of process chemicals.

(ii) Goals and action plans to avoid or reduce the use of and risks associated with hazardous substances and substances of very high concern.

(iii) Development and implementation of procedures for the procurement, handling, storage, and use of process chemicals, disposal of waste containing process chemicals and return of unused process chemicals, to prevent or reduce emissions to the environment (e.g. see BAT 4).

Applicability

The level of detail and degree of formalisation of the CMS will generally be related to the nature, scale and complexity of the plant.

BAT 4. In order to prevent or reduce emissions to soil and groundwater, BAT is to use all of the techniques given below.

Technique		Description	Applicability
a	Set-up and implementation of a plan for the prevention and control of leaks and spillages	A plan for the prevention and control of leaks and spillages is part of the EMS (see BAT 1) and includes, but is not limited to: — site incident plans for small and large spillages; — identification of the roles and responsibilities of persons involved; — ensuring staff are environmentally aware and trained to prevent and deal with spillage incidents; — identification of areas at risk of spillage and/or leaks of hazardous materials and substances of very high concern, and ranking them according to the risk; — identification of suitable spillage containment and clean-up equipment and regularly ensuring it is available, in good working order and close to points where these incidents may occur; — waste management guidelines for dealing with waste arising from spillage control; — regular (at least on an annual basis) inspections of storage and handling areas, testing and calibration of leak detection equipment and prompt repair of leaks from valves, glands, flanges, etc.	The level of detail of the plan will generally be related to the nature, scale and complexity of the plant, as well as to the type and quantity of liquids used.
b	Structuring and management of process areas and raw material storage areas	This includes techniques such as: — impermeable (for example, cemented) floor for process areas and for scrap/feedstock yards; — separate storage for various types of raw materials, close to the production lines; this can be achieved using, for example, compartments or boxes in the storage areas, bunkers.	Generally applicable.
c	Prevention of the contamination of surface run-off water	Production areas and/or areas where process chemicals, residues or waste are stored or handled are protected against surface run-off water. This is achieved by using at least the following techniques: — drainage channels and/or an outer kerb bund around the plant; — roofing with roof guttering of process and/or storage areas.	Generally applicable.
d	Collection of potentially contaminated surface run-off water	Surface run-off water from areas that are potentially contaminated is collected separately and only discharged after appropriate measures are taken, e.g. monitoring, treatment, reuse.	Generally applicable.

	Technique	Description	Applicability
e	Safe handling and storage of process chemicals	This includes the following: — storage in roofed and ventilated areas with floors impermeable to the liquids concerned; — use of oil-tight trays or cellars for hydraulic stations and oil- or grease-lubricated equipment; — collection of spilled liquid; — loading/unloading areas for process chemicals, lubricants and coatings, etc. are designed and constructed in such a way that potential leaks and spillages are contained and sent to on-site treatment (see BAT 36) or off-site treatment. — highly flammable liquids (e.g. methyl formate, TEA, DMEA, mould coatings containing alcohol) are stored separately from incompatible substances (e.g. oxidisers) in enclosed and well-ventilated storage areas.	Generally applicable.
f	Good housekeeping	A set of measures aiming at preventing, or reducing, the generation of emissions (e.g. regular maintenance and cleaning of equipment, work surfaces, floors and transport routes, and containment as well as rapid clean-up of any spillages).	Generally applicable.

BAT 5. In order to reduce the frequency of the occurrence of OTNOC and to reduce emissions during OTNOC, BAT is to set up and implement a risk-based OTNOC management plan as part of the EMS (see BAT 1) that includes all of the following elements:

(i) identification of potential OTNOC (e.g. failure of equipment critical to the protection of the environment ('critical equipment')), of their root causes and of their potential consequences;

(ii) appropriate design of critical equipment (e.g. off-gas treatment, waste water treatment);

(iii) set-up and implementation of an inspection plan and preventive maintenance programme for critical equipment (see BAT 1 (xii));

(iv) monitoring (i.e. estimating or, where possible, measuring) and recording of emissions during OTNOC and of associated circumstances;

(v) periodic assessment of the emissions occurring during OTNOC (e.g. frequency of events, duration, amount of pollutants emitted) and implementation of corrective actions if necessary;

(vi) regular review and update of the list of identified OTNOC under point i following the periodic assessment of point (v);

(vii) regular testing of backup systems.

Applicability

The level of detail and degree of formalisation of the OTNOC management plan will generally be related to the nature, scale and complexity of the plant, and the range of environmental impacts it may have.

1.1.2. **Monitoring**

BAT 6. BAT is to monitor at least once every year:

— the consumption of water, energy and materials used, including process chemicals, expressed as a yearly average;

— the amount of waste water generated, expressed as a yearly average;

— the amount of each type of materials recovered, recycled and/or reused, expressed as a yearly average;

— the amount of each type of residues generated and of each type of waste sent for disposal, expressed as a yearly average.

Description

Monitoring preferentially includes direct measurements. Calculations or recording, e.g. using suitable meters or invoices, can also be used. The monitoring is broken down to the most appropriate level (e.g. to process or plant level) and considers any significant changes in the process or plant.

1.1.3. **Energy efficiency**

BAT 7. In order to increase the overall energy efficiency of the plant, BAT is to use all of the techniques given below.

<table>
<tr><th colspan="2">Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td colspan="4">Management techniques</td></tr>
<tr><td>a.</td><td>Energy efficiency plan and audits</td><td>An energy efficiency plan is part of the EMS (see BAT 1) and entails defining and monitoring the specific energy consumption of the activity/processes (e.g. kWh/t liquid metal), setting objectives in terms of energy efficiency and implementing actions to achieve these objectives.
Audits (also part of the EMS, see BAT 1) are carried out at least once every year to ensure that the objectives of the energy efficiency plan are met and the audits recommendations are followed up and implemented.
The energy efficiency plan may be integrated in the overall energy efficiency plan of a larger installation (e.g. surface treatment activities).</td><td rowspan="2">The level of detail of the energy efficiency plan, of the audits and of the balance record will generally be related to the nature, scale and complexity of the plant and the types of energy sources used.</td></tr>
<tr><td>b.</td><td>Energy balance record</td><td>Drawing up an energy balance record once every year which provides a breakdown of the energy consumption and generation (including energy export) by the type of energy source, for example:
— energy consumption: electricity, natural gas, renewable energy, imported heat and/or cooling;
— energy generation: electricity and/or steam.
This includes:
— definition of the energy boundaries of the processes;
— information on energy consumption in terms of delivered energy;</td></tr>
</table>

Technique		Description	Applicability
		— information on energy exported from the plant; — energy flow information (e.g. Sankey diagrams or energy balances) showing how the energy is used throughout the processes.	

Process and equipment selection and optimisation

c.	Use of general energy-saving techniques	This includes techniques such as: — burner maintenance and control; — energy-efficient motors; — energy-efficient lighting; — optimising steam and compressed air distribution systems; — regular inspection and maintenance of the steam distribution systems to prevent or reduce steam leaks; — process control systems; — variable speed drives; — optimising air conditioning and building heating.	Generally applicable.

Further sector-specific techniques to increase energy efficiency are given in Sections 1.2.1.3, 1.2.2.1, 1.2.4.1 and 1.3.1 of these BAT conclusions.

1.1.4. **Noise and vibrations**

BAT 8. In order to prevent or, where that is not practicable, to reduce emissions of noise and vibrations, BAT is to set up, implement and regularly review a noise and/or vibration management plan, as part of the EMS (see BAT 1), that includes all of the following elements:

— a protocol containing appropriate actions and timelines;

— a protocol for monitoring emissions of noise and/or vibrations;

— a protocol for responding to identified noise and vibration events, e.g. managing complaints and/or taking corrective actions;

— a noise and/or vibration reduction programme designed to identify the source(s), to measure/estimate noise and/or vibration exposure, to characterise the contributions of the sources and to implement prevention and/or reduction measures.

Applicability

The applicability is restricted to cases where a noise and/or vibration nuisance at sensitive receptors is expected and/or has been substantiated.

BAT 9. In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Appropriate location of equipment and buildings	Increasing the distance between the emitter and the receiver, by using buildings as noise screens and by relocating equipment and/or building openings.	For existing plants, the relocation of equipment and openings of the buildings may not be applicable due to a lack of space and/or excessive costs.

Technique		Description	Applicability
b.	Operational measures	These include at least the following: — inspection and maintenance of equipment; — closing of doors and windows of enclosed areas, if possible, or use of self-closing doors; — equipment operation by experienced staff; — avoidance of noisy activities at night, if possible; — provisions for noise control, during production and maintenance activities, transport and handling of feedstock and materials, e.g. reducing the number of material transfer operations, reducing the height from which pieces fall on to hard surfaces.	Generally applicable.
c.	Low-noise equipment	This includes direct drive motors; low-noise compressors, pumps and fans; low-noise transportation equipment.	
d.	Noise control equipment	This includes techniques such as: — use of noise reducers; — use of acoustic insulation of equipment; — enclosure of noisy equipment and processes (e.g. unloading of raw materials, hammering, compressors, fans, shake-out, finishing); — use of building materials with high sound insulation properties (e.g. for walls, roofs, windows, doors).	Applicability to existing plants may be restricted by a lack of space.
e.	Noise abatement	Inserting obstacles between emitters and receivers (e.g. protection walls, embankments).	Only applicable to existing plants, as the design of new plants should make this technique unnecessary. For existing plants, the insertion of obstacles may not be applicable due to a lack of space.

1.1.5. **Residues**

BAT 10. In order to increase material efficiency and reduce the amount of waste sent for disposal, BAT is to set up, implement and regularly review a residues management plan.

Description

A residues management plan is part of the EMS (see BAT 1) and comprises a set of measures aiming to:

I. minimise the generation of residues;

II. optimise the reuse, recycling and/or recovery of residues; and

III. ensure the proper disposal of waste.

The residues management plan may be integrated in the overall residues management plan of a larger installation (e.g. surface treatment activities).

Applicability

The level of detail and the degree of formalisation of the residues management plan will generally be related to the nature, scale and complexity of the plant.

1.2. *BAT conclusions for foundries*

The BAT conclusions in this section do not apply to cadmium, titanium and precious metal foundries, as well as bell and art casting.

1.2.1. **General BAT conclusions for foundries**

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 1.1.

1.2.1.1. *Hazardous substances and substances of very high concern*

BAT 11. In order to prevent or reduce the use of hazardous substances and substances of very high concern in moulding and core-making with chemically bonded sand, BAT is to use alternative substances which are non- or less hazardous.

Description

Hazardous substances and substances of very high concern used in moulding and core-making are substituted by non-hazardous substances or – when this is not feasible – by less hazardous substances, by using for example:

— aliphatic organic (instead of aromatic) binders in moulding and core-making (see BAT 25 (d), (e) and (f));

— non-aromatic solvents for cold-box core-making (see BAT 25 (j));

— inorganic binders in moulding and core-making (see BAT 25 (d), (e) and (f));

— water-based coatings in moulding and core-making (see BAT 25 (l)).

1.2.1.2. *Monitoring of emissions*

1.2.1.2.1. Monitoring of emissions to air

BAT 12. BAT is to monitor channelled emissions to air with at least the frequency given below, and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Substance/Parameter	Process(es)/source(s)	Foundry/furnace type	Standard(s)	Minimum monitoring frequency [1]	Monitoring associated with
Amines	Moulding using lost moulds and core-making [2]	All	No EN standard available	Once every year	BAT 26
Benzene	Moulding using lost moulds and core-making [3]	All	No EN standard available		BAT 26
	Casting, cooling and shake-out using lost moulds including full mould process [3]				BAT 27

Substance/Parameter	Process(es)/source(s)	Foundry/furnace type	Standard(s)	Minimum monitoring frequency ([1])	Monitoring associated with
B[a]P	Metal melting ([4])	Cast iron	No EN standard available	Once every year	-
Carbon monoxide (CO)	Heat treatment ([5])	All	EN 15058	Once every year	BAT 24
	Metal melting	Cast iron: CBC, HBC and rotary furnaces			BAT 38
		NFM ([5])			BAT 43
Dust	Heat treatment ([4])	All	EN 13284-1 ([7]) ([8])	Once every year	BAT 24
	Metal melting			Once every year ([6])	BAT 38 BAT 40 BAT 43
	Nodularisation ([9])	Cast iron		Once every year	BAT 39
	Refining	Steel			BAT 41
	Moulding using lost moulds and core-making	All			BAT 26
	Casting, cooling and shake-out using lost moulds including full mould process	All			BAT 27
	Finishing	All			BAT 30
	Lost foam casting	Cast iron and NFM			BAT 28
	Casting in permanent moulds	All			BAT 29
	Sand reuse	All			BAT 31
Formaldehyde ([4])	Moulding using lost moulds and core-making	All	EN standard under development	Once every year	BAT 26
	Casting, cooling and shake-out using lost moulds including full mould process			Once every year	BAT 27

Substance/Parameter		Process(es)/source(s)	Foundry/furnace type	Standard(s)	Minimum monitoring frequency ([1])	Monitoring associated with
Gaseous chlorides		Metal melting	Cast iron: CBC, HBC and rotary furnaces ([4])	EN 1911	Once every year	BAT 38
			Aluminium ([4])			BAT 43
Gaseous fluorides		Metal melting	Cast iron: CBC, HBC and rotary furnaces ([4])	EN standard under development		BAT 38
			Aluminium			BAT 43
Metals	Cadmium and its compounds	Casting, cooling and shake-out using lost moulds including full mould process ([4])	All	EN 14385	Once every year	-
		Metal melting	All		Once every year	-
		Finishing ([4])	All		Once every year	-
	Chromium and its compounds	Casting, cooling and shake-out using lost moulds including full mould process ([4])	All		Once every year	-
		Metal melting ([4])	All		Once every year	-
		Finishing ([4])	All		Once every year	-
	Nickel and its compounds	Casting, cooling and shake-out using lost moulds including full mould process ([4])	All		Once every year	-
		Metal melting ([4])	All		Once every year	-
		Finishing ([4])	All		Once every year	-

Substance/Parameter	Process(es)/source(s)	Foundry/furnace type	Standard(s)	Minimum monitoring frequency (1)	Monitoring associated with
Lead and its compounds	Casting, cooling and shake-out using lost moulds including full mould process (4)	All		Once every year	-
Lead and its compounds	Metal melting	Cast iron: CBC and HBC (4)		Once every year	BAT 38
Lead and its compounds	Metal melting	NFM (10)		Once every year	BAT 43
Lead and its compounds	Casting in permanent moulds	Lead		Once every year	BAT 29
Lead and its compounds	Finishing (4)	All		Once every year	-
Zinc and its compounds	Metal melting (4)	All		Once every year	-
Nitrogen oxides (NO_X)	Heat treatment (5)	All	EN 14792	Once every year	BAT 24
Nitrogen oxides (NO_X)	Thermal sand regeneration, except for sand originating from the cold-box process (5)	All	EN 14792	Once every year	BAT 31
Nitrogen oxides (NO_X)	Thermal regeneration of sand originating from the cold-box process	All	EN 14792	Once every year	BAT 31
Nitrogen oxides (NO_X)	Metal melting	Cast iron: CBC, HBC and rotary furnaces	EN 14792	Once every year	BAT 38
Nitrogen oxides (NO_X)	Metal melting	NFM (5)	EN 14792	Once every year	BAT 43
PCDD/F	Metal melting	Cast iron: CBC, HBC and rotary furnaces	EN 1948-1, EN 1948-2, EN 1948-3	Once every year	BAT 38
PCDD/F	Metal melting	Cast iron: Induction (4)	EN 1948-1, EN 1948-2, EN 1948-3	Once every year	BAT 38
PCDD/F	Metal melting	Steel and NFM (4)	EN 1948-1, EN 1948-2, EN 1948-3	Once every year	BAT 40 BAT 43
Phenol	Moulding using lost moulds and core-making (11)	All	No EN standard available	Once every year	BAT 26
Phenol	Casting, cooling and shake-out using lost moulds including full mould process (11)	All	No EN standard available	Once every year	BAT 27

Substance/Parameter	Process(es)/source(s)	Foundry/furnace type	Standard(s)	Minimum monitoring frequency [1]	Monitoring associated with
Sulphur dioxide (SO_2)	Thermal regeneration of sand in which sulphonic acid catalysts have been used	All	EN 14791	Once every year	BAT 31
	Metal melting	Cast iron: CBC, HBC and rotary furnaces			BAT 38
		NFM [5] [12]			BAT 43
Total volatile organic carbon (TVOC)	Moulding using lost moulds and core-making	All	EN 12619		BAT 26
	Lost foam, casting				BAT 28
	Casting, cooling and shake-out using lost moulds including full mould process				BAT 27
	Sand reuse				BAT 31
	Metal melting	Cast iron			BAT 38
		Steel and NFM [4]			-
	Casting in permanent moulds [13]	All [4]			BAT 29

[1] To the extent possible, the measurements are carried out at the highest expected emission state under normal operating conditions.
[2] The monitoring only applies in the cold-box process when amines are used.
[3] The monitoring only applies when aromatic binders/chemicals are used or when the full mould process is used.
[4] The monitoring only applies when the substance/parameter concerned is identified as relevant in the waste gas stream based on the inventory of inputs and outputs mentioned in BAT 2.
[5] The monitoring does not apply when only electricity is used.
[6] For any stack associated with a cupola furnace and with a dust mass flow > 0,5 kg/h, continuous monitoring applies.
[7] If measurements are continuous, the following generic EN standards apply instead: EN 15267-1, EN 15267-2, EN 15267-3, and EN 14181.
[8] If measurements are continuous, EN 13284-2 also applies.
[9] The monitoring does not apply when BAT 39 (a) is used.
[10] The monitoring only applies to lead foundries or to other NFM foundries using lead as an alloying element.
[11] The monitoring only applies when phenolic-based binder systems are used.
[12] The monitoring does not apply when only natural gas is used.
[13] The monitoring only applies when cores with chemically bonded sand are used.

1.2.1.2.2. Monitoring of emissions to water

BAT 13. BAT is to monitor emissions to water with at least the frequency given below, and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Substance/parameter		Process	Standard(s)	Minimum monitoring frequency ([1])	Monitoring associated with
Adsorbable organically bound halogens (AOX) ([2])		Waste water from wet scrubbing of cupola off-gases	EN ISO 9562	Once every 3 months ([3])	BAT 36
Biochemical oxygen demand (BOD_5) ([3])		Die-casting, off-gas treatment (e.g. wet scrubbing), finishing, heat treatment, contaminated surface run-off water, direct cooling, wet sand regeneration and cupola furnace slag granulation.	Various EN standards available (e.g. EN 1899-1, EN ISO 5815)		
Chemical oxygen demand (COD) ([3]) ([4])			No EN standard available		
Hydrocarbon oil index (HOI) ([2])			EN ISO 9377-2		
Metals/ metalloids	Arsenic (As) ([2])		Various EN standards available (e.g. EN ISO 11885, EN ISO 15586, EN ISO 17294-2)		
	Cadmium (Cd) ([2])				
	Chromium (Cr) ([2])				
	Copper (Cu) ([2])				
	Iron (Fe) ([2])				
	Lead (Pb) ([2])				
	Nickel (Ni) ([2])				
	Zinc (Zn) ([2])				
	Mercury (Hg) ([2])		Various EN standards available (e.g. EN ISO 12846, EN ISO 17852)		
Phenol index ([5])			EN ISO 14402		
Total nitrogen (TN) ([3])			Various EN standards available (e.g. EN 12260, EN ISO 11905-1)		
Total organic carbon (TOC) ([3]) ([4])			EN 1484		
Total suspended solids (TSS) ([3])			EN 872		

([1]) In the case of batch discharge less frequent than the minimum monitoring frequency, monitoring is carried out once per batch.
([2]) The monitoring only applies when the substance/parameter is identified as relevant in the waste water stream based on the inventory of inputs and outputs mentioned in BAT 2.
([3]) In the case of an indirect discharge, the minimum monitoring frequency may be reduced to once every 6 months if the downstream waste water treatment plant is designed and equipped appropriately to abate the pollutants concerned.
([4]) Either COD or TOC is monitored. TOC monitoring is the preferred option because it does not rely on the use of very toxic compounds.
([5]) The monitoring only applies when phenolic binding systems are used.

1.2.1.3. *Energy efficiency*

BAT 14. In order to increase energy efficiency, BAT is to use all of the techniques (a) to (f), and an appropriate combination of the techniques (g) to (n) given below.

	Technique	Description	Applicability
Design and operation			
a.	Selection of an energy-efficient type of furnace	See Section 1.4.1.	Only applicable to new plants and/or major plant upgrades.
b.	Techniques for maximising the thermal efficiency of furnaces	See Section 1.4.1.	Generally applicable.
c.	Furnace automation and control	See Section 1.4.1.	Generally applicable.
d..	Use of clean scrap	See Section 1.4.1.	Generally applicable.
e.	Improving casting yield and decreasing scrap generation	See Section 1.4.1.	Generally applicable.
f.	Reducing energy losses/improving ladle preheating practices	This includes all of the following elements: — use of clean preheated ladles; — keeping closed lids on ladles to preserve heat; — use of energy-efficient techniques for preheating ladles (e.g. flameless microporous burners or oxy-fuel burners); — use of large (as practically possible) ladles fitted with heat-retaining covers; — minimising the molten metal transfer from one ladle to another; — transferring the molten metal as quickly as possible.	Applicability may be restricted in the case of big ladles (e.g. > 2 t) and bottom pouring ladles due to design constraints.
g.	Oxy-fuel combustion	See Section 1.4.1.	Applicability to existing plants may be restricted by furnace design and the need for a minimum waste gas flow.
h.	Use of medium-frequency power in induction furnaces	Use of medium-frequency (250 Hz) induction furnaces instead of mains frequency (50 Hz) furnaces.	Generally applicable.
i.	Compressed air system optimisation	This includes all of the following measures: — applying an appropriate system maintenance to reduce leaks; — efficient monitoring of operating parameters such as flow, temperature and pressure; — minimising the pressure drops; — applying efficient load management; — reducing the inlet air temperature; — using an efficient compressor control system.	Generally applicable.

Technique		Description	Applicability
j.	Microwave drying of cores for water-based coatings	Use of microwave drying ovens (e.g. with a frequency of 2 450 Hz) for drying cores coated with water-based coatings (see BAT 21 (e)), resulting in rapid and homogeneous drying of the entire core surface.	May not be applicable to continuous casting processes or to the production of large castings, or when cores are made of reclaimed sand containing traces of carbon.
Heat recovery techniques			
k.	Scrap preheating using recovered heat	Scrap is preheated by recovering the heat from hot flue-gases which are redirected to come into contact with the charge.	Only applicable to shaft furnaces in non-ferrous metal foundries and to EAFs in steel foundries.
l.	Heat recovery from off-gases generated in furnaces	Waste heat from hot off-gases is recovered (e.g. through heat exchangers) and reused on site or off site (e.g. in thermal oil/hot water/heating circuits, for steam generation or for preheating of combustion air (see technique (m)). This may include the following: — Excess heat from cupola hot off-gases is used for example for steam production, thermal oil heating, water heating. — Excess heat from the furnace cooling system is used for example for drying of raw material, space heating, water heating. — In fuel-fired furnaces in aluminium foundries, excess heat is used for example for heating the premises and/or the water for the casting cleaning facility. — Low-grade heat is converted into electricity using high-molecular-weight fluids by using the Organic Rankine Cycle (ORC).	Applicability may be restricted by the lack of a suitable heat demand.
m.	Preheating of combustion air	See Section 1.4.1.	Generally applicable.
n.	Waste heat utilisation in induction furnaces	Waste heat from the induction furnace cooling system is recovered using heat exchangers for drying raw materials (e.g. scrap), space heating or hot water supply.	Generally applicable.

Further sector-specific techniques to increase energy efficiency are given in Sections 1.2.2.1 and 1.2.4.1 of these BAT conclusions.

Table 1.1

BAT-associated environmental performance levels (BAT-AEPLs) for specific energy consumption in cast iron foundries

Process – Furnace type	Unit	BAT-AEPL (Yearly average)
Melting and holding – Cold blast cupola	kWh/t of liquid metal	900 – 1 750
Melting and holding – Hot blast cupola		900 – 1 500
Melting and holding – Induction		600 – 1 200
Melting and holding – Rotary		800 – 950
Ladle preheating		50 – 150 (1)

(1) For foundries producing large castings, the upper end of the BAT-AEPL range may be higher and up to 200 kWh/t of liquid metal.

Table 1.2

BAT-associated environmental performance levels (BAT-AEPLs) for specific energy consumption in steel foundries

Process – Furnace type	Unit	BAT-AEPL (Yearly average)
Melting – (EAF/induction)	kWh/t of liquid metal	600 – 1 200
Ladle preheating		100 – 300

Table 1.3

BAT-associated environmental performance levels (BAT-AEPLs) for specific energy consumption in aluminium foundries

Process	Unit	BAT-AEPL (Yearly average)
Melting and holding	kWh/t of liquid metal	600 – 2 000

The associated monitoring is given in BAT 6.

1.2.1.4. *Material efficiency*

1.2.1.4.1. Storage and handling of residues, packaging and unused process chemicals

BAT 15. In order to prevent or reduce the environmental risk associated with the storage and handling of residues, packaging and unused process chemicals and to facilitate their reuse and/or recycling, BAT is to use all of the techniques given below.

Technique		Description
a.	Appropriate storage of various residue types	This includes the following: — Fabric filter dust is stored on impermeable surfaces, in enclosed areas and in closed containers/bags. — Other residue types (e.g. slag, dross, spent furnace refractory linings) are stored separately from each other on impermeable surfaces in covered areas protected from surface run-off water.
b.	Reuse of internal scrap	Reuse of internal scrap directly or after treatment. The degree of reuse of internal scrap depends on its content of impurities.
c.	Reuse/recycling of packaging	Process chemicals packaging is selected to facilitate its complete emptying (e.g. considering the size of the packaging aperture or the nature of the packaging material). After emptying, the packaging is reused, returned to the supplier or sent for material recycling. Preferably, process chemicals are stored in large containers.
d.	Return of unused process chemicals	Unused process chemicals (i.e. which remain in their original containers) are returned to their suppliers.

1.2.1.4.2. Operational material efficiency in the casting process

BAT 16. In order to increase material efficiency in the casting process, BAT is to use either technique (a) or technique (a) in combination with one or both of the techniques (b) and (c) given below.

Technique		Description
a.	Improving casting yield and decreasing scrap generation	See Section 1.4.2
b.	Use of computer-aided simulation for casting, pouring and solidification	A computer simulation system is used to optimise the casting, pouring and solidification process, to minimise the number of defective castings and increase foundry productivity.
c.	Production of light-weight castings using topology optimisation	Use of topology optimisation (i.e. casting simulation by means of algorithms and computer programs) to reduce the product mass while meeting the product performance requirements.

Table 1.4

Indicative levels for operational material efficiency

Foundry type	Unit	Indicative levels (Yearly average)
Cast iron foundries	%	50 – 97 (1) (2)
Steel foundries		50 – 100 (1) (2)
NFM foundries (all types except HPDC) – Pb		50– 97,5 (1)
NFM foundries (all types except HPDC) – metals other than Pb		50 – 98 (1)
NFM foundries (HPDC)		60 – 97 (1)

(1) The lower end of the range is typically associated with the production of complex casting shapes due, for example, to the high number of cores and/or risers/feeders used.
(2) The upper end of the range is typically associated with centrifugal casting.

The associated monitoring is given in BAT 6.

1.2.1.4.3. Reduction of material consumption

BAT 17. In order to reduce material (e.g. chemicals, binders) consumption, BAT is to use an appropriate combination of the techniques given below.

Technique		Description	Applicability
Techniques for aluminium high-pressure die-casting			
a.	Separate spraying of release agent and water	See Section 1.4.2.	Generally applicable.
b.	Minimisation of release agent and water consumption	Measures to minimise the consumption of release agent and water include: — use of an automated spraying system; — optimisation of the release agent's dilution factor; — application of in-die cooling; — closed-mould application of release agent; — measuring the consumption of release agents; — measuring the die surface temperature to indicate hotspots in the die.	Generally applicable.
Techniques for processes using chemically bonded sand and core-making			
c.	Optimisation of binder and resin consumption	See Section 1.4.2.	Generally applicable.
d.	Minimisation of mould and core sand losses	Production parameters of the various product types are stored in an electronic database that allows easy changeover to new products with minimised losses in time and materials.	Generally applicable.
e.	Use of best practices for cold-setting processes	See Section 1.4.2.	Generally applicable.
f.	Recovery of amines from acid scrubbing water	When acid washing is used (e.g. using sulphuric acid) to treat the cold-box off-gases, amine sulphate is formed. The amines are recovered from the treatment of amine sulphate using sodium hydroxide. This may take place on site or off site.	Applicability may be restricted due to safety considerations (explosion hazard).
g.	Use of best practices for gas-hardening processes	See Section 1.4.2.	Generally applicable.
h.	Applying alternative moulding/core-making processes	Alternative moulding/core-making processes using no or a reduced amount of binders include: — lost foam casting process; — vacuum moulding.	Applicability of the lost foam casting process to existing plants may be restricted due to the required infrastructure modifications. Applicability of vacuum moulding may be restricted in the case of large moulding boxes (e.g. above 1,5 m × 1,5 m).

1.2.1.4.4. Sand reuse

BAT 18. In order to reduce the consumption of new sand and the generation of spent sand from sand reuse in the lost mould casting process, BAT is to use one or an appropriate combination of the techniques given below.

	Technique	Description	Applicability
a.	Optimised reconditioning of green sand	The green sand reconditioning process is controlled by a computer system to optimise raw material consumption and green sand reuse, e.g. cooling (evaporative or fluidised bed), addition of binders and additives, moistening, mixing, quality control.	Generally applicable.
b.	Low-waste green sand reconditioning	Green sand reconditioning in aluminium foundries is carried out using a scanner for identifying impurities in green sand based on brightness/colour. These impurities are separated from green sand using an air blast pulse.	Generally applicable.
c.	Preparation of clay-bonded sand by vacuum mixing and cooling	See BAT 25 (b).	Generally applicable.
d.	Mechanical reclamation of cold-setting sand	Mechanical techniques (e.g. breaking of lumps, segregation of sand fractions) using crushers or mills are used to reclaim cold-setting sand.	May not be applicable to silicate-bonded sand.
e.	Cold mechanical reclamation of clay-bonded or chemically bonded sand using a grinding wheel	Use of a rotating grinding wheel to remove clay layers and chemical binders from used sand grains.	Generally applicable.
f.	Cold mechanical reclamation of sand using an impact drum	Use of an impact drum with a spinning internal axis, equipped with small blades, for abrasive cleaning of sand grains. When applied on a mixture of bentonite and chemically bonded sand, a preliminary magnetic separation is carried out to remove parts with magnetic properties from the green sand.	Generally applicable.
g.	Cold reclamation of sand using a pneumatic system	Removal of binders from the sand grains using abrasion and impact. The kinetic energy is provided by a compressed air stream.	Generally applicable.
h.	Thermal reclamation of sand	Use of heat to burn binders and contaminants contained in chemically bonded and mixed sand. This is combined with an initial mechanical pretreatment to bring the sand to the correct grain size and remove any metallic contaminant. In the case of mixed sand, the share of chemically bonded sand should be high enough.	May not be applicable in the case of used sand containing residues from inorganic binders.

Technique		Description	Applicability
i.	Combined reclamation (mechanical-thermal-mechanical) for mixed organic-bentonite sands	After pretreatment (sieving, magnetic separation) and drying, sand is mechanically or pneumatically cleaned to remove part of the binder. In the thermal step, organic constituents are burned and inorganic constituents are transferred to the dust or burned onto the grains. In a final mechanical treatment, these grain layers are removed mechanically or pneumatically and discarded as dust.	May not be applicable for core sands containing acidic binders (because it may alter bentonite characteristics) or in the case of water glass (because it may alter green sand characteristics).
j.	Combined sand reclamation and heat treatment of aluminium castings	After pouring and solidification, moulds/casting units are loaded into the furnace. When the units reach a temperature > 420 °C, the binders are burnt, the cores/moulds disintegrate, and the castings undergo heat treatment. The sand falls to the bottom of the furnace for final cleaning in a heated fluidised bed. After cooling, the sand is reused in the core sand mixer without further treatment.	Generally applicable.
k.	Wet reclamation for green sand, silicate- or CO_2-bonded sands	Sand is mixed with water to produce a sludge. The removal of grain-bound binder residues is performed through intensive inter-particle rubbing of the sand grains. The binders are released into the wash water. The washed sand is dried, screened and finally cooled.	Generally applicable.
l.	Reclamation of sodium silicate sand (water glass) using a pneumatic system	Sand is heated to make the silicate layer brittle before the use of a pneumatic system (see technique (g)). The reclaimed sand is cooled before reuse.	Generally applicable.
m.	Internal reuse of core sand (cold-box or furan-acid binders)	Sand resulting from broken/faulty cores, and excess sand from the core-making machines (after hardening in a specific unit), are fed to a breaking unit. The resulting sand is mixed with new sand for the production of new cores.	Generally applicable.
n.	Reuse of dust from the green sand circuit in mould making	Dust is collected through the exhaust filtration from the shake-out installation and from the dosing and handling stations for dry green sand. The collected dust (containing active binder compounds) can be recycled into the green sand circuit.	Generally applicable.

Table 1.5

BAT-associated environmental performance levels (BAT-AEPLs) for sand reuse

Foundry type	Unit	BAT-AEPL [1] (Yearly average)
Cast iron foundries	%	> 90
Steel foundries		> 80
NFM foundries [2]		> 90

[1] The BAT-AEPLs may not apply when the quantity of used sand is lower than 10 000 t/year.
[2] The BAT-AEPL may not apply in aluminium die casting foundries when water glass is used.

The associated monitoring is given in BAT 6.

1.2.1.4.5. Reduction of generated residues and of waste sent for disposal

BAT 19. In order to reduce the amount of residues generated in metal melting and to reduce the amount of waste sent for disposal, BAT is to use all of the techniques given below.

	Technique	Description
Techniques for all furnace types		
a.	Minimisation of slag forming	Slag forming can be minimised by in-process measures, such as: — using clean scrap; — using a lower metal temperature (as close as possible to the theoretical melting point); — avoiding high temperature peaks; — preventing extended holding of molten metal in the melting furnace or using a separate holding furnace; — making adequate use of fluxes; — making adequate choice of the furnace refractory lining; — applying water cooling of the furnace walls to avoid the wear of the furnace refractory lining; — liquid aluminium skimming.
b.	Mechanical pretreatment of slag / dross / filter dust / spent refractory linings to facilitate recycling	See Section 1.4.2. This may also take place off site.
Techniques for cupola furnaces		
c.	Adjustment of the slag acidity/basicity	See Section 1.4.2.
d.	Collection and recycling of coke breeze	Coke breeze generated during handling, transport and charging of coke is collected (e.g. by using collection systems below conveyor belts and/or charging points) and recycled in the process (injected into the cupola furnace or used for recarburisation).
e.	Recycling of filter dust in cupola furnaces using zinc-containing scraps	Cupola filter dust is partially re-injected into the cupola furnace in order to increase the zinc content in the dust, up to a level that allows Zn recovery (> 18 %).
Techniques for EAFs		
f.	Recycling of filter dust in the EAF	Collected dry filter dust, usually after pretreatment (e.g. by pelletising or briquetting), is recycled in the furnace to enable the recovery of the metallic content of the dust. The inorganic content is transferred to the slag.

BAT 20. In order to reduce the amount of waste sent for disposal, BAT is to prioritise off-site recycling and/or other recovery over disposal for spent sand, undersize sand, slags, refractory linings and collected filter dust (e.g. fabric filter dust).

Description

Off-site recycling and/or other recovery have priority over disposal for spent sand, undersize sand, slags, refractory linings and filter dust. Spent sand, undersize sand, slags and refractory linings can be:

— recycled, e.g. in road construction, building materials (such as cement, bricks, tiles);

— recovered, e.g. filling of mining cavities, landfill construction (such as roads on landfills and permanent covers).

Filter dust can be externally recycled, e.g. in metallurgy, sand fabrication, the construction sector.

Applicability

Recycling and/or other recovery may be restricted by the physico-chemical properties of the residue (e.g. organic/metal content, granulometry).

It may not be applicable in the case of absence of a suitable third-party demand for recycling and/or recovery.

Table 1.6

BAT-associated environmental performance levels (BAT-AEPLs) for waste sent for disposal

Waste type	Unit	BAT-AEPL (1) (Yearly average)		
		NFM foundries	Cast iron foundries	Steel foundries
Slag	kg/t of liquid metal	0 – 50	0 – 50 (2)	0 – 50 (2)
Dross		0 – 30	0 – 30	0 – 30
Filter dust		0 – 5	0 – 60	0 – 10
Spent furnace refractory linings		0 – 5	0 – 20 (3)	0 – 20

(1) The BAT-AEPL may not apply in the absence of a suitable third-party demand for recycling and/or recovery.
(2) For steel or cast iron foundries operating EAFs, the upper end of the BAT-AEPL range may be higher and up to 100 kg/t of liquid metal due to increased slag formation during the metallurgical treatment.
(3) For cast iron foundries operating CBC, the upper end of the BAT-AEPL range may be higher and up to 100 kg/t of liquid metal.

The associated monitoring is given in BAT 6.

1.2.1.5. *Diffuse emissions to air*

BAT 21. In order to prevent or, where that is not practicable, to reduce diffuse emissions to air, BAT is to use all of the techniques given below.

Technique		Description	Applicability
a.	Covering the delivery equipment (containers) and the cargo space of transport vehicles	Cargo space of transport vehicles and delivery equipment (containers) are covered (e.g. with tarpaulins).	Generally applicable.
b.	Cleaning roads and transport vehicle wheels	Roads as well as the wheels of transport vehicles are regularly cleaned, e.g. by using mobile vacuum systems, water lagoons.	Generally applicable.
c.	Using closed conveyors	Materials are transferred using conveyor systems, e.g. closed conveyors, pneumatic conveying. Material drops are minimised.	Generally applicable.

Technique		Description	Applicability
d.	Vacuum cleaning of moulding and casting process areas	The moulding and casting process areas in sand moulding foundries are regularly vacuum-cleaned.	May not be applicable in areas where the sand has a technical or safety-related function.
e.	Substitution of alcohol-based coatings with water-based coatings	See Section 1.4.3.	Applicability may be restricted in the case of large or complex casting shapes because of difficulties for circulation of the drying air. Not applicable to water-glass-bonded sands, the magnesium casting process, vacuum moulding or the production of manganese steel castings with MgO coating.
f.	Control of emissions from quenching baths	This includes the following: — Minimising the generation of emissions from quenching baths by using water-based polymer solutions (e.g. containing polyvinylpyrrolidone or polyalkylene glycol). — Collecting emissions from quenching baths (especially from oil quenching baths) as close as possible to the emission source, using roof ventilation, extraction domes or edge extractors. Extracted off-gases may be treated, e.g. by using an ESP (see Section 1.4.3). — Use of tempered water as quenching media.	Generally applicable.
g.	Control of emission from transfer operations in metal melting	This includes the following: — Extraction as close as possible to the source of diffuse emissions (e.g. dust, fumes) from transfer processes such as furnace charging/tapping using hoods for example. The extracted off-gases are treated using for example fabric filter, wet scrubbing. — Minimisation of diffuse emissions from liquid metal transfer through launders using covers for example.	Generally applicable.

Further process-specific techniques to prevent or reduce diffuse emissions are given in BAT 24, BAT 26, BAT 27, BAT 28, BAT 29, BAT 30, BAT 31, BAT 38, BAT 39, BAT 40, BAT 41 and BAT 43.

1.2.1.6. *Channelled emissions to air*

BAT 22. In order to facilitate the recovery of materials and the reduction of channelled emissions to air, as well as to increase energy efficiency, BAT is to combine waste gas streams with similar characteristics, thus minimising the number of emission points.

Description

The combined treatment of waste gases with similar characteristics ensures more effective and efficient treatment compared to the separate treatment of individual waste gas streams. The combination of waste gases is carried out considering plant safety (e.g. avoiding concentrations close to the lower/upper explosive limit), technical (e.g. compatibility of the individual waste gas streams, concentration of the substances concerned), environmental (e.g. maximising recovery of materials or pollutant abatement) and economic factors (e.g. distance between different production units). Care is taken that the combination of waste gases does not lead to the dilution of emissions.

1.2.1.7. *Emissions to air from thermal processes*

BAT 23. In order to prevent or reduce emissions to air from metal melting, BAT is to use either electricity generated from fossil-free energy sources in combination with techniques (a) to (e), or techniques (a) to (e) and an appropriate combination of the techniques (f) to (i) given below.

	Technique	Description	Applicability
General techniques			
a.	Selection of an appropriate furnace type and maximisation of the thermal efficiency of furnaces	See Section 4.4.1	The selection of an appropriate furnace type is only applicable to new plants and major plant upgrades.
b.	Use of clean scrap	See Section 1.4.1	Generally applicable.
Primary control measures to minimise PCDD/F emissions			
c.	Maximisation of the off-gases' residence time and optimisation of the temperature in the post-combustion chamber in cupola furnaces	In cupola furnaces, the temperature of the post-combustion chamber is optimised (T > 850 °C) and continuously monitored while the off-gases' residence time is maximised (> 2 s).	Generally applicable.
d.	Rapid off-gas cooling	The off-gas is cooled rapidly from temperatures above 400 °C to below 250 °C before dust abatement to prevent the de novo synthesis of PCDD/F. This is achieved by appropriate design of the furnace and/or the use of a quench system.	
e.	Minimising dust build-up in heat exchangers	The build-up of dust along the cooling trajectory of the off-gases is minimised, especially in the heat exchangers, e.g. by using vertical exchanger tubes, efficient internal cleaning of the exchanger tubes, high-temperature de-dusting.	

	Technique	Description	Applicability
Techniques for reducing the generation of NO_X and SO_2 emissions			
f.	Use of a fuel or a combination of fuels with low NO_X formation potential	Fuels with a low NO_X formation potential include natural gas and liquefied petroleum gas.	Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.
g.	Use of a fuel or a combination of fuels with low sulphur content	Fuels with low sulphur content include natural gas and liquefied petroleum gas.	Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.
h.	Low-NO_X burners	See Section 1.4.3.	Applicability to existing plants may be restricted by furnace design and/or operational constraints.
i.	Oxy-fuel combustion	See Section 1.4.3.	Applicability to existing plants may be restricted by furnace design and the need for a minimum waste gas flow.

The BAT-AELs for metal melting are given:

— in Table 1.18 for cast iron foundries;

— in Table 1.20 for steel foundries;

— in Table 1.22 for NFM foundries.

BAT 24. In order to prevent or reduce emissions to air from heat treatment, BAT is to use either electricity generated from fossil-free energy sources in combination with techniques (a) and (d), or all of the techniques given below.

	Technique	Description	Applicability
General techniques			
a.	Selection of an appropriate furnace type and maximisation of the thermal efficiency of furnaces	See Section 1.4.3	Only applicable to new plants and major plant upgrades.
Techniques for reducing the generation of NO_X emissions			
b.	Use of a fuel or a combination of fuels with low NO_X formation potential	Fuels with a low NO_X formation potential include natural gas and liquefied petroleum gas.	Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.

	Technique	Description	Applicability
c.	Low-NO_X burners	See Section 1.4.3.	Applicability to existing plants may be restricted by furnace design and/or operational constraints.
Collection of emissions			
d.	Off-gas extraction as close as possible to the emission source	Off-gases from heat treatment furnaces (e.g. annealing, ageing, normalising, austempering) are extracted using hoods or cover extraction. The collected emissions may be treated using techniques such as fabric filters.	Generally applicable.

Table 1.7

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust and NO_X and indicative emission level for channelled emissions to air of CO from heat treatment

Substance/Parameter	Unit	BAT-AEL (Daily average or average over the sampling period)	Indicative emission level (Daily average or average over the sampling period)
Dust	mg/Nm³	1 – 5 (1)	No indicative level
NO_X		20 – 120 (2) (3)	No indicative level
CO		No BAT-AEL	10 – 100 (3)

(1) The BAT-AEL only applies when the substance/parameter concerned is identified as relevant in the waste gas streams based on the inventory of inputs and outputs mentioned in BAT 2.
(2) In the case of heat treatment over 1 000 °C (e.g. for the production of malleable iron), the upper end of the BAT-AEL range may be higher and up to 300 mg/Nm³.
(3) The BAT-AEL and indicative emission level do not apply in the case of furnaces using only electric energy (e.g. resistance).

The associated monitoring is given in BAT 12.

1.2.1.8. *Emissions to air from moulding using lost moulds and core-making*

BAT 25. In order to prevent or reduce emissions to air from moulding using lost moulds and core-making, BAT is to:

— use an appropriate combination of the techniques (a) to (c) given below in the case of moulding with clay-bonded sand;

— use either technique (d), (e) or (f) and an appropriate combination of the techniques (g) to (k) given below, in the case of moulding and core-making with chemically bonded sand;

— use technique (l) given below for selecting the coatings applied to moulds and cores.

	Technique	Description	Applicability
Techniques for moulding with clay-bonded sand (green sand)			
a.	Use of best practices for green sand moulding	This includes techniques such as: — precise addition of the required quantity of key components (e.g. clay, water, coal dust or other additives) to restore the chemical properties of the returned green sand;	Generally applicable.

	Technique	Description	Applicability
		— regular testing (e.g. daily) of the green sand properties (e.g. moisture, green strength, compactability, permeability, loss on ignition, volatile content).	
b.	Preparation of clay-bonded sand by vacuum mixing and cooling	Mixing and cooling processes are combined into a single process step by operating the sand mixer under reduced pressure, which results in cooling by the controlled vaporisation of the water.	Generally applicable.
c.	Substitution of coal dust	Coal dust is replaced by additives such as graphite, coke flour and zeolites, resulting in significantly lower diffuse emissions during the casting process.	Applicability may be restricted by operational constraints (e.g. less efficient shake-out or occurrence of casting defects).

Techniques for prevention of emissions in moulding and core-making with chemically bonded sand

d.	Selection of a low-emission cold-setting binder system	A cold-setting binder system generating low emissions of formaldehyde, phenol, furfuryl alcohol, isocyanates, etc. is selected. This includes the use of: — no-bake furan resins with low furfuryl alcohol content (e.g. less than 40 wt-%) for production of iron castings for example; — no-bake phenol/furan systems with a low-sulphur acid catalyst for production of steel castings for example; — aliphatic organic binders based for example on aliphatic polyalcohols (instead of aromatic organic binders) for production of iron, steel, aluminium or magnesium castings, etc.; — inorganic geopolymers based on polysialates (for production of grey iron, aluminium and steel castings, etc.); — ester silicate (for production of medium and large steel castings, etc.); — alkyd oil (e.g. for single castings or small batch production in steel foundries); — resol-ester (e.g. for lighter alloys in small or medium production); — cement (for production of very large castings for example).	Applicability may be restricted due to product specifications.
e.	Selection of a low-emission gas curing binder system	A gas curing binder system generating low emissions of amines, benzene, formaldehyde, phenol, isocyanates, etc. is selected. This includes the use of: — inorganic binders, e.g. sodium silicate (water glass), hardened using CO_2 or organic esters, for example in aluminium die-casting; — inorganic geopolymers based on polysialates cured with CO_2 (for production of grey iron, aluminium, steel castings, etc.); — aliphatic organic binders based for example on aliphatic polyalcohols (instead of aromatic organic binders) for production of iron, steel, aluminium or magnesium castings, etc.; — phenolic urethane binders with very low free phenol and formaldehyde content (for production of iron and steel castings, etc.);	Applicability may be restricted due to product specifications.

	Technique	Description	Applicability
		— phenolic urethane binders with reduced amounts of solvents (for production of iron and steel castings, etc.).	
f.	Selection of a low-emission hot-curing binder system	A hot-curing binder system generating low emissions of formaldehyde, phenol, furfuryl alcohol, benzene, isocyanates, etc. is selected. This includes the use of: — inorganic binders such as geopolymers based on polysialates; — inorganic binders cured using a warm-box process without phenol, formaldehyde and isocyanates (for preparing aluminium castings with complex shapes for example); — aliphatic polyurethane warm box binders (used as an alternative to the cold box process).	Applicability may be restricted due to product specifications.
General techniques for moulding and core-making with chemically bonded sand			
g.	Optimisation of binder and resin consumption	See Section 1.4.3.	Generally applicable.
h.	Use of best practices for cold-setting processes	See Section 1.4.3.	Generally applicable.
i.	Use of best practices for gas-hardening processes	See Section 1.4.3.	Generally applicable.
j.	Use of non-aromatic solvents for cold-box core production	Non-aromatic solvents are used that are based either on protein or animal fat (e.g. fatty acid methyl esters of vegetable oil) or on silicate esters in order to reduce emissions of VOCs (e.g. benzene, toluene).	Generally applicable.
k.	Use of best practices for hot-curing processes	Several hot-curing processes may be used and a series of measures are in place to optimise each process including for the following: Hot-box process: — Curing is carried out within the optimum temperature range (e.g. 220 °C to 300 °C). — Cores are usually precoated using water-based coatings to prevent burns at the core surface which may result in brittleness during pouring. — Core blowers and the area around them are well ventilated and exhausted to capture the formaldehyde liberated during curing efficiently. Warm-box process: — Curing is carried out at a lower optimum temperature range than the hot-box process (e.g. 150 °C to 190 °C), resulting in lower emissions and energy consumption than the hot-box process.	Generally applicable.

	Technique	Description	Applicability
		Shell (Croning): — Precoated sands with a phenol-formaldehyde resin are bound using hexamethylenetetramine that decomposes at 160 °C, releasing formaldehyde, necessary for cross-linking the resin, and ammonia. The curing and/or core blower area is well ventilated and exhausted to capture the ammonia and formaldehyde liberated during curing efficiently.	
Techniques related to the coatings applied to moulds and cores			
l.	Substitution of alcohol-based coatings with water-based coatings	See Section 1.4.3.	Applicability may be restricted in the case of large or complex casting shapes because of difficulties for circulation of the drying air. Not applicable to water glass-bonded sands, the magnesium casting process, vacuum moulding or the production of manganese steel castings with MgO coating.

BAT 26. In order to reduce emissions to air from moulding using lost moulds and core-making, BAT is to:

— use an appropriate combination of the techniques given in BAT 25;

— collect the emissions using technique (a);

— treat the off-gases using one or a combination of the techniques (b) to (f) given below.

	Technique	Description	Applicability
Collection of emissions			
a.	Extraction of emissions generated from moulding and/or core-making as close as possible to the emission source	See Section 1.4.3.	Applicability may be restricted in the case of moulding in cast iron and steel foundries producing large castings.

	Technique	Description	Applicability
Off-gas treatment			
b.	Fabric filter	See Section 1.4.3.	Generally applicable.
c.	Wet scrubbing	See Section 1.4.3.	Generally applicable.
d.	Adsorption	See Section 1.4.3.	Generally applicable.
e.	Thermal oxidation	See Section 1.4.3.	Applicability may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases. Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/or operational constraints.
f.	Catalytic oxidation	See Section 1.4.3.	Applicability may be restricted by the presence of catalyst poisons in the waste gases or where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases.

Table 1.8

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust, amines, benzene, formaldehyde, phenol and TVOC from moulding using lost moulds and core-making

Substance/Parameter	Unit	BAT-AEL (Daily average or average over the sampling period)
Dust	mg/Nm^3	1 – 5
Amines		< 0,5 – 2,5 (1)
Benzene		< 1 – 2 (2)
Formaldehyde		< 1 – 2 (3)
Phenol		< 1 – 2 (4)
TVOC	$mg\ C/Nm^3$	15 – 50 (5)

(a) organic binder systems generating low or no emissions of substances classified as CMR 1A, CMR 1B or CMR 2 (see techniques (d), (e) and/or (f) in BAT 25) are used in core-making;

(b) one or both of the following conditions are met:

— thermal or catalytic oxidation is not applicable,

— substitution with water-based coatings is not applicable.

(1) The BAT-AEL only applies in the cold-box process when amines are used.

(2) The BAT-AEL only applies when aromatic binders/chemicals are used.

(3) The BAT-AEL only applies when the substance concerned is identified as relevant in the waste gas streams based on the inventory of inputs and outputs mentioned in BAT 2.

(4) The BAT-AEL only applies when phenolic-based binder systems are used.

(5) In the case of core-making, the upper end of the BAT-AEL range may be higher and up to 100 $mg\ C/Nm^3$ if both of the following conditions (a) and (b) are met:

The associated monitoring is given in BAT 12.

1.2.1.9. *Emissions to air from casting, cooling and shake-out processes in foundries using lost moulds including the full mould process*

BAT 27. In order to reduce emissions to air from casting, cooling and shake-out processes in foundries using lost moulds including the full mould process, BAT is to:

— collect the emissions by using technique (a);

— treat the off-gases using one or a combination of the techniques (b) to (h) given below.

	Technique	Description	Applicability
Collection of emissions			
a.	Extraction of emissions generated during the casting, cooling and shake-out processes as close as possible to the emission source	Emissions generated during the casting (especially emissions from pouring), cooling and shake-out processes are appropriately extracted. For the casting and cooling processes, this includes: — restricting the pouring process to a fixed area or position to facilitate the capture of emissions using ventilators and enclosure (e.g. in serial pouring); — enclosure of pouring and cooling lines. For the shake-out process, this includes: — use of ventilator panels situated on both sides and at the rear of the shaker; — use of enclosed units equipped with roof openings or removable covers (e.g. doghouse); — installation of an extraction point situated underneath the shaker in the sand collection box.	Applicability may be restricted in the case of cast iron and steel foundries producing large castings.
Off-gas treatment			
b.	Cyclone	See Section 1.4.3.	Generally applicable.
c.	Fabric filter	See Section 1.4.3.	Generally applicable.
d.	Wet scrubbing	See Section 1.4.3.	Generally applicable.
e.	Adsorption	See Section 1.4.3.	Generally applicable.
f.	Biofilter	The off-gas stream is passed through a bed of organic material (such as peat, heather, compost, root, tree bark, softwood and different combinations) or some inert material (such as clay, activated carbon, and polyurethane), where it is biologically oxidised by naturally occurring microorganisms into carbon dioxide, water, inorganic salts and biomass. The biofilter is sensitive to dust, high temperatures and high variations in the off-gas composition. Supplementary nutrient feeding may be needed.	Only applicable to the treatment of biodegradable compounds.

Technique		Description	Applicability
g.	Thermal oxidation	See Section 1.4.3.	Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/or operational constraints. Applicability may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases
h.	Catalytic oxidation	See Section 1.4.3.	Applicability may be restricted by the presence of catalyst poisons in the waste gases or where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases.

Table 1.9

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust, benzene, formaldehyde, phenol and TVOC from casting, cooling and shake-out processes in foundries using lost moulds including the full mould process

Substance/Parameter	Unit	BAT-AEL (Daily average or average over the sampling period)
Dust	mg/Nm³	1 – 5
Benzene		< 1 – 2 (1)
Formaldehyde		< 1 – 2 (2)
Phenol		< 1 – 2 (3)
TVOC	mg C/Nm³	15 – 50 (4)

(1) The BAT-AEL only applies when aromatic binders/chemicals are used or when the full mould process is used.
(2) The BAT-AEL only applies when the substance concerned is identified as relevant in the waste gas streams based on the inventory of inputs and outputs mentioned in BAT 2.
(3) The BAT-AEL only applies when phenolic-based binder systems are used in moulding and/or core-making.
(4) The upper end of the BAT-AEL range may be higher and up to 100 mg C/Nm³ when organic binder systems generating low or no emissions of substances classified as CMR 1A, CMR 1B or CMR 2 (see techniques (d), (e) and/or (f) in BAT 25) are used in core-making.

The associated monitoring is given in BAT 12.

1.2.1.10. *Emissions to air from lost foam casting*

BAT 28. In order to reduce dust and TVOC emissions to air from lost foam casting, BAT is to collect the emissions using technique (a) and to treat the off-gases by using an appropriate combination of the techniques (b) to (d) given below.

	Technique	Description	Applicability
Collection of emissions			
a.	Extraction of emissions generated from lost foam casting as close as possible to the emission source	In the lost foam casting processes, emissions from the pyrolysis of the expanded polymer during pouring and shake-out are extracted using, for example an enclosure or a hood.	Generally applicable.
Off-gas treatment			
b.	Fabric filter	See Section 1.4.3.	Generally applicable.
c.	Wet scrubbing	See Section 1.4.3.	Generally applicable.
d.	Thermal oxidation	See Section 1.4.3.	Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/or operational constraints. Applicability may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases.

Table 1.10

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust and TVOC from lost foam casting

Parameter	Unit	BAT-AEL (Daily average or average over the sampling period)
Dust	mg/Nm^3	1 – 5
TVOC	mg C/Nm^3	15 – 50 ([1])

([1]) The upper end of the BAT-AEL range may be higher and up to 100 mg C/Nm^3 if the TVOC abatement efficiency of the waste gas treatment system is > 95 %.

The associated monitoring is given in BAT 12.

1.2.1.11. *Emissions to air from the casting process in foundries using permanent moulds*

BAT 29 In order to prevent or reduce emissions to air from the casting process in foundries using permanent moulds, BAT is to:

— prevent the generation of emissions by using one or a combination of the techniques (a) to (e);

— collect the emissions by using technique (f);

— treat the off-gases by using one or a combination of the techniques (g) to (j) given below.

	Technique	Description	Applicability
Prevention of emissions			
a.	General techniques for gravity and low-pressure die-casting	This includes techniques such as — selection of an appropriate lubricant to prevent castings surface defects; — optimised lubricant preparation and application to avoid excessive use.	Generally applicable.
b.	General techniques for high-pressure die-casting	This includes techniques such as: — proper lubrication of the die and plungers using water-based emulsions of silicone oils, ester oils, synthetic waxes for example; — minimisation of the release agent and water consumption by optimising the spraying process, e.g. use of micro-spraying for application of release agents (see also BAT 17 (b)).	
c.	Optimisation of process parameters for centrifugal and continuous casting	In centrifugal casting, important process parameters such as mould rotation, pouring temperature and mould preheating temperature are optimised (e.g. using flow simulation) to reduce the number of defects and minimise emissions. In continuous casting, the casting rate, casting temperature and cooling rate are optimised to minimise emissions and reduce the amount of water consumed for cooling while reaching the required product specification.	
d.	Separate spraying of release agent and water in high-pressure die-casting	See Section 1.4.2.	
e.	Use of water-free release agents in high-pressure die-casting	Water-free release agents (e.g. in a powdered form) are applied to the die using electrostatic deposition.	

Technique		Description	Applicability
Collection of emissions			
f.	Extraction of emissions generated from the casting process as close as possible to the emission source	Emissions generated from the casting process including high-pressure/low-pressure/gravity die-casting, centrifugal and continuous casting are extracted using enclosures or extraction hoods.	Generally applicable.
Off-gas treatment			
g.	Fabric filter	See Section 1.4.3.	Generally applicable.
h.	Wet scrubbing	See Section 1.4.3.	
i.	Electrostatic precipitator	See Section 1.4.3.	
j.	Thermal oxidation	See Section 1.4.3.	Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/or operational constraints. Applicability may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases.

Table 1.11

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust, TVOC and lead from the casting process in foundries using permanent moulds

Substance/Parameter	Unit	BAT-AELs (Daily average or average over the sampling period)
Dust	mg/Nm^3	1 – 5
Pb		0,05 – 0,1 (1)
TVOC	$mg\ C/Nm^3$	2 – 30 (2) (3)

(1) The BAT-AEL only applies to lead foundries.
(2) The BAT-AEL only applies when TVOC is identified as relevant in the waste gas streams based on the inventory of inputs and outputs mentioned in BAT 2.
(3) The BAT-AEL only applies when cores with chemically bonded sand are used.

The associated monitoring is given in BAT 12.

1.2.1.12. *Emissions to air from finishing*

BAT 30. In order to reduce dust emissions to air from finishing, BAT is to collect the emissions using technique (a) and to treat the off-gases by using one or a combination of the techniques (b) to (d) given below.

	Technique	Description
Collection of emissions		
a.	Extraction of emissions generated from finishing as close as possible to the emission source	Emissions generated from finishing operations, such as deburring, abrasive cutting, fettling, slide grinding, shot blasting, welding, chiselling, needling, are appropriately extracted using, e.g.: — enclosure of the finishing process area; — roof ventilation or dome-shaped roofs; — rigid or adjustable extraction hoods; — extraction arms.
Off-gas treatment		
b.	Cyclone	See Section 1.4.3.
c.	Fabric filter	See Section 1.4.3.
d.	Wet scrubbing	See Section 1.4.3.

Table 1.12

BAT-associated emission level (BAT-AEL) for channelled emissions to air of dust from finishing

Parameter	Unit	BAT-AEL (Daily average or average over the sampling period)
Dust	mg/Nm^3	1 – 5

The associated monitoring is given in BAT 12.

1.2.1.13. *Emissions to air from sand reuse*

BAT 31. In order to reduce emissions to air from sand reuse, BAT is to:

— in the case of thermal sand regeneration, use either electricity generated from fossil-free energy sources or both of the techniques (a) and (b);

— collect the emissions using technique (c);

— treat the off-gases by using one or an appropriate combination of the techniques (d) to (g) given below.

	Technique	Description	Applicability
Techniques for reducing the generation of emissions			
a.	Use of a fuel or a combination of fuels with low NO_X formation potential	Fuels with a low NO_X formation potential include natural gas and liquefied petroleum gas.	Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.

Technique		Description	Applicability
b.	Use of a fuel or a combination of fuels with low sulphur content	Fuels with low sulphur content include natural gas and liquefied petroleum gas.	Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.
Collection of emissions			
c.	Extraction of emissions generated from sand reuse as close as possible to the emission source	Emissions generated from sand reclamation are extracted using an enclosure or a hood for example. This includes extraction of the flue-gases generated from fluidised bed furnaces, rotary kilns or hearth furnaces, etc. used in thermal sand regeneration.	Generally applicable.
Off-gas treatment			
d.	Cyclone	See Section 1.4.3.	Generally applicable.
e.	Fabric filter	See Section 1.4.3.	
f.	Wet scrubbing	See Section 1.4.3.	
g.	Thermal oxidation	See Section 1.4.3.	Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/or operational constraints. Applicability may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases.

Table 1.13

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust and TVOC from sand reuse

Substance/Parameter	Unit	BAT-AEL (Daily average or average over the sampling period)
Dust	mg/Nm^3	1 – 5
TVOC	$mg C/Nm^3$	5 – 20 ([1])

([1]) The upper end of the BAT-AEL range may be higher and up to 50 mg C/Nm^3 with a high share of core sand in sand reuse.

Table 1.14

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of NO_X and SO_2 from sand reuse

Substance/Parameter	Process	Unit	BAT-AEL (Daily average or average over the sampling period)
NO_x	Thermal regeneration of sand originating from the cold-box process	mg/Nm^3	50 – 140
SO_2	Thermal regeneration of sand in which sulphonic acid catalysts have been used		10 – 100

The associated monitoring is given in BAT 12.

1.2.1.14. *Odour*

BAT 32. In order to prevent or, where that is not practicable, to reduce odour emissions, BAT is to set up, implement and regularly review an odour management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements:

— A protocol containing appropriate actions and timelines.

— A protocol for conducting odour monitoring as set out in BAT 33. The protocol may be complemented by measurement/estimation of odour exposure or estimation of odour impact.

— A protocol for response to identified odour incidents, e.g. managing complaints and/or taking corrective actions.

— An odour prevention and reduction programme designed to identify the source(s); to measure/estimate odour exposure; to characterise the contributions of the sources; and to implement prevention and/or reduction measures.

Applicability

The applicability is restricted to cases where an odour nuisance at sensitive receptors is expected and/or has been substantiated.

BAT 33. BAT is to periodically perform odour monitoring.

Description

Odour can be monitored using the following:

— EN standards (e.g. dynamic olfactometry according to EN 13725 in order to determine the odour concentration and/or EN 16841-1 or -2 in order to determine the odour exposure).

— Alternative methods (e.g. estimation of odour impact) for which no EN standards are available. In such a case, ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality can be used.

The monitoring frequency is determined in the odour management plan (see BAT 32).

Applicability

The applicability is restricted to cases where an odour nuisance at sensitive receptors is expected and/or has been substantiated.

BAT 34. In order to prevent or, where that is not practicable, to reduce odour emissions, BAT is to use all of the techniques given below.

Technique		Description	Applicability
a.	Substitution of chemicals containing alcohol-based or aromatic solvents	This includes techniques such as: — the use of water-based coatings (see BAT 25 (l)); — the use of alternative solvents in cold-box core-making (see BAT 25 (h)).	Applicability of water-based coatings may be restricted due to the type of raw material or product specifications (e.g. big moulds/cores, water glass bonded sands, Mg castings, production of manganese steel with MgO coating).

Technique		Description	Applicability
b.	Collection and treatment of amine emissions from the cold-box core-making process	Off-gases containing amines, generated from the gassing of cold-box cores are extracted and treated using for example wet scrubbing, a biofilter, thermal or catalytic oxidation (see BAT 26).	Generally applicable.
c.	Collection and treatment of VOC emissions from chemically bonded sand preparation, pouring, cooling and shake-out	Off-gases containing VOCs, generated from the preparation of chemically bonded sand, pouring, cooling and shake-out are extracted and treated using for example wet scrubbing, a biofilter, thermal or catalytic oxidation (see BAT 26).	

1.2.1.15. *Water consumption and waste water generation*

BAT 35. In order to optimise water consumption and to reduce the volume of waste water generated as well as to improve water recyclability, BAT is to use both techniques (a) and (b), and an appropriate combination of the techniques (c) to (g) given below.

Technique		Description	Applicability
a.	Water management plan and audits	A water management plan and audits are part of the EMS (see BAT 1) and include: — flow diagrams and water mass balances of the plant as part of the inventory of inputs and outputs mentioned in BAT 2; — establishment of water efficiency objectives; — implementation of water optimisation techniques (e.g. control of water usage, reuse/recycling, detection and repair of leaks). Audits are carried out at least once every year to ensure that the objectives of the water management plan are met and the audit recommendations are followed-up and implemented.	The level of detail of the water management plan and audits will generally be related to the nature, scale and complexity of the plant.
b.	Segregation of water streams	See Section 1.4.4.	Applicability to existing plants may be restricted by the layout of the water collection system.
c.	Water reuse and/or recycling	Water streams (e.g. process water, effluents from wet scrubbing, cooling water) are reused and/or recycled in closed or semi-closed circuits, if necessary after treatment (see BAT 36).	The degree of water reuse and/or recycling is limited by the water balance of the plant, the content of impurities and/or the characteristics of the water streams.
d.	Prevention of waste water generation from process and storage areas	See BAT 4 (b).	Generally applicable.

Technique		Description	Applicability
e.	Use of dry dedusting systems	This includes techniques such as fabric filters and dry ESPs (see Section 1.4.3).	Generally applicable.
f.	Separate spraying of release agent and water in high-pressure die-casting	See Section 1.4.2.	Generally applicable.
g.	Use of waste heat for the evaporation of waste water	When waste heat is available on a continuous basis, it can be used to evaporate waste water.	Applicability may be restricted by the physico-chemical properties of the pollutants present in the waste water that can be emitted into the air.

Table 1.15

BAT-associated environmental performance levels (BAT-AEPLs) for specific water consumption

Foundry type	Unit	BAT-AEPL (Yearly average)
Cast iron foundries	m^3/t of liquid metal	0,5 – 4
Steel foundries		
Non-ferrous metal foundries (all types except HPDC)		
Non-ferrous metal HPDC foundries		0,5 – 7

The associated monitoring is given in BAT 6.

1.2.1.16. *Emissions to water*

BAT 36. In order to reduce emissions to water, BAT is to treat waste water using an appropriate combination of the techniques given below.

Technique [1]		Typical pollutants targeted
Preliminary, primary and general treatment, e.g.		
a.	Equalisation	All pollutants
b.	Neutralisation	Acids, alkalis
c.	Physical separation through for example screens, sieves, grit separators, grease separators, hydrocyclones, oil-water separators or primary settlement tanks	Gross solids, suspended solids, oil/grease
Physico-chemical treatment, e.g.		
d.	Adsorption	Adsorbable dissolved non-biodegradable or inhibitory pollutants, e.g. hydrocarbons, mercury, AOX
e.	Chemical precipitation	Precipitable dissolved non-biodegradable or inhibitory pollutants, e.g. metals, fluoride
f.	Evaporation	Soluble contaminants, e.g. salts

Technique (1)		Typical pollutants targeted
Biological treatment, e.g.		
g.	Activated sludge process	Biodegradable organic compounds
h.	Membrane bioreactor	
Solids removal, e.g.		
i.	Coagulation and flocculation	Suspended solids and particulate-bound metals
j.	Sedimentation	Suspended solids and particulate-bound metals or non-biodegradable or inhibitory pollutants
k.	Filtration, e.g. sand filtration, microfiltration, ultrafiltration, reverse osmosis	Suspended solids and particulate-bound metals
l.	Flotation	

(1) The descriptions of the techniques are given in Section 1.4.4.

Table 1.16

BAT-associated emission levels (BAT-AELs) for direct discharges

Substance/Parameter		Unit	BAT-AEL (1)	Origin of waste water stream(s)
Adsorbable organically bound halogens (AOX) (2)		mg/l	0,1 – 1	Wet scrubbing of cupola off-gases
Chemical oxygen demand (COD) (3)			25 – 120	Die-casting, off-gas treatment (e.g. wet scrubbing), finishing, heat treatment, contaminated surface run-off water, direct cooling, wet sand regeneration and cupola furnace slag granulation.
Total organic carbon (TOC) (3)			8 – 40	
Total suspended solids (TSS)			5 – 25	
Hydrocarbon oil index (HOI) (2)			0,1 – 5	
Metals	Copper (Cu) (2)		0,1 – 0,4	
	Chromium (Cr) (2)		0,1 – 0,2	
	Lead (Pb) (2)		0,1 – 0,3	
	Nickel (Ni) (2)		0,1 – 0,5	
	Zinc (Zn) (2)		0,5 – 2	
Phenol index			0,05 – 0,5 (4)	
Total nitrogen (TN) (2)			1 – 20	

(1) The averaging periods are defined in the General considerations.
(2) The BAT-AELs only apply when the substance/parameter concerned is identified as relevant in the waste water stream based on the inventory of inputs and outputs mentioned in BAT 2.
(3) Either the BAT-AEL for COD or the BAT-AEL for TOC applies. The BAT-AEL for TOC is the preferred option because TOC monitoring does not rely on the use of very toxic compounds.
(4) The BAT-AEL only applies when phenolic binding systems are used.

The associated monitoring is given in BAT 13.

Table 1.17

BAT-associated emission levels (BAT-AELs) for indirect discharges

Substance/Parameter		Unit	BAT-AEL [1] [2]	Origin of waste water stream(s)
Adsorbable organically bound halogens (AOX) [3]		mg/l	0,1 – 1	Wet scrubbing of cupola off-gases
Hydrocarbon oil index (HOI) [3]			0,1 – 5	Die-casting, off-gas treatment (e.g. wet scrubbing), finishing, heat treatment, contaminated surface run-off water, direct cooling, wet sand regeneration and cupola furnace slag granulation.
Metals	Copper (Cu) [3]		0,1 – 0,4	
	Chromium (Cr) [3]		0,1 – 0,2	
	Lead (Pb) [3]		0,1 – 0,3	
	Nickel (Ni) [3]		0,1 – 0,5	
	Zinc (Zn) [3]		0,5 – 2	
Phenol index			0,05 – 0,5 [4]	

(1) The averaging periods are defined in the general considerations.
(2) The BAT-AELs may not apply if the downstream waste water treatment plant is designed and equipped appropriately to abate the pollutants concerned, provided this does not lead to a higher level of pollution in the environment.
(3) The BAT-AELs only apply when the substance/parameter concerned is identified as relevant in the waste water stream based on the inventory of inputs and outputs mentioned in BAT 2.
(4) The BAT-AEL only applies when phenolic binding systems are used.

The associated monitoring is given in BAT 13.

1.2.2. BAT conclusions for cast iron foundries

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Sections 1.1 and 1.2.1.

1.2.2.1. *Energy efficiency*

BAT 37. In order to increase energy efficiency in metal melting, BAT is to use an appropriate combination of the techniques given below.

Technique		Description	Applicability
a.	Increase of shaft height in CBC furnaces	See Section 1.4.1.	Only applicable to new plants and major plant upgrades. Applicability to existing plants may be restricted by building and other structural constraints.
b.	Oxygen enrichment of the combustion air	See Section 1.4.1.	Generally applicable.
c.	Minimal blast shut-off periods for HBC furnaces	See Section 1.4.1.	Generally applicable.

Technique		Description	Applicability
d.	Long-campaign cupola	See Section 1.4.1.	Generally applicable.
e.	Post-combustion of off-gases	See Section 1.4.1.	Generally applicable.

The BAT-AEPLs for specific energy consumption are given in BAT 14.

1.2.2.2. *Emissions to air from thermal processes*

1.2.2.2.1. Emissions to air from metal melting

BAT 38. In order to prevent or reduce emissions to air from metal melting, BAT is to:

— use an appropriate combination of process-integrated techniques (a) to (e) in the case of cupola furnaces;

— collect the emissions using technique (f);

— treat the extracted off-gases using one or an appropriate combination of the techniques (g) to (l) given below.

Technique		Description	Applicability
Process-integrated techniques for cupola furnaces			
a.	Control of coke quality	Coke is purchased based on important quality specifications (e.g. fixed carbon, ash, volatile matter, sulphur and moisture content, mean size diameter) which are systematically controlled before use.	Generally applicable.
b.	Adjustment of the slag acidity/basicity	See Section 1.4.3.	
c.	Increase of shaft height in CBC furnaces	See Section 1.4.1.	Only applicable to new plants and major plant upgrades. Applicability to existing plants may be restricted by building and other structural constraints.
d.	Oxygen enrichment of the combustion air	See Section 1.4.3.	Generally applicable.
e.	Long-campaign cupola	See Section 1.4.1.	Generally applicable.

	Technique	Description	Applicability
Collection of emissions			
f.	Off-gas extraction as close as possible to the emission source	In cupola furnaces, the off-gases are extracted either: — above the charge-hole offtake at the end of the cupola stack using ductwork and a downstream fan; or — below the charge-hole offtake using an annular ring. After extraction, the off-gases are cooled for example using: — long ducts to decrease the temperature by natural convection; — air/gas or oil/gas heat exchangers; — water quenching. For induction furnaces, off-gases are extracted, for example using: — hood extraction (e.g. canopy or side-draught hoods); — lip extraction; — cover extraction. For rotary furnaces, off-gases are extracted, for example using hood extraction. For EAFs, off-gases are extracted, for example using: — roof-mounted hood extraction; — canopy or side-draught hoods; — partial furnace enclosures (mobile or fixed) mounted around the furnace and tapping area; — total furnace enclosure using a complete room enclosure around the furnace and tapping area equipped with a moveable roof for charging/tapping operations.	Generally applicable.
Off-gas treatment			
g.	Post-combustion of off-gases	See Section 1.4.3.	Generally applicable.
h.	Cyclone	See Section 1.4.3.	Generally applicable.
i.	Adsorption	See Section 1.4.3.	Generally applicable.
j.	Dry scrubbing	Dry powder or a suspension/solution of an alkaline reagent (e.g. lime or sodium bicarbonate) is introduced and dispersed in the off-gas stream. The material reacts with the acidic gaseous species (e.g. SO_2) to form a solid which is removed by filtration (e.g. fabric filter).	Generally applicable.
k.	Fabric filter	See Section 1.4.3.	Generally applicable.
l.	Wet scrubbing	See Section 1.4.3.	Generally applicable.

Table 1.18

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust, HCl, HF, NO_X, PCDD/F, SO_2, TVOC, lead, and indicative emission level for channelled emissions to air of CO from metal melting

<table>
<tr><th>Substance/Parameter</th><th>Unit</th><th>Furnace type</th><th>BAT-AEL
(Daily average or average over the sampling period)</th><th>Indicative emission level
(Daily average or average over the sampling period)</th></tr>
<tr><td rowspan="2">Dust</td><td rowspan="9">mg/Nm³</td><td>Induction, rotary, EAF</td><td>1 – 5</td><td rowspan="4">No indicative emission level</td></tr>
<tr><td>CBC, HBC</td><td>1 – 7 (1)</td></tr>
<tr><td>HCl</td><td>CBC, HBC</td><td>10 – 30 (2)</td></tr>
<tr><td>HF</td><td>CBC, HBC, rotary furnaces</td><td>1 – 3 (2)</td></tr>
<tr><td rowspan="2">CO</td><td>Rotary furnaces</td><td>No BAT-AEL</td><td>10 – 30</td></tr>
<tr><td>CBC, HBC</td><td>No BAT-AEL</td><td>20 – 220</td></tr>
<tr><td rowspan="3">NO_X</td><td>HBC</td><td>20 –160</td><td rowspan="10">No indicative emission level</td></tr>
<tr><td>CBC</td><td>20 – 70</td></tr>
<tr><td>Rotary furnaces</td><td>20 – 100</td></tr>
<tr><td rowspan="2">PCDD/F</td><td rowspan="2">ng WHO-TEQ/Nm³</td><td>CBC, HBC, rotary furnaces</td><td>< 0,01 – 0,08</td></tr>
<tr><td>Induction</td><td>< 0,01 – 0,08 (3)</td></tr>
<tr><td rowspan="3">SO_2</td><td rowspan="3">mg/Nm³</td><td>HBC</td><td>30 – 100</td></tr>
<tr><td>Rotary furnaces</td><td>10 – 50</td></tr>
<tr><td>CBC</td><td>50 – 150</td></tr>
<tr><td>TVOC</td><td>mg C/Nm³</td><td>All furnace types</td><td>5 – 30</td></tr>
<tr><td>Pb</td><td>mg/Nm³</td><td>CBC, HBC</td><td>0,02 – 0,1 (3)</td></tr>
</table>

(1) For existing HBC plants using wet scrubbing, the upper end of the BAT-AEL range may be higher and up to 12 mg/Nm³ until the next major upgrade of the cupola.
(2) The lower end of the BAT-AEL range can be achieved by using dry lime injection.
(3) The BAT-AEL only applies when the substance/parameter concerned is identified as relevant in the waste gas stream based on the inventory of inputs and outputs mentioned in BAT 2.

The associated monitoring is given in BAT 12.

1.2.2.2.2. Emissions to air from the nodularisation of cast iron

BAT 39. In order to prevent or reduce dust emissions to air from the nodularisation of cast iron, BAT is to use technique (a) or both of the techniques (b) and (c) given below.

Technique		Description
a.	Nodularisation with no magnesium oxide emissions	Use of the in-mould process whereby the magnesium alloy is added as a tablet, directly into the mould cavity, and the nodularisation reaction takes place during pouring.
b.	Off-gas extraction as close as possible to the emission source	When magnesium oxide emissions are generated from the nodularisation technique used (e.g. sandwich, ductilator), off-gases are extracted as close as possible to the emission source using a fixed or movable extraction hood.
c.	Fabric filter	See Section 1.4.3. The magnesium oxide collected may be reused for the production of pigments or refractory materials.

Table 1.19

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust from the nodularisation of cast iron

Parameter	Unit	BAT-AEL [1] (Daily average or average over the sampling period)
Dust	mg/Nm^3	1 – 5

([1]) The BAT-AEL does not apply when technique (a) is used.

The associated monitoring is given in BAT 12.

1.2.3. BAT conclusions for steel foundries

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Sections 1.1 and 1.2.1.

1.2.3.1. *Emissions to air from thermal processes*

1.2.3.1.1. Emissions to air from metal melting

BAT 40. In order to prevent or reduce emissions to air from metal melting, BAT is to use both of the techniques given below.

Technique		Description
Collection of emissions		
a.	Off-gas extraction as close as possible to the emission source	The off-gases from induction furnaces are extracted, for example using: — hood extraction (e.g. canopy or side-draught hoods); — lip extraction; — cover extraction. The off-gases from EAFs are extracted, for example using: — partial furnace enclosures (mobile or fixed) mounted around the furnace and tapping area; — total furnace enclosure using a complete room enclosure around the furnace and tapping area equipped with a moveable roof for charging/tapping operations; — hood extraction (e.g. roof-mounted, canopy or side-draught hoods); — direct extraction through the fourth hole in the furnace roof.

Technique		Description
Off-gas treatment		
b.	Fabric filter	See Section 1.4.3.

Table 1.20

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust and PCDD/F

Parameter	Unit	BAT-AEL (Daily average or average over the sampling period)
Dust	mg/Nm^3	1 – 5
PCDD/F	ng WHO-TEQ / Nm^3	< 0,01 – 0,08 [1]

[1] The BAT-AEL only applies when PCDD/F are identified as relevant in the waste gas stream based on the inventory of inputs and outputs mentioned in BAT 2.

The associated monitoring is given in BAT 12.

1.2.3.1.2. Emissions to air from steel refining

BAT 41. In order to reduce emissions to air from steel refining, BAT is to use both of the techniques given below.

Technique		Description
Collection of emissions		
a.	Off-gas extraction as close as possible to the emission source	Off-gases from steel refining (e.g. from Argon Oxygen Decarburisation (AOD) or Vacuum Oxygen Decarburisation (VOD) converters) are extracted using for example a direct extraction hood or a roof canopy combined with an accelerator stack. Extracted off-gases are treated using technique (b).
Off-gas treatment		
b.	Fabric filter	See Section 1.4.3.

Table 1.21

BAT-associated emission level (BAT-AEL) for channelled emissions to air of dust from steel refining

Parameter	Unit	BAT-AEL (Daily average or average over the sampling period)
Dust	mg/Nm^3	1 – 5

The associated monitoring is given in BAT 12.

1.2.4. **BAT conclusions for non-ferrous metal foundries**

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Sections 1.1 and 1.2.1.

1.2.4.1. *Energy efficiency*

BAT 42. In order to increase energy efficiency in metal melting, BAT is to use one of the techniques given below.

Technique		Description
a.	Molten metal circulation in reverberatory furnaces	A pump is installed on reverberatory furnaces to force the circulation of molten metal and minimise the temperature gradient throughout the molten bath (from top to bottom).
b.	Minimisation of energy losses by radiation in crucible furnaces	Crucible furnaces are covered using a lid and/or equipped with radiant panel linings to minimise energy losses by radiation.

The BAT-AEPLs for specific energy consumption are given in BAT 14.

1.2.4.2. *Emissions to air from thermal processes*

1.2.4.2.1. Emissions to air from metal melting

BAT 43. In order to reduce emissions to air from metal melting, BAT is to collect the emissions using technique (a) and to treat the off-gases using one or a combination of the techniques (b) to (e) given below.

Technique		Description
Collection of emissions		
a.	Off-gas extraction as close as possible to the emission source	Off-gases from shaft, crucible, resistance, reverberatory (hearth-type) and radiant roof furnaces are extracted using hood extraction (e.g. canopy hoods). The extraction equipment is fitted in such a way that it enables the capture of emissions during pouring. Off-gases from induction furnaces are extracted, for example using: — hood extraction (e.g. canopy or side-draught hoods); — lip extraction; — cover extraction. Off-gases from rotary furnaces are extracted, for example using hood extraction.
Off-gas treatment		
b.	Cyclone	See Section 1.4.3
c.	Dry scrubbing	See Section 1.4.3
d.	Fabric filter	See Section 1.4.3
e.	Wet scrubbing	See Section 1.4.3

Table 1.22

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust, HCl, HF, NO_X, PCDD/Fs, SO_2, Pb, and indicative emission level for channelled emissions to air of CO, from metal melting

Substance/Parameter	Unit	BAT-AEL (Daily average or average over the sampling period)	Indicative emission level (Daily average or average over the sampling period)
Dust	mg/Nm³	1 – 5	No indicative emission level
HCl		1 – 3 (¹) (⁶)	
HF		< 1 (¹)	
CO		No BAT-AEL	5 – 30 (²) (³)
NO_X		20 – 50 (⁴) (⁵)	No indicative emission level
PCDD/F	ng WHO-TEQ/Nm³	< 0,01 – 0,08 (⁶)	
SO_2	mg/Nm³	< 10 (⁴) (⁷)	
Pb		< 0,02 – 0,1 (⁸)	

(1) The BAT-AEL only applies to aluminium foundries.
(2) The upper end of the indicative emission level may be higher and up to 70 mg/Nm³ in the case of shaft furnaces.
(3) The indicative emission level does not apply in the case of furnaces using only electric energy (e.g. resistance).
(4) The BAT-AEL does not apply in the case of furnaces using only electric energy (e.g. resistance).
(5) The upper end of the BAT-AEL range may be higher and up to 100 mg/Nm³ in the case of shaft furnaces.
(6) The BAT-AEL only applies when the substance/parameter concerned is identified as relevant in the waste gas stream based on the inventory of inputs and outputs mentioned in BAT 2.
(7) The BAT-AEL does not apply when only natural gas is used.
(8) The BAT-AEL only applies to lead foundries or to other NFM foundries using lead as an alloying element.

The associated monitoring is given in BAT 12.

1.2.4.3. *Emissions to air from the treatment and protection of molten metal*

BAT 44. It is not BAT to use chlorine gas for molten aluminium treatment (degassing/cleaning).

BAT 45. In order to prevent emissions of substances with a high global warming potential from the protection of molten metal in magnesium melting, BAT is to use oxidation control agents with a low global warming potential.

Description

Suitable oxidation control agents (covering gases) with a low global warming potential include:

— SO_2;

— gas mixtures of N_2, CO_2 and/or SO_2;

— gas mixtures of argon and SO_2.

The use of SO_2 results in the formation of a protective layer composed of $MgSO_4$, MgS and MgO.

1.3. *BAT conclusions for smitheries*

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 1.1.

1.3.1. Energy efficiency

BAT 46. In order to increase energy efficiency in heating/reheating and heat treatment, BAT is to use all the techniques given below.

Technique		Description	Applicability
a.	Optimisation of furnace design	This includes techniques such as: — optimisation of key furnace characteristics (e.g. number and type of burners, airtightness, furnace insulation using suitable refractory materials); — minimisation of heat losses from furnace door openings, e.g. by using several liftable segments instead of one in continuous reheating furnaces; — minimisation of the number of feedstock-supporting structures inside the furnace (e.g. beams, skids) and use of suitable insulation to reduce the heat losses from water cooling of the supporting structures in continuous reheating furnaces.	Only applicable to new plants and major plant upgrades.
b.	Furnace automation and control	See Section 1.4.1.	Generally applicable.
c.	Optimisation of feedstock heating/reheating	This includes techniques such as: — ensuring that feedstock heating/reheating target temperatures are consistently met; — switching off equipment during idle periods; — furnace operation optimisation, e.g. furnace capacity utilisation, correction of the air/fuel ratio, improvement of insulation.	Generally applicable.
d.	Preheating of combustion air	See Section 1.4.1.	Applicability to existing plants may be restricted by a lack of space for the installation of regenerative burners.

Table 1.23

Indicative level for specific energy consumption at plant level

Sector	Unit	Indicative level (Yearly average)
Smitheries	kWh/t of feedstock	1 700 – 6 500

The associated monitoring is given in BAT 6.

1.3.2. Material efficiency

BAT 47. In order to increase the material efficiency and to reduce the quantity of waste sent for disposal, BAT is to use all of the techniques given below.

	Technique	Description
a.	Process optimisation	This includes techniques such as: — computerised management of processes, e.g. heating/reheating cycles, hammering sequences; — selection of an appropriate hammer according to raw material size; — adjustment of raw material size, either in the forging line (fully automated) or in the organisational area of the material shearing (manual), in order to minimise the amount of residues and the number of process operations.
b.	Optimisation of raw and auxiliary material consumption	This includes techniques such as: — Use of computer-aided design for optimising forging tools and forging (die) geometry in order to reduce the need for forging tests; — selection of an appropriate type of coolant/lubricant forging, e.g. synthetic lubricant for closed-die forging, water-based dispersions of graphite; — systems for collecting and recirculating coolants/lubricants in closed-die forging.
c	Recycling of process residues	Process residues (e.g. metallic residues from the processes of preparation of raw materials, hammering and finishing; used shot blast media) are recycled and/or reused.

1.3.3. Vibrations

BAT 48. In order to reduce vibrations occurring from the hammering process, BAT is to use vibration-reducing and insulating techniques.

Description

Vibration-reducing and insulating techniques for hammering equipment include the installation of vibration-damping components, e.g. layered elastomeric isolators or viscous spring isolators below the anvil, spring casings below the hammer foundation.

Applicability

Only applicable to new plants and/or major plant upgrades.

1.3.4. Monitoring of emissions to air

BAT 49. BAT is to monitor channelled emissions to air with at least the frequency given below, and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Substance/Parameter	Specific process	Standard(s)	Minimum monitoring frequency [1]	Monitoring associated with
Nitrogen oxides (NO_X)	Heating/reheating, heat treatment	EN 14792	Once every year	BAT 50
Carbon monoxide (CO)	Heating/reheating, heat treatment	EN 15058		

[1] To the extent possible, the measurements are carried out at the highest expected emission state under normal operating conditions.

1.3.5. **Emissions to air**

1.3.5.1. *Diffuse emissions to air*

BAT 50. In order to prevent or reduce diffuse emissions to air, BAT is to use both of the techniques given below.

Technique		Description
a.	Operational and technical measures	This includes techniques such as: — use of closed bags or drums to handle materials with dispersible or water-soluble components, e.g. auxiliaries; — minimising transport distances; — efficient material handling.
b.	Extraction of emissions from shot blasting	Emissions from shot blasting. Extracted off-gases are treated using techniques such as fabric filters.

1.3.5.2. *Emissions to air from heating/reheating and heat treatment*

BAT 51. In order to prevent or reduce NO_X emissions to air from heating, reheating and heat treatment while limiting CO emissions, BAT is to use either electricity generated from fossil-free energy sources or an appropriate combination of the techniques given below.

Technique		Description	Applicability
a.	Use of a fuel or a combination of fuels with low NO_X formation potential	Fuels with a low NO_X formation potential include natural gas and liquefied petroleum gas.	Generally applicable.
b.	Combustion optimisation	Measures taken to maximise the efficiency of energy conversion in the furnace while minimising emissions (in particular of CO). This is achieved by a combination of techniques including good design of the furnace, optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and residence time in the combustion zone, and use of furnace automation and control.	
c.	Furnace automation and control	See Section 1.4.1.	
d.	Flue-gas recirculation	Recirculation (external) of part of the flue-gas to the combustion chamber to replace part of the fresh combustion air, with the dual effect of lowering the temperature and limiting the O_2 content for nitrogen oxidation, thus limiting the NO_X generation. It implies the supply of flue-gas from the furnace into the flame to reduce the oxygen content and therefore the temperature of the flame.	Applicability to existing plants may be restricted by a lack of space.
e.	Low-NO_X burners	See Section 1.4.3.	Applicability to existing plants may be restricted by design and/or operational constraints.

Technique		Description	Applicability
f.	Limiting the temperature of air preheating	Limiting the air preheating temperature leads to a decrease of the concentration of NO_X emissions. A balance has to be achieved between maximising heat recovery from the flue-gas and minimising NO_X emissions.	Generally applicable.
g.	Oxy-fuel combustion	See Section 1.4.3.	Applicability to existing plants may be restricted by furnace design and the need for a minimum waste gas flow.
h.	Flameless combustion	See Section 1.4.3.	Applicability to existing plants may be restricted by furnace design (i.e. furnace volume, space for burners, distance between burners) and the need for a change of the furnace refractory lining. Not applicable to furnaces operating at a temperature lower than the auto-ignition temperature required for flameless combustion.

Table 1.24

BAT-associated emission level (BAT-AEL) for channelled emissions to air of NO_X and indicative emission level for channelled emissions to air of CO

Parameter	Unit	Process(es)	BAT-AEL (Daily average or average over the sampling period)	Indicative emission level (Daily average or average over the sampling period)
NO_X	mg/Nm³	Heating / reheating / heat treatment	100 – 250 ([1])	No indicative level
CO		Heating / reheating / heat teatment	No BAT-AEL	10 – 100

([1]) The upper end of the BAT-AEL range may be higher and up to 350 mg/Nm³ when recuperative/regenerative burners are used.

The associated monitoring is given in BAT 48.

1.3.6. Water consumption and waste water generation

BAT 52. In order to optimise water consumption and to reduce the volume of waste water generated, BAT is to use both of the techniques (a) and (b) given below:

Technique		Description	Applicability
a.	Segregation of water streams	See Section 1.4.4.	Applicability to existing plants may be restricted by the layout of the water collection system.

Technique		Description	Applicability
b.	Water reuse and/or recycling	Water streams (e.g. process water, cooling water) are reused and/or recycled in closed or semi-closed circuits, if necessary after treatment.	The degree of water reuse and/or recycling is limited by the water balance of the plant, the content of impurities and/or the characteristics of the water streams.

Note: BAT 52 only applies when waste water generation is identified as relevant based on the inventory of inputs and outputs mentioned in BAT 2.

1.4. *Descriptions of techniques*

1.4.1. **Techniques to increase energy efficiency**

Technique	Description
Furnace automation and control	The heating process is optimised by using a computer system controlling key parameters such as furnace and feedstock temperature, the air to fuel ratio and the furnace pressure.
Improving casting yield and decreasing scrap generation	Measures are taken to maximise the efficiency of the casting process and to decrease the generation of scrap, e.g.: — optimising melting and pouring operations to reduce, for example, melting losses, excessive pigging, scrap generation rates; — optimising moulding and core-making to reduce scrap generation resulting from deficiencies in moulds and cores; — optimising gating and rising systems; — using insulated exothermic feeders.
Increase of shaft height in CBC furnaces	Increasing the shaft height in cold blast cupola furnaces enables combustion gases to remain in contact with the charge for longer, resulting in a higher heat transfer.
Long-campaign cupola	The cupola furnace is set up for long campaign operation to minimise maintenance and process changes. This may be achieved by using more resistant furnace refractory linings in the shaft, bottom and hearth, by using water cooling of the furnace wall and with water-cooled blasting pipes penetrating deeper into the furnace shaft.
Minimal blast shut-off periods for HBC furnaces	Minimisation of blast shut-off periods by programming the schedules of the moulding and casting processes to ensure a reasonably constant demand for metal.
Oxy-fuel combustion	Combustion air is replaced fully or partially with pure oxygen. Oxy-fuel combustion can be used in combination with flameless combustion.
Oxygen enrichment of the combustion air	Oxygen enrichment of the combustion air is realised either directly at the blast supply or through injection of oxygen into the coke bed, or via the tuyères.
Post-combustion of off-gases	See Section 1.4.3.
Preheating of combustion air	Reuse of part of the heat recovered from the combustion flue-gas to preheat the air used in combustion. This may be achieved for example by using regenerative or recuperative burners (see below). A balance has to be achieved between maximising heat recovery from the flue-gas and minimising NO_X emissions.
Recuperative burner	Recuperative burners employ different types of recuperators (e.g. heat exchangers with radiation, convection, compact or radiant tube designs) to directly recover heat from the flue-gases, which are then used to preheat the combustion air.
Regenerative burner	Regenerative burners consist of two burners which are operated alternately and which contain beds of refractory or ceramic materials. While one burner is in operation, the heat of the flue-gas is absorbed by the refractory or ceramic materials of the other burner and then used to preheat the combustion air.
Selection of an energy-efficient type of furnace	Furnace energy efficiency is taken into consideration for the furnace selection, e.g. furnaces that allow the preheating and drying of incoming charge prior to the melting zone.

Technique	Description
Techniques for maximising the thermal efficiency of furnaces	Measures taken to maximise the efficiency of energy conversion in melting and heat treatment furnaces while minimising emissions (in particular of dust and CO). This is achieved by applying a series of process optimisation measures according to the furnace type including optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and residence time in the combustion zone, and use of furnace automation and control (see above). Measures for some specific furnaces include the following: For cupola furnaces: — optimisation of operational regime; — avoidance of excess temperature; — uniform charging; — minimisation of air losses; — good lining practice. For induction furnaces: — feedstock conditions (e.g. optimum size and density for input materials and scrap); — closure of furnace lid; — minimum holding time; — keeping a liquid heel in the furnace; — addition of carburisers at the beginning of the melting cycle; — operation at maximum power input level; — temperature control to prevent overheating; — prevention of excessive slag build-up by optimising melting temperatures; — minimisation and control of the wear of furnace refractory lining; — when several induction furnaces are in operation, the energy use is optimised through peak load management. For rotary furnaces: — use of anthracite and silicon for melt protection; — adjustment of the continuous or discontinuous speed rotation of the furnace to achieve maximum heat transfer; — adjustment of the power and angle of the burner to achieve maximum heat transfer. For EAFs: — shorter metal melting and/or treatment times using advanced control methods for example for the composition and the weight of the charged materials, the temperature of the melt, as well as by efficient sampling and deslagging methods. For shaft furnaces: — choice of the furnace size according to continuous melt demand, to achieve a continuous melting process; — keeping the shaft filled with charging material to have optimum heat recovery; — adapting the shaft design to the designated charging material for an optimum charging material distribution in the shaft; — regularly cleaning the furnace; — independent control of the fuel/air ratio for each gas-fired burner; — continuous CO or hydrogen monitoring for each row of burners; — addition of oxygen above the melting zone to provide afterburning in the upper level of the shaft; — preheating of the charge using waste heat recovered from the flue-gases. For reverbatory furnaces: — preheating of the charge in the case of dry hearth or side-well reverberatory furnaces; — use of burners with automatic temperature control.

Technique	Description
	For crucible furnaces: — preheating of the crucible prior to charging; — use of crucibles with high thermal conductivity and thermal shock resistance (e.g. graphite); — cleaning of crucible walls immediately after emptying to remove slag or dross.
Use of clean scrap	Melting clean scrap prevents the risk of non-metal compounds being taken up by the slag and/or degrading the furnace or ladle refractory linings.

1.4.2. **Techniques to increase material efficiency**

Technique	Description
Adjustment of the slag acidity/basicity	Use of an appropriate flux (e.g. limestone for acidic and calcium fluoride for basic cupola operations) to render the slag fluid enough to separate from the iron.
Improving casting yield and decreasing scrap generation	See Section 1.4.1.
Mechanical pretreatment of slag / dross / filter dust / spent refractory linings to facilitate recycling	Generated slag / dross / filter dust / spent refractory linings are pretreated on site, by using techniques such as crushing, segregation, granulation, magnetic separation.
Optimisation of binder and resin consumption	Measures to optimise binder and resin consumption include: — use of a sand quality which is consistent with the binder system; — good management of sand storage and sand testing (purity, grain size, shape, moisture); — temperature control; — mixer maintenance and cleaning; — checking mould quality (to prevent and if necessary repair moulding defects); — optimising binder addition process; — optimising mixer operation.
Separate spraying of release agent and water in high-pressure die-casting	Water and release agents are applied separately to the mould using an additional row of nozzles mounted on the spray head. Water is sprayed first, leading to a significant cooling of the mould before the application of the release agent, which results in reduced emissions and consumption of release agents and water.

Use of best practices for cold-setting processes	Practices include the following (according to the binding system used):
	— Temperature control: the temperature of the sand is kept as constant as possible and low enough to prevent emissions caused by evaporation. For phenolic- and furan-acid-catalysed, polyurethane and ester silicate systems, the optimum temperature range is between 15 °C and 25 °C. For resol-ester systems, the optimum temperature range is between 15 °C and 35 °C;
	— for furan-acid-catalysed systems:
	  — the content of free (monomer) furfuryl alcohol in the resin is minimised (e.g. less than 40 wt-%); and
	  — the sulphur content of the acid catalyst is reduced by substituting a portion of the sulphonic acid with a strong sulphur-free organic acid.

Technique	Description
Use of best practices for gas-hardening processes	Practices include the following (according to the hardening process used): For phenolic urethane resins (cold-box process): — the consumption of amines is minimised by optimising the diffusion process within the core, typically through computer simulation for optimisation of the gas flow; — the sand temperature is maintained as constant as possible, between 20 °C and 25 °C, to minimise gassing time and amine consumption; — the moisture of the sand is maintained below 0,1 % and the gassing and purging air is dried; — core boxes are well sealed to allow the amine catalyst gas to be extracted and the cores are thoroughly purged to prevent amine releases during the storage of cores. For resol-ester resins: — the sand temperature is maintained as constant as possible, between 15 °C and 30 °C; — curing of the alkaline phenolic resin is achieved using methyl formate that is gasified by air typically heated up to 80 °C; — core boxes and gassing heads are sealed correctly and the venting of the core box designed to give a slight backpressure so that the curing vapour is held long enough for the reaction to take place. For CO_2-hardened resins (e.g. alkaline phenolic, silicate): — the exact volume of CO_2 gas necessary for curing the resins is used by employing a flow controller and a timer to achieve the best strength and storage time; — for silicate resins, liquid breakdown agents are employed (e.g. soluble carbohydrates) to increase gassing speed. For SO_2-hardened resins (e.g. phenolic, epoxy/acrylic): — the gassing period is followed by purging with either the same inert gas (e.g. nitrogen) used for curing or air, to remove the unreacted excess sulphuric dioxide from the sand; — core boxes are well sealed and the cores are thoroughly purged to prevent gas releases during the storage of cores.
Use of clean scrap	See Section 1.4.1.

1.4.3. **Techniques to reduce emissions to air**

Technique	Description
Adjustment of the slag acidity/basicity	See Section 1.4.2.
Adsorption	The removal of pollutants from a process off-gas or waste gas stream by retention on a solid surface (activated carbon is typically used as the adsorbent). Adsorption may be regenerative or non-regenerative.
Catalytic oxidation	Abatement technique which oxidises combustible compounds in a waste gas stream with air or oxygen in a catalyst bed. The catalyst enables oxidation at lower temperatures and in smaller equipment compared to thermal oxidation. The typical oxidation temperature is between 200 °C and 600 °C.

<table>
<tr><th>Technique</th><th>Description</th></tr>
<tr><td>Cyclone</td><td>Equipment for the removal of dust from an off-gas stream based on imparting centrifugal forces, usually within a conical chamber. Cyclones are mainly used as a pretreatment before further dust abatement or abatement of organic compounds. Multicyclones may also be used.</td></tr>
<tr><td>Dry scrubbing</td><td>Dry powder or a suspension/solution of an alkaline reagent (e.g. lime or sodium bicarbonate) is introduced and dispersed in the off-gas stream. The material reacts with the acidic gaseous species (e.g. SO_2) to form a solid, which is removed by filtration (e.g. fabric filter).</td></tr>
<tr><td>Electrostatic precipitator</td><td>Electrostatic precipitators (ESPs) operate such that particles are charged and separated under the influence of an electrical field. Electrostatic precipitators are capable of operating under a wide range of conditions. Abatement efficiency may depend on the number of fields, residence time (size), and upstream particle removal devices. They generally include between two and five fields, but may contain up to seven fields for the most advanced ESPs. Electrostatic precipitators can be of the dry or of the wet type depending on the technique used to collect the dust from the electrodes. Wet ESPs are typically used at the polishing stage to remove residual dust and droplets after wet scrubbing.</td></tr>
<tr><td>Extraction of emissions generated from moulding and/or core-making as close as possible to the emission source</td><td>Emissions generated from moulding (including the making of patterns) and/or core-making are extracted. The extraction system selected depends on the type of moulding/core-making process.
— Natural/green sand moulding:
Off-gases generated in the natural or green sand preparation areas (e.g. transport, sieving, mixing and cooling) and in the moulding areas, especially during pouring, are extracted. In the case of automatic moulding machines, appropriate extraction systems are used to collect emissions (e.g. roof extraction). In the case of hand moulding, extraction as close as possible to the emission source is achieved using mobile extraction hoods.
— Cold-setting, gas curing, hot-curing processes:
In the case of automatic moulding machines, extraction systems are used to collect emissions (e.g. fixed extraction hoods, canopy extraction). In the case of hand moulding, extraction as close as possible to the emission source is realised using mobile extraction hoods.
In the event that mobile hoods cannot be used due to the size of the mould and/or space restrictions, casting hall extraction is used.
Core shooting machines are enclosed and off-gases are extracted. Extraction is also applied during checking, handling and storage of freshly made cores (e.g. by using hoods at the checking table, above the handling and temporary storage areas).</td></tr>
<tr><td>Fabric filter</td><td>Fabric filters, often referred to as bag filters, are constructed from porous woven or felted fabric through which gases are passed to remove particles. Fabric filters can be in the form of sheets, cartridges or bags with a number of the individual fabric filter units housed together in a group. The use of a fabric filter requires the selection of a fabric suitable for the characteristics of the waste gas and the maximum operating temperature.</td></tr>
<tr><td>Flameless combustion</td><td>Flameless combustion is achieved by injecting fuel and combustion air separately into the combustion chamber of the furnace at high velocity to suppress flame formation and reduce the formation of thermal NO_X while creating a more uniform heat distribution throughout the chamber. Flameless combustion can be used in combination with oxy-fuel combustion (see Section 1.4.1).</td></tr>
<tr><td>Furnace automation and control</td><td>See Section 1.4.1.</td></tr>
</table>

Technique	Description
Low-NO_X burner	The technique (including ultra-low-NO_X burners) is based on the principles of reducing peak flame temperatures. The air/fuel mixing reduces the availability of oxygen and reduces the peak flame temperature, thus retarding the conversion of fuel-bound nitrogen to NO_X and the formation of thermal NO_X, while maintaining high combustion efficiency.
Optimisation of binder and resin consumption	See Section 1.4.2.
Oxygen enrichment of the combustion air	See Section 1.4.1.
Oxy-fuel combustion	See Section 1.4.1.
Post-combustion of off-gases	Post-combustion of CO and other organic compounds contained in furnace off-gases is used to reduce emissions and for heat recovery. The generated heat is recovered with a heat exchanger and used for blast air preheating or other internal purposes. In HBC furnaces, post-combustion takes place in a separate post-combustion chamber preheated by a natural gas burner. In CBC furnaces, post-combustion takes place directly in the cupola shaft. In rotary furnaces, post-combustion is carried out using an afterburner installed between the furnace and the heat exchanger.
Selection of an appropriate furnace type	Selection of the appropriate furnace type(s) based on the level of emissions and technical criteria, e.g. type of process such as continuous or batch production, furnace capacity, type of castings, availability of raw materials, flexibility depending on raw materials' cleanliness and alloy change. The energy efficiency of the furnace is also considered (see technique 'Selection of an energy-efficient type of furnace' in Section 1.4.1).
Substitution of alcohol-based coatings with water-based coatings	Substitution of alcohol-based coatings of moulds and cores with aqueous coatings. Aqueous coatings are dried in ambient air or using drying ovens.
Thermal oxidation	Abatement technique which oxidises combustible compounds in a waste gas stream by heating it with air or oxygen to above its auto-ignition point in a combustion chamber and maintaining it at a high temperature long enough to complete its combustion to carbon dioxide and water. The typical combustion temperature is between 800 °C and 1 000 °C. Several types of thermal oxidation are operated: — Straight thermal oxidation: thermal oxidation without energy recovery from the combustion. — Recuperative thermal oxidation: thermal oxidation using the heat of the waste gases by indirect heat transfer. — Regenerative thermal oxidation: thermal oxidation where the incoming waste gas stream is heated when passing through a ceramic-packed bed before entering the combustion chamber. The purified hot gases exit this chamber by passing through one (or more) ceramic-packed bed(s) (cooled by an incoming waste gas stream in an earlier combustion cycle). This reheated packed bed then begins a new combustion cycle by preheating a new incoming waste gas stream.
Use of best practices for cold-setting processes	See Section 1.4.2.
Use of best practices for gas-hardening processes	See Section 1.4.2.

Technique	Description
Wet scrubbing	The removal of gaseous or particulate pollutants from a gas stream via mass transfer to a liquid solvent, often water or an aqueous solution. It may involve a chemical reaction (e.g. in an acid or alkaline scrubber). In some cases, the compounds may be recovered from the solvent. This includes venturi scrubbers.

1.4.4. **Techniques to reduce emissions to water**

Technique	Description
Activated sludge process	In the activated sludge process, the microorganisms are maintained as a suspension in the waste water and the whole mixture is mechanically aerated. The activated sludge mixture is sent to a separation facility from which the sludge is recycled to the aeration tank.
Adsorption	The removal of soluble substances (solutes) from the waste water by transferring them to the surface of solid, highly porous particles (typically activated carbon).
Aerobic treatment	The biological oxidation of dissolved organic pollutants with oxygen using the metabolism of microorganisms. In the presence of dissolved oxygen, injected as air or pure oxygen, the organic components are mineralised into carbon dioxide and water or are transformed into other metabolites and biomass.
Chemical precipitation	The conversion of dissolved pollutants into an insoluble compound by adding chemical precipitants. The solid precipitates formed are subsequently separated by sedimentation, air flotation or filtration. If necessary, this may be followed by microfiltration or ultrafiltration. Multivalent metal ions (e.g. calcium, aluminium, iron) are used for phosphorus precipitation.
Chemical reduction	The conversion of pollutants by chemical reducing agents into similar but less harmful or hazardous compounds.
Coagulation and flocculation	Coagulation and flocculation are used to separate suspended solids from waste water and are often carried out in successive steps. Coagulation is carried out by adding coagulants with charges opposite to those of the suspended solids. Flocculation is carried out by adding polymers, so that collisions of microfloc particles cause them to bond to produce larger flocs.
Equalisation	Balancing of flows and pollutant loads at the inlet of the final waste water treatment by using central tanks. Equalisation may be decentralised or carried out using other management techniques.
Evaporation	Evaporation of waste water is a distillation process where water is the volatile substance, leaving the concentrate as bottom residue to be handled (e.g. recycled or disposed of). The aim of this operation is to reduce the volume of waste water or to concentrate mother liquors. The volatile steam is collected in a condenser and the condensed water is, if necessary after subsequent treatment, recycled. There are many types of evaporators: natural circulation evaporators; short-tube vertical evaporators; basket-type evaporators; falling film evaporators; agitated thin film evaporators. Typical pollutants targeted are soluble contaminants (e.g. salts).
Filtration	The separation of solids from waste water by passing them through a porous medium, e.g. sand filtration, microfiltration and ultrafiltration.
Flotation	The separation of solid or liquid particles from waste water by attaching them to fine gas bubbles, usually air. The buoyant particles accumulate at the water surface and are collected with skimmers.

Technique	Description
Membrane bioreactor (MBR)	MBR consists of the combination of a membrane process (e.g. microfiltration or ultrafiltration) with a suspended growth bioreactor. In an MBR system for biological waste water treatment, the secondary clarifier and the tertiary filtration step of a traditional aerated sludge system is replaced by membrane filtration (the separation of sludge and suspended solids).
Nanofiltration	A filtration process in which membranes with pore sizes of approximately 1 nm are used.
Neutralisation	The adjustment of the pH of waste water to a neutral level (approximately 7) by the addition of chemicals. Sodium hydroxide (NaOH) or calcium hydroxide ($Ca(OH)_2$) is generally used to increase the pH, whereas sulphuric acid (H_2SO_4), hydrochloric acid (HCl) or carbon dioxide (CO_2) is generally used to decrease the pH. The precipitation of some substances may occur during neutralisation.
Physical separation	The separation of gross solids, suspended solids, metal particles from the waste water using for example screens, sieves, grit separators, grease separators, hydrocyclones, oil-water separation or primary settlement tanks.
Reverse osmosis	A membrane process in which a pressure difference applied between the compartments separated by the membrane causes water to flow from the more concentrated solution to the less concentrated one.
Sedimentation	The separation of suspended particles and suspended material by gravitational settling.
Segregation of water streams	Water streams (e.g. surface run-off water, process water) are collected separately, based on the pollutant content and on the required treatment techniques. Waste water streams that can be recycled without treatment are segregated from waste water streams that require treatment.