Nordic Council
of Ministers

Nordic Foundries Best Available Techniques (BAT)

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Martin Wänerholm

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Summary

The BAT Group of the Nordic Council of Ministers has decided to conduct a project on Best Available Techniques (BAT) for the foundries and smitheries in the Nordic countries. No smitheries satisfies the criteria of the Industrial Emissions Directive (IED) and therefore this report focuses only on foundries.

The objectives when compiling this report have been to:

- Provide an overview of the foundry sector in the Nordic countries.
- Present currently used and potential environmental techniques in foundries in the Nordic countries.
- Present the Key environmental issues with the perspective of foundries in the Nordic countries.
- Present and describe techniques that shall be included in the considerations of representing BAT in foundries.

The scope of the work has been to include foundries using permanent and non-permanent moulds. The focus has been on processes specific for the foundry industry, from simulation of the casting to cast products, and to a minor extent some general processes of significant relevance to casting.

The provided information can be utilised by operators, environmental consultants and environmental authorities. The projects might also be useful as a Nordic input to the Technical Working Group in the revision of the BAT conclusions for the “Smitheries and Foundries Industry” according to the IED.

Metal casting has a long tradition and it has previously been a large industry in the Nordic countries but the number of foundries has decreased. Today Sweden has the largest number of foundries in the Nordic countries.

The key environmental issues (KEI) in the scope of this study are (in non-prioritised order)

- Air emissions (dust and VOC)
- Noise emission and vibrations
- Emissions to water and water use
- Chemical use and risks
- Waste/residues
- Energy use
- Raw material
- Transports

Presented BAT at foundries describes

- BAT for control of air emissions
- BAT to prevent noise emissions and vibrations
- BAT for control of wastewater emission
- BAT High pressure die casting
- BAT sand and binders
- BAT for chemicals handling and substitution
- BAT for waste management and minimisation
- BAT for construction simulation
- BAT for energy
- BAT metal and melting
- BAT for environmental management

Technical applicability, economic cost and environmental benefits from the different BAT varies widely and is strongly case dependent. It is also worth stressing that due to processes, products, current foundry design and if it is an old existing or new foundry the foundries are not always free to choose BAT. Presented BAT candidates are listed below.

BAT Candidates Emissions to Air

- Bag-house filter
- Pressure drop gauge
- Dust filter measurements
- Filter heating

- Using fluorescent powder to check for problem in bag-house filter
- Particle monitor
- Acid scrubber to clean amine
- Oil mist filter
- Plan for reduction of VOC
- Lid on coating vessel
- Use coating only when needed
- Coal Dust replacement
- Cleaning VOC and odour with biofilter
- Cleaning VOC odour with RTO

BAT Candidates Noise emission

- Tipping scrap indoors
- Noise reducing plan
- Noise simulation
- Silencers on ventilation systems
- Additional insulation of fans and ducts

BAT Candidates Chemicals

Chemicals responsibility

BAT Candidates Waste and residues

- Recycling management
- Equipment for mechanical sand regeneration
- Reuse of rest sand outside the foundry
- Bricketing

BAT Candidates Simulation

- Simulation
- Optimized inlet and gating system

BAT Candidates Energy

- Energy audit
- Blasting raw material before melting
- Crushing inlet and gating system
- Insulated ladles
- Use of lid on furnace and ladle
- Flameless ladle heating

BAT Candidates Metal and melting

- Scrap handling
- Using deoxidiser
- Flushing ladle with argon
- Inoculation control
- Automatized in-stream inoculation

BAT Candidates High and Low pressure die casting

- Maintenance of die tool
- Preheat die tool
- IR camera
- Use of vacuum dosing furnace

BAT Candidates Management and general

- Circular economy
- Material Flow Cost Accounting (MFCA)
- Management system
- Digitalization
- Environmental communication

Emerging techniques

- New release agent for High pressure die casting
- Ignition of VOC at the sand mould
- New inorganic sand binder
- Reclaim green sand to core production

Preface

The Nordic Council of Ministers, the BAT Group under the Working Group for sustainable consumption and production, has commissioned to the Swedish foundry and casting research institute Swerea SWECAST AB to prepare a Best Available Techniques (BAT) report for foundries in the Nordic countries.

The information provided by this report is intended to be used by operators, environmental consultants and environmental authorities with relevant competence. This report may also be used as Nordic input for the Technical Working Group in the revision of the BAT conclusions for the “Smitheries and Foundries Industry” according to the Industrial Emission Directive (IED). The foundry sector is very complex with a lot of different metals, different ways of melting, different ways to do the casting. It is difficult to make one report describing all different variants and this report is therefore a simplified picture of the sector.

46 potential BAT candidates and an three emerging technique are included in the report which addresses measures to reduce air emissions, noise emission and production of waste at foundries.

This work couldn't have been done without all the foundries in the Nordic countries that have answered a lot of questions. Thanks for all help.

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The BAT project has been followed on by the Nordic BAT Group. The members of the BAT Group are:

- Kaj Forsius, Finnish Environment Institute.
- Susanne Särs, Environmental and Health Protection Agency of the Aland Islands.
- Birgitte Holm Christensen, Danish Environmental Protection Agency.
- Anne Kathrine Arnesen, The Norwegian Environment Agency.
- Maria Enroth, Swedish Environmental Protection Agency.
- Kristina Svinhufvud, Swedish Environmental Protection Agency.
- Sigurdur Ingason, Environment Agency of Iceland.
- Lena Ziskason, Environment Agency of Faroe Island.

List of abbreviations

BAT	Best Available Techniques
BREF	Best Available Technology Reference Document
EMS	Environmental management systems
HPDC	High pressure die casting
IED	The Industrial Emissions Directive (2010/75/EU)
KEI	Key environmental indicators
LPDC	Low pressure die casting
RTO	Regenerative Thermal Oxidation
VOC	Volatile organic compounds
XRF	X-ray fluorescence

Introduction

The current EU BREF documents are from 2005 and are focused on smitheries and foundries. The first part of this project was to investigate which foundries in the Nordic countries meet the requirements of the industrial emissions directive IED and if there are any smitheries that meet the requirements.

When it comes to smitheries the requirement is “operation of smitheries with hammers the energy of which exceeds 50 kilojoules per hammer, where the calorific power used exceeds 20 MW.” Industry associations for forging, authorities in Nordic countries, and a number of possible smitheries were contacted. There are a number of forging facilities that meet the first requirement that the hammer energy exceeds 50 kilojoules per hammer, but no smitheries have been identified that at the same time fulfil the demand for calorific power used. It cannot be excluded there may be some companies in the Nordic countries that meet both requirements, but such has not been identified in this project. After this finding, it was decided that the rest of this work would focus solely on foundries.

The way to find out which foundries are affected by the directive was made in the same way as for forging plants. Contact was made with industry associations and authorities and lists of company names were compared. The different sources listed almost the same companies, but the authorities' lists generally contained some more companies than the industry associations' lists. Among other things, there were some companies that cast but not melt the metal, companies only melting and companies no longer existing. On the industry associations' lists were some companies that were not on the authorities' lists. This may give reasons for the authorities and industry associations in each country to meet to discuss this discrepancy, and to obtain consensus.

Methodology

The companies identified received a questionnaire about techniques used today, if the company itself considers this to be BAT, or if there is knowledge of some better technology. This questionnaire is in an annex to this report. The questionnaire was followed up with more questions to the companies that were considered to be in the forefront of technological development, based on their questionnaire replies.

Swerea SWECAST is a research institute based in Sweden specializing on foundry and casting. Experts in different fields and subjects within the institute have thereby also contributed with facts and knowledge about different steps in foundry techniques and the casting process. The combined knowledge from questionnaires, interviews and expert input has been used to produce the list of BAT. Moreover, benchmark and harmonization discussions have been held with partners in Denmark and Finland. The

final decision of what to be KEI and BAT was made by the experts. Some of the BAT listed needed a more detailed explanation.

This report describes techniques used including technology but also way of working that can be at least as important.

The objectives

The objectives when compiling this report have been to:

- Provide an overview of the foundry sector in the Nordic countries.
- Present currently used and potential environmental techniques in foundries in the Nordic countries.
- Present the Key environmental issues with the perspective of foundries in the Nordic countries.
- Present and describe techniques that shall be included in the considerations of representing BAT in foundries.

1. The Nordic foundries

1.1 Finland

There are 30 foundry members in the Association of Finnish Foundry Product Industries. Foundries are usually small and medium size with wide customer base and wide variety of cast products and materials. Typical castings are cast components to diesel motors, paper machines, telecommunication, heavy vehicles (tractors, earthmovers, forest machines), lifts and power production applications.

The production of iron and steel castings 2016 was 58,000 tons and non-ferrous metals 5,000 tons. Finnish foundries are employing 1,600 people.

Number of IED foundries 10–15.

1.2 Åland Island

There is no foundry relevant to the IED on the Åland Islands.

1.3 Denmark

The Association of Danish Foundries, (Danske Støberiers Brancheforening) has 14 member companies (7 ferrous and 7 non-ferrous foundries). Not all of these foundries are IED.

The members were in 2015 employing 1,144 people, and the produced tonnage was 78,000 ton of iron-castings and 4,000 tons of non-ferrous castings (total 82,000 tons).

Produced parts are mainly for following sectors: Pumps, Agriculture, Automotive, Marine, Off-shore, Hydraulics.

Outside the Association of Danish Foundries are a number (5 or 6) of HPDC companies working mainly in Al-alloys. The largest is the in-house plant at Grundfos. There is also one relatively large producer of Zn parts, Linimatic.

Further there are several small (1–2 employees) founders that mainly serve artists and museums. These are not operating on industrial scale.

Number of IED foundries 5–10.

1.4 Norway

The foundry production in Norway 2016 was nearly 30,000 tons iron. 50% of this was sold on export. For aluminium the production was just over 6,000 tons and 90% of this was sold to other countries. The statistics is based on 17 reporting members in the Norwegian foundry association. The total number employee is 700–800.

Number of IED foundries 5–10.

1.5 Sweden

In Sweden there are total of 100 foundries, 40 casting iron or steel and 60 casting nonferrous metal. Foundries are usually small and medium size with wide customer base and wide variety of cast products and materials. Swedish foundries are employing 8,000 people.

The production in 2016 of iron castings was 210,000 tons, steel 21,000 tons, aluminum and magnesium 47,000 tons, copper 4,000 tons and zink 8,500 tons. The numbers is based on statistics from the Swedish Foundry Association.

Number of IED foundries 15–20.

1.6 Iceland

There is no foundry relevant to the IED on Iceland.

1.7 Faroe Islands

There is no foundry relevant to the IED n Faroe Islands.

2. Brief regulatory review

The BREF document on Smitheries and Foundries Industry will soon be revised according to the IED. The current BREF is from 2005.

Annex I of the IED includes:

- "Operation of smitheries with hammers the energy of which exceeds 50 kilojoule per hammer, where the calorific power used exceeds 20 MW."
- "Operation of ferrous metal foundries with a production capacity exceeding 20 tonnes per day."
- "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."

2.1 Finland

The IED is implemented in Finland as part of the renewed Environmental Protection act (527/2014) and Decree (713/2014). Environmental permits for IED companies are reviewed case by case and shall fulfil the BAT conclusions under the IED.

2.2 Åland Islands

Åland has its own provincial laws in a number of important areas based on its autonomous position. The environmental licensing for industrial plants is outlined in the Provincial law on environmental protection (ÅFS 2008:124, changed ÅFS 2015:14) and decree (ÅFS 2008:130, changed ÅFS 2015:15).

2.3 Denmark

IED is implemented in Denmark and included in the Executive Order for environmental permitting of companies (BEK nr 1517 af 07/12/2016) which was made effective recently and is a part of the environmental regulation system. Environmental permits for IED companies are reviewed case by case and shall fulfil the BAT conclusions under the IED.

2.4 Norway

The IED is implemented in Norwegian legislation by the Pollution Regulations and Waste Regulations.

Environmental permits for IED companies are reviewed case by case and shall fulfil the BAT conclusions under the IED.

2.5 Sweden

The regulations of the IED are implemented in Swedish law by general binding rules, mainly in the Ordinance on Industrial Emissions (2013:250). The General Rules of Consideration and the provisions on the licensing process in the Swedish Environmental Code are not changed due to the implementation of the IED. BAT conclusions are implemented as a parallel system through general binding rules which are recurrently updated due to the publication of new BAT conclusions.

The environmental licensing for industrial plants outlined in the Swedish Environmental Code is based on case-by-case assessments of environmentally hazardous activities and taking into account the local conditions. Licensing of large and medium-size installations takes place by courts or County administrative boards.

2.6 Iceland

The environmental regulations for industry licensing are based on the IED directive since the first of June 2017, when IED implemented in Iceland.

2.7 Faroe Islands

The Faroe Islands have their own laws in a number of important areas based on their autonomous position. The environmental legislation for industrial plants is outlined in the Act on environmental protection from 1988.

3. Casting

3.1 Introduction

In metalworking, casting means a process, in which liquid metal is poured into a mould that contains a hollow cavity of the desired shape. When the shape is filled, the metal is allowed to cool and solidify. The solidified part is ejected or broken out of the mould to complete the process. Casting is most often used for making complex shapes that would be difficult or uneconomical to make by other methods. There are a number of methods for casting, but these can be generally divided into permanent and non-permanent moulds.

To determine which casting method to apply, the first step is to determine the technical requirements on the product one wants to cast, and from this determine the appropriate metal. Choice of metal then to some extent controls the casting method to be used. It is therefore not relevant to say that one casting method is BAT and another is not. However, within each method there is good or less good practice. The design of a product and the choice of casting method are often outside the foundry's influence and therefore not discussed more in this document.

3.2 Non-permanent moulds

Non-permanent moulds are often based on sand. When producing a sand mould a first important step is to make a simulation of the casting. There are a number of different parts of the process that can be simulated, but the most common and most necessary is to simulate how the mould should be designed for the filling of the metal to be as good as possible, to avoid cavities or pores that can result in poor quality of the casting. The experiences from these simulations may even influence the design of the cast product.

Based on the design and simulation a model of the cast product is made. The model is often made of wood, metal or plastic. Generally the foundry does not make this model themselves. Therefore, it is considered outside the scope of this document to discuss what is BAT for model making.

Figure 1: Part of a model made of wood

One common method for mould making is to place the model in an iron frame, mould flask, and pack sand around it. Cavities are created in the finished casting by placing a sand core in the mould. For the sand in the mould and in the core to hold together different types of binders used. When the model has formed an imprint into the sand the model is removed and reused for the next mould.

Figure 2: Mould flask waiting to be filled with sand

Figure 3: Core placed in a mould of green sand

Another way is to print the sand mould in a sand printer with additive manufacturing. This is a new method and there is no need for a wood or plastic model which shortens the time from idea to finished casting. It is also possible to make more complicated moulds than with normal sand moulds. Today the method is mostly used for prototypes and not series production.

Figure 4: Sand printer at Swerea SWECAST

Figure 5 is a simple picture of foundry using sand. Text in red is environmental impacts described in chapter 4.

Figure 5: The foundry non-permanent moulds (example sand)

3.2.1 *Other methods than sand*

A special version of casting is a model made of styrofoam, and sand is formed around this. The styrofoam model is never removed but burned when the melt is poured into the mould, which may give rise to some smoke. This is not a very common method in the Nordic countries.

Another method is investment casting where a wax model is formed. The wax model is dipped in slurry of sand and binder and formed into a hard shell around the wax. Next, this is heated, and the wax melts and flows out and may be used to form a new model. What remains is a shell where the casting takes place. This is not a very common method in the Nordic countries.

3.2.2 *Different types of binders for the sand*

There are several ways to hold the sand in the mould and core together and most sand foundries use some kind of binder. There are advantages and disadvantages of each type of binder and it is difficult to say which to consider as BAT.

Green sand

For green sand water, bentonite clay and a carbonaceous material (coal dust) or a replacement for this is added. This is a very common way to make moulds.

Chemical binders

There are also a number of chemical binders. Most chemical binders used consist of organic compounds, but also inorganic compounds are possible. The binder system consists of two different parts that react in the sand to create a fixed mould or core. A binder resembles the curing of plastics; the foundry buys sand and binder and mixes it at site.

Inorganic binders are good from an environmental perspective as they do not give rise to emissions to air. But they do not work in all applications. They consist of sodium silicate, which is cured in different ways.

Among the organic binders there are a variety of options to choose from.

A further alternative is a method wherein the sand already at delivery is coated with a binder.

Other ways to hold the sand together

There are also several other methods to keep the sand together. One example is vacuum, where a binder is not needed. Creating the vacuum requires much energy.

3.2.3 *Coating*

To avoid that the sand sticks on the cast product a protective coating is sometimes used. The coating often contains graphite and some kind of thickener dissolved in water or alcohol. It establishes a protective layer between the sand and the metal. When

alcohol is used, the emissions to air need to be minimized. For water based coating energy-use for the drying of the water instead needs to be minimized. If the foundry ch

Figure 6: Coating of mould with a brush. Previously published in Gjuteriet / Gjuteriinformation AB

oses

water or alcohol based coating often depends of technical reasons.

The sand is normally circulated and re-used in the foundry several times. But for technical reasons, such as wearing down of the sand grains and contamination with other dusts, a certain proportion of new sand is added at each circulation. This means that the same amount of sand that is added at each circulation also must be sent away from the foundry at each circulation. For reasons of cost, efficiency and waste minimization foundries try to achieve an as high rate of circulation as possible, while avoiding to compromising any quality aspects of the products. For environmental reasons most foundries tries to achieve a good secondary use for the mould sand, so that it not only ends up in landfills. Different sand for example different level of silica can affect what secondary use that is possible.

3.3 Permanent moulds

There are several ways to make casting with permanent moulds. Figure 7 is a simple picture of foundry using high pressure die casting. Text in red is environmental impacts described in chapter 4.

Figure 7: The foundry permanent moulds (example high pressure diecasting)

3.3.1 Gravity die casting

Gravity die casting is a repeatable casting process used for non-ferrous alloy parts, typically aluminium, zinc and copper base alloys.

The mould is made of iron or steel. First the mould is preheated and then gravity is used to fill the mould with the liquid alloy. The method is suited to medium to high

volumes products and typically parts are of a heavier sections than high pressure die casting (see below), but thinner sections than sand casting.

A variation of this is a method where the mould is tilted from horizontal to vertical position during filling which gives a better filling.

3.3.2 Low Pressure Die Casting

Low Pressure Die Casting (LPDC) is a method used for metals as aluminium and brass where the melt is pressed from below into the metal mould. The advantage is less turbulence that gives a product with better structure and less cassation.

The mould is normally made from two steel halves mounted in the casting machine. The metal is melted either in a central furnace and then transported to each casting machine in a movable casting crucible or the liquid metal is transported from a smelter next door to the receiving furnace for future transport by the metal launder system to the holding furnaces next to each caster and casting crucible. There are advantages and disadvantages with both options.

LPDC means that molten metal is pressed with low speed into the Mould, leading to a very smooth and sound filling of the space between the two steel halves named cavity. The melt gives off heat to the steel Mould and the metal solidifies. The steel Mould would be cooled either by water or pressure air. The Mould opens and the cast product is taken out. Thanks to low speed filling the casting get very sound with high strength even at thin wall casting by use of sand cores and complicated geometries.

There are two basic types of LPDC casting machines; either with movable casting crucible using long fill tubes or fixed casting crucible with movable casting machine using several short fill tubes for continuous casting like the vacuum & pressure riser-less casting.

The advantage is a cast product nearly free of porosity with good structure and low cassation.

3.3.3 Centrifugal casting

Centrifugal casting or rotocasting is a casting technique that is typically used to cast thin-walled cylinders or rollers. In centrifugal casting, a permanent mould is rotated continuously about its axis at high speeds as the molten metal is poured. The molten metal is centrifugally thrown towards the inside mold wall, where it solidifies after cooling.

3.3.4 Continuous casting

In continuous casting the liquid metal is poured through a graphite nozzle forming tubes or metal rods. The method is used for copper and iron. The product is free from porosities, sand and other inclusions.

3.3.5 *High pressure die casting*

The most commonly used permanent mould is used for High pressure die casting (HPDC). The HPDC permanent moulds are made of steel, referred to as die tool. HPDC is used for magnesium, zinc, aluminium and some other metals. The die tools are made from two steel halves mounted in a die casting machine. The metal is melted either in a furnace adjacent to each die casting machine, or is melted in a central furnace and are then transported to each machine. There are advantages and disadvantages with both options.

HPDC means that molten metal is pressed at high speed into the die tool, leading to an almost instantaneous and complete filling of the space between the two steel halves. The melt gives off heat to the tool parts and the metal solidifies. The tool opens and the cast product is taken out. Thanks to high-speed injection and high injection pressures the melt can be extruded into very thin sections and be able to fill complicated geometries.

There are two basic types of die casting machines; hot-chamber machines, and cold-chamber machines. The difference is how the melt is fed into the machine. The two types of casting machines have different areas of application.

The principle of cold chamber die casting is seen in Figure 8.

Figure 8: Principle of High pressure die casting.

Note: a. The die tool is closed. Melt is poured into the filling chamber.

b. The shot piston presses the melt into the die tool cavity with great speed and pressure. The melt is subjected to pressure during solidification.

c. When the melt has solidified the tool is opened and the ejector pins eject the finished casting from the movable die halves.

Release agent is sprayed in to the halves of the tool. The tool is shut and a new cycle begins.

3.3.6 Release agent

The die tool must be lubricated between each shot with a release agent, normally water with a small amount of oil or wax in it. There are some new methods that use a powder instead of water and oil but this one is not common today. The lubrication of the die tool is important both to achieve the intended casting quality, and to keep the lifetime of the die tool. The lubrication also has some effect on the cooling. The lubricant coating facilitates the form filling and it acts as an insulator between the casting alloy and the tool surface.

3.3.7 Vacuum

Some foundries now use a new type of HDPC, in which the melt is both pulled in by vacuum while also pushed by high pressure into the melting chamber. This combined force provides a more accurate filling, and also reduces oxygen to dissolve into the melt, which otherwise results in air bubble inclusions into the component, and consequential scrapping of goods.

3.4 Melting and pouring

Metal is melted in a furnace. There are several variants, and it is difficult to say that a certain type of furnace is BAT as it depends on a number of factors which furnace is used. Some furnaces use electricity and other use burning gas or coal which of course gives different emissions.

3.4.1 Induction furnace

The most common furnace for melting iron and steel is an induction furnace. In an induction furnace, the metal charge material is melted or heated by current generated by an electromagnetic field.

3.4.2 Cupola furnace

Some very large foundries use a cupola furnace. The construction of a conventional cupola consists of a vertical steel shell which is lined with a refractory brick. The charge consists of alternate layers of the metal to be melted, coke fuel and limestone flux. The fuel is burnt in air which is introduced through tuyeres positioned above the hearth. The hot gases generated in the lower part of the shaft ascend and preheat the descending charge. The cupola furnace is used for melting iron.

The advantages are continuous melting, high melt rates, relatively low operating cost and ease of operation and there is no need for clean or dry raw material. . The disadvantages are the larger emissions than from induction furnace.

3.4.3 Electric arc furnace

Electric arc furnace is used for melting steel. The furnace generally consists of a cylindrical steel shell which is lined with acid or basic refractories. The roof which can normally swing away to facilitate charging, generally contains three carbon electrodes operating on a high tension three-phase power supply. These electrodes protrude vertically through the roof and an electric current passes directly through them and into the metal bath. The distance between the electrodes and the metal bath is automatically controlled and determines the power input into the bath. The furnace have a lot of advantages. The disadvantages are the larger emissions than from induction furnace.

3.4.4 *Shaft furnace*

A furnace of upright form. The heating is made by burning gas. A furnace in the form of a vertical cylinder that is charged at the top and tapped at the bottom in which hot gas is forced upwards through the contained solids. It gives a good melt and is energy efficient as the combustion gases heat the scraped / unmelted metal on the way down to the melting chute and oxides from the scrap can be removed from the melting chute (at least in newer ovens). In smaller foundries, resistive furnaces are probably still dominant.

3.4.5 *Electric resistance furnace*

Furnace only used for non-iron foundries. Common in small foundries.

3.4.6 *Other types of furnace*

There are also other furnaces where electricity or burning gas is used.

3.4.7 *Buying melt on thermos*

Some foundries buy the melt on thermos directly from a smelter. Then there is no melting at the foundry, no energy consumption of melting and no air emissions from melting at the foundry but at the smelter. But on the other side there is a need of transportation of the melt. It is therefore difficult to say if this is BAT or if it is BAT to melt at the foundry. It depends on the performance of the melting facility and the actual distance for transportation. The aspect should be dealt with by the technical working group revising the BAT conclusions under the IED.

3.4.8 *Holding furnace*

Sometimes the melt is poured from the melting oven to a holding furnace until all is set for pouring the metal in to mould. Sometimes the melt is also transported in heated metal launder system.

3.4.9 *Pouring the metal*

To ensure that the melt is distributed properly in the mould a so-called inlet and gating system is used.

For most casting except HPDC the melt is poured into a ladle, which in turn is used to pour the molten metal into the finished moulds. In some foundries the melt is transferred from a larger ladle to a smaller ladle before the pouring into the mould. To compensate for the heat loss at each intermediary pouring it is common to start with an overheated melt. At each intermediary pouring there is a risk that oxygen dissolves into the metal. This can corrupt the properties of the cast component and give rise to higher cassation. This especially concerns steel.

3.4.10 *Slag*

If there is contamination in the melt, such as for example remainders of sand or dissolved gases, these normally float up to the surface of the melt, forming a slag. This slag is removed and later turns up as waste and scrap from the foundry.

When pouring iron and steel and to avoid that the slag follows the melt into the mould a slag filter is normally used. Another way is to use a ladle which is emptied through the bottom of the ladle because the slag is floating on top of the melt.

3.5 *Shake-out and the last steps*

3.5.1 *Sand*

When the casting is completed the sand is removed in a shake-out step. It is then important that the sand binder allows the sand to easily come off from the cast product. For the casting made in a permanent mould with sand core a core knock out and shaking units would be used to get a fast removal of the sand.

The sand is usually reused to new moulds in the foundry and the casting is allowed to cool. A sand reclaiming unit will be used, this is either mechanical or using heat.

3.5.2 *General*

The resulting product from the casting procedure is generally a larger product than the metal component intended. Due to production necessities, the pouring of the molten metal, the gating system is added to the metal component. These have of course also solidified together with the component, and they need to be removed. Since they are pure metal, they can be removed and be melted again. After removal of gating system, the component is processed to remove sharp edges or sand that has stuck to the surface and to obtain its intended surface. Blasting is sometimes used.

Small products of aluminium go to a barrel polish rotating with water and plastic or ceramic chips to get a good surface. From this process there is a sludge of aluminium particles and rest from the chips, this is sent away as waste.

Some foundries also have a more advanced mechanical processing with drilling or grinding. This is more like a mechanical industry and not described more in detail in this document. But if the foundry has this process there is often metal chips that will be melted again in the process. There can be a rest of oil on the metal chips.

Only some few foundries conduct surface coating, such as painting, which is therefore not further discussed in this report.

For many casted products you use heat treatment to give the right properties. Sometimes this is done inside the foundry, sometimes the product is sent away.

4. Key environmental issues (KEI) and environmental impact of foundry and casting

The KEI in the scope of this study are (in non-prioritised order):

- Air emissions (dust and VOC)
- Noise emission and vibrations
- Emissions to water and water use
- Chemical use and risks
- Waste/residues
- Energy use
- Raw material
- Transports

In the next chapter, BAT are described within each of the listed KEIs.

The environmental impacts for every KEI are listed below. These questions are often handled in some kind of management system for example ISO 14001.

4.1 Air emissions

4.1.1 *Particles and dust*

A number of processes in a foundry cause emissions of dust and particles to air. The melt causes emissions of dust that contain metal oxides. The melt may also be treated with various additives, such as when adding magnesium to establish the properties needed for producing ductile iron. This addition results in a rather heavy momentary smoke of small particles. There is a lot of different way of treat the melt with magnesium and it is difficult to say what system is BAT. But often which method that is used depends on technical demands on the product. Other dust and particle sources are smoke associated with casting, dust from the shake-out when the sand moulds are opened and when the is removed from the castings, metal-containing dust from cleaning when inlet and gating system and sharp edges are removed, and dust from the final blasting of the components, that contains a mixture of metal and sand.

For example it is difficult to collect all air from the shake-out, especially large cast components.

Sometimes the emissions from the melt are not cleaned probably because the risks of sparks from the melt will end up in the filter and cause a fire. But cyclone can be used before the filter to prevent sparks to get into the filter.

4.1.2 Volatile organic compounds VOC

Foundries have some emissions of volatile organic compounds VOC. Some of these may be harmful and some may merely cause annoying odours for local residents.

High pressure die casting

High pressure die casting use release agents which normally consists of some percent oil or wax and the rest water, leading to an emission of oil mist. Sometimes there is a diffuse leakage of the oil mist leaving via the general ventilation.

Low pressure die casting

Low pressure die casting use Mould coating which normally consists of some percent graphite or silicate and the rest water, leading to a small emission. When use of sand core there is a diffuse leakage of phenol mist leaving via the general ventilation.

Sand casting

Foundries using sand also have air emissions of VOC, mainly originating from the organic binders used to manufacture moulds and cores. When the hot melt is poured into the moulds many of the chemical substances contained in the binder are released or generated due to binder decomposition. One share of the chemicals goes immediately to the air during the casting, and some is released at the shake-out when the sand is removed from the product. Common air emissions resulting from organic binders are benzene and formaldehyde. Which substances that are actually released, and in which amounts, depends on type of binder used. For green sand there is carbonaceous material added and this can react and give rise of emissions.

For one special binder system frequently used for the cores an amine is used as a catalyst for the chemical reaction of the binder. The amines used generally have a very unpleasant odour and the emissions require cleaning.

Other binders also give rise to VOC in various degrees. The exception is the inorganic binder with sodium silicate hardened with carbon dioxide that from an environmental viewpoint is a very good binder and does not give rise to emissions of VOCs. But for technical reasons, it is not possible to use this binder in production of all kind of products.

Other air emissions from sand foundries are associated with coating. The coating is added to get smoothen the surface between the sand and metal, and also to minimize the amount of sand that sticks to the metal. There are two types of coating, water or alcohol-based, which often have a content of isopropyl alcohol. Water based coatings would not give any VOC emissions but has other drawbacks, both technically and with

regards to energy needed for drying the coating. The water-based coating also contains biocides which may be a problem for the work environment. It is therefore not safe to say that the water based coating is simply better. There are different ways to attach the coating to the sand. Small surfaces are painted manually but larger surfaces may be spray painted or dipped into the coating in large vessels. Isopropanol is evaporating from the coated sand, normally this is burnt off.

4.2 Noise emissions and vibrations

4.2.1 *Receiving the raw material*

There are several noisy operations in foundries and vibrations can also occur.

Unloading of incoming metal scrap is often done by simply tipping the scrap off the truck, resulting in a very loud instantaneous sound. Foundries using aluminium normally receive their raw material as ingots and therefore have a more controlled unloading.

Figure 9: Aluminium ingots

Transport to and from the foundry can also be a source of disturbance. Sand foundries receive truck loads with sand that blows new sand into a sand silo. Such filling also causes noise disturbances.

4.2.2 *The casting process*

The casting process itself is not so loud.

The problem that can arise is that it is often very high temperatures inside a foundry and to get a decent working environment gates or windows are often open, which lead to noise from inside can spread into the surroundings. This is also a waste of heat that could been taken care of.

4.2.3 *Fans and ventilation*

The most common cause of noise nuisance for neighbours are otherwise fans and ventilation on the foundry roof.

4.2.4 *Other activities*

There are also other activities causing noise for example blasting with steel sand or dry ice-blasting. For aluminium foundries barrel polishing give a high noise level.

4.3 Emissions to water and water use

Foundries using sand rarely have significant amounts of contaminated process water. Foundries using high pressure die casting use a release agent that is sprayed on the tools between each shot. Today usually the release agent is composed of water with a small amount of oil or wax. Much of this evaporates but there will still be some oily water that flows down from the machines and have to be taken care of. Foundries using low pressure die casting and cooling of mould with water, often are using a closed water system and only a small amount of used water will go through oil separator before going to the public draining system.

4.4 Chemicals use and risks

Foundry industry is not chemical-intensive. However, there are some chemicals, mainly oils for machines release agents for high pressure die casting and binder to the sand. Some foundries also have their own metal processing with lathes and drilling, but this is not considered to be specific for the foundry industry and is therefore not addressed specifically in this report.

The binders to the sand often consist of two different components mixed in the sand. These can react very intensive with each other if mixed outside the sand.

For the LPDC process the ultrasonic cleaning is sometimes used for mould by use of caustic soda, which will be handled in closed system. The waste will be treated as hazardous waste.

Some metals are complicated to handle. For example molten magnesium where there is a risk of fire and explosions. Therefore magnesium melt always is protected with

a protective gas. Before it was SF₆ but this will not be used in the future because it is a greenhouse gas. Today SF₆ is replaced by several other gases but most common is SO₂.

4.5 Waste/Residues

There are waste/residues of foundry production.

The melt may contain oxygen and impurities from scrap or sand. These impurities are often floating to the surface and form a slag. The most common for iron and steel foundries is that the slag will be placed in a landfill, for which the foundry will need to pay a fee. When the slag is to be removed from the surface of the molten metal is always a risk that some pure metal is included. The slag from for example aluminium foundries is sent back to larger smelters.

In sand foundries most of the sand is being internally recycled. Technical reasons however require that a certain amount of new sand continuously is added so that that basically the same amount of excess sand is generated as waste. Nordic foundries recycle about 6 million tonnes and the total waste generated is in the order of 400,000 tonnes of sand residue. Today about 65% of sand waste is used to build cover constructions on landfill, but the landfill sites will all be covered in the near future. So, instead of being used the sand will become waste. It is also important to take into account the effect of organic/inorganic material from for example binder etc. on the utilization of sand waste.

From high pressure die casting there is some oil contaminated water that may be purified or sent away as waste. This comes mainly from the release agent sprayed on the tools between each shot, but also various types of oils to high pressure die cast machines.

Other residues resulting from foundries is material t collected in cleaning equipment for air, such as fabric filters, containing dust with metal or sand or a mixture of the two or residues from cleaning the air from gas for example amine or SO₂ used for some binders. There are also small amounts of binders and oils sent away as waste.

4.6 Energy use

One of the foundries' most important environmental aspects is the use of energy. There are many places where the input energy is lost as heat, for example when lids are not used on furnace and ladles. Energy savings can also be made on support processes, such as on air compression systems. In this report, however, the focus is on the energy-consuming steps that are specific for the foundry industry and not on the support systems. Wasting energy is both an economic and an environmental loss for the foundry. The choice of source for the electricity is of course important. A foundry normally uses 13–16% of the energy for heating, 8–9% for ventilation, 5–6% for compressed air, 1–4% for cooling, 60% for production process incl. melting and 5–11% for the rest.

To compensate for the temperature drop during filling and transportation normally melt is overheated in the furnace which needs a lot of extra energy.

There is metal residue from the parts resulting from the inlet and gating system. This is often remelted directly inside the foundry but sometimes the foundry sends this away. The amount of inlet and gating system circulated is related to the energy efficiency of the foundry, since large inlet and gating system means that a large amount of non-component related metal needs to be melted.

For many casted products heat treatment is used. There is example when a product is heated much longer than necessary.

Energy efficiency is connected with material efficiency. Those both categories have to take into account when optimizing the total efficiency of the production.

4.7 Raw material

The foundries use a lot of different metals to make the optimal alloy. Some are not good from environmental point of view for example lead used in bronze, lead is also often a contamination in aluminium. Some other metals are very rare or come from areas with conflicts.

The metals can be recycled again and again. Iron and steel foundries uses metal scrap and other foundries using recycled metals. This is very good but the metals are not always used in an optimal way. For example sometimes a foundry makes a very specific alloy with special metals. When recycled the specific alloy ends up at a foundry that don't want these special metals in their casting. Instead they "dilute" the metal with clean metal to lower the percentage of the unwanted metal.

4.8 Transports

Foundries use a lot of transports both for raw material and products but also for waste and finished products. Sometimes the foundry has the influence to choose and manage the transport sometimes it is decided by supplier or customers.

Castings from Nordic foundries are often exported all over the world but of course mainly to Scandinavia and the rest of Europe.

5. BAT for foundries

The overview of BAT at foundries is described in this chapter. Specific BAT candidates, which are selected as the most relevant to consider in preventing environmental impacts from foundries are described in more detail in the following chapters and mentioned with chapter reference in the list below. In chapter 6, the criteria used when identifying BAT candidates are listed. The list contains mostly techniques used in foundries in the Nordic countries but also some techniques from used in other industries or in foundries in Europe but can be used also in the Nordic countries.

Potential environmental impacts from foundries, and also possibilities to mitigate the impacts, are strongly case dependent, for a number of reasons. The KEI and the sources of potential environmental impacts from foundries in different situations were discussed in the previous chapter.

Some of the techniques described in the report are methods to make a better quality of the casted products. Better quality give less cassation which means less metal needed to be melted again saving energy and emissions.

5.1 BAT for control of air emissions

- Use hoods and fans to collect emissions or encapsulate processes that may cause air emissions, such as dust, particles, gases or odours, so that the open air can be effectively cleaned from pollutions.
- Work to minimise VOC and odour and if this is not possible use cleaning equipment. Example on cleaning equipment is Biofilter or RTO (this techniques are not used in the Nordic foundries today but in other countries). *See 7.9, 7.13 and 7.14.*
- Design and use ventilation and exhaust hoods properly.
- When changes are made to the ventilation systems, review the entire ventilation systems so that it is still works properly.
- Use bag-house filter or better technology to clean dust from air. These can give very low emissions (normally 1–4 mg/m³ but requirements from authorities often 5 mg/m³). This cannot be used for all processes. For example foundries using cupola often use a wet abatement technique. *See 7.1.*
- Adapt the filter media so that it is correctly chosen for the type and amount of dust.
- Make sure the collection of dust from the filter does not leak or escape when emptying the filter.
- Consider whether the dust collected in the filters can be reused or incinerated at some step in the process.

- High pressure die casting should use oil mist filter. *See 7.8.*
- Perform regular maintenance and service of filter systems and fans. This reduces the risk of pollution, reduces energy consumption and reduces noise.
- Perform regular monitoring and measurement of filter equipment. *See 7.3.*
- Install pressure drop gauges on the filter equipment. Establish procedures that describe how often the gauge should be checked and what is the normal level, as well as measures to take if something deviates from normal. *See 7.2.*
- Use fluorescent powder to identify leakage in fabric filters. *See 7.5.*
- For larger amounts of dust, use particle meter/monitoring that enables control of dust levels between services. There are different variants from simple alerts to system that constantly logs the exact amount of dust emission. *See 7.6.*
- If continuous dust meter is used calibrate them periodically.
- If there is a risk that the filter function deteriorates because of cold climate, the filter should be equipped with heating coils. *See 7.4.*
- For the sake of work environment and to avoid spreading dust, use vacuum cleaner instead of compressed air or broom to remove excessive waste sand.
- Take measures to secure that any outdoor handling of sand does not generate airborne dust.
- If an open cooling tower is used ensure there is no risk for legionella that can be spread to the surroundings.

5.2 BAT to prevent noise emissions and vibrations

Many of these things may be handle in a management system *see 15.3 and 8.2.*

- Unload scrap indoors. *See 8.1.*
- Perform shake-out indoors, as far as possible given the size of the casting.
- Perform cleaning indoors, as far as possible given the size of the casting.
- For LPDC using sand core, perform de-coring by core knock out indoors.
- Measure the noise at nearby properties and if necessary use noise simulation. Especially important after changes in the foundry. *See 8.3.*
- Carry out regular noise rounds, where somebody walks around and listens and measures on the company's fans, exhausts, etc.
- Prioritize regular maintenance of fans, motors, belts, bearings, etc.
- Control working hours to minimise disturbances for neighbours.
- Turn off fans, etc. when not in use.
- Inform staff about noise requirements for the foundry.
- Keep doors and windows closed whenever possible.

- Educate forklift drivers in quiet driving.
- Try placing noisy activities shielded from nearby homes for example blasting with steel sand or dry ice-blasting.
- If forklift transports take place outdoors make sure the ground is level and paved.
- Limit time slots for transportation.
- Keep noise levels as a criterion when purchasing new equipment.
- If the above measures do not help, carry out an investigation to identify potentials to reduce noise by installing silencer or shield sources of noise. *See 8.4 and 8.5.*
- If silencer is used it is important to regularly check and clean the silencer if necessary.
- If vibrations may cause problems, measure vibration impacts at nearby properties.
- If there is a problem with vibration, check if the frequency of the vibrating machines can be adjusted or if the vibrating machines can be isolated from the floor.
- Control working hours so vibrating activities do not take place when the neighbours are asleep.

Figure 10: Forklift

5.3 BAT for control of wastewater emission

- Clean water from die spraying and other processes like mould cooling producing polluted waste water.
- If it is possible reuse the water in some way for example recycling of water from barrel polish.
- If contaminated scrap metal is stored outside store it under a roof or otherwise it is important to use cleaning equipment in the water drainage system.
- To protect surface water drainage system for example at leakage of chemicals use a lid to the system or a closing valve.

5.4 BAT High pressure die casting

- Avoid that the melt comes in contact with oxygen in the air for example by using vacuum dosing furnace instead of open scoop to take when taking melt from the furnace to the filling chamber in the machine. It also provides more precise dosing. *See 14.4.*
- Optimize the amount of piston lubrication. Too much lubrication involves the risk that the piston lubrication leaks and comes in contact with the melt resulting in heavy smoke. Too little piston lubrication means the machine is faltering which can lead to lower production and more cassation.
- The time from that the melt is taken from the furnace to the melt is inserted in the filling chamber in the machine should be as short as possible.
- Automatize spraying of release agents and optimise the amount of release agent
- Use infrared camera or similar tool to ensure the temperature of the tool and adjust cooling accordingly. *See 14.3.*
- Review whether the current release agent can be replaced with new variations.
- Preheat the die tools for longer life. *See 14.2.*
- Establish sufficient maintenance of die tools to prolong the lifetime, including also blasting and grinding of the surface of the die tool. *See 14.1.*

Figure 11: Open scoop taking the melt from the furnace.

5.5 BAT sand and binders

- If the green sand is used replace the normal carbonaceous material (coal dust) with one that reduces VOC emissions. *See 7.12.*
- If green sand is used try to minimize the amount of carbonaceous material that is used to minimize VOC emissions.
- Review the possibilities to change binders to one with a lower environmental impact, such as shifting to a process without binders.
- Store the components of the binder system so that they cannot react with each other.
- Sand should be reused in the process. For sand with chemical binders the foundry should at least have a mechanical sand reclamation. *See 10.2.*
- Use as little binders as possible. Study and monitor the strength of the cores and moulds to determine how much binder is needed.
- Perform maintenance of the sandmixer to ensure a good mixing and to avoid excessive use of binders.
- Use as little sand as possible.
- When using a binder system hardened with an amine, clean the air with an acid scrubber. An acid scrubber can give very low emissions normally under 1mg/m^3 but the regulations from authorities can vary. This is important both for time when the core is made but also after the core is ready because amine evaporates from core sometime after they are produced. Some foundries also have the core in an oven for about one hour to remove residual gasses. *See 7.7.*
- Investigate if it is possible to decrease the use of coating. *See 7.11.*
- When drying water based coating seek to minimize energy consumption.
- If an alcohol based coating is used, use lids on coating troughs. *See 7.10.*
- If a trough with flowing coating is used ensure that the coating can be reused several times.
- If an alcohol based coating is used burn the coating on the core. Of course it is important to be aware of risk with the use of open flame.
- Optimise the mixing of coating and follow the quality of the coating by for example control the viscosity.
- Make sure that the plant internal recycling rate of the sand is as high as possible. The maximum rate depends on type of binder used.
- If the sand cannot be recycled internally the sand should preferably be used for some other purpose outside the foundry rather than end up in a landfill. The use of the sand for other purpose is often regulated and there is often a need of a chemical analysis of the content. *See 10.3.*

- At shake-out try to separate the core sand from the moulding sand. This is particularly important if these have different binders. This may be difficult especially with automatic green sand moulding line.
- Do not use cold sand. This is particularly important when using furan as a binder. When using furan sand it is especially important that the sand is also dry.

Figure 12: Burning alcohol based coating. Previously published in Gjuteriet / Gjuteriinformation AB

5.6 BAT for chemicals handling and substitution

- Correct labelling is important and should be done based on chemical legislation. Especially to avoid mixing the different components in the binder system since this can result in severe chemical reactions.
- Have absorbent material available. Sand foundries can use sand.
- Assign a person to have responsibility for the management and the control of new chemicals. *See 9.1.*
- Store chemicals so there is no risk for spill to ground or water. Store liquid chemicals in collection containers that will collect any spill.

5.7 BAT for waste management and minimisation

The basis of this work is to minimise the up come of waste.

- Minimise spilling sand that ends up as waste. Avoid for example spilling sand on the floor.
- Maintenance of transport belts and elevators for sand is essential to reduce internal waste.

- Sort waste to facilitate recycling.
- Proper sorting of recycled metal can increase the amount that can be recycled. *See 10.1.*
- Avoid to store sand directly on ground outside to minimise dust blowing away in the wind.
- If there is sand on the ground outside the foundry use a road sweeper to collect this to avoid dust blowing in the wind.
- Investigate the possibilities to use some of the waste as a resource in other contexts. For example sand can be used for construction work, it can also be used to cover old landfills or used in concrete. Slag from iron and steel can sometimes be crushed and used in construction work.

5.8 BAT for construction simulation

- Use simulation to optimize the casting process. Things that should be simulated are the flow, thermal solidification, cooling and defects. *See 11.1 and 11.2.*
- Make several simulations to get better result.
- Continuously verify the simulations compared to real data.
- Properly executed and interpreted simulations reduce the risk of having to scrap castings, and thereby improve the yield.
- Design and position inlet and gating system in such way that it can easily be broken off instead of need to use a saw that requires more energy.
- When building new foundries or new production facilities it is possible to use production modelling successfully to find bottlenecks and other critical points in the manufacturing systems. Models can vary from relatively simple spreadsheets to use of advanced computer systems.
- Close cooperation between buyer and constructor to have a product that is easy to cast which give lower cassation.

5.9 BAT for energy

Many of these things may be handled in a management system see chapter 15.3

5.9.1 General

- Handle raw material indoors to avoid exposing it to moisture.
- Take advantage of waste heat from ventilation, cooling water from furnaces or compressors to heat and dry the raw material.

- Pre-dry metal chips which may contain oil or oil-emulsion by for example centrifugation.
- Crush scrap and return with a machine for fragmentation or ask the suppliers of scrap to deliver scrap in the right size. *See 12.3.*
- To achieve energy efficiency, establish a short melting time, rapid overheating and immediate casting without unnecessary delay time. Sometimes this is not done because this gives a high cost from the electricity provider.
- Pack the raw material as tightly as possible in the furnace.
- Charge in the right order.
- Press briquettes of metal chips that are used as raw material. The briquettes reduce the charging time compared to loose metal chips and also provide some reduction in energy consumption during melting. Cannot be used for all furnace. Especially interesting for aluminium. *See 10.4.*
- Use low drop during tapping from the furnace.
- Move the melt quickly from the furnace to the place for casting.
- Use lid on the melting furnace, holding furnace and ladle as much as possible. If it's not possible to use lid on furnace one alternative is to have a layer of slag at the top. *See 12.5.*
- The use of highly insulating lining in ladle greatly reduces heat loss. Highly insulated ladles have possibly inferior mechanical strength so it is doubtful whether they are suitable for treatment of ductile iron. *See 12.4.*
- Plan preheating of ladles and preparation of moulds so that they are ready in time when the melt is ready.
- Use lids on the ladle or place it upside down between uses. *See 12.5.*
- Place the ladle on insulation material to reduce heat transfer to the floor.
- Try preheating ladle with newer technology than conventional gas burner for example with a flameless system or electrical heating (Not used in Nordic foundries today but in other countries). *See 12.6.*
- Use the right ladle size with respect to the melt amount.
- Make practical tests to find out what it costs to overheat the melt kWh / degree / tonne and make everyone in the personal aware of this.
- Use the maximum electric power as early as possible and then throughout the melting process to provide the fastest and most energy-efficient melting process. Sometimes this is not done because this give a high cost from the electricity provider.
- Use meter showing furnace energy consumption for each charge and note this together with temperature and the charge weight for each melt. If the comparison is made with the previous melts, operators can detect the variations in energy consumption and directly reduce energy consumption.

- To avoid excessive melting time it is important to quickly arrive at the right alloy composition of the melt. It is therefore important to weigh the different compositions. Weighing is also important to determine the energy consumption per ton of melt and find energy efficient practices. For monitoring production it is also good to weigh the amount of tapped melt and slag weight.
- Measure the temperature often instead of guessing.
- After the use of temperature lance replace the probe tip and let the lance tip drop in temperature before the next measurement.
- If there is waste heat from the process, streamline the process first. Once this is done the waste heat should be used either internally or sent to external recipients, alternatively stored for use at a later time.
- Recycle heat from the cooling water and from the cooling of castings.
- Optimizing heat treatment so that the goods are not heat treated unnecessarily.
- Lower temperature if the furnace is not in use and lower ventilation if not needed.
- Conduct energy audit. *See 12.1.*
- Use heat exchanger to handle excess heat from the processes.
- When collecting heat in the process for reuse, do not mix heat with high temperature (for example directly after pouring) with low temperature (for example at the end of the cooling area).

5.9.2 *Induction furnace*

- Add easily digestible materials such as pig iron in the bottom of the furnace.
- The furnace energy efficiency increases if it has a melt early to work with.
- Charge the furnace in such a way that the residual heat is utilized. Fill hot furnace at the end of the shift, for example in the evening.
- Large amount of slag indicates that improvements can be made, both in terms of energy consumption and metal recovery.
- If necessary the charging material should be blasted before use to remove sand and rust. *See 12.2.*

5.9.3 *Iron and steel*

- Make sure to have the correct carbon content from the beginning by keeping track of the carbon content in the various raw materials. To redeem more carbon in the already molten material takes time and often require elevated temperatures. This requires excessive energy use. An iron-carbon alloy has the lowest melting point at 4.3% carbon but often it is the desired end result that controls how much carbon is used.
- Calculate which combination that gives the right carbon content in the melt. There is software available for this.

5.10 BAT metal and melting

5.10.1 Iron and steel

- Use feeders that do not cause problems in sand contents. For example use of fluorinated feeders can give a higher level of fluorine in the waste sand if the residues of the feeder end up in the sand.
- Set quality requirements on purchased scrap. Pure raw material gives less slag. *See 13.1.*
- Inspect the quality and purity of the received scrap.
- Optimise the composition, the alloy content and the shape of the scrap.
- Use modern techniques and tools to charge optimization, such as computer program for calculating the composition of the charge.
- Large ladles for steel can be flushed with argon to effectively minimize the risk of entrapped oxygen within the melt. Entrapped oxygen can cause defects and cassation. *See 13.3.*
- When iron is treated with magnesium to produce ductile iron ensure that added magnesium is kept within the melt.
- If possible use a method for producing ductile iron which give less smoke to the air or try to minimise the smoke emitted to the air for example by using methods where the melt is treated in ladle with lid so the smoke can be collected or that the magnesium is added down in the melt and not to the surface.
- If inoculation is added directly to the cast beam ensure that the inoculant ends up into the melt and is not somehow ejected besides the melt.
- Measure that the right amount of inoculant is in the melt after inoculation. *See 13.4.*
- Use automated inoculation if possible. *See 13.5.*
- When using a cupola furnace add 2–3% extra oxygen, then the amount of combustion gases and the amount of coke can be reduced.

5.10.2 General

- Calibrate the instrument for measuring temperature.
- Use quick and reliable process control of the melt to avoid incorrect mixture that could lead to cassation or unnecessary overdose of substances, such as of magnesium for ductile iron treatment.
- Use deoxidisers/degassing to remove oxygen/hydrogen and other gases in the melt to avoid cassation. Can be used for steel and other metals but not used for iron. *See 13.2.*

- Use only the amount of deoxidiser/degassing agent that is really required to regulate gas levels.
- When a holding furnace is used, procedures for correct maintenance are important to avoid oxides that can build up and overtime can influence melt quality.

5.11 BAT for environmental management

These techniques are not specific for the foundry industry and sometimes more used in other industry but can help also foundries to work better.

- Work with lean manufacturing or similar systems.
- Use standardized working operations so all operators use the best method.
- Use FMEA (Failure modes and effects analysis) design and production. FMEA means to assess each production step and analyse what can go wrong, the severity if something goes wrong, how often it happens, or can happen, how likely it is that the failure is discovered, as well as to form preventive actions.
- Evaluate before new technology is purchased.
- Plan internal and external transports and logistics and review the internal process flows.
- Use a standardized management system, such as a ISO 9001, ISO 14001, or ISO 50001. *See 15.3.*
- Assess the foundry's environmental aspects, such as waste management, suppliers' environmental performance, and apply life cycle thinking of the supply chains (even if it does not include a complete lifecycle assessment).
- Develop a policy to establish what environmental decisions are allowed to cost, as well as take environmental aspects into account when purchasing goods and services.
- Try to apply circular economy. This may mean trying to extend the lifetime of equipment used throughout the production, by repairing or by improved maintenance. Other examples may be to considering remodelling the business model of the company, to establish a take back system of products for recycling valuable alloys, for product refurbishment, or for establishing an environmentally based relationship with the customers. *See 15.1.*
- Check for other practices, methods, tools and standards that may be useful to improve or assess the environmental performance of the business. Examples are life cycle assessment, described in the international ISO 14040 family of standards, or the ISO 14060 family standards providing guidance about how to measure, mitigate and adapt to greenhouse gases and climate change. *See 15.4, and 15.5.*

- The environmental manager or coordinator should be supported in their work either internally from different people in the organization or externally.
- Use material flow cost analysis MFCA or similar to map the economic costs of spill and wasting of material and energy resources. *See 15.2.*
- Have procedures for all operations, such as for melting, how to buy chemicals, how to handle and manage waste.
- Energy, noise, chemicals and waste are some factors to consider when purchasing new equipment.

6. BAT Candidates

In the following chapters the identified BAT candidates are described. They were chosen according to the following priorities:

- BAT, which addresses the identified Key Environmental Indicators
- BAT, which is assessed to have a significant reduction of emissions and impact
- BAT, which is economically and technically viable taking into consideration the cost and advantages

Every BAT candidate is described with seven headlines:

- Introduction
- Applied process and techniques. Short description of the techniques
- Environmental benefits
- Applicability. Which foundries can use this
- Cross-media effect. If the use of the technique influence something else for example use of energy
- Economics. If there is any information about the cost to use the techniques. This is a very rough estimation
- Reference. Some examples of foundries using the technique today. A lot more foundries may use the technique

This is a selection of course there can be other techniques that also may be BAT candidates.

The technical and economic applicability of BAT candidates differ a lot case-by-case. It is also noteworthy that the selection of techniques is not always in the hands of the foundry. All techniques cannot be used by all foundries.

The BAT Candidates have been plotted with their number in green in the following pictures Figure 13 and Figure 14.

Figure 13: The foundry non-permanent moulds (example sand)

Figure 14: The foundry permanent moulds (example high pressure diecasting)

7. BAT Candidates Emissions to Air

7.1 Bag-house filter

7.1.1 *Introduction*

Dust abatement by bag-house filters is an effective method to clean particles from gases. Thanks to the research and development of filter media, there is a wide range of different filtering solutions, coupled with other modern components in the filter system, the valves and the electronic equipment.

7.1.2 *Applied process and techniques*

The system is based on negative pressure. Hoods and ventilation channels lead dust into a bag-house filter.

Figure 15: Bag-house filter.

7.1.3 Environmental benefits

Depending on the type of process dust, these modern filter systems give a high degree of separation. Many applications have low emissions to the external environment (normally 1–4 mg/m³ but requirements from authorities often 5 mg/m³). Right adapted effective hoods provides a cleaner internal working environment with health benefits, and extends service intervals on mechanical equipment with less wear and tear, caused by dust.

7.1.4 Applicability

In principle, most foundries use this technology. The differences lie in the individual adaptation of the system to the needs of the process. Many factors influence the choice of technology for filtering. Examples affecting; Temperature, type of dust, moisture, pressure requirements, amount of dust, particle size, ATEX-classification, etc. Some process cannot use this, for example cupola furnace often use a wet abatement technique.

7.1.5 Cross-media effect

There is need of electricity and compressed air. A right customised filter systems with continuous service, lower operating expenses. Electricity and compressed air consumption is reduced by a canal system in balance, and if the filter media are changed with the correct range for maintaining dimensioned pressure drop in the system. The use of frequency converters for fans is saving electricity when parts of the plant requires less ventilation or is not used.

The equipment generates noise.

7.1.6 Economics

You cannot make a “general price list” when needs vary from individual small machine 2,000 m³/h, large complex systems of several hundred thousand m³/h, and cost of several hundred thousand euro.

7.1.7 Reference

Several foundries in the Nordic countries also commonly used in several countries in Europe.

7.2 Pressure drop gauge

7.2.1 *Introduction*

It is often difficult to see if a fabric filter is working properly or not. There can be a small tear in the filter media that a person cannot see with her bare eye but that may result in higher emission of dust.

7.2.2 *Applied process and techniques*

One way to have a better control of the filter is to use a pressure drop gauge connected to the filter. The gauge measures the difference in pressure between the inside and outside of the filter bag. If there is a variation in pressure difference it could indicate that something is wrong with the filter.

7.2.3 *Environmental benefits*

Earlier detection of dust abatement problems.

7.2.4 *Applicability*

A pressure drop gauge can be used for a lot of different filters. If a pressure drop gauge is used it is important that the staff controlling the gauge know what a normal value is and at what value they should react.

7.2.5 *Cross-media effect*

No cross-media effect.

7.2.6 *Economics*

There are simple analog for a few hundred euros, to advanced electronic for some thousands euro.

7.2.7 *Reference*

Several foundries both in the Nordic countries and the rest of Europe.

7.3 Dust filter measurements

7.3.1 Introduction

Emissions of dust particles are removed from the air by dust filters. The regular maintenance of these filters is important for the filters to work properly. It is also important to check that the filter works by measuring the throughput and the dust emissions.

7.3.2 Applied process and techniques

An external consultant is commissioned to perform measurements of the throughput from the filter (m^3/h) as well as dust content (mg/m^3), and sometimes also the amount of different metals compared to the total amount of dust (%). It is important to use standards for performing the measurements.

7.3.3 Environmental benefits

To achieve the intended environmental protection from the filter, it is important that the filter works properly or whether corrective actions need to be taken.

7.3.4 Applicability

All foundries should do this but the measurement frequency may vary between different foundries depending on how much the filter is used.

7.3.5 Cross-media effect

No cross-media effects.

7.3.6 Economics

A measurement of one single filter may cost from EUR 3,000. The actual cost depends on how many filters needs to be measured and how far the consultant has to travel. It is often more economic to measure several filters at the same time to reduce the cost of travel for the consultant.

Big foundries normally don't measure every filter every year but has a rolling schedule.

7.3.7 Reference

Several foundries both in the Nordic countries and the rest of Europe.

7.4 Filter heating

7.4.1 *Introduction*

In the Nordic countries there is a risk that the filter will not work properly in the winter because of the cold weather.

7.4.2 *Applied process and techniques*

There are several techniques but normally there is some heating loops built in to the filter.

7.4.3 *Environmental benefits*

Filter heating ensures the functionality of the filter in the cold winter.

7.4.4 *Applicability*

This should only be used if there can be a problem with the filter because of cold weather.

7.4.5 *Cross-media effect*

Electricity is used for heating.

7.4.6 *Economics*

Not available.

7.4.7 *Reference*

Not very common.

7.5 Using fluorescent powder to check for problem in bag-house filter

7.5.1 *Introduction*

It is often difficult to see if a fabric filter is working properly or not. There can be a small tear in the filter media that a person cannot see directly but will give a higher emission of dust.

7.5.2 *Applied process and techniques*

One technique to identify small tears in the filter media is to use a fluorescent powder that is sprayed on the filter bag. By illuminating with a UV lamp even small damage on the filter can be detected.

7.5.3 *Environmental benefits*

There is an earlier detection of problems with the dust abatement.

7.5.4 *Applicability*

This technique can be used on all fabric filters. Sometimes the staff at the foundry can do this otherwise an external company can do this when they are doing maintenance of the filter.

7.5.5 *Cross-media effect*

Need of fluorescent powder.

7.5.6 *Economics*

No data.

7.5.7 *Reference*

Several foundries in the Nordic countries for example Arvika Gjuteri, a foundry in Sweden.

7.6 Particle monitor

7.6.1 *Introduction*

Measuring is important, since without measuring it is impossible to know if the performance is alright, within limits and towards targets and goals. Unfortunately, measurements of particle emissions are done very seldom, maybe not even once a year. Significant dust sources may need to be measured more frequently, and therefore different automatic particle monitors can be used.

7.6.2 *Applied process and techniques*

A particle monitor is monitoring the dust emission in real time. There are different variants, ranging from smaller systems that set off an alarm at a predefined level of dust, up to large monitoring systems that continuously log the amount of particle emissions.

7.6.3 *Environmental benefits*

Dust abatement problems are detected early.

7.6.4 *Applicability*

A particle monitor can be used in a lot of different filter systems but often for bigger filter systems. To function properly particle monitors need to be calibrated regularly.

7.6.5 *Cross-media effect*

No cross-media effects.

7.6.6 *Economics*

There are different variants, ranging from smaller system at around EUR 3,000, up to larger system at around EUR 20,000.

7.6.7 *Reference*

Several foundries in the Nordic countries for example SKF, a foundry in Sweden.

7.7 Acid scrubber to clean amine

7.7.1 *Introduction*

Some of the binders are catalysed with an amine with a very unpleasant odour. The air therefore needs to be cleaned before being emitted. An acid scrubber is used for this.

7.7.2 *Applied process and techniques*

The air from the core making where the amine is used is collected and transferred to the acid scrubber. In the acid scrubber normally sulfuric acid but also other acid is used. The acid is sprayed into a chamber where it meets the air with amine. The amine is dissolved in the acid and can then be removed. The acid is sent away as waste. In Germany the acid is sent for reuse but this possibility is not available in the Nordic countries.

7.7.3 *Environmental benefits*

An acid scrubber is very effective and gives a very low remainder of amine in the cleaned air and there is no problem with odour after this process. An acid scrubber can give very low emissions normally under 1mg/m³ but the regulations from authorities can vary.

7.7.4 *Applicability*

All foundries using amine as a part of the binder system for sand.

7.7.5 *Cross-media effect*

There is a need of acid and electricity to make the process running. The acid is sent away as waste.

7.7.6 *Economics*

Rather expensive.

7.7.7 *Reference*

Several foundries in the Nordic countries and the rest of Europe for example Arvika Gjuteri, a foundry in Sweden

7.8 **Oil mist filter**

7.8.1 *Introduction*

Foundries using high pressure die casting normally spray water mixed with oil on the die tool. Most of this evaporates from the tool to form an oil mist in the air.

7.8.2 *Applied process and techniques*

There are good oil mist filters that can be connected to each HPDC machine. The functionality of the filter results in very good air quality, with often so low concentration of oil mist that the air can be recirculated into the foundry without health risks.

7.8.3 *Environmental benefits*

Lower emissions of oil mist to the air.

7.8.4 *Applicability*

Most foundries using HPDC could use an oil mist filter. However, sometimes the process give very low emission of oil mist so a filter is not needed. It is as always therefore important to first perform measurements of the air quality.

In order to make the most out of the oil mist filter it is also important to have a hood that collects all oil mist from the machine.

There may be a problem with magnesium where it is a risk for magnesium coming into the filter causing fire.

7.8.5 *Cross-media effect*

There will be waste from the filter.

7.8.6 *Economics*

Not available.

7.8.7 *Reference*

Several foundries in the Nordic countries using HPDC.

7.9 Plan for reduction of VOC

7.9.1 *Introduction*

Foundries using sand normally have a binder holding the sand together. If this is an organic chemical binder there is a risk it will lead to emissions of VOC when the hot melt is poured into the mould. Mould or core preparation may also cause VOC emissions.

7.9.2 *Applied process and techniques*

One way to handle VOC is to use a cleaning technique for the emissions. But before investing in such techniques, other possibilities should be investigated. Every foundry should have a plan for this. This plan should include at least:

- Measurements of the scale of VOC emission, and types of emissions.
- Investigate the binders may be substituted with some other technology.
- Investigate whether carbonaceous material (coal dust) in green sand may be substituted to additives with lower emissions.

- Investigate whether it is possible to reduce the amount of *carbonaceous material* in green sand.
- Investigate whether it is possible to reduce the amount of binders used, without reducing quality of the core and the mould?

Figure 16: Preparing measurements on a roof of a foundry

7.9.3 *Environmental benefits*

Reduction of VOC emissions, which is good for both the working environment and the outdoor environment.

7.9.4 *Applicability*

All foundries using sand binders can have a plan to lower the emissions of VOC.

7.9.5 *Cross-media effect*

No cross-media effects.

7.9.6 *Economics*

Decreasing the amount of carbonaceous material or binder may save money, but substituting carbonaceous material or binder might increase costs.

7.9.7 *Reference*

For example Arvika Gjuteri, a foundry in Sweden.

7.10 Lid on coating vessel with alcohol based coating

7.10.1 Introduction

To avoid that the sand sticks on the cast product a protective coating is sometimes used. The coating often contains graphite and some kind of thickener dissolved in water or alcohol. It establishes a protective layer between the sand and the metal. Sometimes the whole sand core or mould is dipped in to the coating. If an alcohol is used for the coating it will evaporate to the air.

7.10.2 Applied process and techniques

If the whole core or mould is dipped into the coating it is important to use a lid of the container with coating.

7.10.3 Environmental benefits

Lid prevents some emission of alcohol to the air, it also lower the risk of open fire.

7.10.4 Applicability

The lid cannot be used when the dipping is done but all the time when dipping is not going on.

7.10.5 Cross-media effect

No cross-media effects.

7.10.6 Economics

A lid is not very expensive and in the same time the need of extra alcohol is minimised. Lid also gives a better working environment.

7.10.7 Reference

Several foundries in the Nordic countries.

7.11 Use coating only when needed

7.11.1 Introduction

To avoid that the sand sticks on the cast product a protective coating is sometimes used. The coating often contains graphite and some kind of thickener dissolved in water or alcohol. It establishes a protective layer between the sand and the metal. When alcohol is used, the emissions to air need to be minimised. For water based coating energy-use for the drying of the water instead needs to be minimised. The coating is often bought ready to use but after a while there is a need of add some more water or alcoholic caused by evaporation.

7.11.2 Applied process and techniques

Sometimes coating is used by old habit, even though it is not needed. The first step is to overlook where coating really is needed. Of course if coating is needed it should be used otherwise it can cause cassation.

Next is to have a controlled mixing of the coating with a regular control of the viscosity to ensure the right composition.

7.11.3 Environmental benefits

If use of coating can be reduced there is an environmental benefit from the resource savings.

If too much alcohol is used more will evaporate to the air. If too much water is used it will take longer time for the drying using more energy.

It is important to have the right viscosity to get the right effect of the coating.

7.11.4 Applicability

Every foundry using coating should be aware of this.

7.11.5 Cross-media effect

No cross-media effects.

7.11.6 Economics

If use of coating can be reduced there is a cost saving.

A viscosity meter is not so complicated and not so expensive. The saving is the use of less alcohol or less heat to dry the core with water based coating.

7.11.7 Reference

Several foundries.

7.12 Coal dust replacement

7.12.1 *Introduction*

Foundries are using so called green sand that use bentonite to hold the sand together and carbonaceous material (coal dust) to get smooth surface. The problem with some of the carbonaceous materials are that it gives rise to emissions of volatile organic compounds, VOC, when the melt is poured into the mould.

7.12.2 *Applied process and techniques*

There are different types of carbonaceous material.

7.12.3 *Environmental benefits*

Lower emissions of VOC, which is good both for the working environment and the outdoor environment.

7.12.4 *Applicability*

Foundries using green sand with carbonaceous material can try this. It may not work for all foundries. Substituting carbonaceous material with one with lower emissions can give initial product quality problems, so it is recommended it is introduced gradually.

7.12.5 *Cross-media effect*

No cross-media effects.

7.12.6 *Economics*

It can be more expensive than normal carbonaceous material.

7.12.7 *Reference*

Several foundries in the Nordic countries and the rest of Europe, for example Arvika Gjuteri, a Swedish foundry.

7.13 Cleaning VOC and odour with biofilter

7.13.1 Introduction

Odour may be a problem especially foundries that use binders for sand forms. First one should try to reduce the source of the odour. If that is not possible there are some techniques for cleaning the air before emission.

7.13.2 Applied process and techniques

Biofiltration is one possible odour abatement technique. The function of biofilter is based on micro-organisms (bacteria), which is laid on organic carrier material (bed material) like wood, chips, peat, bark etc. Biofiltration consists of a sorption phase of pollutants on a carrier surface and a subsequent degradation phase by micro-organisms, which are settled in an aqueous phase on the carrier substance.

Main factors affecting the sizing of a biofilter system are the volumetric flow rate of the waste gas stream, the type of waste gas constituents and their concentration as well as the type of filter media. To make optimum use of available space, several enclosed biofilter modules may be vertically stacked.

7.13.3 Environmental benefits

Lower emissions of VOC and compounds causing odour.

7.13.4 Applicability

The applicability is limited to large series casting foundries with almost continuous production, as biofilters need very stable conditions throughout the year. It is an air cleaning system for emissions with low VOC content.

Advantages

- Suitable for clean large flows with relatively low levels of organic substances
- Cleaning efficiency 70–90%
- Disadvantages
- Requires large areas
- Requires constant access to VOCs, long break in the foundry production may not occur
- High cost

7.13.5 Cross-media effect

Requires some humidity, a controlled temperature and continuous operation.

7.13.6 Economics

It is difficult to say the exact cost because the size of the facility may vary a lot between different foundries but in general it is an expensive method. There is a theoretical calculation of an example foundry with

- 106,000 m³ air /h to be cleaned
- 45 ton VOC/year
- 3,620 ton production of casting/year
- Biofilter volume 981 m³

Then the investment cost is calculated to EUR 1,168,000 and the total annual netto cost is EUR 170,000/year.

Another example: Based on 33,000 m³/h air flow, 0% humidity, 30 °C temperature; production time: 1,920 h/year, 240 days; 1 m³ water (without wastewater) = EUR 3.0/m³, 1 m³ wastewater = EUR 7.0/m³, 1 kWh electricity = EUR 0.1/kWh

Investment costs for biofilters, scrubber system, fan, control unit, internal gas and water piping and engineering: EUR 325,000 and a total yearly cost EUR 24,000.

7.13.7 Reference

No Nordic foundries use this method today. The method is used in some larger foundries in Germany.

7.14 Cleaning VOC and odour with RTO

7.14.1 Introduction

Odour may be a problem from foundries, especially foundries using binders for sand moulds. First it is important to try to reduce the source of the odour and if that is not possible there are some techniques for cleaning the air before emission.

7.14.2 Applied process and techniques

One technique that is used in some foundries in Europe is Regenerative Thermal Oxidation, RTO where the VOC is incinerated. The process begins with that the waste gas is fed through the regenerative heat exchanger, and is preheated to near combustion temperature. In the combustion chamber, the contaminants are oxidized at temperatures around 800 °C. The resulting combustion heat reduces the necessary burner power in relation to the level of contaminants. For concentrations near autothermal level the burner can be switched to ignition flame.

7.14.3 Environmental benefits

Lower emissions of VOC and compounds making odour.

7.14.4 Applicability

RTO is a process for emissions with high VOC concentration.

7.14.5 Cross-media effect

If the VOC concentration is very low ($<< 100 \text{ mg/Nm}^3$) preferably a pre-concentration with a zeolite rotary concentrator or a fixed bed should be used in combination with the RTO. Otherwise there is a need to put in extra fuel.

7.14.6 Economics

An example based on $30,000 \text{ Nm}^3/\text{h}$ air flow, 0% humidity, 50°C temperature; VOC 100 mg/Nm^3 , production time: 1,920 h/year, 240 days; $1 \text{ kWh} / 10.5 \text{ Nm}^3$ natural gas = EUR 0.03/kWh, 1 kWh electricity = EUR 0.07/kWh.

Investment costs for a regenerative thermal oxidiser, fan, control unit, raw gas and clean gas piping, stack, transport, engineering installation and commissioning: EUR 530,000 (plant capacity: $30,000 \text{ Nm}^3$ per hour) and a total yearly cost EUR 49,000.

7.14.7 Reference

No Nordic foundries use this method today. The method is used in some larger foundries in Europe.

8. BAT Candidates Noise emission

8.1 Tipping scrap indoors

8.1.1 *Introduction*

Iron and steel foundries use a lot of scrap to the melt. Delivery is done by truck and it is not unusual that the trucks simply tip the load of scrap on the yard, resulting in a very high instantaneous source of noise.

8.1.2 *Applied process and techniques*

Indoor scrapyards is a good idea to reduce noise disturbances, and also to keep the scrap dry.

8.1.3 *Environmental benefits*

Noise disturbances from tipping decrease. The scrap is held dry. Dry and warm scrap requires less energy to melt. Wet scrap charged in the furnace may cause explosions.

8.1.4 *Applicability*

All foundries can use this technique. The scrapyard housing can be more or less complex. Examples are how much insulation to use to reduce the noise disturbance, and whether the excess heat from the foundry processes should be used to dry and/or preheat the scrap. Noise disturbance from tipping will also decrease if the doors can be kept closed.

8.1.5 *Cross-media effect*

There maybe be a need of a new building, some electricity to the lighting in the building, and maybe also some extra heat transportation equipment (fans for ventilation channels or pumps for heat exchangers, etc.) if the scrap should be dried or preheated in the indoor scrapyard.

8.1.6 *Economics*

The economics may vary widely, from pure noise walls to isolated housing constructions with heat exchange solutions.

8.1.7 *Reference*

Several foundries in the Nordic countries for example SKF, a Swedish foundry.

8.2 Noise reducing plan

8.2.1 *Introduction*

One of the most important key environmental issues for foundries is the problem with noise disturbing neighbours. Noise is not only a disturbing factor it may also cause health problem for example high blood pressure. Some foundries use silencer on the ventilations and fan and that is a good technique to use but also rather expensive. It is better to start with some simpler things that can help a lot. The most important is to have a plan for how to handle noise problem and how to work with this questions in the ordinary work.

8.2.2 *Applied process and techniques*

A plan for working with noise may include some of these steps:

- Measure the noise at nearby properties and if necessary use noise simulation. Especially important after changes in the foundry. In some situations the continuous noise measurements can be used especially near housing.
- Carry out regular noise rounds where somebody goes around and listen and measures on the company's fans exhaust etc.
- Prioritize regular maintenance of fans, motors, belts, bearings, etc.
- Control working hours so noisy activities do not take place when the neighbours are asleep.
- Turn off fans, etc. when not in use.
- Inform the staff about the noise requirements for the foundry.
- Keep doors and windows closed whenever possible.
- Try placing noisy activities shielded from nearby homes.
- Educate truck drivers in quiet driving
- If truck transport takes place outdoors, make sure the ground is level and paved.
- Limit times for transportation.
- Keep noise levels as a criterion when purchasing new equipment.
- If the above measures do not help should an investigation be carried out showing potential to reduce noise by installing silencer or shield sources of noise.
- If silencer is used, it is important to regularly check and clean the silencer if necessary.

Figure 17: Shield on roof to prevent noise from fan spreading to the surroundings

8.2.3 *Environmental benefits*

A lower noise level.

8.2.4 *Applicability*

All kind of foundries can work in this way. However Iron and steel foundries that use scrap metal are more challenged than foundries (Al, Mg and Bronze) that have raw metal supplied on pallets. If they cannot do all steps the can start with some.

8.2.5 *Cross-media effect*

No special cross-media effect.

8.2.6 *Economics*

The economics depends on how many of the steps the foundry will use. A simple noise measurement may cost EUR 1,000. Have a person walking around the foundry to listen maybe one hour per month or week and to turn of fans when not in use or plan the production in a better way will not cost very much.

8.2.7 *Reference*

Several foundries in the Nordic countries.

8.3 **Noise simulation**

8.3.1 *Introduction*

Noise disturbances may be very subjective. Therefore, before solving noise issues by for example investing in new equipment, it is important to acquire an objective overview of the noise situation. One way to do this, is to understand how the foundry contributes to the total noise level of the neighbourhood, as well as to understand which measures are effective and cost efficient. Measurement of noise levels can often be enough to provide an understanding of the situation, but if the noise environment is complicated, with roads, railroads or other industries nearby, noise simulation may be a good tool.

8.3.2 *Applied process and techniques*

In a noise simulation software tool all noise sources, such as fans, doors, ventilation blowout etc. is measured. Buildings and the surroundings is drawn up in the software virtual world. A special function calculates and models noise levels at different distances from the foundry. A result is presented on a map where for example different noise levels are represented as different colours.

This makes it possible to for example see which sources give the highest contribution to the total noise level at different locations on the map.

The model allows testing for example what happens if a fan is moved, if a silencer is installed on a blowout or what is the result if there will be a new fan on the roof.

Before any investments are made any model results should of course be validated with real measurements.

Figure 18: Example noise simulation. Different colours represent different noise levels.

8.3.3 Environmental benefits

A visual simulation tool makes it possible to see the noise distribution landscape, and to more easily prioritize which sources to prioritize and which measures to take.

8.3.4 Applicability

All foundries can use this. Since the modelling is time consuming, however, it may only be recommended for foundries having problem with noise disturbances, and where ordinary noise measurements does not give conclusive results, possibly because of other disturbing activities as roads or other industries. It is important to test the model to decide the accuracy.

8.3.5 Cross-media effect

No cross-media effect.

8.3.6 Economics

It is time consuming to measure all fans, ventilations etc. and also to build the model in the computer. The cost therefore depends on number of noise sources to measure and model.

It may cost around EUR 5,000 to several EUR 10,000 to noise model a site. This may be well-spent, if it results in pinpointing an elusive noise source.

8.3.7 *Reference*

Several foundries in the Nordic countries for example Union Electric Åkers, a Swedish foundry.

8.4 **Silencers on ventilation systems**

8.4.1 *Introduction*

Fans and air streams are causes of noise from ventilation systems. Ventilation noise can be emitted from the plant via inlets, outlets and from cabinets. Air must of course be able to pass the inlet and outlet, and therefore these openings of the ventilation systems are also sources where noise can be emitted to the surroundings. Noise can also escape through different pipes / ducts.

8.4.2 *Applied process and techniques*

Silencers can be installed on the ventilation canals / pipelines. Silencers should be installed as closely as possible to the noise source, such as at the outlet or the inlet, to avoid that the sound waves propagates through the ventilation ducts and spreads and amplifies before reaching the silencer.

Different types of ventilation silencers are:

- Reactive
- Absorptive
- Combinations of these

8.4.3 *Environmental benefits*

Silencers decrease the noise emissions to the surroundings.

8.4.4 *Applicability*

A silencer can be used in a lot of different ventilation outlet.

Reactive silencers are tuned to attenuate sound at a particular frequency, such as blade frequency. Reactive silencers are relatively expensive and unusual in the ventilation context.

Absorptive silencers suppress a broad spectrum of sound. They are relatively cheap and common in ventilation context.

8.4.5 *Cross-media effect*

If the silencer is installed in a ventilation channel with a dust stream it is important to regularly clean the inside of the silencer.

8.4.6 *Economics*

An absorption silencer has simple construction and can be produced efficiently. The price of an absorption silencer, for example, cylindrical silencers, is therefore not so high, about EUR 70–1,300.

Big absorptive, or cylinder baffle silencers, are often used in large or very large flows. They are often custom made, and the cost is a significant part of the total cost of the entire ventilation system.

From a total cost point of view, it is often better to choose a more expensive and silent fan than to have a custom made silencer. This cost optimization should always be made when considering ventilation silencers.

8.4.7 *Reference*

Several foundries in the Nordic countries for example Arvika Gjuteri, a Swedish foundry. There is a lot more information about noise in the publication from the Nordic Council of ministers: "Bullerdämpning av externt industribuller från livsmedelsindustri och hamnar". Though it was not specifically compiled for the foundry sector much can also be applied on foundries.

8.5 **Additional insulation of fans and ducts**

8.5.1 *Introduction*

The noise radiates from ventilation ducts. The noise levels strongly depend on the design of duct.

8.5.2 *Applied process and techniques*

If noise radiates from a duct or a connected hood, and if it is not possible to reduce the noise that goes into and through a duct, additional sound insulation may be a very good option.

8.5.3 *Environmental benefits*

Insulation lowers the noise levels in the surroundings.

8.5.4 *Applicability*

Additional insulation of ducts can be an alternative to the silencer ducts if the ducts are not as long or where the silencers cannot be used.

The effect of noise damping that can be achieved depends on the thickness of the insulation and on the type of insulating material. Commonly achieved noise reduction is between 5–30 dB.

Additional insulation can of course be bulky and difficult to implement in small volumes and when ducts, pipes and equipment are close together.

8.5.5 *Cross-media effect*

No cross-media effect.

8.5.6 *Economics*

This method is costly for long or many ventilation ducts. It is most commonly used to silence ducted fans, since the total cost will not be too high. Insulation of a large ducted fan or duct, cost at around EUR 135 /m².

8.5.7 *Reference*

There is a lot more information about noise in the publication from the Nordic Council of ministers: "Bullerdämpning av externt industribuller från livsmedelsindustri och hamnar". Though it was not specifically compiled for the foundry sector much can also be applied on foundries.

9. BAT Candidates Chemicals

9.1 Chemicals responsibility

9.1.1 *Introduction*

Foundry industry is not chemical-intensive. However, there are some chemicals, mainly oils for machine, release agents for high pressure die casting and for binders to sand core and sand casting.

9.1.2 *Applied process and techniques*

Have a person responsible of the use chemicals in the foundry. This person work with approving new chemicals before use, help the different departments focusing on how to minimise the risk of chemical use or how to replace chemicals not good for the environment.

To facilitate the chemicals responsibility it may be good to use some IT-tool, such as top procure some chemicals management data base service or software.

9.1.3 *Environmental benefits*

Decreased chemicals risks to health and environment.

Less use of hazardous chemicals.

9.1.4 *Applicability*

All foundries can work with this.

9.1.5 *Cross-media effect*

No cross-media effects.

9.1.6 *Economics*

Difficult to say how much this will cost. If some chemicals management data base service or software is used the cost may depend on number of chemicals used in the foundry.

It will be a cost for the person responsible for the chemicals management, but whether this cost is higher than not having such an assigned responsibility or not is difficult to say.

9.1.7 *Reference*

Several foundries in the Nordic countries for example Arvika Gjuteri and SKF, two Swedish foundries.

10. BAT Candidates Waste and residues

10.1 Recycling management

10.1.1 *Introduction*

The foundry processes produces some waste, for example dust, slag or sand.

10.1.2 *Applied process and techniques*

To decide the recycling possibilities, first all waste produced in the factory need to be identified and see what can be done to minimise the amount (see also Material flow cost accounting).

Next step is to consider if the waste can be used as a resource somewhere else. To facilitate using waste as resource it is important to sort the waste into different useful fractions.

10.1.3 *Environmental benefits*

Less waste.

10.1.4 *Applicability*

All foundries can do this.

10.1.5 *Cross-media effect*

There is a need for space to make a good sorting of the waste.

10.1.6 *Economics*

Waste is often associated with some cost, and recycling may therefore save money.

10.1.7 *Reference*

Several foundries in the Nordic countries.

10.2 Equipment for mechanical sand regeneration

10.2.1 *Introduction*

When a chemical binder is used to hold the sand together there is often remainders of the binder in the sand after shake-out. This remainder makes it difficult to reuse the sand again in the foundry.

10.2.2 *Applied process and techniques*

To be able to reuse the sand the foundry needs to use a sand recovery equipment. The sand to be purified contains lumps of mould and / or core sand, and certain metal residues. Sand lumps are first crushed in a lump crusher. Then a magnetic separation is used to rid the sand of metal residues. Then, if the sand contains some moisture and other material than sand grains, the sand is sifted and then dried. The next is a mechanical step, done to remove the binder residues from the sand. It can be done by scrubbing or by compressed air.

It is possible to also use thermal cleaning when the sand is heated, but this process is seldom needed for to be able to reuse the sand for new moulds.

Even chromite sand separation can be a good idea.

10.2.3 *Environmental benefits*

The sand can be used more times.

10.2.4 *Applicability*

All sand foundries should investigate the possibility to reuse the sand, as well as their need for mechanical sand regeneration.

10.2.5 *Cross-media effect*

There is a need of electric power for the mechanical sand regeneration. It may generate more dust.

10.2.6 *Economics*

The sand system is different at every foundry and there is also a great variation how much sand is circulating in the system, so it is difficult to say the cost for the equipment.

10.2.7 *Reference*

Several foundries in the Nordic countries.

10.3 Reuse of rest sand outside the foundry

10.3.1 Introduction

Foundries using sand often recycle the sand several times in the foundry. But for technical reasons there is a need to replace some of the used sand with new sand at each cycle. The foundry therefore needs to get rid of the replaced and used sand. Used foundry sand may be a good resource to use in different applications throughout the society instead of using virgin sand. Whether the sand can be used to replace virgin sand in different applications is not up to the foundry to decide, but to avoid sending sand to waste it is important for the foundries to find good second uses of their used form sand.

10.3.2 Applied process and techniques

Where the used sand can be applied depends on what kind of binder it contains. One area cannot be generally application for all used sand of the same kind. Instead every sand foundry need to analyse their used sand with regards to constituents, such as hazardous substances. Normally there are no hazardous substances in the used sand.

Sand has been used for:

- Cover old landfill, especially sand holding bentonite which forms a very dense layer
- Use as material to build on, roads, buildings or parking areas. . Before utilization the environmental quality of the sand must be analysed
- Build walls against noise
- Manufacturing of bricks
- To mix with other material to make good soil for cultivation
- Use in concrete or cement

10.3.3 Environmental benefits

The sand does not need to be waste on a landfill. Sand is a natural resource taken from sand pits. By increasing the second use of used foundry sand, the sand in natural sand pits can be saved and the expansion of sand pits can go slower.

10.3.4 Applicability

All foundries using sand.

10.3.5 Cross-media effect

Less need of new sand.

10.3.6 Economics

Normally an industry has to pay to get rid of waste. In this case the foundries do not have to pay more than maybe the transport. In Denmark foundries pay EUR 80/ton to get rid of waste sand.

10.3.7 Reference

Several foundries in the Nordic countries.

10.4 Briquetting

10.4.1 Introduction

Sometimes foundries use small size raw material such as metal chips or metal powder. There are some difficulties with charging the furnace with such material because of the risk that the material will blow away. Small sized raw material often originate from somewhere in the process, and is to be melted back into the production again.

10.4.2 Applied process and techniques

Small metal chips can be pressed together into briquettes to be used as raw material. Briquettes reduce the charging time compared to loose metal chips.

Figure 19: Briquettes of aluminium

10.4.3 Environmental benefits

Briquettes reduce energy consumption during melting. If the foundry can remelt its own recycled material instead of sending it away there is less need of transportation.

10.4.4 *Applicability*

Briquetting can be used to make briquettes of a lot different materials but mostly used for aluminium. Cannot be used for all furnace for example can there be a problem with induction furnace.

10.4.5 *Cross-media effect*

The machine needs electricity. Sometimes some chemical is needed to hold the briquettes together.

10.4.6 *Economics*

The bricketing machine cost between EUR 40,000 and EUR 250,000.

10.4.7 *Reference*

Several foundries in the Nordic countries.

11. BAT Candidates Simulation

11.1 Simulation

11.1.1 *Introduction*

Casting is a complex method with a lot of parameters. If something goes wrong in the process the foundry may need to remelt the product. To avoid the costs and other consequences of this simulation is used. Simulation is used as a tool to improve, optimize and get a better understanding of the process. Another important aspect is that simulation is a good way of increasing the knowledge about the influence of different material, production and product parameters. It is important that the foundries work with simulation in a systematic way in order to improve the precision of the results. The need of physical testing is also minimized by use of simulations.

11.1.2 *Applied process and techniques*

Most methods for the production of castings can be simulated with the simulation program occurring on the market. The simulation gives an almost exact image of the mould filling and solidification. Simulation can also provide a better understanding of the process and how the different parameters affect the quality of the final casting.

11.1.3 *Environmental benefits*

Simulation is a tool for make better quality in the products and less cassations of the material. Less cassations leads to less metal to be remelted which means less use of energy and material for making moulds and so on.

11.1.4 *Applicability*

All foundries can work with simulation. There is different software for simulation. In order to fully benefit from the use of simulation the company needs to dedicate resources to build up their knowledge. It might not be good enough to just occasionally perform simulations.

11.1.5 *Cross-media effect*

No cross-media effects.

11.1.6 Economics

The foundry may need to purchase simulation software EUR 45,000 to EUR 150,000 + a yearly fee. For maintenance and support and person who know how to use the software. It may be considered rather expensive. But use of simulation will also save money for the foundry with less cassation.

11.1.7 Reference

Several foundries in the Nordic countries.

11.2 Optimized inlet and gating system

11.2.1 Introduction

When the melt is poured in to the mould there is an inlet and gating system with some amount of extra cast metal to ensure the mould is filled completely. This extra metal will not be used in the finished product but will be removed and melted again. Sometimes there is a need of a saw to take the inlet system away from the rest of the product.

11.2.2 Applied process and techniques

The first step is to design the inlet and gating system so it is as small as possible but still works effectively. By a right design of the inlet and gating system it is also possible to easily turn or break off the inlet instead of using a saw.

11.2.3 Environmental benefits

Minimise the inlet and gating system to reduce the amount metal needed to be melted again.

There is less need of after processing energy when it is possible to break of the inlet instead of using a saw.

11.2.4 Applicability

All foundries should work with this.

11.2.5 Cross-media effect

There is a need of computer simulation.

11.2.6 *Economics*

It will take some time to make the simulation but less time is needed to take the inlet system away and less metal needs to be melted again. See also the cost of simulation software.

11.2.7 *Reference*

Several foundries in the Nordic countries, for example Holsbyverken a Swedish foundry.

12. BAT Candidates Energy

12.1 Energy audit

12.1.1 *Introduction*

A foundry uses a lot of energy for all processes. This is an environmental issue, but for the foundry it is also an economic issue.

12.1.2 *Applied process and techniques*

Many different things can be done to reduce the energy use. But to do this systematically a good knowledge of the process is needed. This may be done by performing an energy audit. The aim of an energy audit is to answer how much energy is supplied to the organization and that is used to power the company's operations, including buildings and transport, on an annual basis. It shows how the energy is distributed in different parts of the business. The audit is done by performing actual measurements and calculations for the costs for the energy. An energy audit also includes suggestions on how the business can be more energy efficient.

12.1.3 *Environmental benefits*

Potential to save energy.

12.1.4 *Applicability*

Can be done by all foundries.

12.1.5 *Cross-media effect*

No cross-media effects.

12.1.6 *Economics*

The cost depends on the size of the foundry but it often starts at EUR 5,000 and above.

12.1.7 *Reference*

Several foundries in the Nordic countries for example Union Electric Åkers and Arvika.Gjuteri, two Swedish foundries.

12.2 Blasting raw material before melting

12.2.1 *Introduction*

Often some of the sand sticks to the finished cast product if sand is used in the casting process. The risk is that such sand will follow the material into the melt, since some faulty casts will be taken to cassation and will be re-melted. If these parts include sand it will both lead to that the melting demand more melting energy and a slag will be formed which will have to be sent to waste. To avoid this it is important to clean the material.

12.2.2 *Applied process and techniques*

Blasting is used to remove sand from the material that will be melted again.

12.2.3 *Environmental benefits*

Less sand to the melt will give a better melt, will not need so much energy and less waste.

12.2.4 *Applicability*

Foundries using sand.

12.2.5 *Cross-media effect*

Electricity is needed for the blasting. There is a waste produced.

12.2.6 *Economics*

No information.

12.2.7 *Reference*

Several foundries in the Nordic countries for example Holsbyverken, a Swedish foundry.

12.3 Crushing inlet and gating system

12.3.1 *Introduction*

Inlet and gating system may be melted again after it is broken off from the cast product. These are sometimes rather large and may therefore be difficult to put into the furnace. They can also have sand stuck to them, which means higher energy consumption and slag forming.

12.3.2 *Applied process and techniques*

There are different machines for crushing the raw material.

12.3.3 *Environmental benefits*

Improved furnace efficiency which lowers energy consumption. Separation of great deal of the sand during crushing which lower energy consumption and give less waste.

12.3.4 *Applicability*

All foundries with large raw material or large in-duct channels

12.3.5 *Cross-media effect*

Electricity is used for the crusher.

12.3.6 *Economics*

No information.

12.3.7 *Reference*

Used by some foundries in the Nordic countries.

12.4 Insulated ladles

12.4.1 *Introduction*

Conventional lining of casting or transport ladles are not only there to protect the ladle itself. They also provide insulation against heat loss during filling and transport. The lining of ladles is made by conventional bricks or cement with a thickness of about 100 mm or above. The ladle is normally pre-heated with a gas burner. The melt is often overheated because there is some heat loss when the melt is in the ladle.

12.4.2 *Applied process and techniques*

There are insulation materials that can be used in the ladle so that preheating is not necessary and the heat loss is minimised so that there is no reason to overheat the melt.

12.4.3 *Environmental benefits*

Saving of energy.

12.4.4 *Applicability*

Foundries using ladles.

12.4.5 *Cross-media effect*

Have to use an insulation material.

12.4.6 *Economics*

Some of these numbers are a few years old.

From the present material change, the actual energy savings result to approximately EUR 168,000/year. The system operates only about six to seven times with the same ladle liner. Therefore, this technical solution is primarily for non-continuous processes. Such as single taps at high temperature levels can be found for example in steel foundries. Case study: 5 t ladle, 5 tons furnace, 1,500 °C tapping temperature. If a loss of temperature reduction by 30 °C in a 5 t pan 60 kWh of energy can be saved in the overheating process, this will corresponds to about EUR 6/melt. The energy cost savings alone do not justify the investment. A stable temperature may also give production and product quality advantages.

12.4.7 *Reference*

Used by some foundries in the Nordic countries for example Österby Gjuteri, a Swedish foundry.

12.5 **Use of lid on furnace and ladle**

12.5.1 *Introduction*

Every foundry uses a lot of energy to make the melt from scrap metal or ingots. A lot of energy is lost from the furnace if lid is not used.

12.5.2 *Applied process and techniques*

There are different types of lid that can be used on furnace but also on ladle.

12.5.3 *Environmental benefits*

Lids save energy.

12.5.4 *Applicability*

This is a very simple solution to save energy. It cannot be used when filling or emptying the furnace or ladle but else the lid may be on, to save energy. But even if lids is a simple technique it is not used everywhere.

Figure 20: Furnace with lid.

12.5.5 *Cross-media effect*

No cross-media effects.

12.5.6 *Economics*

In relation to the cost of a furnace or ladle it is a rather small cost that also saves money.

12.5.7 *Reference*

Several foundries in the Nordic countries.

12.6 **Flameless ladle heating**

12.6.1 *Introduction*

Many foundries use conventional ladle preheating flares, based on natural gas or liquefied petroleum gas-air burners. These kinds of preheating procedures are, generally speaking, connected to the following disadvantages: they may cause hot

spots during preheating the ladles, cause high volume flow rates and require a long warm-up time.

12.6.2 *Applied process and techniques*

There are burners which function without open fire. For this purpose a geometrically adjusted and insulated cap is placed on the ladle. Inside the cap an integrated burner transmits the heat indirect to the ladle as infrared radiation. There are also electrical ways of preheat the ladle.

12.6.3 *Environmental benefits*

Potential energy savings in the process of up to 50 per cent due to lower heating up time and more efficient heat transfer.

Lower emissions compared to natural gas burner with open flame.

No hot spots during preheating giving longer life time of the lining in the ladle.

12.6.4 *Applicability*

More expensive than using open burner. For optimal operation the “burner-stone” is shaped individually, which may cause the supply and storage of several shapes

12.6.5 *Cross-media effect*

Gas is still used but in a lower amount. There are also electrical ways of preheat the ladle using electricity instead of gas.

12.6.6 *Economics*

Saves a lot of fuel. Single station systems are available where the investment costs are between EUR 40,000 and EUR 50,000.

12.6.7 *Reference*

Not very common in the Nordic countries but used of some foundries in Europe.

13. BAT Candidates Metal and melting

13.1 Scrap handling

13.1.1 *Introduction*

Iron and steel foundries use metal scrap as raw material, and they are mixing different scrap fractions to produce the right alloy composition of the melt.

13.1.2 *Applied process and techniques*

The first important step is to have an agreement with the scrap supplier to deliver well defined scrap. Quality standards of scrap and auditions of scrap suppliers are important to use.

Figure 21: Example of scrap delivered to an iron foundry

When the scrap arrive to the foundry it is important to have an inspection of the truck with scrap so it is clean without oil and fulfil the requirements of the foundry and maybe also a chemical analyse of the scrap to assure the quality.

Next step is to plan the melt. This should be done with a special computer program that takes into account the scrap that is present and which gives a recipe of how much of different scrap should be used to obtain the optimal melt. For example an XRF (X-ray fluorescence) can be used to sort the metals.

13.1.3 *Environmental benefits*

Clean scrap results in lower emissions of dust when melted.

With the right composition of the melt from the beginning there is no need for adjustments. Adjustments otherwise demands the melt to be put on standby causing use of more energy.

13.1.4 *Applicability*

All foundries using scrap should work in this way.

13.1.5 *Cross-media effect*

No cross-media effects.

13.1.6 *Economics*

It is not expensive to order the right scrap or to control the scrap at delivery.

To make an optimal melt you need a special computer program.

13.1.7 *Reference*

Several foundries in the Nordic countries.

13.2 *Using deoxidiser/degassing*

13.2.1 *Introduction*

It is important to prevent oxygen and other gases from the air to dissolve into the melt. The gases can form cavities and inorganic inclusions which will lead to lower quality and more cassation.

13.2.2 *Applied process and techniques*

To minimise gas dissolution, some deoxidiser/degassing agent is put in to the melt. The deoxidiser/degassing agent is different depending on metal used and gases the have to be removed. The deoxidiser/degassing agent reacts with the gases creating inorganic material floating to the surface of the melt as a slag. The slag can be removed.

13.2.3 *Environmental benefits*

Less gases in the melt leads to less cassation.

13.2.4 *Applicability*

All foundries except iron foundries use this.

Almost all steel foundries use this technique but a lot of work can be done to optimise the process for example in what way the deoxidiser is added to the melt.

13.2.5 *Cross-media effect*

This technique requires deoxidiser/degassing agent and it is important to choose an environmental friendly variant It will produce more slag.

13.2.6 *Economics*

No investments needed. This is consumables with not very high price. This technique produces more slag that can cost to get rid of but this offset by lower cost for cassation.

13.2.7 *Reference*

Several foundries in the Nordic countries.

13.3 Flushing ladle with argon

13.3.1 *Introduction*

Especially for steel foundries it is important to avoid oxygen and other gases from the air to dissolve into the melt. The oxygen can lead to lower quality and more cassation. Sometimes also dissolved nitrogen is a problem in steel.

13.3.2 *Applied process and techniques*

Argon is used to flush through the melt sometimes together with adding deoxidiser agent. Oxygen and other gases more easily solve into argon than into the melt and are then transported out from the melt. The argon also provides a good stirring of the melt helping the deoxidiser agent to react, and less amount of deoxidiser can be used.

13.3.3 *Environmental benefits*

There is less amount of slag produced compared to traditional deoxidiser with aluminium.

13.3.4 *Applicability*

Steel foundries with large ladle can use this technique.

13.3.5 *Cross-media effect*

Need of argon.

13.3.6 *Economics*

There is a need of some tool to let the argon into the ladle, maybe a new ladle and argon. The cost for investment is estimated to start at EUR 10,000.

13.3.7 *Reference*

For example Sandvik SRP, a Swedish foundry.

13.4 **Inoculation control**

13.4.1 *Introduction*

In cast iron production, inoculants are used to control the solidification structure, and by that the final properties. The inoculant is often added as late as possible by in-stream inoculation to avoid the risk of fading. It is important to have good control over inoculation.

13.4.2 *Applied processes and techniques*

The effect of the inoculant is to control the solidification microstructure and by that the final properties. The effect and the yield of the addition of inoculant can be made by microstructure analysis and by different evaluations of material properties. Microstructure investigation is based on microscopy and evaluations of microstructural constituents. Material properties may be evaluated by for example thermal analysis. In that case the temperature is registered during the cooling of an iron sample in a sampling vessel, and the resulting cooling curve is analyzed. The cooling curve depends on the amount of added inoculant. This is done before the casting process so it is possible to adjust the melt.

13.4.3 *Environmental benefits*

The yield of the addition is increased and overdosing can be avoided.

13.4.4 *Applicability*

In principle, inoculation control can be used by any cast iron foundry.

13.4.5 *Crossmedia effect*

A controlled addition of the inoculant minimizes the risk for defects and scrapped castings. Scrapped castings are used as foundry returns but that also means the same amount of iron has to be melted more than once before ending up in a cast component, and that means unnecessary amounts of energy.

13.4.6 *Economics*

Microstructure analysis and evaluation of final properties is already often used as for quality control. The investment can therefore be considered small and any additional costs can be expected to be balanced by the beneficial effects from an increased yield of the addition.

13.4.7 *Reference*

Several foundries in the Nordic countries.

13.5 **Automatized in-stream inoculation**

13.5.1 *Introduction*

In cast iron production, inoculants are used to control the solidification structure, and by that the final properties. Inoculants are often added as late as possible. The reason is that the effect of the inoculation is fading quickly by time in the melt.

13.5.2 *Applied processes and techniques*

Automatized in-stream inoculation is done to maximize and control the effect of the inoculant. In-stream inoculation is done when pouring the iron into the mold, and an additional benefit is an optimized dissolution into the metal.

13.5.3 *Environmental benefits*

In-stream addition minimizes the risk of effect fading from the inoculation, and therefore enables optimization of the effect of the addition, while at the same time minimizing the risk for formation of defects and quality deviations. By automation the yield of the addition can be increased and overdosing can be avoided.

13.5.4 *Applicability*

In principle, automatized in-stream inoculation can be used by any cast iron foundry.

13.5.5 *Crossmedia effect*

Controlled and exact addition of inoculant as late as possible minimizes the risk for defects and scrapped castings. Scrapped castings are used as foundry returns but that also means the same amount of iron has to be melted more than once before ending up in a cast component, and that means unnecessary amounts of energy.

13.5.6 *Economics*

The investment to install automatized in-stream inoculation system is foundry dependent but the cost can be expected to be balanced by the beneficial effects from an optimized and controlled addition.

13.5.7 *Reference*

Several foundries in Europe.

14. BAT Candidates High and Low pressure die casting

14.1 Maintenance of die tool

14.1.1 Introduction

The die tool is worn in the process. Maintenance is important to prolong the life of the tool.

14.1.2 Applied process and techniques

Maintenance of die tools is used for longer lifetime, including blasting and grinding of the surface of the tool.

Figure 22: The two halves of a die tool, waiting to be put into the HPDC-machine. Previously published in Gjuteriet/Gjuteriinformation AB

14.1.3 Environmental benefits

Production of a new tool demands a lot of resources and energy. A worn tool can cause more cassation of the products. Less cassations leads to less metal to be remelted which means less use of energy and material.

14.1.4 *Applicability*

Can be used of all foundries using HPDC and LPDC. Especially important for foundries using aluminium or magnesium.

14.1.5 *Cross-media effect*

There can be a dust emission from the blasting.

14.1.6 *Economics*

Not performing maintenance will cause shorter lifetime of the die tool and the production of a new tool may be considered a large investment.

14.1.7 *Reference*

Most of the foundries using HPDC and LPDC.

14.2 **Preheat die tool**

14.2.1 *Introduction*

The die tool is worn in the process the result is lower quality on the products. A new tool is also a big cost. Therefore it is important to prolong the life of the tool.

14.2.2 *Applied process and techniques*

There are channels in the tool. These channels are used to preheat the tool with warm oil or water before casting. The oil or water is heated electrically. The channels are also used to cool the mould after every casting circle.

14.2.3 *Environmental benefits*

Production of a new tool demands a lot of resources and energy. A worn tool can cause more cassation of the products. Less cassations leads to less metal to be remelted which means less use of energy and material.

14.2.4 *Applicability*

Can be used of all foundries using HPDC.

14.2.5 *Cross-media effect*

There is a need of electricity to heat and circulate the oil or water.

14.2.6 *Economics*

Not to do preheat the tool will cause shorter lifetime of the die tool and the production of a new tool may be considered a large investment.

14.2.7 *Reference*

Most of the foundries using HPDC and LPDC.

14.3 **IR camera**

14.3.1 *Introduction*

Foundries using High pressure die casting, HPDC, need to cool the die tool between every shot. Often this is done by spraying water on the tool. But often the tool does not have the same temperature over the whole area and it is therefore difficult to get the right amount of water. Today the calculation of the amount of lubricant that is needed often is based on experience and test measuring.

14.3.2 *Applied process and techniques*

There is an increased use of IR camera in the foundry industry and through them come more opportunities to indirectly control the lubrication of the die, with the objective of the tool surface temperature is kept as constant as possible. A more even die temperature means that the die can run more cycles. The camera gives a picture of what areas need extra or less cooling.

14.3.3 *Environmental benefits*

To produce a new tool demands a lot of resources and energy. A more even temperature on the die tool maybe prolong the life time of the tool. A worn tool can cause more cassation of the products. Less cassations leads to less metal to be remelted which means less use of energy and material.

14.3.4 *Applicability*

Can be used of many foundries using HPDC. The foundry can buy one camera and use it at several machines when necessary.

14.3.5 Cross-media effect

No cross-media effect.

14.3.6 Economics

There are different types of IR-cameras from very simple to very complex. It is enough to have one camera per foundry. Not to do this may cause shorter lifetime of the die tool and the production of a new tool is a big investment.

14.3.7 Reference

Several foundries in the Nordic countries for example Ankarsum Die Casting, a Swedish foundry

Figure 23: Picture from computer program connected to IR-camera. Picture showing different temperatures in a die tool

dry.

14.4 Use of vacuum dosing furnace

14.4.1 Introduction

During High pressure die casting for aluminium a scoop is often used to take the melt from the open furnace to the machine. The problem with this is that the melt is exposed a longer time for oxygen in the air. The oxygen can dissolve into the melt causing extra slag or causing defect in the cast product.

14.4.2 Applied process and techniques

Avoid that the melt comes in contact with oxygen in the air for example if it is possible by a lid on the furnace and take out the right amount melt using vacuum ceramic container instead of open scoop to take melt to the machine.

Figure 24: Vacuum dosing furnace

14.4.3 Environmental benefits

The method gives lower loss of heat in the melt. If there is less oxygen in the melt it could to some extent lead to less slag.

14.4.4 Applicability

All foundries using high pressure die casting for aluminium can use this method.

14.4.5 *Cross-media effect*

Energy is needed to create the vacuum.

14.4.6 *Economics*

No information.

14.4.7 *Reference*

Some foundries in the Nordic countries for example Ankarsrum Die Casting, a Swedish foundry.

15. BAT Candidates Management and general

15.1 Circular economy

15.1.1 *Introduction*

Circular economy intends to achieve positive economic development without increased resource use.

15.1.2 *Applied process and techniques*

A key mechanism to establish a circular economy is to transform the business model of a company or of several companies in a value chain. The business models need to be changed from material-based businesses, to businesses satisfying needs and offering performance values regardless of material and resource consumption. The practical aspects of the circular economy include prolonged efficient lifetime by optimized design or service intervals, re-use and refurbishment, closed loop recycling to maintain alloys and generally resource efficient recycling systems.

15.1.3 *Environmental benefits*

The main environmental benefits of circular economy are to save resources by maintaining values in produced goods. It shall be stressed that in order to actually achieve the potential environmental benefits of a circular business model, lifetime prolongation, re-use, refurbishment, recycle and recycle logistics also need to be environmentally efficient.

15.1.4 *Applicability*

Any foundry can be part of a circular economy business model, either by themselves changing their business model into some form of a circular material handling, or by becoming part of a customer's or supplier's circular value chain.

15.1.5 *Cross-media effect*

A circular business model does not immediately change the production process of the individual products of a foundry, but in the long run they may lead to fewer items produced, due to reuse and longer product life-time, or to a change in designs for longer life cycles.

15.1.6 *Economics*

Much of today's metal industry is to a large part already based on recycling of metals, and to a smaller degree also on reuse and refurbishment of metal components, the transition from today's economic models into a circular economy is not a major leap. Cast components may gradually be designed and marketed for a circular business model, or may gradually become components of circular business models for compound products.

15.1.7 *Reference*

Some foundries in the Nordic countries for example Union Electric Åkers, a Swedish foundry.

15.2 **Material Flow Cost Accounting (MFCA)**

15.2.1 *Introduction*

MFCA is a standardized method for counting the costs for material and energy spill in a production unit.

15.2.2 *Applied process and techniques*

An MFCA is performed as a practical investigation of the amounts of the material and the energy entering a production step and of the energy and the material leaving the production step, and all materials are assigned its economic cost. The result of the investigation is a list of costs for the different spills and where these costs occur. The information is provided to the production management, who may take different decisions to minimize or avoid the costs. MFCA is an international standard ISO 14051:2011.

15.2.3 *Environmental benefits*

The intended environmental benefits of MFCA is to save resources, as well as saving all other environmental loads associated with producing and transporting the material that is ending up as spill.

15.2.4 *Applicability*

Any foundry may gain economic and environmental benefits from regularly performing an MFCA. Can be difficult for subcontractors.

15.2.5 *Cross-media effect*

MFCA leads to waste minimization, an energy and other resource savings.

15.2.6 *Economics*

MFCA is an investigation technique, with costs similar to Value Stream Assessment or Risk Assessment.

15.2.7 *Reference*

Used in other industries not so common in Nordic foundries yet.

15.3 **Management system**

15.3.1 *Introduction*

A management system supports an organization to coordinate its decisions and actions towards its goals, in line with its policy and vision. There are many ways to organize a management system. Here we will refer to the management systems as published by the international standardization organization ISO. To facilitate world trade ISO has published two certifiable management systems that are related to management of the foundry's environmental aspects within the context of this report;

- ISO 14001 – Environmental management systems
- ISO 50001 - Energy management systems

It may be argued that also the quality management systems, as specified in ISO 9001, relates to environmental aspects, since it intends to minimize waste, mistakes and failure to meet customer requirements.

15.3.2 *Applied process and techniques*

A management system according to the mentioned ISO standards is a continual process, iterating through the Plan, Do, Check and Act-stages. At the Plan-stage, the organization decides on what to do and how to do it. At the Do-stage, the organization does what it has planned. At the Check-stage the organization follows up on how its intentions have been met. At the Act-stage the organization takes

corrective actions towards yet another loop of Plan-Do-Check-Act and so on. Parts of the Plan-stage is a strategic view of the organisation's stakeholders, its risks and opportunities, and a (re-)formulation of its policy.

One very important thing to get a well-functioning management system is to base the work on measurements. For example the foundry need to know how much energy it is using or how much waste is produced.

15.3.3 *Environmental benefits*

Environmental benefits of a managements system are that the organization has a consistent overview of its policies and targets, and that the day-to-day operation and decisions can be validated and benchmarked to targets. Since emission, waste or energy reduction goals are decided by the organization's management team it will not be omitted due to pressing economic or production related matters without a conscious decision.

15.3.4 *Applicability*

All foundries can apply a management system with a structured Plan-Do-Check-Act approach for their environmentally related responsibilities. However, smaller foundries may need help to scale their management system to appropriately reflect their needs.

15.3.5 *Cross-media effect*

A management system is needed to exploit the environmental benefits of other environmental techniques.

15.3.6 *Economics*

There is a cost for introducing a management system in an organization. The highest cost relates to the organizational cultural change, to change from reactive day-to-day way of working towards working with a systematic Plan-Do-Check-Act driven organization. An organization that is already ISO 9001-certified finds it easier to start working also with environmentally related aspects of their organization.

15.3.7 *Reference*

Several foundries in the Nordic countries.

15.4 Digitalization

15.4.1 Introduction

Here digitalization addresses the ability to use computers to automate process control. The level of digitalization and automation still varies widely in the foundry industry.

15.4.2 Applied process and techniques

There are no known limits to how to apply digitalization, but here three environmentally related techniques for digitalization will be mentioned:

- *Automation*: Monitoring of temperature to avoid over heating that results in too high energy use, or to under heating, that results in quality problems and consequential need to repeat the production.
- *Logging*: Collection of production spill and quality loss data for for example MFCA-assessments, to be used for calculating production spill costs.
- *Management*: Easy access to relevant performance values in relation to for example energy reduction targets, to provide easy feedback to operators.

15.4.3 Environmental benefits

Environmental benefits with digitalization are to support foundry managers and operators to meet environmental goals without having to focus on them. Much may even be automated, as part of the equipment.

15.4.4 Applicability

Digitalization is relevant for any foundry. SMEs may find digitalized documentation and automated individual machines to be within reach. Large foundries may consider strategic paths towards fully automated factories, with automated control of waste and emissions.

15.4.5 Cross-media effect

Digitalization is not limited to environmental benefits, but may be installed to facilitate environmental efficiency and environmental information within the factory.

15.4.6 Economics

Digitalization ranges from very small to very high costs. It is recommended that a thorough cost-benefit analyses is made in order to avoid digitalization that does not also lead to benefits.

15.4.7 Reference

Different foundries work with digitalization and automation in different ways.

15.5 Environmental communication

15.5.1 Introduction

Environmental communication is a wide term to describe how an organization exchanges environmentally relevant information with external stakeholders. Environmental communication often is a precondition to get paid for environmental investments, and may also provide the incentives for further environmental improvements. Here we focus on four types of environmental communication; The environmental report, Environmental communication with customers, Environmental communication with suppliers, and Environmental communication with the community.

15.5.2 Applied process and techniques

The environmental report (which may be part of the yearly economical report or a separate report) summarizes the company's environmental aspects, in terms of quantifications and in terms of risks and opportunities, and also how the company handles these aspects. For example environmental report, which include eco balance analysis gives good general information.

Environmental communication with customers may be done in several different ways:

- *Labelling or declaration:* Presenting environmental facts about the production and products.
- *Sales dialogue:* Presenting and discussing different material- and production options with different environmental consequences together with a customer representative.
- *Environmental procurement guidelines:* Agreement with customer to follow a specific guideline for environmental aspects of product and production.

Environmental communication with suppliers is similar to communication with customer, except for the different role:

- *Requesting environmental information:* Requesting that the supplier disclose information which shows that they operate environmentally responsibly.
- *Supplier dialogue:* Establish a dialogue with the supplier, both to learn if there may be environmental benefits from changing anything in how the contract is run, and to learn from each other.
- *Environmental procurement guidelines:* Agreement with supplier to follow a specific guideline for environmental aspects of product and production. This approach may be favourable if a customer requests the same guidelines.

Environmental communication with the local community is part of a responsible relationship with neighbours, local government and local NGOs. A good communication with the local community can save time and costs and avoid environmental consequences before they occur or at an early stage.

15.5.3 Environmental benefits

Environmental communication is an enabler for environmental benefits.

The environmental report: Financiers and insurance companies can provide better conditions for companies that consciously manage their risks, such as risks for higher waste management costs, higher energy costs, transport costs, etc.

Environmental communication with customers and suppliers

Communicating about environmentally beneficial improvements is no guarantee, but environmentally conscious customers may favour your offer, hence replacing a less environmentally friendly alternative.

Customers may not be aware of that their environmental footprint can be improved by combining efforts with their suppliers, hence a dialogue about alternatives may lead to environmentally favourable decisions.

Environmental communication with suppliers may in particular save on transport. If this is combined with MFCA (see separate section) it may also lead to less spill and waste.

15.5.4 Applicability

Any foundry can apply environmental communication, but such communication needs to be well-established in the organizations management system, for stakeholder dialogues to be an integral part of the organization's long term strategy and behaviour.

15.5.5 *Cross-media effect*

No cross media-effect.

15.5.6 *Economics*

As mentioned above environmental communication is part of an organization's management system, and some of the communication costs does not require more costs than meetings with stakeholders. However, costs for different information material may be in the following ranges (SME-Large company):

- Environmental report: EUR 2,000–15,000
- Environmental label or declaration: EUR 5,000–50,000
- Customer and supplier dialogue (additional information and training): EUR 2,000–25,000
- Environmental procurement guideline (learn to apply an existing guideline): EUR 2,000–10,000
- Environmental dialogue with community (prepare and hold meeting): EUR 2,000–10,000
- Requesting information from supplier: EUR 2,000–50,000
- Environmental communication with suppliers: EUR 2,000–15,000

15.5.7 *Reference*

Different foundries work with communication in different way. Danish companies have to deliver a "Green balance" annually together with the financial statement.

16. Emerging techniques

There are a lot of emerging techniques but this report focus on available techniques and therefore this chapter only includes a few examples.

16.1 New release agent for High pressure die casting

16.1.1 *Introduction*

Today high pressure die casting uses a release agent with a small amount oil or wax mixed with water that is sprayed on the die tool between each shot.

16.1.2 *Applied process and techniques*

There are two types of new release agents.

One use a powder instead of the water and the other use more concentrated oil/wax without water.

16.1.3 *Environmental benefits*

There will be less oil mist to clean. There will also be less water with oil/wax that has to be cleaned or sent as waste.

16.1.4 *Applicability*

Difficult to say something about applicability today.

16.1.5 *Cross-media effect*

There may be a need of a new type of die tool with better cooling system because the water that is sprayed today also have a cooling effect.

16.1.6 *Economics*

Not known.

16.1.7 *Reference*

Tested of different foundries both in the Nordic countries and in the rest of Europe but no one in the Nordic countries regularly use this technique..

16.2 **Ignition of VOC at the sand mould**

16.2.1 *Introduction*

The sand binder used today can give emissions of VOC when the melt is poured into the mould. One way is to change binder. If this is not possible another way minimise the emission is to clean the outgoing air. It would be better if the air could be cleaned close to the source.

16.2.2 *Applied process and techniques*

In a research project a method has been tested where a metal frame is placed over the sand mould where there is a VOC emission. High voltage is used to make an ignition flame which will make the VOC to start burning giving some kind of combustion of the VOC.

16.2.3 *Environmental benefits*

Less VOC emission to air.

16.2.4 *Applicability*

Rather large sand moulds.

16.2.5 *Cross-media effect*

Use energy to make the ignition.

16.2.6 *Economics*

Not possible to buy today.

16.2.7 *Reference*

Only test have been done with a pilot in LIFE+ research project Odourless casting.

16.3 New inorganic sand binder

16.3.1 *Introduction*

There is one common inorganic sand binder today, sodium silicate but it cannot be used for all casting purposes. Instead most foundries use an organic binder giving rise to emissions of VOC to the air.

16.3.2 *Applied process and techniques*

Instead of the organic binders used today an inorganic variant is used.

16.3.3 *Environmental benefits*

No emissions of organic compounds to the air.

16.3.4 *Applicability*

Not known which foundries that can use this in the future.

16.3.5 *Cross-media effect*

Need heating of the core box.

16.3.6 *Economics*

Not known. More expensive than traditional binders.

16.3.7 *Reference*

Some foundries in Germany are testing this now.

16.4 Reclaim green sand to core production

16.4.1 *Introduction*

Today cores in green sand foundries are manufactured with new sand and therefore some of the green sand is sent away as waste.

16.4.2 *Applied process and techniques*

Mechanical reclamation, where coal dust and bentonite is grinded or rubbed off from the sand grain surfaces.

16.4.3 *Environmental benefits*

Sand that otherwise can be a waste will be used again in the foundry.

16.4.4 *Applicability*

Not known which foundries that can use this in the future.

16.4.5 *Cross-media effect*

Special equipment for the reclamation, and use of energy.

16.4.6 *Economics*

Not known.

16.4.7 *Reference*

Not used in the Nordic countries. Some foundries in Europe is testing this technique.

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Sammanfattning

Nordiska ministerrådets BAT-grupp har beslutat att genomföra ett projekt om Bästa tillgängliga teknik (BAT) för gjuterier och smidesanläggningar i de Nordiska länderna. Inga smidesanläggningar uppfyller kriterierna i industriutsläppsdirektivet (IED) och därför har den här rapporten fokuserat enbart på gjuterier.

Målen vid sammanställningen av den här rapporten har varit att:

- ta fram en översikt över gjuteribranschen i de Nordiska länderna
- beskriva använda och potentiella miljötekniker i gjuterier i de Nordiska länderna
- beskriva viktiga miljöaspekter ur de nordiska gjuteriernas perspektiv
- identifiera och beskriva tekniker som hänsyn bör tas till när beskriver BAT för gjuterier.

Arbetet har innefattat gjuterier som använder permanenta och icke permanenta former. Fokus har varit på processer specifika för gjuteriindustrin, från simulering av gjutning till de gjutna produkterna, och i mindre omfattning några generella processer som är speciellt relevanta för gjutning.

Den beskrivna informationen kan användas av gjuterier, miljökonsulter och miljömyndigheter. Projektet kan också bli användbart som ett nordiskt inspel till den tekniska arbetsgruppen i arbetet med revisionen av BAT-slutsatser för "Smitheries and Foundries Industry" i enlighet med IED.

Metallgjutning har en lång tradition och har tidigare varit en stor industri i de Nordiska länderna, men antalet gjuterier har minskat. Idag har Sverige flest gjuterier av de Nordiska länderna.

De viktigaste miljöaspekterna som behandlas i denna rapport är (inte prioriterad ordning):

- Utsläpp till luft (partiklar och VOC)
- Buller och vibrationer
- Utsläpp till vatten och vattenanvändning
- Användning av kemikalier och risker
- Avfall/restprodukter
- Energianvändning
- Råvaror
- Transporter

Beskrivna BAT för gjuterier innefattar:

- BAT kontroll av emissioner till luft
- BAT för att förhindra buller och vibrationer
- BAT kontroll av utsläpp till vatten
- BAT pressgjutning
- BAT sand och bindemedel
- BAT kemikaliehantering och substitution
- BAT avfallshantering och minimerade avfallsmängder
- BAT simulering
- BAT energi
- BAT metall och smälta
- BAT miljöledning

Teknisk användbarhet, ekonomiska kostnader och miljöfördelar för de olika BAT varierar kraftigt från fall till fall. Det är också värt att betona att på grund av befintliga processer, produkter eller utformning av gjuterierna är de inte alltid fria att välja BAT. Presenterade BAT-tekniker listas i nedan.

BAT kandidater utsläpp till luft

- Textila spärrfilter
- Använda tryckfallsmätare
- Stoftmätning
- Uppvärmda filter
- Använda fluorescerande pulver för att kontrollera textila spärrfilter
- Stoftmätare
- Syraskrubber för att rena amin
- Oljedimfilter
- Plan för att reducera VOC
- Lock på blackkar
- Använda black endast vid behov
- Sotersättningsmedel
- Rena VOC och lukt med biofilter
- Rena VOC och lukt med RTO

BAT kandidater buller

- Tippa skrot inomhus
- Bullerreduceringsplan
- Bullersimulering
- Ljuddämpare på ventilationen
- Tilläggsisolera fläktar och ventilationskanaler

BAT kandidater kemikalier

- Kemikalieansvarig

BAT kandidater avfall och restprodukter

- Kartlägga avfallsflöden
- Mekanisk sandåtervinning
- Använda restsand utanför gjuteriet
- Brikettering

BAT kandidater simulering

- Simulering
- Optimerat ingjutsystem

BAT kandidater energi

- Energikartläggning
- Blästra råmaterial före smältning
- Krossa ingjutsystem
- Isolerade skänkar
- Lock på ugnar och skänkar
- Flamlös skänkfövärmning

BAT kandidater metall och smältning

- Skrothantering
- Användning av deoxidationsmedel
- Spola skänk med argon
- Ympkontroll
- Automatisk ympning

BAT kandidater pressgjutning

- Underhåll av pressgjutverktyg
- Förvärm pressgjutverktyg
- IR kamera
- Använd vakuumdoseringsugn

Kommande tekniker

- Nya släppmedel för pressgjutning
- Antändning av VOC i sandform
- Nya oorganiska bindemedel
- Använda råsand för kärntillverkning.

Appendix

All IED foundries in the Nordic countries were contacted in the project with this questionnaire. The foundries also were asked to reflect if used technique is BAT or if the foundry knows some better technique.

Air

- What technology / working practices do you use to clean the outgoing air from dust, oil mist, odour and volatile organic compounds VOC?
- What technology / working practices do you use to prevent emissions to air to arise at all?

Chemicals (process chemicals and auxiliary chemicals)

- How do you work to reduce the amount of chemicals used?
- How do you work to replace hazardous chemicals?
- How do you handle hazardous chemical substances?

Energy

- How do you ensure that the raw material (metal) is dry and free from oil, paint or sand?
- How do you ensure optimal packing in the oven e.g. by crushing large material?
- How do you work to optimize the melt (for example, apply packing density, melting time, to charge in the right order, to fill the oven while still hot for example after the end of the day)?
- How are you working to reduce the need to overheat the melt?
- Do you use holding furnace, and what do you do to minimize the time it is used?
- Do you use a lid on furnaces / ladles during production / operating break?
- What kind of preheat of the ladle do you use?
- How do you reduce energy consumption for preheating ladle (e.g. insulation, plan melting so that you do not need to reheat unnecessarily, lid on ladles)?
- How do you work to reduce the energy consumption for melting?
- How do you work with taking care of waste heat?

Management

- Do you have a systematic improvement in production and logistics, such as a certified management system according to (ISO 9001, EMAS, ISO 14001, ISO 50001)?

Waste

- How do you store waste?
- How are you working to minimize the amounts of waste in general?
- How are you working to minimize the amounts of slag?
- Is your waste used as a resource somewhere else, or could it be done?

Simulation

- How do you use simulation to reduce scrap?
- Do you use simulation to verify process stability (e.g. temperature impact on shrink / suction)?
- In what way do you use the results from the simulation to make feedback to the customer and to influence the design?
- Noise
- What technologies / working practices are you taking to reduce noise from the foundry?

Sand

- Do you have sand reclamation, what kind of reclamation and what degree of recovery do you reach? Please comment both core and moulding sand
- The sand that is recycled internally how it is used in the foundry?
- How do you work to reduce the amount of sand that is spent?
- What happens to the sand that you cannot reuse?

Binder

- How do you minimize the use of binders?
- What are the possibilities out replace your binder with one more environmental friendly?
- Which binders do you use?

Water

- How do you purify any water that occurs?
- How do you minimize the amount of water that occurs?

Die casting

- How do you mixture the release agent?
- How do you spray release agents?
- How do you take care of release agent residues?
- How do you minimize the use of release agents?
- How do you work to extend the life of the tools?

Blackening (coating of cores)

- What kind of blackening/coating of cores do you use?
- How do you do to reduce the amount of blackening/coating?
- If you have water blackening how do you dry it?
- If you have alcohol-based black, how do you do to reduce emissions to the air?
- Do you burn of alcohol-based black?

Oven

- What do you use for the type of furnace?

Other

- Do you quantify and describe the environmental impact of your products, raw materials or waste, using e.g. environmental labelling, life cycle analysis, or in any other way?
- Do you reuse your own products for remelting when customers no longer want to use them?
- Something else we have not asked about but that you want to highlight? For example, special techniques / working practices that you use.

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Nordic Foundries

The Nordic Council of Ministers BAT Group under the Working Group for sustainable consumption and production, commissioned to Swerea SWECAST AB to prepare a Best Available Techniques (BAT) report for foundries in the Nordic countries. The objectives have been to:

- Provide an overview of the foundry sector in the Nordic countries.
- Present currently used and potential environmental techniques in foundries in the Nordic countries.
- Present the Key environmental issues with the perspective of foundries in the Nordic countries.
- Present and describe techniques that shall be included in the considerations of representing BAT in foundries.

This report focuses only on foundries as no smitheries satisfies the criteria of the Industrial Emissions Directive (IED). Swerea SWECAST is a research institute based in Sweden specializing on foundry and casting.

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