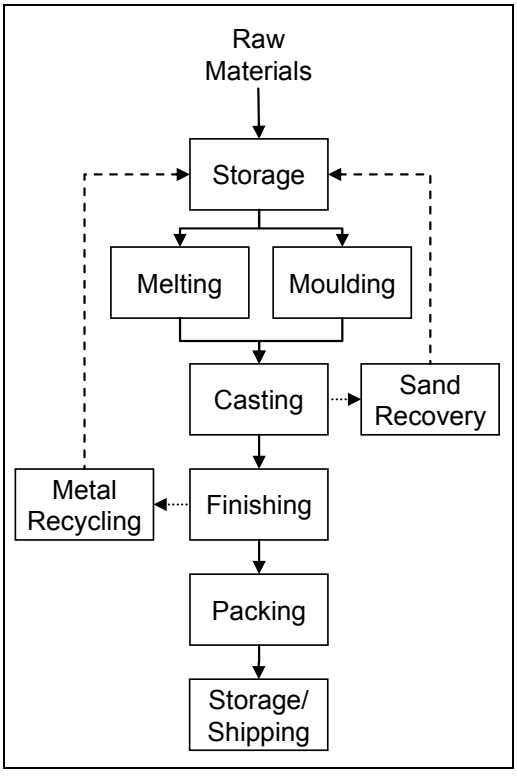
European Bank
for Reconstruction and Development

Sub-sectoral Environmental and Social Guidelines: Foundries

PROCESS DESCRIPTION

Foundries melt ferrous (iron and steel) and non-ferrous (mainly aluminium, copper, zinc, lead, tin, nickel, magnesium, and titanium) and alloys and reshape them into products at or near their finished shape through the pouring and solidification of the molten metal or alloy into a mould.

The typical foundry process activities are shown in the figure below:



Melting: different types of furnaces are used depending on the type of metal. The metal may require treatment such as desulphurisation, deslagging, refining, and deoxidisation. Metal flux can be added to the melt to combine with impurities to form a slag which is removed before pouring.

Moulding: there are two basic types of moulds.

- Lost Moulds (single use): These moulds are generally made from sand and are lost in the process. These are mainly used in ferrous casting but are also used in non-ferrous casting

- Permanent Moulds (multi-use): These moulds are normally metallic and are mainly used for non-ferrous casting.

Sand moulds are bonded together to form the desired shape using the natural properties of the clay particles within the sand (85% of moulds are made from green sand which is a mix of sand, clay, carbonaceous material and water) or a chemical binder.

Permanent moulds are made from metal with a higher melting point than the casting metal and can be reused to produce large quantities of the same piece.

Casting: different pouring systems are used depending on the metal and the type of mould, e.g. by gravity (lost mould), injection under low or high pressure, or by centrifugal force. The metal is allowed to solidify and the mould is broken away and, in the case of lost moulds, the sand is shaken from the metal parts. Most of the sand can be reused. The casting is then subject to further controlled cooling.

Finishing: depending on the casting process, different steps may be required, e.g. shot blasting, grinding, deburring, thermal treating, inspection and testing. Welding to join or repair castings may be required as well as chemical cleaning before coating operations.

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KEY ENVIRONMENTAL, HEALTH AND SAFETY RISK/LIABILITY ISSUES

Air Emissions

The foundry process generates metal laden mineral dusts, acidifying compounds, incomplete combustion products and volatile organic compounds (VOCs).

- Particulates may be generated during each of the process steps consisting of varying levels of dust, metallic materials, metal and mineral oxides. Storage, handling and transport of raw materials may be responsible for significant fugitive dust emissions;

- Emissions from furnaces and pouring include nitrogen oxides, sulphur oxides, carbon monoxide and carbon dioxide, hydrogen sulphide, polycyclic aromatic hydrocarbons (PAH), volatile organic compounds (VOC), hydrogen chloride, heavy metals, lead, dioxins and furans;

- VOCs are also emitted by the use of resins, organic solvents and coatings in mould and core making;

- Organic compounds are thermally decomposed during metal pouring and are emitted during shake-out and cooling.

Energy Consumption

The casting process is highly energy intensive: the majority (40-60%) is consumed in the melting process. Cooling generates a hot water or air stream which can be used as a heat source.

Water Consumption

Water consumption may be high but is dependent on the type of furnace used, the type of flue-gas cleaning and the casting method. Water is used for cooling and quenching operations and wet dedusting systems. In most foundries, the water is recirculated, but a high percentage evaporates.

Solid Wastes

The main wastes are sand, slag, refactory waste, and residues from air and water abatement/treatment systems (dust, scrubber liquors and sludges).

- The largest waste by volume is moulding and core sand. The majority of the sand mould can be recovered and reused internally within the process or externally, e.g. for construction material. Chemically bonded sand may be difficult to recover and sand from brass and bronze foundries is hazardous and must be disposed of through appropriate waste removal contractors;

- Slag may be up to 25% of the solid waste and may consist of metal oxides, melted refractory materials, sand, and coke ash. Valuable metal content can be recovered and the slag reused, e.g. in construction and as coarse aggregate;

- Collected dust may be sufficiently high in metal content to be classified as hazardous waste or to make metal recovery feasible. It should be recirculated to the furnace to the extent possible;

- Sludge from wastewater treatment may contain heavy metals, oil and grease. Some may be internally recycled but the majority is landfilled.

Wastewater

In general, the volume of wastewater is small but may be contaminated with metals, suspended solids and oils and therefore require treatment prior to disposal.

Stormwater may become contaminated through contact with material stockpiles or airborne contaminants and where necessary should be captured and treated before discharge.

Materials Storage

Raw materials range from fine dusts to large single items, e.g. scrap items. Windborne dust from products stored outdoors can be a significant source of emissions and therefore dust suppression measures should be adopted such as covered storage, silos, wetting and use of windbreaks.

- Powdered materials should be stored in sealed silos or bags;
- Sand should be stored in bags, bulk containers or silos;
- Scrap should be stored in segregated piles based on grade and alloy composition;
- Liquids (including fuels) should be stored in drums, bulk containers or tanks within contained areas.

Loose powdered materials and sand should be transported via pneumatic conveyor.

Soil and Water Contamination

Direct soil and water pollution may occur from accidental leaks and spills. In addition, scrap metal may include unwanted contaminants, e.g. cadmium, lead, zinc, oil, PAH and plastics. These have the potential to cause land contamination in un-surfaced storage areas and to the wider deposition of contaminants via air emissions from the melting process. Therefore, land may be contaminated by either current or previous operations at the site. It is common for foundry operations to be co-located with smelting, refining and coking plants which may also give rise to contamination.

Noise and Vibration

Noise and vibration are significant hazards in foundry processes.

- Noise from furnace charging and fans can exceed 100dB(A);
- The shake-out stage where casts are knocked from their moulds can be very noisy and give rise to vibration;
- Sand reclamation uses ball mills or vibrating crushers;
- Fettling[1] or dressing, can involve shotblasting, welding, grinding, chiselling.

Noise may reach levels that are hazardous to health. Process buildings and noisy equipment should be enclosed and insulated.

Hand-arm vibration syndrome from the prolonged use of vibrating tools and machinery causes effects on the body's blood circulation known as 'vibration white finger' (VWF). Other damage may be caused to the nerves and muscles of the fingers and hands causing numbness and tingling, reduced grip strength and sensitivity. Pain and stiffness in the hands,

[1] Removal of imperfections, excess metal or sand after casting.

and joints of the wrists, elbows and shoulders are other possible symptoms.

Appropriate PPE should be provided and good occupational health systems are required to monitor and control employee long-term exposure to noise and vibration.

Respiratory Hazards

- When dry, casting sand, fettlings and kiln linings produce silica dust known as respirable crystalline silica (RCS), this can cause silicosis which leads to disablement and death and is made worse by smoking.

- Ferrous foundry fume may cause cancer. Other foundry fumes and spray mists can cause lung diseases including asthma.

- Asbestos was used on a large scale for many years as a fire proofing and insulation material and may be encountered in a wide range of forms within the fabric of older buildings. Asbestos fibres, which are extremely hazardous when inhaled (causing mesothelioma and fibrous thickening in the lungs), may be released when the asbestos containing material is disturbed during maintenance or demolition. Asbestos must be removed under controlled conditions by licensed contractors where possible. Particular attention should be given to buildings constructed before the 1980s.

Burns and Heat Stress

High temperatures and direct infrared radiation (IR) can cause fatigue and dehydration for those working in the vicinity. Direct IR can also cause damage to sight. Burns and scalds may occur through contact with hot surfaces, metal or water especially during maintenance activities.

Fire & Explosion

Handling of liquid metal may result in explosions, causing metal run-out and burns. The hot melted metal can cause combustion of liquid fuels and flammable chemicals.

OTHER ENVIRONMENTAL, HEALTH AND SAFETY RISK/LIABILITY ISSUES

Confined Spaces

There is a risk of entrapment in storage areas and other confined spaces. Particularly at risk are those involved in the creation of sand moulds, where the stored sand may collapse and maintenance workers performing repairs on a furnace or servicing a fuel tank or trailer, sump, silo or bunker. Entry into confined spaces must be strictly controlled and avoided wherever possible.

Ionising Radiation

Gamma ray testing is used to determine steel quality and integrity. This should be conducted in a controlled restricted area.

All incoming scrap should be tested for radioactivity before use.

Polychlorinated Biphenyls (PCBs)

PCBs are a group of substances which are good electrical insulators. Typically, PCBs may be present as constituents of hydraulic oils or dielectric fluids in electrical switchgear, transformers and fluorescent light starters. PCBs are extremely toxic and become concentrated within the food chain. Any products that may contain PCBs must be disposed of by licensed contractors in accordance with national regulations. Particular

attention should be given to buildings constructed before the 1980s.

Machinery/Product Handling

Moving parts of machinery can result in entanglement and entrapment. Particular attention should be paid to conveyors and handling, cutting and grinding activities.

Collision

Heavy loads are lifted and moved at elevated heights using hydraulic platforms and cranes presenting a serious safety hazard. Grinding and cutting activities may eject pieces of scrap metal causing injury.

Manual Handling and Repetitive Work

Lifting and carrying heavy or awkwardly shaped objects, such as bags and small moulds, can result in manual handling injuries.

Slips, Trips and Falls

These often occur on the same level and are primarily caused by uneven surfaces, inappropriate footwear, lighting, weather conditions, trailing cables and pipe work especially during unblocking, maintenance and cleaning activities.

Permitting

Foundry operations in the EU are subject to national regulations under the Integrated Pollution Prevention and Control Directive (2008/1/EC). Operations outside the EU will still be subject to local regulations.

KEY SOCIAL, LABOUR AND COMMUNITY RISK/LIABILITY ISSUES

Air Quality

Particulate emissions from some works can have a significant impact on local air quality and for large installations, the risk of transboundary pollution must be considered.

Accumulative Contamination

The slow build-up of contaminants on land and dwellings in the community through the deposition of fine metal particulate and other pollutants can expose residents and the ecosystem to health risks. Crop and livestock production and quality may be affected. The use of on site emission controls will minimise such impacts.

Noise

Many parts of the process are noisy and may cause disturbance to the local neighbourhood, for example,

- Vehicle and delivery operations;
- The mould shake-out stage;
- Sand reclamation;
- Fettling, dressing and finishing of castings.

OTHER SOCIAL, LABOUR AND COMMUNITY RISK/LIABILITY ISSUES

Dust and Odour

- Public/environmental health and nuisance issues associated with dust and vented fumes can arise from production activities and may have a significant effect on neighbouring

locations. This may be important if there are neighbouring residential and industrial activities in the area;

- Some of the substances produced or used have the potential to cause offensive odour to neighbouring communities.

Transport

Transport of products by road can be a significant issue. This might lead to road noise and traffic congestion.

FINANCIAL IMPLICATIONS

- Many countries are signatories to the Kyoto Protocol and have adopted targets for the reduction of CO_2 emissions. Where Governments have set up carbon emission reduction programmes industrial processes have been required to reduce their CO_2 emissions through the setting of targets. This can result in a need for substantial investment in new/clean technologies to achieve the emission targets. These targets may be reflected in environmental permits;
- Under the EU Emissions Trading Scheme (ETS) Member States allocate allowances for carbon emissions to industrial sites, including some larger foundries. The scheme can create both financial assets or liabilities and entities can trade their carbon allowances;
- Injuries may lead to increased payroll costs to replace skilled workers and lost production time;
- Capital investment may be required to comply with new environmental, health and safety requirements;
- There is a relatively high potential for soil and groundwater contamination to be present which can be very costly to remediate;
- Fines, penalties and third party claims may be incurred for non-compliance with environment, health and safety regulations.

IMPROVEMENTS

Environmental, Health and Safety Improvements

General

- Environment, health and safety training for all employees and contractors;
- Good housekeeping should be maintained at all times in all areas to reduce the likelihood of incidents and accidents;
- Systems should be subject to frequent and equipment inspection;
- Routine equipment maintenance should be undertaken to keep small leaks and spills to a minimum and maintain equipment efficiency;
- Controls should be implemented to minimise the exposure to fume and dust, noise and vibration, e.g.
    - Mechanical controls such as enclosures, use of filters and PPE;
    - Administrative controls such as limiting exposure time, health surveillance;
    - Operator behaviour through training and instructions.

Airborne Emissions

- Cover all transport vehicles and storage areas to reduce dust;
- Maximise use of silos for bulk powder storage;
- Optimise process design to reduce off-gas emissions and pollutant content, e.g. recirculation of waste gases to sinter plant;
- Installation or upgrade of abatement technology to minimise exposure to toxic raw materials and product and to control the release of emissions, e.g. enclosure of equipment, use of wet de-dusting systems, appropriate ventilation with filters, gas balancing systems, bag filter house, cyclones, filters, and wet or alkali scrubbers.

Noise & Vibration

- Enclosure of noisy machines to isolate people from the noise where practicable;
- Limitation of scrap handling and transport during unsocial hours;
- Reduction of exposure times for people working near noisy machinery and provide personal protective equipment where people have to enter noisy areas.

Heat

- Shield surfaces where close contact is expected. Implement safety buffer zones;
- Install cooling ventilation;
- Reduce exposure times for people working in extreme heat and provide personal protective equipment to provide protection from hot surfaces and materials.

Water and Wastewater

- Minimise the consumption of water in the process and equipment cleaning;
- Segregate process water, rainwater and indirect cooling water streams to reduce the hydraulic loading to waste water treatment equipment or sewers;
- Consider upgrades to wastewater treatment facilities;
- Use dry cleaning methods wherever practicable for solids, e.g. vacuum extraction, wipe down equipment that is accessible rather than washing and rinsing it;
- Recycle wastewater where possible back to the processes or to secondary uses such as for cleaning;
- Emergency storage lagoons may be needed to prevent contaminated firewater reaching controlled waters;
- Maintain on site abatement equipment.

Energy Efficiency

- Improve insulation to minimise heat loss;
- Use heat and energy recovery techniques;
- Use of waste gas through a heat exchanger to recover thermal energy and as a fuel to produce hot water, air, steam and power;
- Preheat clean scrap.

Storage

- Bulk containment must be:
  - inspected regularly to prevent leakage;
  - provided with secondary spill containment;
  - installed with automatic alarms and shut off systems.
- Maximise use of silos for powdered material;
- Pave stockyards to prevent pollutant infiltration to soil and groundwater.

Waste

- Recover and re-use raw materials and waste products where practicable. Consider opportunities for selling used sand to construction industry;

Health & Safety

- Provision of personal protective equipment (PPE) that is fit for the task to prevent injury and maintain hygiene standards. Staff should be trained in the correct selection, use and maintenance of PPE;
- Redesign manual processes to avoid heavy lifting/repetitive activities;
- Install mechanical lifting aids where possible and rotate work tasks to reduce repetitive activities;
- Separate people from vehicles and machinery were practicable:
  - Ensure that the process layout reduces opportunities for process activities to cross paths;
  - Installation of safeguards on moving parts of conveyor belts to reduce risk of entrapment of employees;
  - Install walkways and signage to separate people from vehicle movements to reduce risk of collision;
- Route cables and pipework under walkways to prevent slips, trips and falls;
- Construct walkways of non-slip materials.

Fire & Explosion

- Control the effect of fires and explosions by segregating process, storage, utility and safe areas;
- Provide the local fire department with a list and volume of products stored on the premises;
- Use explosion-proof equipment and conductive materials and ensure that equipment is grounded and bonded;
- Introduce accident, fire and explosion precautions and emergency response procedures.

Social Community and Labour Improvements

- Implement a programme of assessment of routine monitoring of worker health;
- Implement a grievance/dispute resolution mechanism for workers and members of the community to raise issues with the Company.

GUIDE TO INITIAL DUE DILIGENCE SITE VISITS

During the initial site visit, the issues will vary according to the type of process being used and product being produced and depending on the level of environment, health and safety management already introduced.

General

- Confirm organisational responsibilities and systems for environment, health and safety;
- What process chemicals are used?
- Note signs of poor housekeeping, such as signs of spillages and high numbers of empty drums. Particularly note any recent spills;
- Note the noise levels at the site. Is there any evidence that noise abatement measures deployed?
- Check the condition of any assets, facilities, equipment and production areas. Look for wear and tear and poor maintenance.

Air Emissions Management

- Is there local exhaust ventilation? Is it maintained?
- Is powdered material/sand moved around the site by conveyor or by vehicle?

Noise

- Note the noise levels at the site. Is there any evidence of noise abatement measures deployed? Are staff wearing hearing protection?

Water Abstraction & Management

- What amounts and quality of water are required? Where is the water obtained from? Is the water recycled?

Liquid Waste Management

- What liquid effluents are produced? What discharge control measures are employed?
- Is effluent and wastewater treated before discharge? If so, check the condition of the treatment plant and location of discharge points for wastewater from the facility;
- What does the quality of these discharges look like? Note the colour and appearance of adjacent watercourses;
- Note whether the wastewater treatment plant discharges to ground, a local watercourse or the municipal wastewater treatment works. Higher environmental risks will be associated with facilities discharging to water courses without adequate treatment because there is additional protection at that point;
- Is the water quality tested? What are the waters tested for? Where are the samples taken from, how often? Do the discharges have to meet set standards?

Solid Waste Management

- Note the type of solid waste disposal;
- Check that solid waste storage equipment is in a good condition;
- Check that waste storage areas are clear of debris and that skips are covered to prevent waste escaping. For example, check that

waste containers have lids or are stored in an area with a roof;

- Check for flora/vegetation zones near storage sites that are not growing very well because this will indicate the possibility of pollution.

Transport of Cast Product from the Site

- Is this by rail, road or water or a combination of these?
- Where are the areas for loading/unloading of material located? Are they located near any water bodies or other possibly sensitive features? Is there any containment to prevent run-off of contaminated water?
- Does road haulage cause excessive traffic through any neighbouring residential areas?

Fuel and Bulk Material Storage Arrangements

- What fuels and materials are stored in bulk on site?
- To gauge the potential for spillages and leaks consider the following:
  - Are there any underground storage tanks?
  - Are surface storage tanks and usage areas hard surfaced and contained? Are these in good condition or are cracks present? Are these regularly tested for leakages?
  - Is the size of the containment adequate for the volume of the materials stored?

Health & Safety

- Are staff wearing Personal Protective Equipment?
- Check signage around the site:
  - Does it convey the health and safety risks?
  - Are fire exits and/or evacuation routes clearly marked?
  - Are there demarcated routes for pedestrians and vehicles?
- Check for automatic safeguards on machinery to prevent accidental injury;
- Is there a worker health monitoring programme? What does it check for?

Incident Management

- Is fire fighting and first aid equipment available?
- Have there been any recent (within the last three years) incidents on site such as fatalities, fires/explosions, spills?

Inspections & Regulation

- Check the conditions and duration of validity for all permits;
- Has the organisation been subject to environment, health and safety or quality audits by customers/insurers? What was the outcome of these audits?
- Find out what insurances are in place (health, hygiene, fire etc). Identify number and type of claims against insurance;

- Have the premises been inspected recently (within the past 2 years) by the regulatory authorities for health, hygiene and environment? What were their findings?

Investment

- Review budgets for capital expenditure (capex) and operational expenditure to cover environment, health and safety matters. Does the business plan have line items for environment, health, safety and social improvements as well as asset management and maintenance?

- If investment or refinancing will lead to restructuring of the organisation what will be the potential impacts on health and safety at the operation and wider community? Have these been considered and assessed by the company?

- If the company plans to invest in new technology, what will be the impacts and benefits for human resources?

Social, Labour and Community

- Check that labour standards, contracting and remuneration are in line with national law and are consistent with the average for the sector;

- Check that hours worked, including overtime, are recorded and staff should receive written details of hours worked and payment received;

- Check that wages and working hours are consistent with the average for the sector and national standards;

- Has the Company received inspections from the local labour inspectorate in the previous three years? Have these resulted in any penalties, fines, major recommendations or corrective action plans?

- Does the organisation have a grievance mechanism which allows employees to raise workplace concerns?

- Are employees free to form, or join, a worker's organisation of their choosing?

Take note/ask questions relating to any activities that address the improvements listed in the improvements section of this document

ACTION PLANS

Dependent on the individual business, select appropriate improvements from the list above to include in the action plan. As a minimum, any business should be required to have the following in place:

Environmental, Health and Safety

- Operational procedures to manage environmental, health, safety and social risks;

- Monitoring programmes;

- Improvement objectives, targets and project plans;

- Training for personnel;

- Regular inspections, checks and audits with records to demonstrate achievement of the required level of performance against legal requirements and improvement action;

- Operational procedures to manage environmental, health, safety and social risks;

- Emergency plans for environment, health and safety accidents;
- Waste management plan (waste minimisation, re-use, recycling, monitoring);
- Senior management review/demonstrated involvement in environment, health, safety and hygiene management

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