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## **How to comply with your environmental permit**

### **Additional guidance for:**

### **Non-Ferrous Metals and the Production of Carbon and Graphite (EPR 2.03)**

How to comply with your environmental permit

Additional guidance for: Non-Ferrous Metals and the Production of Carbon and Graphite (EPR 2.03)  
Version 2, September 2014

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Natural Resources Wales

Cambria House

29 Newport Road

Cardiff

CF24 0TP

0300 065 3000 (Mon-Fri, 8am - 6pm)

[enquiries@naturalresourceswales.gov.uk](mailto:enquiries@naturalresourceswales.gov.uk)

[www.naturalresourceswales.gov.uk](http://www.naturalresourceswales.gov.uk)

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## Introduction

In “*Getting the basics right – how to comply with your environmental permit*” (GTBR) we described the standards and measures that we expect businesses to take in order to control the risk of pollution from the most frequent situations in the waste management and process industries.

This sector guidance note (SGN) is one of a series of additional guidance for Part A(1) activities listed in Schedule 1 of the Environmental Permitting Regulations (the Regulations). We expect you to use the standards and measures in this note **in addition** to those in GTBR to meet the objectives in your permit.

Sometimes, particularly difficult issues arise such as problems with odour or noise. You may then need to consult the “horizontal” guidance that gives in depth information on particular topics. Annex 1 of GTBR lists these.

The IPPC Directive requires that the Best Available Techniques (BAT) are used. When making an application, explain how you will comply with each of the indicative BATs in this sector guidance note. Where indicative BAT is not included, where you propose to use an alternative measure or where there is a choice of options you should explain your choice on the basis of costs and benefits. Part 2 of Horizontal Guidance Note H1 Environmental Risk Assessment (see GTBR Annex 1) gives a formal method of assessing options which you should use where major decisions are to be made.

We will consider the relevance and relative importance of the information to the installation concerned when making technical judgments about the installation and when setting conditions in the permit.

Modern permits describe the objectives (or outcomes) that we want you to achieve. They do not normally tell you how to achieve them. They give you a degree of flexibility.

Where a condition requires you to take appropriate measures to secure a particular objective, we will expect you to use, at least, the measures described which are appropriate for meeting the objective. You may have described the measures you propose in your application or in a relevant management plan but further measures will be necessary if the objectives are not met.

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The measures set out in this note may not all be appropriate for a particular circumstance and you may implement equivalent measures that achieve the same objective. In cases where the measures are mandatory this is stated.

In response to the application form question on Operating Techniques, you should address each of the measures described as indicative BAT in this note as well as the key issues identified in GTBR.

Unless otherwise specified, the measures and benchmarks described in this note reflect those of the previous Sector Guidance Note. They will be reviewed in the light of future BREF note revisions. In the meantime we will take account of advances in BAT when considering any changes to your process.

### **Installations covered**

This note covers activities described in paragraphs (a) to (f), (h) and (i) of Part A (Part A (1) in England and Wales) of Section 2.2 of Schedule 1 to the Regulations and also installations described in Section 6.2 Part A (1) paragraph (a) and Section 6.3 Part A paragraph (a) subparagraph (ii).

### **Non - ferrous metals**

Section 2.2 Part A (1)

- (a) Unless falling within Part A (2) of this Section, producing non-ferrous metals from ore, concentrates or secondary raw materials by metallurgical, chemical or electrolytic activities.
- (b) Melting, including making alloys, of non-ferrous metals, including recovered products (refining, foundry casting, etc.) where:
  - (i) the plant has a melting capacity of more than 4 tonnes per day for lead or cadmium or 20 tonnes per day for all other metals; and
  - (ii) any furnace, bath or other holding vessel used in the plant for the melting has a design holding capacity of 5 tonnes or more.
- (c) Refining any non-ferrous metal or alloy, other than the electrolytic refining of copper, except where the activity is related to an activity described in paragraph (a) of Part A (2), or paragraph (a), (d), or (e) of Part B, of this Section.
- (d) Producing, melting or recovering by chemicals means or by the use of heat, lead or any lead alloy, if:
  - (i) the activity may result in the release into the air of lead and
  - (ii) in the case of lead alloy, the percentage by weight of lead in the alloy in molten form is more than 23 per cent if the alloy contains copper and 2 per cent in other cases.

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- (e) Recovering any of the following elements if the activity may result in their release into the air: gallium; indium; palladium; tellurium; thallium.
- (f) Producing, melting or recovering (whether by chemical means or by electrolysis or by the use of heat) cadmium or mercury or any alloy containing more than 0.05 per cent by weight of either of those metals or, in aggregate, of both.
- (h) Manufacturing or repairing involving the use of beryllium or selenium or an alloy containing one or both of those metals if the activity may result in the release into the air of any of the substances listed in paragraph 12 of Part 2 to this Schedule; but an activity does not fall within this paragraph by reason of it involving an alloy that contains beryllium if that alloy in molten form contains less than 0.1 per cent by weight of beryllium and the activity falls within paragraph (a) or (d) of Part B of this Section.
- (i) Pelletising, calcining, roasting or sintering any non-ferrous metal ore or any mixture of such ore and other materials.

This sector guidance does not cover:

- (g) Mining zinc or tin bearing ores where the activity may result in the release into water of cadmium or any compound of cadmium in a concentration which is greater than the background concentration.

### **Carbon activities**

Section 6.2 Part A (1)

- (a) Producing carbon or hard burnt coal or electro-graphite by means of incineration or graphitisation.

### **Tar and bitumen activities**

Section 6.3 Part A (1)

- (a) (ii) Heating tar or bitumen for the manufacture of electrodes or carbon based refractory materials, where the carrying out of the activity by the person concerned at the location in question is likely to involve the use in any period of 12 months of 5 tonnes or more of tar or of bitumen or, in aggregate, of both.

### **Interpretation of Part A (1)**

In paragraph (g), “background concentration” means any concentration of cadmium or any compound of cadmium which would be present in the release irrespective of any effect the activity may have had on the composition of the release and, without prejudice to the generality of the foregoing, includes such concentration of those substances as is present in:

- (i) water supplied to the site where the activity is carried out
- (ii) water abstracted for use in the activity

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(iii) precipitation onto the site on which the activity is carried out.

### **Key issues**

Primary extraction processes which use sulphur containing ores generate substantial quantities of sulphur dioxide. Most ores and concentrates contain a range of other elements, many of which can have a significant impact on the environment if allowed to escape, for example substances in list I and II of the Dangerous Substances Directive.

Scrap and other secondary raw materials may be contaminated with chlorinated organic compounds such as plastics, lubricants or solvents. These are a potential source of dioxins.

### **Fugitive emissions to air**

Pyro-metallurgical processes subject plant to high temperatures and aggressive atmospheres. In addition, the need to move heavy items such as ladles has a potential to cause physical damage to furnaces and ducting. The risk of fugitive emissions into the air is so high that it requires separate consideration as a key issue in any application.

### **Energy requirements**

Significant energy is needed to melt the metal being processed in pyrometallurgical processes. Primary extraction processes require a high energy input to extract metals from their ores and to purify them.

### **Accident risk**

You need to pay particular attention to the storage and use of liquefied gases such as oxygen, chlorine and LPG.

Loss of electrical supplies to control systems and to pollution abatement systems may lead to uncontrolled discharges to air and water.

Flooding, whether caused by rainfall or due to fire fighting activities, may lead to uncontrolled emissions to water.

### **Noise**

Non-ferrous metallurgical processes have many sources of noise. You should pay particular attention to:

- movement and storage of scrap
- location and sound insulation of large fans and air filtration systems
- rolling mills
- casting installations, especially billet casters
- internal transport.

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## **Long-distance and transboundary pollution**

The largest processors require an assessment of the potential for longdistance environmental impacts.

## **Monitoring**

Many non-ferrous metal processing installations have the potential to release long-term contaminants, such as heavy metals. Each site should carry out an assessment of the potential for releases and their possible impacts. This assessment will form the basis of any decision about the need for an environmental monitoring programme.

## **Solid waste recovery, recycling and disposal**

The secondary non-ferrous metals industry makes a significant contribution to recycling metallic wastes; but it also creates significant waste. The following are of particular interest:

- slags and drosses from melting operations
- sand from casting operations and insulation and refractory materials from maintenance operations

## **Site restoration**

Areas to consider for remediation include:

- storage areas used for slags, drosses and other residues, and
- fuel storage areas.

Most non-ferrous metals processes are located on sites which have been used for industrial activities for many years. In many cases, the ground is contaminated by previous activities such as mining, waste disposal activities or earlier metallurgical processes. Where past contamination is likely it is important to assess the level of pre-existing contamination, so that it does not become confused with potential future contamination arising from newer permitted activities.

## **Summary**

The potential for fugitive emissions is the main issue for each of the metal groups, as well as the following for particular groups:

- For the production of copper: SO<sub>2</sub>, dust, metal compounds, organic compounds, waste water (metal compounds), residues such as furnace linings, sludge, filter dust and slag. Dioxin formation during treatment of secondary copper materials is also an issue.
- For the production of aluminium: fluorides (including HF), dust, metal compounds, SO<sub>2</sub>, carbonyl sulphide (COS), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), greenhouse gases (perfluorocarbons and CO<sub>2</sub>), dioxins (secondary), chlorides and HCl. Residues such as bauxite residue, spent pot lining, filter dust and salt slag and waste water (contaminated with oil and ammonia).

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- For the production of lead, zinc and cadmium: dust, metal compounds, VOCs (including dioxins), odours, SO<sub>2</sub>, other acid gases, waste water (contaminated with metal compounds), residues such as sludge, the iron-rich residues, filter dust and slag.
- For the production of precious metals: VOCs, dust, metal compounds, dioxins, odours, NO<sub>x</sub>, other acid gases such as chlorine and SO<sub>2</sub>. Residues such as sludge, filter dust and slag and waste water (contaminated with metal compounds and organic compounds).
- For the production of refractory metals, hard metal powder and metal carbides: dust, solid hard metal and metal compounds, waste water (contaminated with metal compounds), residues such as filter dust, sludge and slag. Process chemicals such as hydrogen fluoride (HF) are used for processing tantalum and niobium and are highly toxic. You need to take this into account in the handling and storage of these materials.
- For the production of ferro alloys: dust, metal compounds, CO, CO<sub>2</sub>, SO<sub>2</sub>, energy recovery, waste water (contaminated with metal compounds), residues such as filter dust, sludge and slag.
- For the production of alkali and alkaline earth metals: chlorine, HCl, dioxin, sulphur hexafluoride (SF<sub>6</sub>), dust, metal compounds, CO<sub>2</sub>, SO<sub>2</sub>, waste water (contaminated with metal compounds), residues such as sludge, aluminate, filter dust and slag.
- For the production of nickel and cobalt: VOCs, CO, dust, metal compounds, odours, SO<sub>2</sub>, chlorine and other acid gases, waste water (contaminated with metal compounds and organic compounds), residues such as sludge, filter dust and slag.
- For the production of carbon and graphite: PAHs, hydrocarbons, dust, odour, SO<sub>2</sub>, waste water prevention, residues such as filter dust.

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# **1 Managing your activities**

## **1.1 Accident management**

## **1.2 Energy efficiency**

## **1.3 Avoidance, recovery and disposal of wastes**

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## 1.1 Accident management

### Indicative BAT

1. You should address the following in your management system:
  - storage and use of liquefied gases such as oxygen, chlorine and LPG
  - loss of electrical supplies to control systems and to pollution abatement systems (this may lead to uncontrolled discharges to air and water)
  - flooding, whether caused by rainfall or due to fire fighting activities.

## 1.2 Energy efficiency

### Indicative BAT

You should where appropriate:

- 1 Produce steam and electricity from the heat raised in waste heat boilers.
- 2 Use the heat of reaction to smelt or roast concentrates or melt scrap metals in a converter.
- 3 Use hot process gases to dry feed materials.
- 4 Pre-heat furnace charge using the energy content of furnace gases or hot gases from another source.
- 5 Use recuperative burners for the pre-heating of combustion air.
- 6 Use CO produced as a fuel gas.
- 7 Consider the use of oxygen as it is recognised to have advantages in many cases and reduces the overall gas volume, allows autogenic operation and can allow smaller abatement plant.
- 8 Ensure process optimisation to minimise hot metal transfers.  
Note that energy recovery before or after abatement is applicable in the majority of cases but local circumstances are important, for example, where there is no outlet for the recovered energy.

## 1.3 Avoidance, recovery and disposal of wastes

In general the waste streams comprise:

- furnace slags and drosses
- furnace maintenance waste such as insulation and refractory
- maintenance wastes, especially furnace wastes such as insulation, refractory and linings
- de-watered sludges from water treatment plant
- transport and packaging waste including drums.

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## Indicative BAT

You should where appropriate:

1. Store materials such as drosses, which may dissolve or react with water, under cover.
2. Apply the following options:

Source of the residues	Associated metals	Residue	Options for dealing with them
Raw materials handling, etc.	All metals	Dust, sweepings	Feed for the main process
Smelting furnace	All metals	Slag	Construction material after slag treatment. Abrasive industry. Parts of slag may be used as refractory material, e.g. slag from the production of chromium metal
	Ferro alloys	Rich slag	Raw material for other ferro alloy processes
Converting furnace	Cu	Slag	Recycle to smelter
Refining furnaces	Cu	Slag	Recycle to smelter
	Pb	Skimmings	Recovery of other valuable metals
	Precious metals (PMs)	Skimmings and slag	Internal recycle
Slag treatment	Cu and Ni	Cleaned slag	Construction material. Matte produced
Melting furnace	All metals	Skimmings	Return to process after treatment
		Slag and salt slag	Metal recovery, recovery of salt and other material
Electro-refining	Cu	Electrolyte bleed	Recovery of Ni
		Anode remnants	Return to converter
		Anode slime	Recovery of precious metals
Electro-winning	Zn, Ni, Co, PMs	Spent electrolyte	Re-use in leaching process
Fused salt electrolysis	Al	Spent pot lining	Carburant or disposal
		Excess bath	Sale as electrolyte
		Anode stubs	Recovery
	Na and Li	Cell material	Scrap iron after cleaning
Distillation	Hg	Residues (hollines)	Re-use as process feed
	Zn, Cd	Residues	Return to process
Leaching	Zn	Ferrite residues	Safe disposal, re-use of liquor
	Cu	Residues	Safe disposal
	Ni/Co	Cu/Fe residues	Recovery, disposal
Sulphuric acid plant	Primary Cu, Pb, Zn	Catalyst	Regeneration
		Acid sludges	Safe disposal

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		Weak acid	Leaching, disposal
Furnace linings	All metals	Refractory	Crush, for possible recovery of metallic inclusions. May require treatment to minimise potential hazards before final disposal.
Milling, grinding	Carbon	Carbon and graphite dusts	Use as raw material in other processes
Pickling	Cu, Ti	Spent acid	Recovery
Dry abatement systems	Most – using fabric filters or EPs	Filter dust	Return to process, recovery of other metals, disposal
Wet abatement systems	Processes using scrubbers or wet EPs	Filter sludge	Return to process, recovery of other metals, disposal
Waste water treatment sludge	Most	Hydroxide or sulphide sludges	Safe disposal, re-use

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# **2 Operations**

- 2.1 Copper and copper alloys**
- 2.2 Aluminium and aluminium alloys**
- 2.3 Lead, zinc and cadmium**
- 2.4 Precious metals**
- 2.5 Refractory metals**
- 2.6 Ferro alloys**
- 2.7 Alkali and alkaline earth metals**
- 2.8 Carbon and graphite electrodes**

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## 2 Operations

### 2.1 Copper and copper alloys

#### Wire, rod and tube production

**Air:** Melting must be done under reducing conditions in order to minimise the amount of oxygen absorbed in the molten metal and in the case of rod to protect the refractory. With natural gas as a fuel this can be achieved by operating the burners fuel-rich to achieve a carbon monoxide (CO) concentration of under 1% in the products of combustion at the burners. The counter-current flow whereby hot gases rising up the shaft give up their heat to descending solid copper means that any oils or grease on the copper are distilled out, giving a VOC release. Carbon monoxide and VOCs could be greatly reduced by after-burning, but at the cost of a significant reduction in energy efficiency.

Extrusion and drawing require pre-heating furnaces, which release products of combustion. After processing, lubricants need to be removed from the product. This cleaning operation has a potential for VOC and particulate release.

**Noise:** The melting process involves handling large amounts of copper cathode with potential for random noise if handled carelessly. Saws and product handling are also potential sources. The gas burners and shaft can generate resonance noise.

#### Indicative BAT

You should where appropriate:

1. Minimise carbon monoxide generation by sequential monitoring of combustion conditions and independent automatic control of fuel/air ratios at the burners.
2. Design the charge handling system to avoid the possibility of contaminating feedstock with hydraulic oils or lubricants.
3. Operate purchasing and inspection procedures to prevent charging of material contaminated with drawing or extrusion lubricants.

#### Melting copper, melting and making copper alloys

**Water:** Water is used as a coolant and some casting tracks will generate oil-contaminated water. If you use oily swarf you must design your storage and handling to prevent cutting oils contaminating water discharges.

**Waste:** Furnace operations give rise to slags and drosses. Furnace rebuilds also generate solid waste. Filtration systems generate significant quantities of dust.

**Air:** You need to control fugitive releases, in particular from operations involving transfer of molten metal. Contained emissions to air will normally require filtration to

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remove metal oxides. You should use dual filtration to remove highly toxic materials such as cadmium. Afterburning may be necessary to minimise releases of VOCs.

**Energy:** Energy requirements are significantly influenced by the need to minimise air pollution. In particular, afterburners and large extraction and filtration systems.

**Noise:** All foundry operations involve moving lumps of metal around. Charging and casting machines are particularly likely to cause annoyance. Sound insulation around cleaning mechanisms, and fans on large filtration plants, need to be well designed and properly maintained.

#### **Indicative BAT**

You should where appropriate:

1. Pay particular attention to procedures designed to ensure that unwanted materials such as alloys containing cadmium are not accidentally included in furnace charges.
2. Design and operate the dust removal system to minimise the quantity of dust held inside the filter chamber, so as to minimise the risk of fires.
3. Assess the potential impact of releases which may arise as a consequence of a fire in extraction ducts, filters or the oxide area. This assessment shall include consideration of emissions from the furnace during any emergency shut-down of the filter plant.
4. Adapt the design of the furnace, its pollution abatement systems and the manner in which it is operated to the raw materials used and the intended product. Where volatile metals, such as zinc, are present the furnace must be well hooded to permit the removal of fume to a suitable filtration plant. The hooding and enclosure system must be capable of containing fume during charging and casting, as well as during melting and any associated refining.
5. Where raw materials that are not pre-treated and are contaminated with organic materials are being processed, furnaces must be fitted with suitable after-burners to destroy smoke and VOCs generated by decomposition.
6. In all furnaces, minimise fume generation by effective furnace control. For copper or cupro-nickel alloys this alone may give sufficient abatement. For other metals you are likely to need additional abatement.

Machining wastes such as swarf, millings and turnings are likely to be contaminated with cutting oils. If the melting furnace is not designed to prevent the emission of smoke, or is

not fitted with an after-burner, then the oils must be removed from such wastes before they are charged to the furnace. This may be achieved by washing, by the use of centrifuges or after-burners or a combination of such techniques.

8. A typical swarf dryer consists of an indirectly heated drum where the swarf is heated to approximately 400°C to drive off volatile fluids. The exhaust gas from this drum is then passed through an after-burner at 850°C to destroy the VOCs before discharge into the air.

9. If fine millings are being processed, or if alloys containing lead are being handled, then it will be necessary to cool and filter the exhaust gases before discharge.

10. If material contaminated with chlorinated cutting oils is to be charged to a furnace or swarf dryer, then that furnace or dryer shall be fitted with an abatement plant capable of reducing the concentration of dioxins in the emission to 0.1 ng/m<sup>3</sup>.

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## 2.2 Aluminium and aluminium alloys

### Production of aluminium by electrolysis

**Air:** There are potentially significant releases of oxides of carbon, perfluorinated hydrocarbons (PFCs), particulates, hydrogen fluoride and metallurgical fume containing fluorides from the reduction cells. PFCs are released during anode effects. There is the potential for significant releases of sulphur dioxide from the cells, and chlorine, hydrogen chloride, oxides of nitrogen and metallurgical fume from the refining operations. Carbon oxides are generated during electrolysis and in smaller quantities as products of combustion arising from the casting shop and other operations. There are potential dust emissions from the extensive handling operations involving alumina and other dusty materials.

**Waste:** Cathodes removed from cells during periodic rebuilding are an issue. The carbon is saturated with fluoride salts, and also the nitrogen present in the original anthracite will have been converted into soluble cyanides. The cast shop/refining operation generates drosses, which require treatment in secondary recycling plants.

**Energy:** Smelting aluminium is highly energy-intensive. Energy efficiency in the cell is reduced if the alumina concentration falls below a critical level, causing an “anode effect”. Power consumption increases and the cell heats up.

**Accidents:** Out-of-control anode effects can cause the surface crust to melt, increasing fluoride emissions. Undetected weakening of cell walls can cause run-outs of electrolyte and metal, releasing local fume and smoke.

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### **Indicative BAT**

1. Carry out electrolysis using centre worked pre-baked cells with automatic multiple alumina feed points.
2. Maintain active cell databases and monitor cell operating parameters to minimise energy consumption and reduce the frequency and duration of anode effects.
3. You should have complete hood coverage of the cells connected to a gas exhaust and filter. The cell hoods must be robust and extraction rates adequate. A sealed anode butt cooling system must be provided.
4. On a long-term basis you must achieve more than 99% fume collection from the cells. Time taken to open hoods and change anodes should be kept to a minimum. A programmed system should be used for cell operations and maintenance.
5. Use efficient cleaning methods to remove fluorides from returned butts. Only do this in an area with effective extraction and filtration.
6. Use low sulphur carbon for electrode manufacture where local, regional or longer-range environmental impact studies require reductions in sulphur dioxide emissions.
7. Treat primary exhaust gases using an alumina scrubber and fabric filter to remove at least 99.8% of fluorides present. The alumina used in the scrubber should be recycled to the reduction cells.
8. Treat exhaust gas from the anode bake furnace using an alumina scrubber and fabric filter to remove fluorides.
9. Treat tars and pitch fume from mixing and forming processes using a coke filter.

### **Secondary melting and remelt of aluminium and aluminium alloys**

**Air:** Where salt fluxes are used, there is significant potential for air pollution.

**Waste:** Where furnaces are used to recover metal from lower grades of scrap, they can generate drosses and slags.

**Accidents:** The use of liquid chlorine to refine molten metal has a significant accident potential. Charging oily, greasy or plastic coated scrap will generate much smoke and heat in the exhaust system and may destroy the filtration plant.

### **Extraction of aluminium metal from secondary raw materials**

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**Water:** No water is used in this process, but slags and drosses can contaminate water if they come into contact. Any leachate is likely to contain ammonia, dissolved salts and sulphide as well as suspended solids.

**Air:** Dry milling will give rise to dust and effective filtration is required. Materials must not get wet.

**Waste:** A significant portion of waste may not be amenable to recovery.

**Accidents:** Flooding of stocks of dross, slag or oily swarf can cause water contamination.

**Noise:** Milling operations are potentially noisy.

#### **Indicative BAT**

You should where appropriate:

1. Prevent emissions of dust and fume, by:

- the use of enclosures or hoods provided with extraction to the fume arrestment system over charging, drossing and tapping areas
- where possible, the use of sealed systems for feeding and for dross cooling
- handling and storing slags, drosses and recovered metallics within waterproof buildings to stop them getting wet.

2. Fit swarf dryers with an abatement plant capable of reducing the concentration of dioxins in the emission to 0.1ng/m<sup>3</sup>.

## **2.3 Lead, zinc and cadmium**

### **Recovery of lead or zinc from secondary raw materials**

#### ***Recovery of lead from scrap batteries***

**Water:** Risk of acid spills from raw materials handling.

**Waste:** Includes unusable materials arising from the breaking activity, slags from melting and filter plant dusts.

**Air:** Furnace operations give rise to metallic fume, some sulphurous exhausts and acid mists.

**Energy:** Acid mists in exhausts limit the possibility of recovering energy from furnace gases.

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### **Indicative BAT**

You should where appropriate:

1. Prevent excessive accumulation of raw materials.
2. Design and maintain your reception area to prevent acid spillage.
3. Ensure reliable operation of the breaker to ensure consistent feed to smelting furnace.
4. Provide good containment and reliable temperature control to prevent fugitive emissions of lead fume into the atmosphere.
5. Effectively manage waste produced by the process, in particular to avoid accumulations and cross-contamination.

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### ***Recovery of lead in kettles from other scrap and residues***

**Waste:** Drosses, which cannot be recycled, and scrap plant items.

**Air:** Metallic fume from melting, smoke and VOCs from organic contaminants

**Accidents:** Failure on the melting pot allowing molten metal direct contact with the heating gases. Failure of temperature controller causing furnace to overheat. Fires in fabric filters caused by the carryover of incandescent particles.

#### **Indicative BAT**

You should where appropriate:

1. Only use kettles for cleaning lead. For existing plant only, where scrap containing organic contaminants may be present, e.g. in cases where it cannot easily be segregated at source or at a treatment site, it may be melted in kettles. The gas extraction system and after-burner should be capable of extracting all of the gases from the melting pot during peak production of gases from the combustion of any material present, in particular during charging and drossing off. For a new plant, scrap containing organic contaminants should be melted in alternative processes.
2. Effective purchasing and sorting procedures should ensure that unsatisfactory material is not charged to the melter. Where materials with organic contaminants such as pitch are to be processed, then the furnace design should permit adequate combustion of evolved gases and smoke.
3. Good temperature controls with a failsafe system to prevent overheating should be used.

### ***Refining lead/Melting and alloying processes for lead***

**Waste:** Drosses that cannot be recycled may contain arsenic and are potentially hazardous if exposed to moisture.

**Air:** The process involves removal of dry drosses and has potential for generating dusts rich in heavy metals. Metallurgical fume generated at the metal surface.

**Accidents:** Overheating molten metal caused by control failure, or by failure of container allowing metal to spill into firing zone.

#### **Indicative BAT**

You should where appropriate:

1. Have temperature controls with failsafe system to prevent overheating.
2. Collect and filter dust and fume from drossing operations.

### ***Melting and alloying processes for zinc***

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When alloys are made from impure raw materials, fluxes containing zinc chloride, magnesium chloride and sodium silicofluoride may be used. This results in the release of gaseous silicon tetrafluoride, which can only be removed by hydrolysis to hydrogen fluoride in a wet scrubber.

#### **Indicative BAT**

You should where appropriate:

1. Prevent overheating using temperature controls with failsafe system.
2. Collect and filter dust and fume from dressing operations.
3. If fluxes containing sodium silicofluoride are used, hydrolyse to hydrogen fluoride in a wet scrubber.

## **2.4 Precious Metals**

### **Silver**

#### ***Secondary smelting operations***

**Water:** Is used as a coolant, and may also be used as a gas scrubbing medium. Surface water contamination from dusty raw materials and intermediates.

**Waste:** Includes blast furnace slags and waste refractory generated during maintenance.

**Air:** Dioxins may be generated during the incineration of photographic film, paper and sludge. Photographic emulsions may be gelatine based, in which case inadequate incineration can give rise to foul odours. Incinerator ash is dry, dusty and easily blown. The smelting and cupellation stages can give rise to fume containing lead and silver. Any mercury which enters the system will be discharged at the smelting stage.

**Energy:** The potential for dioxin formation at the incineration stage is such that high-temperature after-burning is likely to be necessary as are heat recovery and re-use.

**Accidents:** Fire in the paper or film storage hopper causing air and water pollution.

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### **Indicative BAT**

You should where appropriate:

1. Have a well-designed raw materials receipt, storage and blending facility that ensures consistent feed to incinerator and smelter
2. Minimise dioxin releases from incineration by passing exhaust gases through an after-burner operated at 1100°C, with 6% v/v oxygen present in the exhaust. After leaving the after-burner, the gases must be quenched rapidly to below 160°C to avoid synthesis of dioxins.
3. Use dry scrubbing systems to minimise release of particulate and of acid gases formed by decomposition of chlorides and bromides in film, and to avoid generating aqueous wastes.
4. Recover energy from hot exhaust gases.
5. Prevent losses of metallurgical fume by effective design, construction and maintenance of extraction and filtration systems.
6. Fit effective fire detectors and extinguishers to incinerator storage hopper.
7. Note that using copper as a collector for the precious metal may have a lower environmental impact than using lead.

### ***Silver remelting operations***

Certain silver alloys, in particular those used for soldering, contain significant amounts of cadmium. There is a potential risk of cadmium emissions to air from these alloys.

### **Indicative BAT**

1. The class of permit required for any silver remelt operation depends upon the cadmium content. This should be assessed against Schedule 1 Part 2, Section 2.2 Part A (1) (f) of the Regulations.
2. If any of the alloys being handled contains more than 0.05% cadmium, then extraction and filtration equipment is necessary.

### ***Gold***

#### ***The Miller process for purification of reclaimed gold***

**Air:** Excess chlorine, condensed chlorides and other metallurgical fume are generated.

**Waste:** Dross, skimmings, filter bags, furnace liners and most other solid wastes from this process are recycled to smelters.

**Accident:** There is a potential for loss of containment on the chlorine system.

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### **Indicative BAT**

You should where appropriate:

1. Operate your system to control the temperature of the melt and rate of lancing to minimise loss of chlorine gas.
2. Use a scrubbing system to remove vaporised metal chlorides and metal oxides.
3. Ensure effective treatment for scrubber effluent.
4. Address possible loss of containment in the chlorine system in the accident management plan.

### **Platinum group metals**

**Water:** Waste liquors from the filtration process and from scrubbers.

**Air:** The following substances may be released:

- dusts, odour and products of incomplete combustion from pre-treatment incineration
- chlorine, hydrogen chloride, oxides of nitrogen and nitrosyl chloride from dissolution
- ammoniacal solutions from some of the solvent extraction phases
- hydrogen chloride and ammonium chloride fume from the decomposition of complex compounds containing ammonium chloride ammonia obtained from cylinders of liquid ammonia is cracked to generate the protective atmosphere used in the decomposition furnaces
- dusts, some of which are highly toxic, from materials handling operations
- a metallurgical fume that contains lead from fire refining.

**Energy:** The high toxicity and potential environmental impact require comprehensive containment and treatment systems for all emissions. Energy efficiency takes second place to effectiveness and reliability.

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**Accidents:** Spills from liquid chlorine and liquid ammonia used on-site. Major spillages of reaction liquids could cause water contamination. The solvent extraction system may involve the use of flammable solvents.

### **Indicative BAT**

You should where appropriate:

1. Pay attention to process design and stock control so as to minimise inventories of liquefied gases and flammable solvents.
2. Design your process control systems to minimise the reagent requirements and losses from the reactor of gases such as ammonia, chlorine and hydrogen chloride.
3. Ensure effective procedures for identifying solid materials in process or awaiting dispatch.
4. Use effective dust control procedures in all areas where potentially dusty materials may be handled. You must design the procedures to be adequate for the toxicity of the materials being handled.
5. Use comprehensive treatment systems to minimise emissions into the atmosphere of acid gases, halogens, oxides of nitrogen, ammonia, metallic fume and particulate matter of any description.
6. Use comprehensive treatment systems to ensure that liquid discharges meet acceptable limits before discharge.

## **2.5 Refractory metals**

These include chromium, manganese, tungsten, vanadium, molybdenum, titanium, tantalum, niobium and rhenium.

### ***Chromium (using a thermite process)***

**Water:** Leaching operations involve aqueous solutions of hexavalent chromium.

**Air:** The thermite process is vigorous and intensely hot, with a high potential for discharge of a metallurgical fume containing chromium.

**Land:** Escaping dust and fume may contaminate land.

**Waste:** Used pots and slags containing unreacted chrome ore and soluble salts.

**Accidents:** The leaching stages involve handling solutions of hexavalent chromium, which has a high potential for environmental damage in the event of spillage. The thermite stage, once started, cannot be stopped before reaction is complete. Any failure of the plant or accidental pre-ignition will give rise to severe local fumigation.

**Energy:** The manufacture of chromic oxide requires significant energy input, involving successive leaching and evaporation stages. The thermite process itself is markedly exothermic, but the heat cannot be re-used. Energy is also needed for the substantial extraction systems.

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### **Indicative BAT**

You should where appropriate:

1. Ensure effective control of the leaching and concentrating stages in order to prevent water pollution.
2. Prevent fugitive discharges into the air during roasting and the thermite process.
3. Minimise solid waste production by ore pre-treatment.

## ***Tungsten***

### ***Production from ores or concentrates and secondary tungsten carbide raw materials not suitable for recovery (via paratungstate route)***

**Water:** The initial leaching phase generates a liquid waste.

**Air:** Dust releases are possible whenever dry materials are handled. Ammonia is consumed and then evolved as the process proceeds.

**Waste:** The leaching process generates significant quantities of sludge. Wastes from handling ammonium paratungstate (APT - an intermediate in the extraction process) are not significant.

### **Indicative BAT**

You should where appropriate:

1. Prevent liquid losses during leaching stage.
2. Treat and dispose of solid residues safely.
3. Prevent loss of ammonia to air.
4. Prevent dust losses to air.

### ***Processing tungsten carbide secondary raw materials***

Two major processes are available for processing tungsten carbide scrap:

- the Goldstream process
- the zinc process.

Tungsten carbide scrap which cannot be recovered by these methods can be oxidised and converted to ammonium paratungstate (APT), then processed in accordance with the primary cycle above.

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## **Vanadium**

The only vanadium produced in the UK is in the form of the ferro alloy (see page 27).

## **Molybdenum**

### **(a) Roasting sulphide ores to produce molybdenum trioxide**

**Water:** Operation of acid plant.

**Air:** Dust from handling raw material and product, fine dust from filtration plant, and sulphur dioxide from the roasting stage.

**Waste:** Gangue from flotation plant, solids from filtration system and sludges from acid plant.

**Accidents:** Loss of extraction leading to significant acid gas releases.

### **(b) Production of molybdenum metal by hydrogen reduction of molybdenum oxides**

**Energy:** The small scale and high temperatures make the process relatively inefficient.

**Accidents:** With hot hydrogen there is always a possible explosion risk.(c) Recovery of molybdenum from secondary materials

Molybdenum and vanadium catalysts are widely used in the petrochemical industry.

The metals are recovered as their oxides by:

- heating in air to 600°C to remove sulphur, carbon and hydrocarbons – this converts the metals to their oxides
- 
- leaching out the molybdate and vanadate
- separation of molybdate and vanadate
- treatment of alumina support to recover cobalt and nickel.

## **Titanium**

### **Manufacture of titanium by magnesium reduction of titanium tetrachloride**

**Energy:** Titanium is made from titanium chloride and metallic magnesium, which are “high-energy” raw materials. Little extra energy is needed apart from these and the arc furnace.

**Accidents:** Titanium tetrachloride will react vigorously with water or moist air to give dense white fumes of hydrochloric acid and titanium dioxide particulate. Any accidental spillage will have considerable local impact.

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### **Indicative BAT**

You should where appropriate:

1. Use effective storage and handling systems to prevent loss of the titanium chloride.
2. Have well-rehearsed emergency procedures to handle any accidental spillage.

### ***Niobium***

**Process:** Small amounts of niobium are used in the manufacture of ferro-niobium and nickel niobium alloys by the aluminium thermite process. This is similar to the process used to manufacture chromium as described above.

## **2.6 Ferro alloys**

A major use of elements such as chromium, vanadium, silicon and manganese is as constituents of alloy steels. Since it is more convenient to add these elements to steel in the form of master alloys, they are frequently manufactured in this form in arc furnaces. The process can be classified as:

- **Primary** – metal oxide/ore with iron ore/scrap plus reductant combine to yield ferro alloy and reductant oxide and slag.
- **Secondary** – metal scrap plus iron scrap yields ferro alloy.

The reductants most frequently used are carbon, silicon and aluminium.

### ***Ferro-chrome***

**Water:** Significant quantities are used as a coolant and for slag granulation.

**Waste:** The quantity of slag generated is mainly influenced by the quantity of ores used. Other wastes include furnace refractories and filtration plant dusts. The slag can be crushed to recover entrained metal, and is sufficiently inert to permit its use in civil engineering.

**Air:** There is significant potential for air pollution, important potential sources being raw material handling and furnace operation.

**Energy:** This is a high-energy operation and there are significant opportunities for minimising energy use, namely:  
raw materials selection to minimise slag generation  
heat recovery from hot exhaust gases prior to cleaning  
recovery of energy value of CO by using exhaust as fuel gas.

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**Noise:** Arc furnaces can be very noisy.

#### **Indicative BAT**

You should where appropriate:

1. Control raw materials acquisition to ensure optimum feed to the process.
2. Use effective dust and fume control.
3. Review opportunities for energy recovery.
4. Minimise waste-water generation.

#### ***Other ferro alloys***

Ferro-silicon, ferro-manganese, ferro-nickel and ferro-boron can be produced using arc furnace technology. Ferro-tungsten can also be made in an arc furnace, though due to its high melting point, it cannot be removed by tapping. Instead, when the amount of metal has reached the desired weight, the furnace is switched off and allowed to cool. The for crushing and screening.

#### ***Production of ferro-manganese in blast furnaces***

**Energy:** As a consequence of the high energy and coke requirements, production of ferromanganese in a blast furnace is not likely to be considered BAT when compared with an arc furnace.

## **2.7 Alkali and alkaline earth metals**

### **Sodium metal by electrolysis of fused sodium chloride in Downs Cells**

**Water:** The first stage of the process involves purification of salt by dissolution and recrystallisation. There is a small bleed to remove soluble impurities in the incoming salt.

**Air:** Large quantities of chlorine are generated and stored during this process. Molten sodium in contact with air fumes violently and is highly inflammable.

**Energy:** The process is energy-intensive, involving a dissolution and recrystallisation stage as well as the electrolysis step.

**Accidents:** Potential for accidents can arise from chlorine leaks and spillages, spillages of molten sodium and fires.

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### **Indicative BAT**

You should where appropriate:

1. Have operating and maintenance procedures to minimise the amount of sodium that comes into contact with air.
2. Ensure chlorine collection, storage and handling systems comply with the requirements for chlor-alkali production.
3. Have emergency power supplies for chlorine extraction fans.
4. Have emergency scrubbing systems capable of absorbing chlorine production to allow for emergency shut-down.
5. Have fire and emergency procedures with provision for regular and realistic drills.

### ***Lithium by electrolysis of fused lithium chloride in Downs Cells***

Lithium metal is, like sodium, produced by fused salt electrolysis using Downs cells. Apart from using lithium chloride as the main electrolyte, the process differs in the following details.

- Lithium is much less reactive and can be skimmed off and cast into moulds. These are covered with oil to prevent oxidation.
- Much smaller quantities of lithium are manufactured, and consequently the quantity of chlorine is not sufficient to warrant recovery as gas. Instead it is used to manufacture sodium hypochlorite for sale.
- There are no releases to water, and the risk of fire is much reduced. Otherwise the factors and requirements are similar to that for sodium, above.

### **Magnesium by electrolysis of fused magnesium chloride**

**Water:** Contaminated water from the chlorinator off-gas treatment plant will require treatment before discharge

**Air:** Dusts and products of combustion, and associated gas cleaning, from the calcination process. Chlorine from the electrolysis process. Fugitive emissions of magnesium oxide from molten metal handling. Fugitive emissions of chlorine from the electrolytic reduction process.

**Energy:** Preparation of magnesium chloride has a high energy demand, as does its electrolysis.

**Accidents:** Chlorine gas is being generated in quantity and transferred between stages. Molten magnesium is being handled.

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### Indicative BAT

You should where appropriate:

1. Minimise the emission of products of combustion and associated gas cleaning from the calcination process.
2. Minimise fugitive emissions of chlorine from the electrolytic reduction process.
3. Minimise fugitive emissions of magnesium oxide from metal transfer and casting operations
4. Treat contaminated water from the chlorinator off-gas treatment plant before discharge.
5. Provide emergency systems to prevent losses of chlorine during power failure.

## Calcium and strontium metal

Small quantities of calcium or strontium metal can be manufactured by a metallo-thermic reaction using the relevant oxide and aluminium powder.

The oxide is ground and mixed with aluminium powder, then pressed into briquettes. These are heated to 1300°C in a vacuum furnace, at which temperature the calcium (or strontium) distils off and can be condensed in the cooler part of the furnace.

This is a very small-scale process with limited potential for pollution.

### Nickel by the carbonyl process

**Waste:** The residue from the carbonyl extraction stage consists mainly of nickel oxide, but contains sufficient precious metals to warrant further processing. This material is not discarded but transferred for further processing.

**Air:** Nickel carbonyl is highly toxic and also a carcinogen. Significant quantities of dusty raw materials are handled.

**Accidents:** A major release of carbonyl could have serious health and environmental consequences.

### Indicative BAT

You should where appropriate:

1. Minimise carbonyl process inventory to minimise potential accident impact.
2. Ensure adequate back-up and redundancy in gas handling systems to minimise the risk of leaks arising from breakdown.
3. Provide back-up power supplies for safety and environmentally critical items.
4. Provide effective incineration and filtration systems for handling waste gases.
5. Operate comprehensive gas leak detection systems.
6. Operate an effective emergency control system with regular and realistic exercises.

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## 2.8 Carbon and graphite electrodes

Manufacture of carbon electrodes is included within this note because a major proportion of the installations where this activity is carried on are directly associated with installations defined within Section 2.2 Part A (1). Carbon electrodes and furnace linings are used for a variety of metal production processes, in particular primary aluminium smelting, making ferro alloys and steel-making. The most frequently used raw materials are petroleum coke, anthracite, pitch and bitumen.

### **Manufacture of pre-baked carbon anodes from petroleum coke and coal-tar pitch for aluminium manufacture**

**Air:** All operations involving hot pitch are potential sources of fume. Pitch fume evolved during baking may not be completely burned before discharge through the chimney. All transfer operations of petroleum coke are potential sources of grit and dust emissions. Inadequately cleaned returned butts have the potential to cause significant fluoride emissions through the bake furnace stack. This fluoride can also damage ring furnace refractories with the potential to cause loss of pitch fume.

Sulphur present in raw materials remains in the baked anode. When the anode is consumed in the associated aluminium works, this sulphur is discharged to air as sulphur dioxide.

**Energy:** These processes are high energy users.

**Accidents:** Hot pitch represents a significant fire hazard.

#### **Indicative BAT**

You should where appropriate:

1. Minimise the sulphur content of raw materials.
2. Clean returned anode butts effectively.
3. Use planned maintenance cycles for the ring furnace refractory.
4. Provide effective fire prevention and response systems.
5. Treat ring furnace exhaust gases to remove fluorides before discharge into the air.

### ***Manufacture of graphite electrodes***

**Air:** See previous section on carbon anodes, except that fluoride is not an issue. In addition, there is dust from machining activities.

### ***Søderberg electrodes***

There are two forms of Søderberg electrodes: pre-formed electrodes or paste. Both are self-baking electrodes. For aluminium electrolysis, **the problems of pitch fume generation associated with Søderberg anodes are such that they are not regarded as BAT.**

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### ***Special carbon products***

A range of products such as seals, brushes and crucibles are produced in a similar way to carbon and graphite electrodes.

Potential emissions are similar. Certain special processes may be encountered:

#### ***(a) High-purity graphite manufacture***

The process is the same as graphite manufacture, but modified to remove included impurities such as metals. Freons are passed through the insulating carbon bed and decompose to generate chlorine and fluorine. These gases react with metallic impurities to form salts, which are volatile at the operating temperature. The gases are condensed to remove undecomposed freons, then dry scrubbed to remove excess halogens and metal salts.

***Air:*** Loss of freon, dusts and acid gases.

# 3 Emissions and monitoring

**3.1 Point source emissions to water**

**3.2 Point source emissions to air**

**3.3 Fugitive emissions to air**

**3.4 Noise and vibration**

**3.5 Monitoring**

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### 3. Emissions and monitoring

#### 3.1 Point source emissions to water

<b>Indicative BAT</b>			
1. Achieve as a minimum the benchmark values for point source emissions to water listed in Annex 1 unless alternative values are justified and agreed with the Agency.			
2. Apply the following options as appropriate:			
<b>Source of waste water</b>	<b>Associated process</b>	<b>Minimisation methods</b>	<b>Treatment methods</b>
Process water	Alumina production, lead acid battery breaking, pickling	Return to process as far as possible	Neutralisation and precipitation, electrolysis.
Indirect cooling water	Furnace cooling for most metals, electrolyte cooling for Zn	Use sealed or air cooling system, and monitoring to detect leaks.	Settlement.
Direct cooling water	Al, Cu, Zn castings, carbon electrodes	Settlement. Closed cooling system.	Settlement, precipitation if needed.
Slag granulation	Cu, Ni, Pb, Zn, precious metals, ferro alloys		Settlement, precipitation if needed.
Electrolysis	Cu, Ni, Zn	Sealed system. Electro-winning of electrolyte bleed.	Neutralisation and precipitation.
Hydro-metallurgy (blow down)	Zn, Cd	Sealed system.	Settlement, precipitation if needed.
Abatement system (blow down)	Wet scrubbers, wet EPs and scrubbers for acid plants	Re-use of weak acid streams if possible.	Settlement, precipitation if needed.
Surface water	All	Design rainwater collection and removal drains to prevent contamination. All raw materials, products and wastes with a potential to contaminate water to be stored under cover.	Settlement, precipitation if needed, filtration.

#### 3.2 Point source emissions to air

In general, the nature and source of the emissions expected from each activity comprise the following:

- primary exhausts from furnaces
- collection hoods around charging doors, tap hole and launders
- casting stations and flame cutting locations
- raw material conveyor transfer points
- storage tank and silo vents
- ladle pre-heating stations

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Process stage	Component in off gas	Treatment method
Materials handling and storage	Dust and metals	Correct storage, handling and transfer. Dust collection and fabric filter if necessary
Grinding, drying	Dust, metals	Process operation. Gas collection and fabric filter
Sintering/roasting, smelting, converting, fire refining	VOCs, dioxins	After-burner, adsorbent or activated carbon addition
	Dust and metal compounds	Gas collection, gas cleaning in fabric filter, heat recovery
	Carbon monoxide	After-burner if necessary
	Sulphur dioxide	Sulphuric acid plant (for sulphidic ores) or scrubber
Slag treatment	Dust and metals	Gas collection, cooling and fabric filter
	Sulphur dioxide	Scrubber
	Carbon monoxide	After-burner
Leaching and chemical refining	Chlorine	Gas collection and re-use, wet chemical scrubber
Carbonyl refining	Carbon monoxide, hydrogen	Sealed process, recovery and re-use. Afterburner and dust removal in fabric filter for tail gas
Solvent extraction	VOC (depends on the solvent used and should be determined locally to assess the possible hazard)	Containment, gas collection, solvent recovery. Carbon adsorption if necessary
Thermal refining	Dust and metals	Gas collection and fabric filter
	Sulphur dioxide	Scrubber if necessary
Molten salt electrolysis	Fluoride, chlorine, PFCs	Process operation. Gas collection, scrubber (alumina) and fabric filter.
Electrode baking, graphitisation	Dust, metals, SO <sub>2</sub> , fluoride, PAHs, tars	Gas collection, condenser and EP, afterburner or alumina scrubber and fabric filter. Scrubber if necessary for SO <sub>2</sub>
Metal powder production	Dust and metals	Gas collection and fabric filter
	Dust, Ammonia	Gas collection and recovery. Acid medium scrubber
High-temperature reduction	Hydrogen	Sealed process, re-use
Electro-winning	Chlorine, acid mist	Gas collection and re-use, wet scrubber, demister
Melting and casting	Dust and metals	Gas collection and fabric filter
	VOCs, dioxins (organic feed)	After-burner (carbon injection)
<b>Note:</b> Ceramic filters may be used in preference to fabric filter where hot gases, or gases which may contain hot particles, are to be filtered. Hot electrostatic precipitators would be used in a gas cleaning system prior to a sulphuric acid plant or for wet gases.		

- exhausts from slag coolers
- exhausts from chemical processes.

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### 3.3 Fugitive emissions to air

At most installations where non-ferrous metals processes are carried out, fugitive emissions to air give rise to a significant proportion of the overall environmental impact and should be reduced as far as practicable.

Potential sources of fugitive emissions to air which require particular attention are:

- handling and storage of dusty raw materials such as concentrates, foundry sand, drosses
- smelting and melting and refining furnaces and their associated extraction systems
- transfer operations involving molten metal
- casting and associated activities
- handling, storage and disposal of wastes such as drosses, slags and skimmings
- fume treatment plant, particularly handling collected dusts
- ladle heating stations.

#### Indicative BAT

You should where appropriate:

1. Seal furnaces and reactors.
2. Minimise open molten metal transfers.
3. Ensure adequate extraction of process exhausts designed for the maximum rate of emission.

### 3.4 Noise and vibration

#### Indicative BAT

1. You should pay particular attention to the following:
  - movement and storage of scrap
  - location and sound insulation of large fans and air filtration systems
  - rolling mills
  - casting installations, especially billet casters
  - internal transport
  - electric arc furnaces.

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### 3.5 Monitoring

#### Indicative BAT

Where appropriate:

1. Monitor emissions to air to demonstrate you are meeting your permit requirements. See Annex 1 for guidance on achievable levels and BAT.
2. Monitoring of process effluents released to controlled waters should include at least:

Parameter	Monitoring frequency
Flowrate	Continuous and integrated daily flowrate
pH	Continuous
Temperature	Continuous
COD/BOD	Flow-weighted samples or composite samples, weekly analysis, reported as flow-weighted monthly averages.
Turbidity	Continuous
Metals which are likely to be released by the activity	Flow-weighted samples or composite samples, weekly analysis, reported as flow-weighted monthly averages.

3. Monitoring of process effluents released to sewer should include at least:

Parameter	Monitoring frequency
Flowrate	Continuous and integrated daily flowrate
pH	Continuous
Temperature	If the process may generate an effluent >25°C, continuous monitoring is appropriate
COD/BOD	Flow-weighted samples or composite samples, weekly analysis, reported as flow-weighted monthly averages.
Total organic carbon (TOC)	Dependent on process

4. The following table indicates the likely monitoring frequencies for releases to air in this sector:

Substance	Availability of methods for	
	Continuous	Extractive
SO <sub>2</sub>	Y	Y
NO <sub>x</sub>	Y	Y
Particulate	Y	Y
VOC	Y	Y
HCl	Y	Y

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HF		Y
Metals		Y
Dioxins and furans		Y
CO	Y	Y

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# 4 Annexes

**Annex 1 Emission benchmarks**

**Annex 2 Other relevant guidance  
and abbreviations**

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## 4. Annexes

### Annex 1- Emission benchmarks

The emissions quoted below are daily averages based upon continuous monitoring during the period of operation.

Where emissions are expressed in terms of concentrations and where continuous monitors are employed, it is recommended that limits are defined such that:

- not more than one calendar monthly average during any rolling twelve month period shall exceed the benchmark value by more than 10%
- not more than one half hour period during any rolling 24 hour period shall exceed the benchmark value by more than 50% (for the purpose of this limit half hourly periods commence on the hour and the half hour).

Where spot tests are employed:

- the half hour limit above shall be applied over the period of the test
- the mean of three consecutive tests taken during a calendar year shall not exceed the benchmark value by more than 10%.

#### Reference conditions for releases to air

The reference conditions of substances in releases to air from point-sources are:

- temperature 0 °C (273K)
- pressure 101.3 kPa
- no correction for water vapour or oxygen.

To convert measured values to reference conditions, see the Monitoring Guidance<sup>1</sup> for more information.

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<sup>1</sup> Natural Resources Wales Technical Guidance Notes M1 and M2 provide extensive guidance on the monitoring of stack emissions to air. The conversion referred to is given in TGN M2

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## General requirements applicable to most installations

Emission	Benchmark level as monthly average or from an extractive sample	Maximum allowed daily average when continuous monitoring is used provided monthly value is met	Techniques which may be considered to be BAT	Comment
Total particulate <sup>a</sup>	5mg/Nm <sup>3</sup>	10 mg/Nm <sup>3</sup>	Fabric filters. Wet scrubber for suitable types of dust	For some high temperature processes ceramic filters may be BAT
Oxides of nitrogen <sup>b</sup> (as NO <sub>2</sub> )	100 mg/Nm <sup>3</sup>	200 mg/Nm <sup>3</sup>	Low NOx burner	Oxy fuel burner gives reduced gas volume and better energy efficiency
	300 mg/Nm <sup>3</sup>	500 mg/Nm <sup>3</sup>	Oxy fuel burner	
Sulphur dioxide <sup>c</sup>	50 mg/Nm <sup>3</sup>	200 mg/Nm <sup>3</sup>	If scrubbing system is used	BAT will normally be to control sulphur releases by employing low sulphur fuels. Using higher sulphur fuels then scrubbing to achieve release limits will give rise to potentially significant cross media effects
	500 mg/Nm <sup>3</sup> , much lower if natural gas used as fuel	500 mg/Nm <sup>3</sup> , much lower if natural gas used as fuel	If control exercised via sulphur content of fuel	
Hydrogen chloride <sup>d</sup>	10 mg/Nm <sup>3</sup>	20 mg/Nm <sup>3</sup>	Avoid scrap contaminated with chlorinated cutting oils and other chlorine sources	Presence in exhaust is an indicator of possible presence of dioxins
Carbon monoxide <sup>e</sup>	150 mg/Nm <sup>3</sup>	300 mg/Nm <sup>3</sup>	Effective burner control	
VOCs <sup>f</sup> (as carbon)	50 mg/Nm <sup>3</sup>	100 mg/Nm <sup>3</sup>	Pre-treatment of potentially contaminated material. Effective	
			burner control. Control over charging activity	
Dioxins <sup>g</sup>	0.1 ng/Nm <sup>3</sup> ITEQ		Purchase and inspection of scrap to avoid contaminated material. Pretreatment. Carbon injection to filter	The BAT Reference document refers to higher levels under some circumstances. Where there is uncertainty about the individual isomers that are reported as "less than", a dual approach will be adopted where these values will be assumed to be zero and the result compared to these values as the limit of detection

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It will not be necessary to specify limits for all of the above in all installations. For example, limits on products of combustion should not be applied to unheated milling plant handling drosses or slags.

a. BREF tables 3.40; 3.41; 4.33; 4.34; 4.35; 5.47; 5.48; 6.16; 8.3; 8.4; 8.5; 8.6; 8.7; 8.8; 8.9; 9.11; 10.9; 11.16; 12.11; 12.12; 12.13; 12.14; 12.15 and 12.16.

b. BREF tables 3.40; 4.34; 4.35; 5.47; 5.48; 6.16 and 11.16.

c. BREF tables 3.40; 3.41; 5.48; 6.15 and 12.12.

d. BREF tables 4.34; 4.35; 6.16 and 11.17.

e. IPC Technical Guidance S2 2.03.

f. BREF tables 3.40; 4.35; 5.47; 5.48; 6.15; 6.16; 11.16 and 11.17.

g. BREF tables 3.40; 3.41; 4.35; 5.47; 5.48; 6.16 and 11.16.

### VOCs

Some associated activities using VOCs, in particular (but not limited to) cleaning and degreasing operations, will require you to comply with the Solvent Emissions Directive 1999/13/EC including the use of a solvent management plan. A reduction scheme may be used instead of emission limits.

Emission	Activity	Threshold annual use of solvent	Benchmark value as toluene mg/Nm <sup>3</sup>	Basis for the benchmark
Solvents (various), see Solvent Directive 1999/13/EC	Coating and degreasing	2–10 tonnes > 10 tonnes	20 mg/Nm <sup>3</sup> 20 mg/Nm <sup>3</sup>	15% fugitive emission, 10% fugitive emission, fugitive emission expressed as % of use

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High risk, Extremely hazardous to health, such as benzene, vinyl chloride and 1,2-dichloroethane	Various		2 –5 mg/Nm <sup>3</sup>	Parity with previous UK Guidance Notes
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Additional or varied benchmarks for emissions to air from specific activities

**a). Copper and copper alloys – additional values for other components based on extractive samples.**

**(i) Melting copper, making and melting copper alloys including pre-treatment**

Emission	Benchmark level	Techniques which may be considered to be BAT	Comment
Phosphorus (as P <sub>2</sub> O <sub>5</sub> )	5 mg/Nm <sup>3</sup> Phosphorus (as P <sub>2</sub> O <sub>5</sub> ) <sup>a</sup>		When phosphor copper is used for deoxidising copper
	50 mg/Nm <sup>3</sup>	Limitation on maximum concentration of phosphorus in product. Wet scrubbing followed by highenergy filters, or high-energy venturi scrubbers	Manufacture of phosphor copper

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Copper, lead, zinc, or their compounds <sup>b</sup>	2 mg/Nm <sup>3</sup> in total	Filtration	The suite of metals for which limits are defined may be extended beyond the list specified to include all those likely to be present, whether present intentionally or as a consequence of error. Also metals which are not present in the raw materials may be excluded.
Cadmium, arsenic, nickel or their compounds <sup>b</sup>	0.5 mg/Nm <sup>3</sup> in total	Raw materials purchasing specification. Examination and testing upon receipt	
Beryllium <sup>c</sup>	0.005 mg/Nm <sup>3</sup>	Avoid. If deliberately introduced, then absolute filtration is required	Used to improving precipitation and hardening in the manufacture of intricate castings

a. IPC Technical Guidance S2 2.03.

b. BREF tables 3.41 and 3.42.

c. By extrapolation from occupational exposure limits.

**(ii) Copper rod, wire and tube production: gas-fired shaft furnaces melting high purity copper**

Emission	Benchmark level	Techniques which may be considered to be BAT	Comment
Particulate <sup>a,b</sup>	5 mg/Nm <sup>3</sup>	Fabric filter. Quality control over raw materials and optimised combustion	
VOCs	50 mg/Nm <sup>3</sup> (15 mg/Nm <sup>3</sup> )		
CO <sup>a,b,c</sup>	1% at the burners (100 mg/Nm <sup>3</sup> if after-burners fitted)	Independent control of fuel/air ratio for each burner, with sequential gas monitoring	

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NOx <sup>a,b</sup> (as NO <sub>2</sub> )	100 mg/Nm <sup>3</sup> (300 mg/Nm <sup>3</sup> )	Low NOx burner Oxy-fuel burner	After-burners will increase emissions of NOx substantially
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a BREF Section 3.1.4.

b BREF table 3.40.

c IPC Technical Guidance S2 2.03.

***(b) Aluminium and aluminium alloys additional values for other components based on extractive samples***

*i) - Primary aluminium production: electrolysis cells <sup>a</sup>*

Emission	Benchmark level	Techniques which may be considered to be BAT	Comment
Particulate	5 mg/Nm <sup>3</sup>	Fabric filter	
Sulphur dioxide	30 kg/tonne of metal produced	Control via sulphur content of anodes	
Polyfluorinated hydrocarbons	0.1 kg /tonne	Optimise anode effect frequency	
Hydrogen fluoride	0.2mg/Nm <sup>3 b</sup>	Use fabric filter precoated with alumina	The alumina used to be fed to the cell
Total fluoride	0.5mg/Nm <sup>3 b</sup>		

a BREF table 4.33.

b Total mass release of fluorides from electrolysis, refining and anode manufacture shall not exceed 1.0 Kg F per tonne of metal produced at existing plant and 0.6 kg F per tonne of metal produced at new plant.

**ii) Furnaces for melting aluminium and its alloys: holding furnaces a**

Emission	Benchmark level	Techniques which may be considered to be BAT	Comment
Hydrogen chloride	10 mg/Nm <sup>3</sup>	Control of raw materials. Dry scrubbing using lime insulated filter	If present when chlorine is not used, then origin should be identified
Fluorides	1 mg/Nm <sup>3</sup>	As above	May be added as a constituent of a refining flux or as a contaminant from a primary smelter

**c) Lead, zinc and cadmium – additional values for other components based on extractive samples**

(i) - All activities <sup>abc</sup>

Emission	Benchmark level	Techniques which may be considered to be BAT	Comment
Copper, lead, zinc, nickel, or their compounds	2 mg/Nm <sup>3</sup> in total as metal	Filtration	The suite of metals for which limits are defined may be extended beyond the list specified to include all those
Antimony, tin, tellurium	2 mg/Nm <sup>3</sup> in total as metal	Filtration	

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Cadmium, arsenic, mercury, thallium, selenium	0.5 mg/Nm <sup>3</sup> in total as metal	Raw materials Purchasing specification. Examination and testing upon receipt	likely to be present, whether present intentionally or as a consequence of error. Also metals which are not present in the raw materials may be excluded
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- a. BREF tables 5.47 and 5.49.
- b. IPC Guidance IPR 2/4.
- c. IPC Guidance IPR 2/5.

**(ii) Smelting operations where sulphur compounds are evolved <sup>a</sup>**

Emission	Benchmark level	Techniques which may be considered to be BAT	Comment
Sulphur dioxide	99.7% removal Where the gas stream contains more than 5% sulphur dioxide	Conversion to sulphuric acid in double contact acid plant	Conversion to sulphuric acid in double contact acid plant
	200 mg/Nm <sup>3</sup>	Single contact plant with gas scrubbing	Where the gas contains less than 5% sulphur dioxide or small installations where acid recovery is not practicable
Acid mist	50 mg/Nm <sup>3</sup>		

- a. BREF table 5.46.

**(d) Precious metals <sup>ab</sup> – additional values for other components based on extractive samples**

Activity	Emission	Benchmark level	Techniques which may be considered to be BAT
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Silver recovery: pretreatment Including incineration of photographic film	Lead, silver and their compounds	No individual element to exceed 2 mg/Nm <sup>3</sup>	Filtration
Smelting silver residues	As above	As above	As above
Silver remelt operations	Cadmium	0.5 mg/Nm <sup>3</sup>	As above
Miller process	Chlorine	3 mg/Nm <sup>3</sup>	Process control and alkaline scrubber
	Metal chlorides	5 mg/Nm <sup>3</sup>	As above
	Zinc oxide	5 mg/Nm <sup>3</sup>	Reheating followed by fabric filter
All dry PGM activities and processes	Platinum group metals	Total metal content not to exceed 0.05 mg/Nm <sup>3</sup>	High-efficiency filtration
Dissolution of PGMs	Chlorine and nitrosyl chloride	Total not to exceed 2 mg/Nm <sup>3</sup>	Counter-current alkaline scrubber
	Hydrogen chloride	10 mg/Nm <sup>3</sup>	
	Oxides of nitrogen	200 mg/Nm <sup>3</sup>	
Precipitation	Ammonia	15 mg/Nm <sup>3</sup>	Water scrubbing
Ignition	Ammonium chloride	10 mg/Nm <sup>3</sup>	Process control to prevent loss of fine dusts, scrubbing to remove hydrochloric acid
	Hydrogen chloride	10 mg/Nm <sup>3</sup>	
	Oxides of nitrogen	300 mg/Nm <sup>3</sup>	
	Platinum group metals	Total metal content not to exceed 0.05 mg/Nm <sup>3</sup>	
Fire refining	As lead process	Table (i) of Section 3.2.1.2.(c)	

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a BREF Section 6.4, table 6.4.

b IPC Technical Guidance Note S2 4.04.

**(e) Refractory metals and ferro alloys – additional values for other components based on extractive samples**

Activity	Emission	Benchmark level	Techniques which may be considered to be BAT	Comment
Preparation and decomposition of ammonium paratungstate <sup>a</sup>	Ammonia	50 mg/Nm <sup>3</sup>	Wet scrubbing	
Recovery of tungsten by the zinc process	Zinc and zinc oxide	5 mg/Nm <sup>3</sup>	Filtration	
Molybdenum <sup>a</sup>	Sulphur dioxide, acid mist Ammonia	50 mg/Nm <sup>3</sup>		For sulphur releases, see table (ii) of Section 3.2.1.2 (c)
All processes <sup>b</sup>	Chromium, manganese, tungsten, vanadium, molybdenum, titanium, tantalum, niobium and rhenium and their compounds as appropriate	2 mg/m <sup>3</sup>		

a BREF table 8.4.

b BREF tables 8.3; 8.4; 8.7; 8.9 and 9.11.

**(f) Alkali and alkaline earth metals – additional values for other components based on extractive samples**

*Final discharge to air after chlorine recovery and scrubbing*

Emission	Benchmark level	Techniques which may be considered to be BAT	Comment

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Chlorine <sup>a</sup>	1 mg/Nm <sup>3</sup>	Liquefaction, followed by treatment of inerts in a multistage scrubber	Cell room air shall also be treated to this standard by scrubbing
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a BREF table 10.9.

**(g) Nickel carbonyl process a – additional values for other components based on extractive samples**

Emission	Benchmark level	Techniques which may be considered to be BAT	Comment
Nickel carbonyl	0.01 mg/Nm <sup>3</sup>	Incineration	The release limit should be set at the practicable limit of detection

a. BREF Section 11.1.3.5, table 11.17.

**h) Carbon manufacture – additional values for other components based on extractive samples**

Activity	Emission	Benchmark level	Techniques which may be considered to be BAT	Comment
Pitch storage <sup>a</sup>	Volatile hydrocarbons	10 mg/Nm <sup>3</sup>	Condenser, adsorber	Gases should be back vented during delivery
	Condensable hydrocarbons	50 mg/Nm <sup>3</sup>		
Mixing and grinding <sup>b</sup>	Polycyclic aromatic hydrocarbons VDI <sup>i</sup>	10 µg/Nm <sup>3</sup>	Adsorber/dry scrubber	A regenerative afterburner has been used on some applications
	Polycyclic aromatic hydrocarbons VDI <sup>ii</sup>	100 µg/Nm <sup>3</sup>		
	Total hydrocarbons	25 mg/Nm <sup>3</sup>		

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Bake furnace Exhaust gases	Benzo-[a]- pyrene	0.05 mg/Nm <sup>3</sup> **	Alumina scrubber filter unit.  ** Lower values	The alumina used in this filter to be recycled into the reduction cell feed
	Polycyclic aromatic hydrocarbons OSPAR 11	3 mg/Nm <sup>3</sup> **		
	Total hydrocarbons	10 mg/Nm <sup>3</sup>	are reported in the BREF but have been challenged. Further reductions should be sought for new plant.	
	Gaseous fluoride	0.2mg/Nm <sup>3</sup>		
	Total fluoride	0.5mg/Nm <sup>3</sup>		

- a. BREF table 12.11.      b. BREF table 12.12.    c. BREF table 12.13.    d. BREF table 12.14.
- e. For reporting convention for polycyclic aromatic hydrocarbons see table 12.10 in BREF 12.4.3.1.

### ***Emissions to water***

Benchmark emissions to water associated with the use of BAT are given in the following table. These are not emission limit values, and site-specific issues such as the raw material, the process and other technical characteristics will be taken into account when setting emission limit values:

<b>Substance</b>	<b>mg/litre</b>
Total hydrocarbon oil	2
Biological oxygen demand (BOD) (5 day ATU at 20°C)	2.5
Chemical oxygen demand (COD) (2 hour)	125
Suspended solids	35
Cadmium and cadmium compounds expressed as Cd	0.01

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Mercury and mercury compounds expressed as Hg	0.005
Copper and copper compounds expressed as Cu	0.5
Lead and lead compounds expressed as Pb	0.2
Arsenic and arsenic compounds expressed as As	0.1
Nickel and nickel compounds expressed as Ni	0.5
Zinc and zinc compounds expressed as Zn	0.5
Inorganic fluoride expressed as F	20
Silver expressed as Ag	0.5

The benchmarks are generally applicable for emissions to freshwater rivers. For discharges to estuaries higher values than those given above need to be justified on a site-specific basis at the time of the application. For very sensitive situations lower levels are achievable.

## Annex 2- Other relevant guidance and abbreviations

For a full list of available Technical Guidance and other relevant guidance see Appendix A of GTBR (see NRW website)

In addition to the guidance in GTBR the following guidance is relevant to this sector:

- BREF – BAT in the Non-Ferrous Metals Industry
- BREF note on Associated Foundry and Casting Operations
- The Categorisation of Volatile Organic Compounds, 1995 HMIP Research Report No DOE/HMIP/RR/95/009 (see NRW website)

### Abbreviations

**APP** Alkaline peroxide process  
**AOX** Absorbable organic halogens  
**BAT** Best available techniques  
**BOD** Biochemical oxygen demand  
**BREF** BAT Reference Document  
**BSI** British Standards Institute  
**CCLA** Climate change levy agreement  
**CEM** Continuous emissions monitoring  
**CHP** Combined heat and power  
**COD** Chemical oxygen demand  
**COS** Carbon oxy sulphide  
**EAL** Environmental action level  
**EMAS** EC Eco Management and Audit Scheme  
**EMS** Environmental management system  
**EP** Electrostatic precipitator  
**EQS** Environmental quality standard  
**ETP** Effluent treatment plant  
**Gangue** Valueless material associated with an ore  
**Kw** Kilowatt  
**Kwh** Kilowatt hour  
**ITEQ** International Toxicity Equivalent  
**MCERTS** Monitoring Certification Scheme  
**NOx** Oxides of Nitrogen  
**PAH** Polyaromatic hydrocarbons  
**PFC** Polyfluorinated hydrocarbons

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**PGM** Platinum group metals  
**PM10** Particulate matter <10microns  
**PMs** Precious Metals  
**QA** Quality assurance  
**QC** Quality control  
**SECp** Specific energy consumption  
**TSS** Total suspended solids  
**TOC** Total organic carbon  
**VOC** Volatile organic compound