



**How to comply with your environmental permit**

**Additional information for:**

**The Inorganic Chemicals Sector (EPR 4.03)**

**Document Owner: National Service/ Knowledge, Strategy & Planning (KSP)**

**Version History:**

<b>Document Version</b>	<b>Date Published</b>	<b>Summary of Changes</b>
1.0		Document created
2.0	September 2014	Rebrand to NRW

**Published by:**

Natural Resources Wales

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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.

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 applies to activities regulated under the following sections of schedule 1 of the Regulations: The manufacture or use of inorganic chemicals, Section 4.2, and the manufacture of chemical fertilizers, Section 4.3.

A few inorganic installations may also be described in Section 4.7, manufacturing activities involving carbon disulphide or ammonia.

#### **Part A(1) - Section 4.2 - Inorganic Chemicals**

(a) Producing inorganic chemicals such as:

- (i) gases, such as ammonia, hydrogen chloride, hydrogen fluoride, hydrogen cyanide, hydrogen sulphide, oxides of carbon, sulphur compounds, oxides of nitrogen, hydrogen, oxides of sulphur, phosgene
  - (ii) acids, such as chromic acid, hydrofluoric acid, hydrochloric acid, hydrobromic acid, hydroiodic acid, phosphoric acid, nitric acid, sulphuric acid, oleum and chlorosulphonic acid
  - (iii) bases, such as ammonium hydroxide, potassium hydroxide, sodium hydroxide
  - (iv) salts, such as ammonium chloride, potassium chlorate, potassium carbonate, sodium carbonate, perborate, silver nitrate, cupric acetate, ammonium phosphomolybdate
  - (v) non-metals, metal oxides, metal carbonyls or other inorganic compounds such as calcium carbide, silicon, silicon carbide, titanium dioxide
  - (vi) halogens or interhalogen compound comprising two or more of halogens, or any compound comprising one or more of those halogens and oxygen.
- (b) Unless falling within another Section of this Schedule, any manufacturing activity which uses, or which is likely to result in the release into the air or into water of, any halogens, hydrogen halides or any of the compounds mentioned in paragraph (a)(vi), other than the treatment of water by chlorine.
- (c) Unless falling within another Section of this Schedule, any manufacturing activity involving the use of hydrogen cyanide or hydrogen sulphide.
- (d) Unless falling within another Section of this Schedule, any manufacturing activity, other than the application of a glaze or vitreous enamel, involving the use of any of the following elements or compound of those elements or the recovery of any

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compound of the following elements - antimony, arsenic, beryllium, gallium, indium, lead, palladium, platinum, selenium, tellurium, thallium – where the activity may result in the release into the air of any of those elements or compounds or the release into water of any substance listed in paragraph 13 of Part 2 of this Schedule.

- (e) Recovering any compound of cadmium or mercury.  
Unless falling within another Section of this Schedule, any manufacturing activity involving the use of mercury or cadmium or any compound of either element or which may result in the release into air of either of those elements or their compounds.
- (f) Unless carried out as part of any other activity falling within this Schedule -
  - (i) recovering, concentrating or distilling sulphuric acid or oleum
  - (ii) recovering nitric acid
  - (iii) purifying phosphoric acid
- (g) any manufacturing activity (other than the manufacture of chemicals or glass or the coating, plating or surface treatment of metal) which -
- (h) involves the use of hydrogen fluoride, hydrogen chloride, hydrogen bromide or hydrogen iodide or any of their acids and
  - (ii) may result in the release of any of those compounds into the air
- (i) unless carried out as part of any other activity falling within this Schedule, recovering ammonia
- (j) extracting any magnesium compound from sea water.

#### Part A(1) - Section 4.3 - Chemical Fertilizer Production

- (a) Producing (including blending which is related to their production), phosphorus, nitrogen or potassium based fertilizers (simple or compound fertilizers).
- (b) Converting chemical fertilizers into granules.

#### Part A(1) - Section 4.7 - Manufacturing activities involving carbon disulphide or ammonia

- (a) Any manufacturing activity which may result in the release of carbon disulphide into the air.
- (b) Any activity for the manufacture of a chemical which involves the use of ammonia or may result in the release of ammonia into the air other than an activity in which ammonia is only used as a refrigerant.

## **Directly associated activities**

As well as the main activities described above, the installation will also include directly associated activities which have a direct technical connection with the main activities and which may have an effect on emissions and pollution. These may involve activities such as:

- storage and handling of raw materials
- storage and dispatch of finished products, waste and other materials
- control and abatement systems for emissions to all media
- waste treatment or recycling
- combustion plant
- air separation plant

## **Key Issues**

The inorganic chemicals sector comprises a large number of specifically different installations with relatively few common factors. With the majority of activities undertaken by only one or two operators and only a handful undertaken by more than 3 operators, the main environmental issues tend to be site specific.

A few general issues are:

### **Fugitive emissions to air**

Many inorganic processes involve the handling of solid materials. Fugitive releases of dust and small particulates (e.g. from conveyor system joints, from stock-piles, and from packages) are significant issues on many plants. Where gases or liquids with moderately high vapour pressures (e.g. acid gases, ammonia, or volatile inorganic compounds) are handled, there is potential for fugitive releases. These may come from flanges, pumps, agitators and valves with seals, storage tanks, tanker connections, sample points, or other sources. These fugitive releases can occur through relaxation or progressive wear-and-tear of sealing materials, through sloppy operation, maintenance or design, or through failure of equipment. Apart from releases of material through accidental mal-operation or equipment failure, fugitive losses from individual pieces of equipment are often small, but on a large-scale plant the aggregated effect can be very significant.

The basic rules are:

- minimise fugitive releases of solids, liquid and gaseous substances by specifying the right equipment and the right materials of construction at the design stage
- For on-going fugitive emission prevention, use formal inspection and detection programmes

Substitute higher quality items for equipment which continues to generate significant fugitive emissions.

## **Point source emissions to air**

Many processes release dust, fume or wet particulates, some of which may contain toxic substances such as heavy metal compounds. Some processes release acid gases, ammonia or volatile inorganic or organic compounds.

Releases from point sources should be individually characterised, including those from process and storage vessels as well as those from abatement systems.

## **Waste minimisation and waste disposal routes**

As with waste water generation, reaction specificity, kinetics, yield, etc. are major factors in the generation of waste. For many syntheses the ratio of waste to product is high - so the key issue again is to avoid waste generation in the first place by optimizing the reaction arrangements.

Some parts of the sector generate significant quantities of waste that are non-combustible, so there are major disposals to landfill. The Landfill Directive reduces the options for disposal of many chemical waste streams. You must minimise waste as far as possible, always re-using and recycling in preference to disposal.

## **Point source emissions to water**

Producing effluent streams containing complex pollutants such as mixed soluble and insoluble organics, chlorinated hydrocarbons, heavy metals, or non-biodegradable compounds should be avoided where possible. Where this is not practicable these waste water streams need to be minimized and then segregated and treated separately before being discharged to communal effluent treatment facilities.

## **Odour**

Many of the substances produced or used have the odour potential to cause offence to neighbouring communities. Odours arise from handling inherently malodorous substances and also from fugitive releases of organic solvents. This is a major concern for some installations.

## **Energy efficiency**

Some installations are very large users of energy and the direct or indirect release to air of combustion products often is the biggest single environmental impact arising.

## **Noise and Vibration**

Noise and vibration are constant features of most large volume inorganics plants - from compressors and other machinery, steam relief valves, large combustion units etc.

## **Accident prevention and control**

Whilst major accident hazards and associated environmental risks are likely to be covered by the requirements of the COMAH Regulations, you should demonstrate that you have lesser risks well controlled. Loss of containment of liquids that have

contaminated land, groundwater and surface water are particular issues in this sector.

# **1 Managing your Activities**

**1.1 Environmental performance indicators**

**1.2 Energy Efficiency**

**1.3 Efficient use of raw materials and water**

**1.4 Avoidance, recovery and disposal of wastes**

## 1. Managing your activities

### 1.1 Environmental performance indicators

#### **Indicative BAT**

You should where appropriate:

1. Monitor and benchmark your environmental performance, and review this at least once a year. Your plans for minimising environmental impacts should be incorporated into on-going Improvement Programmes. Indicators can be derived using the Horizontal Guidance Note H1 Environmental Risk Assessment (see GTBR Annex 1). It is suggested that indicators are based on tonnes of inorganics produced (tOP) as they provide a good basis for measuring performance within an installation or a single company year on year.

In addition to the guidance in Getting the Basics Right, guidance prepared in support of the COMAH Regulations may help you in considering ways to reduce the risks and consequences of accidents, whether or not they are covered by the COMAH regime. Guidance is available on the Health and Safety Executive website as well as Natural Resources Wales website.

### 1.2 Energy efficiency

Some large processes are major users of heat and power and others produce energy from their exothermic reactions. For these there may be greater opportunities for optimising energy efficiency in comparison to the smaller installations in the sector and to many other industrial sectors. The integrated nitrogenous fertilizer sites have the greatest scope for energy integration in the sector but there is a practical limit to the complexity of highly integrated systems which can be effectively operated. Knock-on difficulties can occur during sequential start up and during major upsets so the absolute maximum of process integration may not always produce the best environmental performance in practice.

### 1.3 Accident management

#### **Indicative BAT**

You should where appropriate:

1. Assess the environmental impact of each process and choose the one with the lowest environmental impact. (We recognise that your choice may be constrained, for example, by the integration of processes on a complex site).

## 1.4 Efficient use of raw materials and water

As a general principle, you need to demonstrate the measures you take to:

- reduce your use of all raw materials and intermediates
- substitute less harmful materials, or those which can be more readily abated and when abated lead to substances that are more readily dealt with
- understand the fate of by-products and contaminants and their environmental impact.

In the chemical sectors raw material selection is usually fixed by the chemistry and chemical engineering design of the process. There may be several different processes that can be used to manufacture a particular product but these may differ in product yield, in the wastes that they generate and in the potential for environmental harm of their raw materials.

The purity of raw materials will often affect yields and the presence of impurities may result in the need for excessive recycle and/or recovery operations with consequent higher energy consumption. The use of high purity raw materials will generally minimise the environmental impact of that process but may have other adverse consequences, e.g. the use of oxygen rather than air may have benefits in reduced emissions to air but these have to be weighed against the energy requirements for air separation, as well as any cost implications.

Water is used in most inorganics installations for cooling, for process use and for cleaning.

A recirculating system with indirect heat exchangers and a cooling tower is preferable to a once-through system for cooling purposes. This avoids most of the heat transfer to the aquatic environment and reduces the risk of undetected contamination. It is also likely to reduce the quantity of treatment chemicals needed. However, you are likely to need a water make-up treatment plant and there will be a concentrated purge stream from the system. You can sometimes use air cooling in place of water but the fans needed use energy and may be noisy.

Water may be used in direct contact with process materials for either scrubbing or quench cooling. In most cases you can recirculate the water after stripping out the absorbed substances. You will normally need a purge stream to avoid the build-up of contaminants and to remove water that is produced in the process. This will need treatment before discharge (although in some cases it may be used in another process).

Water used for cleaning can be reduced by a number of techniques, e.g. by using dry methods where possible and spray cleaning rather than whole vessel filling.

Water should be reused wherever possible and a hierarchy of sources and opportunities for reuse may be established using pinch analysis.

#### **Indicative BAT**

You should where appropriate:

1. Maximise heat transfer between process streams where water is needed for cooling. Use a recirculating system with indirect heat exchangers and a cooling tower in preference to a once-through cooling system.
2. Where water is used in direct contact with process materials, recirculate the water after stripping out the absorbed substances.
3. Use cleaning techniques that reduce the quantity of water needed.
4. Establish opportunities for reuse using pinch analysis.

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

Waste should be recovered unless it is technically or economically impractical to do so.

You should list in detail the nature and source of the waste from each activity as the response to the emissions inventory requirement of the Application. Where there are a very large number of relatively small streams it may be appropriate to aggregate similar and comparatively insignificant waste streams.

#### **Indicative BAT**

You should where appropriate:

1. Demonstrate that the chosen routes for recovery or disposal represent the best environmental option. Consider avenues for recycling back into the process or reworking for another process wherever possible.
2. Where you cannot avoid disposing of waste, provide a detailed assessment identifying the best environmental options for waste disposal.

## **2 Operations**

**2.1 Design of a new process**

**2.2 Storage and handling of raw materials, products and wastes**

**2.3 Plant systems and equipment**

**2.4 Reaction stage**

**2.5 Separation stage**

**2.6 Purification stage**

**2.7 Chemical process controls**

**2.8 Analysis**

## 2. Operations

### Introduction

Suitable techniques to prevent pollution and to minimize it at source are discussed under the following headings:

- design of a new process
- storage and handling of raw materials, products and wastes
- plant systems and equipment
- reaction stage
- separation and isolation
- purification and/or final product preparation
- chemical process controls
- analysis.

It is not possible to include all techniques which could be classed as “clean technology” because the sector is so diverse.

### 2.1 Design of a new process

Environmental issues should be an integral part of discussion at every stage of the design of a process, beginning with the initial concepts. There should be a formal and comprehensive study of the likely environmental consequences from:

- the use of all raw materials, and production of all intermediates and products
- all routine emissions, discharges and solid/liquid waste streams and
- non-routine or unplanned releases and disposals from, for example:
  - start-ups and shutdowns
  - off-specification products
  - spillages and
  - pressure relief.

You should plan to measure, control and record the quantity and quality of every emission, discharge and waste stream from the process. This includes releases generated from non-routine cleaning or maintenance operations.

You should consider all realistic options for minimising pollution from the outset, and where end-of-pipe techniques are proposed, the costs of abatement, waste treatment and waste disposal should be formally compared with alternatives for waste minimisation at source.

The whole study should use formal HAZOP techniques, and the quality and effectiveness of the study will depend upon the calibre and the commitment of the members of the team involved - which should include process engineers, designengineers, operational staff (including those who operate shared facilities like

waste-water treatment plants, etc.) and it is vital that environmental specialists are also members of the team.

A key purpose of the first part of the HAZOP study is the production of a preliminary environmental statement for the proposed operation, and this should cover the following points:

- Identification and characterisation. This should identify all potential releases.
- Segregation of all releases. This allows measurement and diagnosis; it also retains the flexibility to pursue recovery, recycling and other waste minimisation opportunities.
- Treatment of waste streams at source. Most segregated waste streams are more concentrated, of lower volume, and less complex mixtures than combined flows so separate treatment should be considered.
- Containment of spills. It is important to ensure that all potential spillages are contained, the potential for recovery considered and, where this is not feasible, suitable disposal routes developed.
- Fugitive emissions. Specification of equipment should take into account the likelihood of fugitive emissions, and the positions of piping and of vessels should allow rapid detection and rectification of leaks.
- Provision for effluent flow equalisation and for emergency discharges. If effluent treatment is on-site the installation must be capable of dealing with fluctuations in flow, composition and concentration - which usually means the provision of holding and balancing tanks. Emergency effluent storage may be required to cope with unusual events such as fire-fighting water.
- Abatement system reliability. If, in the event of primary system failure, the process cannot be stopped quickly enough to prevent an emission then strong consideration should be given to the provision of a secondary back-up system.

#### **Indicative BAT**

You should where appropriate:

1. Consider all potential environmental impacts from the outset in any new project for manufacturing chemicals.
2. Undertake the appropriate stages of a formal HAZOP study as the project progresses through the process design and plant design phases. The HAZOP studies should consider amongst other things the points noted above.

## **2.2 Storage and handling of raw materials, products and wastes**

The design of storage facilities depends upon the properties of the raw materials, products and wastes that are being stored. This includes their toxicity, environmental persistence and flammability. Storage areas are subject to the same risks as the main processing areas: overpressure, leakage, equipment failure and fire. However the material inventories are generally greater and the level of surveillance is

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generally lower. Additional guidance on the storage of chemicals is provided in the “Emissions from Storage” BREF (see Reference 3).

### **Indicative BAT**

You should where appropriate:

1. Store reactive chemicals in such a way that they remain stable, such as under a steady gas stream, for example. If chemical additions are necessary then tests should be carried out to ensure the required chemical composition is maintained. Inhibitors may also be added to prevent reactions.
2. Vent storage tanks to a safe location.
3. Use measures to reduce the risk of contamination from large storage tanks. In addition to sealed bunds, use double-walled tanks and leak detection channels.
4. Use HAZOP studies to identify risks to the environment for all operations involving the storage and handling of chemicals and wastes. Where the risks are identified as significant, plans and timetables for improvements should be in place.

## **2.3 Plant systems and equipment**

A wide range of ancillary equipment is required throughout the process, which may include: ventilation, pressure relief, vacuum raising, pumps, compressors, agitators, valves, purging and heating/cooling. Some of these systems give rise to a waste stream, for example wet vacuum systems or dust extraction equipment, and all of them have the potential to give rise to fugitive emissions. You should formally consider potential emissions from plant systems and equipment such as:

- the concentration, mass-flow and air impact of the substances vented to atmosphere
- the potential for contamination by extract air of rain-water run-off from the roof
- whether the ventilation system should be fed to an abatement unit
- noise levels and adequate silencing arrangements.

Valve leakage performance is significant in minimising fugitive losses and should be a major factor in valve selection. The duties and conditions in each vessel and section of piping should be considered in a systematic HAZOP study to identify and quantify significant risks to the environment from the valves chosen for those parts of the plant activity in question.

### **Indicative BAT**

You should where appropriate:

1. Formally consider potential emissions from plant systems and equipment and have plans and timetables for improvements, where the potential for substance or noise pollution from plant systems and equipment has been identified.
2. Carry out systematic HAZOP studies on all plant systems and equipment to identify and quantify risks to the environment.
3. Choose vacuum systems that are designed for the load and keep them well maintained. Install sufficient instrumentation to detect reduced performance and to warn that remedial action should be taken.

### **Over-pressure protection systems**

Most pressurised vessels will use relief valves or bursting discs, or a combination of the two, to provide emergency pressure relief. Emergency venting may be through an absorption system, to a dump tank or directly to atmosphere, and the need for equipment to collect and treat the release will depend on the likely impact of a discharge. It is imperative that the relief system is designed to cope with all conceivable conditions, because under some emergency situations the vented stream might be liquid or a two-phase foaming mixture, which would impose a different set of design constraints from simple gas relief. All equipment installed in the venting system should be maintained in a state of readiness even though the system is rarely used. Relief valves may be mounted downstream of bursting discs or between pairs of bursting discs to protect the valve seats from corrosion, with pressure gauges and alarms installed between the discs and valve to warn of perforation of a disc or operation of the relief device. Sometimes a small-capacity relief valve is installed, discharging to an abatement system, with, in parallel and at a slightly higher pressure setting and discharging directly to atmosphere, a large-capacity device to deal with fire induced relief.

### **Indicative BAT**

You should where appropriate:

1. Carry out a systematic HAZOP study for all relief systems, to identify and quantify significant risks to the environment from the technique chosen.
2. Identify procedures to protect against overpressure of equipment. This requires the identification of all conceivable over-pressure situations, calculation of relief rates, selection of relief method, design of the vent system, discharge and disposal considerations, and dispersion calculations. In some cases careful design can provide intrinsic protection against all conceivable over-pressure scenarios, so relief systems and their consequential emissions can be avoided.
3. Maintain in a state of readiness all equipment installed in the venting system even though the system is rarely used.

### **Heat exchangers and cooling systems**

All heat exchange systems have the potential for process streams to leak into the heating/cooling fluid, or vice versa. The “Industrial Cooling Systems” BREF (see Reference 3) provides detailed information on BAT for water-cooled heat exchangers and cooling-tower systems.

### **Indicative BAT**

You should where appropriate:

1. Consider leak detection, corrosion monitoring and materials of construction, preferably in a formal HAZOP study. Plans and timetables for improved procedures or replacement by higher integrity designs should be in place where the risks are identified as significant.
2. If corrosion is likely, ensure methods for rapid detection of leaks are in place and a regime of corrosion monitoring in operation at critical points. Alternatively, use materials of construction that are inert to the process and heating/cooling fluids under the conditions of operation.
3. For cooling water systems, use techniques that compare favourably with relevant techniques described in the “Industrial Cooling Systems” BREF.

### **Purging facilities**

Plant will normally require purging with air between batches and campaigns, and prior to maintenance activities; similarly, prior to start-up, air is often displaced from the system by an inert gas to ensure that a flammable atmosphere does not form. Purging leads to non-condensable gases carrying organic vapours being vented from the system.

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### **Indicative BAT**

You should where appropriate:

1. Assess the potential for the release to air of VOCs and other pollutants along with discharged purge gas and use abatement where necessary.

## **2.4 Reaction stage**

It is important to consider how the chemistry and engineering options may contribute to releases to the environment from the reaction stage, both directly and as a consequence later in the process. It is also important that these considerations are made at the process design stage - before plant design and equipment selection is commenced. It is difficult to overstate the importance of an adequate understanding of the physical chemistry involved in the reaction scheme, followed by sound application of reactor engineering principles at the process design stage.

Newer techniques involving small, low-inventory "fast" reactors have the potential to achieve better yields whilst generating considerably lower quantities of waste and waste-water. These usually operate continuously (allowing a steady state to be attained with obvious simplification of control and improved product consistency/quality) or semi-continuously where a batch of reactants is prepared before being processed through the reactor. Individual fast reactors are usually custom-built for each reaction in order to optimise reaction specificity and maximise yields - and though they may appear to offer less flexibility than conventional reactor systems, in many cases the equipment is so small that individual pieces can be constructed cheaply and installed easily whenever a reaction change is required. This is a good illustration of why proper attention to process design before starting plant design pays dividends.

### **Indicative BAT**

You should where appropriate:

1. With a clear understanding of the physical chemistry, evaluate options for suitable reactor types using chemical engineering principles.
2. Select the reactor system from a number of potentially suitable reactor designs – conventional stirred tank reactor (STR), process-intensive or novel-technology - by formal comparison of costs and business risks against the assessment of raw material efficiencies and environmental impacts for each of the options.
3. Undertake studies to review reactor design options based on process-optimisation where the activity is an existing activity and achieved raw material efficiencies and waste generation suggest there is significant potential for improvement. The studies should formally compare the costs and business risks, and raw material efficiencies and environmental impacts of the alternative systems with those of the existing system. The scope and depth of the studies should be in proportion to the potential for environmental improvement over the existing reaction system.
4. Maximise process yields from the selected reactor design, and minimise losses and emissions, by the formalised use of optimised process control and management procedures (both manual and computerised where appropriate).
5. Minimise the potential for the release of vapours to air from pressure relief systems and the potential for emissions of organic solvents into air or water, by formal consideration at the design stage - or formal review of the existing arrangements if that stage has passed.

## Minimisation of liquid losses from reaction systems

Different products are often made in successive campaigns, and at the end of each campaign it is important to remove as much potential contamination by the preceding batch as possible. This gives rise to waste.

### Indicative BAT

You should where appropriate:

1. Use the following features that contribute to a reduction in waste arising from clean-outs:

- Low-inventory continuous throughput reactors with minimum surface area for cleaning.
- Minimum internals such as baffles and coils in the reactor.
- Smooth reactor walls, no crevices.
- Flush bottom outlet on reaction vessels.
- All associated piping to slope back to the reactor or to a drain point.
- Sufficient headroom under the reactor for collection of all concentrated drainings in drums or other suitable vessel, if necessary.
- Minimal pipework, designed to eliminate hold-up and to assist drainage.
- Pipework designed to allow air or nitrogen blowing.
- System kept warm during emptying to facilitate draining.
- HAZOP studies used to assess the potential for the choking of lines by high-melting-point material.
- Campaigns sequenced so that cleaning between batches is minimised.
- Campaigns made as long as possible to reduce the number of product change-overs.
- Where a complete clean is necessary, use cleaning methods that minimise the use of cleaning agents, (e.g. steam-cleaning, rotating spray jets or high-pressure cleaning) or use a solvent which can be re-used.

Carry out HAZOP studies to minimise the generation of wastes and to examine their treatment/disposal.

- Consider use of disposable plastic pipe-liners.
- Eliminate or minimise locations for solids to settle-out.
- Consider duplicate or dedicated equipment where it can reduce the need for cleaning that is difficult.

## Minimisation of vapour losses

There are many techniques for minimising the potential for vapour losses and for collection and abatement of vapour displaced into vent lines.

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For example, during the charging of vessels, vapour losses can be reduced by using dip-pipe or bottom-filling instead of splash-filling from the top. This also reduces the risks of static-induced explosion. Volatiles evaporated from reactor systems can be collected ahead of an abatement system in order to achieve direct recovery of the material, the most common method being condensation. You should always consider opportunities to enhance the performance of abatement systems, e.g. by increasing the heat transfer area or chilling the coolant medium for condensation, or by changing the packing or absorbent in absorption towers.

#### **Indicative BAT**

You should where appropriate:

1. Review your operating practices and review vent flows to see if improvements need to be made.
2. Consider opportunities to enhance the performance of abatement systems.

## **2.5 Separation stage**

On completion of the reaction it is usually necessary to separate the desired product from the other components in the reaction system.

### **Liquid-vapour separations**

The most widely used vapour-liquid separation techniques are evaporation, steam- or gas-stripping and distillation. Contaminants in the liquid phase can cause excessive foaming and the presence of inert noncondensable gases can depress the performance of condensers.

#### **Indicative BAT**

You should where appropriate:

1. Choose your separation technique following a detailed process design and HAZOP study. Follow formal operating instructions to ensure effective separation and minimisation of losses. Adhere to design conditions such as heat input, reflux flows and ratios, etc.
2. Install instrumentation to warn of faults in the system, such as a temperature, pressure or low coolant-flow alarms.

## Liquid-liquid separations

The most widely used liquid-liquid separation techniques are 2-phase extraction with water or solvent, decantation, centrifuging and multi-stage contacting.

Small quantities of surfactant substances can affect dispersion and coalescence, and even with good separation there is usually a secondary haze which, typically, accounts for up to 1% of the required substance remaining in the wrong phase and ending up in the waste stream.

In batch operations, a common problem which results in loss of organics to drain is detection of the interface between the aqueous phase and the organics phase and stopping the flow in time.

### Indicative BAT

You should where appropriate:

1. Use techniques which maximise physical separation of the phases (and also aim to minimise mutual solubility) where practicable.
2. When the phases are separated, use techniques which prevent (or minimise the probability and size of) breakthrough of the organics phase into a waste-water stream. This is particularly important where the environmental consequences of subsequent releases of organics to air or into controlled waters may be significant (eg. where the effluent is treated in a DAF unit or some of the organic components are resistant to biological treatment).
3. When a separation is done by hand, use a "dead man's handle", backed-up by good management, to improve the chance of the flow being properly controlled as the phase-boundary approaches.
4. Consider if automatic detection of the interface is practicable.
5. Where you are discharging to drain, consider whether there should be an intermediate holding or "guard" tank to protect against accidental losses from the organics phase.

## Solid-liquid separations

Different separation techniques will be BAT for different applications, with factors like solubility, crystallisation rate and granular size being important. The main solid-liquid techniques are centrifuging, filtration, sedimentation, clarification, drying and ion exchange.

### **Indicative BAT**

You should where appropriate:

1. Use techniques to minimise, re-use and/or recycle rinse water, and to prevent breakthrough of solids.
2. Install instrumentation or other means of detecting malfunction as all of the techniques are vulnerable to solids breakthrough
3. Consider installing "guard" filters of smaller capacity downstream which, in the event of breakthrough, rapidly 'clog' and prevent further losses.
4. Have good management procedures to minimise loss of solids, escape of volatiles to air and excessive production of waste water.

## **2.6 Purification stage**

Waste associated with the purification stage may arise from:

- impurities in the raw materials - so a change in the raw material specifications may reduce waste arisings
- by-products generated by the process - so a change in reaction conditions, catalyst, solvent, etc may improve the selectivity of the reaction and reduce or eliminate by-product formation.

### **Purification of liquid products**

Liquid products are usually refined by distillation, with filtration used to remove solid contaminants. Sources of loss are:

- gas entrainment. Gas or vapour flow will carry away volatile material either as vapour or as entrained droplets. Additional condenser heat-exchange area or colder heat-exchange fluid can improve the recovery rate, and coalescing demisters are relatively cheap and easy to install
- ineffective separation. A better separation in the distillation column can be achieved by using more stages (theoretical plates) or more reflux. Modern types of packing or high-efficiency trays can often produce a marked improvement for a modest capital investment
- filtration. Enclosed filtration is usually used and this is not normally a source of great vapour loss to air. Liquid discharged during cleaning or changing of filters should be returned to the process.

### **Purification of solid products**

Washing and crystallising activities have the potential to produce large volumes of dilute liquors so counter-current systems should be used wherever possible.

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During drying, you should aim to produce the maximum concentration of solvent in the gas to allow recovery of the solvent. The use of vacuum can improve both solvent recovery and energy efficiency.

## 2.7 Chemical process controls

Reaction conditions such as temperatures, pressures, rocking or stirring rates, catalyst age, input and output flow rates, addition of materials (and so on) are imperative to the efficient conversion of raw materials to product.

### **Indicative BAT**

You should where appropriate:

1. Monitor the relevant process controls and set with alarms to ensure they do not go out of the required range.

## 2.8 Analysis

### **Indicative BAT**

You should where appropriate:

1. Analyse the components and concentrations of by products and waste streams to ensure correct decisions are made regarding onward treatment or disposal. Keep detailed records of decisions based on this analysis in accordance with management systems.

## **3 Emissions and monitoring**

**3.1 Point source emissions to air**

**3.2 Point source emissions to water**

**3.3 Point source emissions to land**

**3.4 Fugitive emissions**

**3.5 Odour**

**3.6 Noise and vibration**

**3.7 Monitoring**

## 3 Emissions and monitoring

### 3.1 Point source emissions to air

The diversity of this broad sector is such that a wide range of different emissions will arise. You should aim first to prevent emissions and then to minimise emissions at source. Only when you have done this should you use abatement techniques as necessary. You will often need a combination of techniques to abate emissions.

You should formally consider the following when dealing with your emissions to air:

- the information in this guidance note
- relevant equivalent sections in the guidance notes for the speciality organics chemical sector and the organic chemical sector
- the abatement guidance note
- the BREF on Common Waste Water and Waste Gas Treatment / Management Systems in the Chemical Sector
- other specific BREFs as relevant to the activity e.g. Chlor-alkali.

The selection of BAT for a specific installation will depend on many factors including;

- gas flow rate (average rate, range, rate of variation)
- pollutant types and inlet concentrations
- presence of impurities (e.g. water, dust, corrosives)
- concentration required in the exhaust
- safety
- investment and operating cost
- plant layout
- availability of utilities

Depending on these factors, a combination of techniques may be needed to satisfy the requirements of BAT. Measures for prevention and minimisation should be applied, then abatement techniques used if necessary.

#### **Particulate matter**

The methods available for minimising or reducing discharges of particulate matter to the atmosphere are described in the Abatement Guidance Note A3 (see Reference 3, Annex 2).

#### **Volatile organic compounds**

Abatement of volatile organic compounds (VOCs) is described in the Abatement Guidance Note A3 (see Reference 3, Annex 2) and that note should be consulted where VOC emissions are significant.

## General emissions

There are many methods available for reducing and minimising discharges of gaseous pollutants in emissions to atmosphere. Some of the main types are as follows:

- absorption
- condensation
- thermal decomposition
- adsorption
- filtration
- electrostatic precipitation

### Indicative BAT

You should where appropriate:

1. Formally consider the information and recommendations in the BREF on Common Waste Water and Waste Gas Treatment/ Management Systems in the Chemical Sector (see Reference 1, Annex 2) as part of the assessment of BAT for point-source releases to air, in addition to the information in this note.
2. The benchmark values for point source emissions to air listed in Annex 1 should be achieved unless we have agreed alternative values.
3. Identify the main chemical constituents of the emissions, including VOC speciation where practicable.
4. Assess vent and chimney heights for dispersion capability and assess the fate of the substances emitted to the environment.

## 3.2 Point source emissions to water

Water is used for some reactions (process water), for cooling and for cleaning.

Waste water streams can generally be categorized as:

- contaminated with hydrocarbons
- contaminated with heavy metals
- contaminated with chlorinated hydrocarbons, and/or
- acidic and alkaline

It is unlikely that any single waste water treatment technique will be adequate to render harmless the waste water to be discharged. For example, a waste water stream with a low pH and a high organics content would require both pH adjustment and a means removing the organic compounds. Treatment methods should be applied as appropriate.

### Useful in plant treatment techniques include:

- For hydrocarbons, combinations of: air or steam stripping; granular activated carbon; ion exchange; reverse osmosis; electro dialysis; oxidation, including wet oxidation.
- For heavy metals, combinations of: oxidation/reduction; precipitation; filtration.
- For aqueous waste, **wet air oxidation** is generally more energy-efficient than

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incineration and is capable of oxidising complex molecules, including some pesticides, with up to 99.9% removal efficiencies. However, tests are normally required to confirm or otherwise the appropriateness of this technique.

Advantages of wet oxidation include:

- emissions of nitrogen oxides are virtually eliminated where the oxidation temperature is low
- emissions of dust or inorganic oxides are eliminated, and
- the oxidation is carried out in a closed system, which reduces the risk of release of unconverted material in the event of a process upset such as runaway reactions

Possible disadvantages include:

- a minimum concentration of oxidisable material is required to allow autothermal operation; below this concentration an extra energy source is required.
- Where recovery or chemical treatment of liquid wastes is not feasible, thermal destruction is the next preferred alternative. A correctly designed and operated incinerator ensures a high degree of controlled combustion, allows recovery of heat and abatement of polluting emissions.

### **Indicative BAT**

You should where appropriate:

1. Control all emissions to avoid a breach of water quality standards as a minimum. Where another technique can deliver better results at reasonable cost it will be considered BAT and should be used.
2. Use the following measures to minimise water use and emissions to water:
  - Where water is needed for cooling, minimize its use by maximising heat transfer between process streams.
  - Use water in recirculating systems with indirect heat exchangers and a cooling tower rather than a once through system. (A water make-up treatment plant and a concentrated purge stream from the system to avoid the build up of contaminants are likely to be necessary.)
  - Leaks of process fluids into cooling water in heat exchangers are a frequent source of contamination. Monitoring of the cooling water at relevant points should be appropriate to the nature of the process fluids. In a recirculatory cooling system, leaks can be identified before significant emission to the environment has occurred. The potential for environmental impact is likely to be greater from a once through system. Planned maintenance can help to avoid such occurrences.
  - Reduce water used for cleaning.

- Strip process liquor and treat if necessary, then recycle/reuse.
- Use wet air oxidation for low volumes of aqueous effluent with high levels of organic content, such as waste streams from condensers and scrubbers
- Neutralise waste streams containing acids or alkalis to achieve the required pH for the receiving water.
- Strip chlorinated hydrocarbons in waste streams with air or steam and recycle by returning to process where possible.
- Recover co-products for re-use or sale.
- Periodically regenerate ion exchange columns.
- Pass waste water containing solids through settling tanks, prior to disposal.
- Treat waste waters containing chlorinated hydrocarbons separately where possible to ensure proper control and treatment of the chlorinated compounds. Contain released volatile chlorinated hydrocarbons and vent to suitably designed incineration equipment.
- Non-biodegradable organic material can be treated by thermal incineration. However, the thermal destruction of mixed liquids can be highly inefficient and the waste should be dewatered prior to incineration.

### 3.3 Point source emissions to land

The wastes produced by the sector can be classified into types as follows:

- by-products for which no internal use or external sale is available
- residues from separation processes such as distillation
- catalysts which have declined in performance and require replacement
- filter cake, activated carbon, ion exchange resins, molecular sieves and other treatment materials
- sludges from waste water treatment
- emptied containers and packaging
- maintenance and construction materials

Landfill may be suitable for a limited number of wastes which are non polluting or are solidified or encapsulated to prevent release of contaminants. For example, some metal compounds when treated with lime are highly insoluble. Landfill of wastes should only be contemplated after all other alternatives have been thoroughly examined and rejected.

The following wastes are likely to be landfilled:

- spent process residues
- spent molecular sieve
- spent ion exchange resins
- polymer and sludge from reaction vessels

#### **Indicative BAT**

You should where appropriate:

1. Use the following measures to minimise emissions to land:

- Use settling ponds to separate out sludge (Note: Sludge can be disposed of to incinerator, encapsulation, land or lagoon depending upon its make up.)
- Chlorinated residues should be incinerated and not released to land. (Chlorinated hydrocarbons are not to be released to the environment due to their high global warming and ozone depletion potentials.)
- Either recycle off specification product into the process or blend to make lower grade products where possible
- Many catalysts are based on precious metals and these should be recovered, usually by return to the supplier.

### 3.4 Fugitive emissions

#### **Fugitive emissions to air**

On many installations fugitive emissions may be more significant than point source emissions.

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### **Indicative BAT**

You should where appropriate:

1. Identify all potential sources and develop and maintain procedures for monitoring and eliminating or minimising leaks.
2. Choose vent systems to minimise breathing emissions (for example pressure/ vacuum valves) and, where relevant, should be fitted with knock-out pots and appropriate abatement equipment.
3. Use the following techniques (together or in any combination) to reduce losses from storage tanks at atmospheric pressure:
  - maintenance of bulk storage temperatures as low as practicable, taking into account changes due to solar heating etc.
  - tank paint with low solar absorbency
  - temperature control
  - tank insulation
  - inventory management
  - floating roof tanks
  - bladder roof tanks
  - pressure/vacuum valves, where tanks are designed to withstand pressure fluctuations
  - specific release treatment (such as adsorption condensation)

### **Fugitive emissions to surface water, sewer and groundwater**

Fugitive emissions, primarily from leaks and spillages, may occur into cooling water, site drainage water and groundwater. Their control must form part of a programme of good design, monitoring, maintenance and operating procedures.

### **Indicative BAT**

You should where appropriate:

1. Provide hard surfacing in areas where accidental spillage or leakage may occur, e.g. beneath prime movers, pumps, in storage areas, and in handling, loading and unloading areas. The surfacing should be impermeable to process liquors.
2. Drain hard surfacing of areas subject to potential contamination so that potentially contaminated surface run-off does not discharge to ground.
3. Hold stocks of suitable absorbents at appropriate locations for use in mopping up minor leaks and spills, and dispose of to leak-proof containers.
4. Take particular care in areas of inherent sensitivity to groundwater pollution. Poorly maintained drainage systems are known to be the main cause of groundwater contamination and surface/above-ground drains are preferred to facilitate leak detection (and to reduce explosion risks).
5. Additional measures could be justified in locations of particular environmental sensitivity. Decisions on the measures to be taken should take account of the risk to groundwater.

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6. Surveys of plant that may continue to contribute to leakage should also be considered, as part of an overall environmental management system. In particular, you should consider undertaking leakage tests and/or integrity surveys to confirm the containment of underground drains and tanks.

### 3.5 Odour

The requirements for odour control will be installation-specific and depend on the sources and nature of the potential odour. Some compounds, such as hydrogen sulphide and mercaptans or ammonia and amines, are particularly pungent but many other compounds such as chlorine or sulphur dioxide can also cause offence at low levels. Where there are highly odorous materials, use the strictest techniques to prevent trace emissions.

Even the treatment of otherwise innocuous substances can cause an unpleasant odour e.g. the biological treatment of waste-water. Poor design or operation of facilities intended to be aerobic may not provide sufficient aeration. This can cause anaerobic conditions and the formation of odorous compounds. You should also remember that volatile compounds may be released when the waste-water is first exposed to the atmosphere. You may need to prevent their emission by covering the tank or separator and recovering the compounds.

### **Indicative BAT**

You should where appropriate:

1. Manage the operations to prevent release of odour at all times.
2. Where odour releases are expected to be acknowledged in the permit, (i.e. contained and treated prior to discharge or discharged for atmospheric dispersion):
  - for existing installations, the releases should be modelled to demonstrate the odour impact at sensitive receptors. The target should be to minimise the frequency of exposure to ground level concentrations that are likely to cause annoyance
  - for new installations, or for significant changes, the releases should be modelled and it is expected that you will achieve the highest level of protection that is achievable with BAT from the outset
  - where there is no history of odour problems then modelling may not be required although it should be remembered that there can still be an underlying level of annoyance without complaints being made
  - where, despite all reasonable steps in the design of the plant, extreme weather or other incidents are liable, in our view, to increase the odour impact at receptors, you should take appropriate and timely action, as agreed with us, to prevent further annoyance (these agreed actions will be defined either in the permit or in an odour management statement).
3. Where odour generating activities take place in the open, or potentially odorous materials are stored outside, a high level of management control and use of best practice will be expected.
4. Where an installation releases odours but has a low environmental impact by virtue of its remoteness from sensitive receptors, it is expected that you will work towards achieving the standards described in this guidance note, but the timescales allowed to achieve this might be adjusted according to the perceived risk.
5. Where further guidance is needed to meet local needs, refer to Horizontal Guidance Note H4 Odour (see GTBR, Annex 1).

### **3.6 Noise and vibration**

Noise surveys, measurement, investigation (which can involve detailed assessment of sound power levels for individual items of plant) or modelling may be necessary for either new or existing installations depending upon the potential for noise problems. You may have a noise management plan as part of your management system. The operation of safety valves and other release devices for high pressure systems can be extremely noisy.

### **Indicative BAT**

You should where appropriate:

1. Install particularly noisy machines such as compactors and pelletisers in a noise control booth or encapsulate the noise source.
2. Where possible without compromising safety, fit suitable silencers on safety valves.
3. Minimise the blow-off from boilers and air compressors, for example during start up, and provide silencers.

## **3.7 Monitoring**

There is a suite of Environment Agency guidance on monitoring, known as the M series, which is included in the list of references in Annex 1 of GTBR.

### **Monitoring and reporting of emissions to air**

#### **Indicative BAT**

You should where appropriate:

1. Carry out an analysis covering a broad spectrum of substances to establish that all relevant substances have been taken into account when setting the release limits. The need to repeat such a test will depend upon the potential variability in the process and, for example, the potential for contamination of raw materials. Where there is such potential, tests may be appropriate.
2. Monitor more regularly any substances found to be of concern, or any other individual substances to which the local environment may be susceptible and upon which the operations may impact. This would particularly apply to the common pesticides and heavy metals. Using composite samples is the technique most likely to be appropriate where the concentration does not vary excessively.
3. If there are releases of substances that are more difficult to measure and whose capacity for harm is uncertain, particularly when combined with other substances, then "whole effluent toxicity" monitoring techniques can be appropriate to provide direct measurements of harm, for example, direct toxicity assessment.

#### **Indicative BAT**

You should where appropriate:

1. Monitor and record:
2. • the physical and chemical composition of the waste
3. • its hazard characteristics
4. • handling precautions and substances with which it cannot be mixed.

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## Monitoring and reporting of waste emissions

### Environmental monitoring ( beyond installation)

#### Indicative BAT

You should where environmental monitoring is needed:

1. Consider the following in drawing up proposals:

- determinands to be monitored, standard reference methods, sampling protocols
- monitoring strategy, selection of monitoring points, optimisation of monitoring approach
- determination of background levels contributed by other sources
- uncertainty for the employed methodologies and the resultant overall uncertainty of measurement
- quality assurance (QA) and quality control (QC) protocols, equipment calibration and maintenance, sample storage and chain of custody/audit trail
- reporting procedures, data storage, interpretation and review of results, reporting format for the provision of information.

#### Process variables

Some process variables may affect the environment and these should be identified and monitored as appropriate. Examples might be:

- raw materials monitoring for contaminants where contaminants are likely and there is inadequate supplier information
- plant efficiency where it has an environmental relevance
- abatement equipment performance (e.g. bag filter pressure drop)
- energy consumption across the plant and at individual points-of-use in accordance with the energy plan.
- fresh water use across the activities and at individual points-of-use should be monitored as part of the water-efficiency plan.

#### Indicative BAT

You should where appropriate:

1. Identify those process variables that may affect the environment and monitor as appropriate.

# **4 Annexes**

**Annex 1 Emission benchmarks**

**Annex 2 References**

## 4 Annexes

### Annex1 – Emission benchmarks

#### Emissions to air associated with the use of BAT

Released substance	Benchmark value (mg/Nm <sup>3</sup> ) See Note (a)	Comments and basis for the benchmark. (Based on IPC S2 4.03 and S2 4.04 unless otherwise indicated)
Ammonia	10 - 50	10 mg/Nm <sup>3</sup> for acid scrubbing (BREF), 30 for NH <sub>3</sub> plants, 10 – 50 for fertilizer production (see Note (b))
Antimony	5	
Arsenic	1	
Benzene	5	
Beryllium	0.002	
Bromine	10	
Cadmium and compounds (as Cd)	0.05	
Carbon disulphide	5	
Carbon monoxide	100	
Chlorides (gaseous) (as HCl)	10	See Note (c) for TiO <sub>2</sub> manufacture
Chlorine dioxide (as Cl)	10	
Chromium (III)	5	Reduced to 1 mg/Nm <sup>3</sup> when mixed with Cr(VI) or a soluble Ni compound
Chromium (VI)	0.5 - 1	0.5 mg/Nm <sup>3</sup> when present as chromates of Ca, Sr, Cr(III) or Zn; 1mg/Nm <sup>3</sup> for all other Cr(VI) compounds
Cyanide dust (inorganic)	5	
Cyanogen chloride	1	
1,2-Dichloroethane	1 - 5	1mg/Nm <sup>3</sup> by incineration treatment (BREF)
Fluorides (gaseous) (as HF)	10	
Heavy metals (other than Hg and Cd)	1.5	Waste Incineration Directive
Hydrogen bromide	5	
Hydrogen chloride	10	
Hydrogen cyanide	2 - 5	
Hydrogen fluoride	5	

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Hydrogen iodide	5	
Hydrogen sulphide	5	
Indium	1	
Iodine	10	
Lead and compounds (inorganic)	2	
Mercaptans and Organic sulphides (as methyl mercaptan)	2	
Mercury and compounds (as Hg)	0.05	
Nickel and compounds	2 - 10	2 mg/Nm <sup>3</sup> for soluble Ni compounds
Nitrogen oxides (acid-forming as NO <sub>2</sub> )	50 - 200	200 mg/Nm <sup>3</sup> for wet scrubbing, 50 for Selective Catalytic Reduction (SCR)
Nitrous oxide (N <sub>2</sub> O)	200	Selective Non-Catalytic Reduction (SNCR)
Phosphorus pentasulphide	5	
Phosphorus trichloride	10	
Platinum	0.002 - 1	0.002 mg/Nm <sup>3</sup> for soluble Pt compounds
Selenium	1	
Sulphur oxides (as SO <sub>2</sub> )	50 - 100	50 mg/Nm <sup>3</sup> for wet alkaline scrubbing (cf. 40 mg/Nm <sup>3</sup> achievable according to WW&WG Treatment BREF); 100 for semi-dry scrubbing. For H <sub>2</sub> SO <sub>4</sub> plants see Note (d) below.
Tellurium	1	
Particulate matter	5 - 20	See Note (b) for ammonium nitrate & phosphate production
Phosphine	1 - 5	1 mg/Nm <sup>3</sup> for small uses like semiconductor manufacture; 5 mg/Nm <sup>3</sup> for larger-scale use or production.
Phosphorus oxides (as P <sub>2</sub> O <sub>5</sub> )	50	
Phosphorus oxychloride	10	
Thallium	0.05	
VOC total Class A	20	See Note (e)
VOC Total Class B (expressed as carbon)	75	See Note (e)

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Note (a) - General conditions

- The reference conditions applicable to the above levels are: temperature 273 K (0 °C), pressure 101.3 kPa (1 atmosphere), no correction for water vapour or oxygen.
- Where the terms "as" or "expressed as" are used, a correction should be carried out using the ratio of the atomic or molecular weights of the substances, as appropriate.
- Releases should be essentially colourless, free from persistent mist or fume and free from droplets. Releases should not give rise to an offensive odour noticeable outside the site where the process is carried on.

Note (b) - Ammonium nitrate or ammonium phosphate fertilizers

The following ammonia and particulate levels are achievable in the specified parts of ammonium nitrate or phosphate production:

Ammonium nitrate or phosphate activity		Ammonia (mg/Nm <sup>3</sup> )	Particulate matter (mg/Nm <sup>3</sup> )
Ammonium nitrate production	Prill towers and melt granulators	10	15 (excluding insolubles)
	Neutralisers/reactors	50	30
	Coolers and dryers	50	30
	Evaporators	50	15
Ammonium phosphate production		10	50

Note (c) -

Titanium Dioxide Directive

Titanium dioxide manufacture is subject to EC Directive 92/112/EEC which gives the following emission limits:

Substance	Emission limit value (mg/Nm <sup>3</sup> )
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Chlorine (chloride route)	- daily average	5
	- at any time	40
Sulphur oxides (sulphate route) (as SO <sub>2</sub> )		10 kg/t of TiO <sub>2</sub>
Particulates	- main sources	50
	- minor sources	150

Note (d) - Sulphuric acid plants

Sulphuric acid plants can achieve the highest levels of conversion of SO<sub>2</sub> to SO<sub>3</sub> and sulphuric acid by a variety of combinations of double-conversion/absorption, single conversion/absorption, "low-bite" caesium catalyst, and tail-gas abatement. However, whatever the combination of techniques the following are the benchmarks for conversion efficiencies based on the feed of SO<sub>2</sub> to the "contact plant" (and the equivalent losses to air).

During start-ups, significantly higher release of SO<sub>2</sub> can be experienced but techniques should be employed to limit the releases to the levels in the last column below.

Sulphur conversion efficiencies	Normal operation		Start-up
	Conversion efficiency	Maximum loss	Maximum loss over first 5 hours
New plant	99.9 %	0.1 %	1.0 %
Existing plant	99.7 %	0.3 %	2.0 %

Note (e) - Volatile Organic Compounds (VOCs)

Where possible release of VOCs should be individually identified and, where practicable, monitored separately. The term 'volatile organic compounds' includes all organic compounds released to air in the gas phase.

The VOC benchmark concentration levels apply where the following total mass release rates are exceeded, but releases below these mass emission rates may not be trivial for some substances so may still require controls and the setting of appropriate ELVs:

- Total Class A 100 g/ hr

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- Total Class B 5 tonnes/ yr or 2 kg/ h, whichever is the lower (expressed as carbon)

The use of a release concentration limit is not normally appropriate in the case of a release from an air deficient saturated vapour space, such as displacement from a storage tank or process vessel. An approach based on limiting total mass released or mass per unit of production is more appropriate.

### Emissions to water associated with the use of BAT

Substance	Level (mg/l) Note (a) and (b)
Total hydrocarbon oil content (IR method)	1 - 3
Biological oxygen demand (BOD) (5 day ATU @ 20°C)	20 - 30
Chemical oxygen demand (COD) (2 hour)	30 - 125
Total nitrogen (as N)	10 - 15
Ammoniacal nitrogen (as N)	1 - 5
Suspended solids (dried @ 105°C)	20 - 30
Halogenated Organic Compounds AOX	1
Mercury	0.005
Cadmium	0.01
Copper, chromium, nickel and lead (each)	0.5
Zinc and tin (each)	2

#### Note (a)

The levels given here are ranges achievable after effluent treatment and are not release limits. They are given on the basis of flow weighted monthly averages. For pollutants resistant to biodegradation, achievement of the levels will require isolation at source and separate specialised treatment.

#### Note (b)

Some of the substances noted above (and others not noted above) will be included in List I or in List II of substances to which legislation stemming from the Dangerous Substances Directive applies. Individual ELVs set in accordance with the requirements of the Dangerous Substances Directive may be significantly lower than the benchmark values associated with BAT.

## Annex 2 – References

For a full list of available Technical Guidance and other relevant guidance see Appendix A of GTBR (see our website) In addition to the guidance in GTBR the following guidance is relevant to this sector:

### Reference 1 IPPC Reference Documents on Best Available Techniques (BREF) - European Commission

BREFs with content relevant to the Inorganic Chemicals sector include:

- Chlor-Alkali manufacture, (December 2001)
- Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilizers, (August 2007)
- Large Volume Organic Chemical Industry, (February 2003)
- Organic Fine Chemicals, (August 2006)
- Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector, (February 2003)
- Emissions from Storage of Bulk or Dangerous Materials, (July 2006)
- Cooling Systems, (December 2001)
- Cement and Lime Production, (December 2001)
- Monitoring Systems, (July 2003)
- Economic and Cross-media issues under IPPC, (July 2006)
- Refineries, (February 2003)
- Waste Incineration, (August 2006)
- Waste Treatments, (August 2006)
- Large Combustion Plant, (July 2006).

**Reference 2 Sector Plan** for the Chemicals Industry.

### Reference 3 Releases to air references:

- Part B PG1/3 Boilers and Furnaces 20-50 MW net thermal input (ISBN 0-11-753146-4-7)
- Part B PG1/4 Gas Turbines 20-50 MW net thermal input (ISBN 0-11-753147-2)
- Pollution abatement technology for particulate and trace gas removal, HMIP Technical Guidance Note (Abatement) A3, 1994, ISBN 0-11-752983-4

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