EUROPEAN COMMISSION
DIRECTORATE-GENERAL JRC
JOINT RESEARCH CENTRE
Institute for Prospective Technological Studies
Competitiveness and Sustainability Unit
European IPPC Bureau

Integrated Pollution Prevention and Control

Preparation for the review of the BREF on Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW)

Comparative analysis of the first series of chemical BREFs

December 2007

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INTRODUCTION

Following comments made by industry and Member States at a number of Information Exchange Forum (IEF) meetings, the European IPPC Bureau proposed to carry out a comparative analysis of the existing chemical BREFs to prepare for the review of the BREF on Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW). The IEF supported this proposal.

The need for this comparative analysis was also identified in the concluding remarks of the CWW BREF which suggested that the information/data from the vertical chemical BREFs could be useful input for this review.

The main objective of this document is to set guidelines and recommendations for the review of the CWW BREF, based mainly on a comparative analysis of the information contained in the first series of chemical BREFs (eight BREFs in total). This document will help the Technical Working Group (TWG) with the preparation and the review of the CWW BREF.

However, even though this document has been written for the purpose of the revision of the CWW BREF, these guidelines and recommendations may also be useful when revising the vertical chemical BREFs.

The entire series of chemical BREFs was the main source of information for the development of this document. However, key stakeholders were consulted during the development of this document, e.g. industry representatives, Member States and some of the authors of the first series of chemical BREFs.

This document is organised in 5 chapters:

- Chapter 1 presents the differences between a vertical and a horizontal BREF. It also provides a general overview on the content of each of the documents pertaining to the first series of chemical BREFs
- Chapter 2 lists the section numbers of the techniques to consider in the determination of best available techniques (BAT) described for the abatement of air and water pollutants in each of the documents across the series of chemical BREFs
- Chapter 3 shows the section numbers of the BAT described for the abatement of air and water pollutants in each of the documents across the chemical BREFs. It also gives specific information on the BAT described for waste water and waste gas abatement in each BREF
- Chapter 4 presents four case studies. The first two are related to waste water treatment, i.e. heavy metals removal and AOX abatement. The last two relate to waste gas treatment, i.e. NO_X abatement and dust removal
- Chapter 5 presents the guidelines and recommendations for the review of the CWW BREF.

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1 GENERAL INFORMATION ON THE FIRST SERIES OF CHEMICAL BREFS

1.1 Vertical and horizontal BREFs

[1, European Commission, 2003, 9, European Commission, 2007, 12, UMWELTBUNDESAMT, 2000]

The series of BREFs (33 documents in total) consists of "vertical" sector specific BREFs addressing one or more of the industrial activities listed in Annex 1 to the IPPC Directive and "horizontal" subject BREFs addressing IPPC issues across industry sectors (i.e. common waste water and waste gas systems, energy efficiency, storage and cooling systems). There are also two horizontal documents which do not contain BAT conclusions which are called REFs, i.e. monitoring, and economics and cross-media effects reference documents. These horizontal (B)REFs do not stem from named activities in Annex 1 but from the general approach of IPPC within the Directive itself.

The full series of BREFs makes up a matrix of information to reduce the amount of duplication between them. In this sense, it is important to understand the differences between horizontal and vertical BREFs and how they may complement each other. A "vertical" BREF takes precedence over a "horizontal" BREF because the exchange of information has allowed the specificities of the sector in question to be taken into account. When a relevant environmental issue is not specifically dealt with/addressed in a "vertical" BREF, the relevant "horizontal" BREF(s) applies.

The same principle applies to the BAT chapters. Because the "vertical" BREFs intend to minimise the duplication of information with other reference documents, they generally do not repeat "horizontal BAT". Avoiding repetition leads to smaller BREF documents, and this is strongly advocated by end-users.

The CWW BREF was one of the first chemical BREFs to be developed. Its scope covers the whole chemical sector and it has been widely used in the development of, and is referenced in, a number of other chemical BREFs. Because some of the techniques described in the CWW BREF are used in sectors other than the chemical industry, the CWW BREF is also referenced in a number of non-chemical BREF documents, e.g. Cement and Lime Manufacturing Industries, Food, Drink and Milk Industries, Ceramic Manufacturing Industry, Surface Treatment of Metals and Plastics, and Surface Treatment using Organic Solvents BREFs.

Figure 1.1 shows the borderline between vertical and horizontal chemical BREFs using as an example waste water treatment.

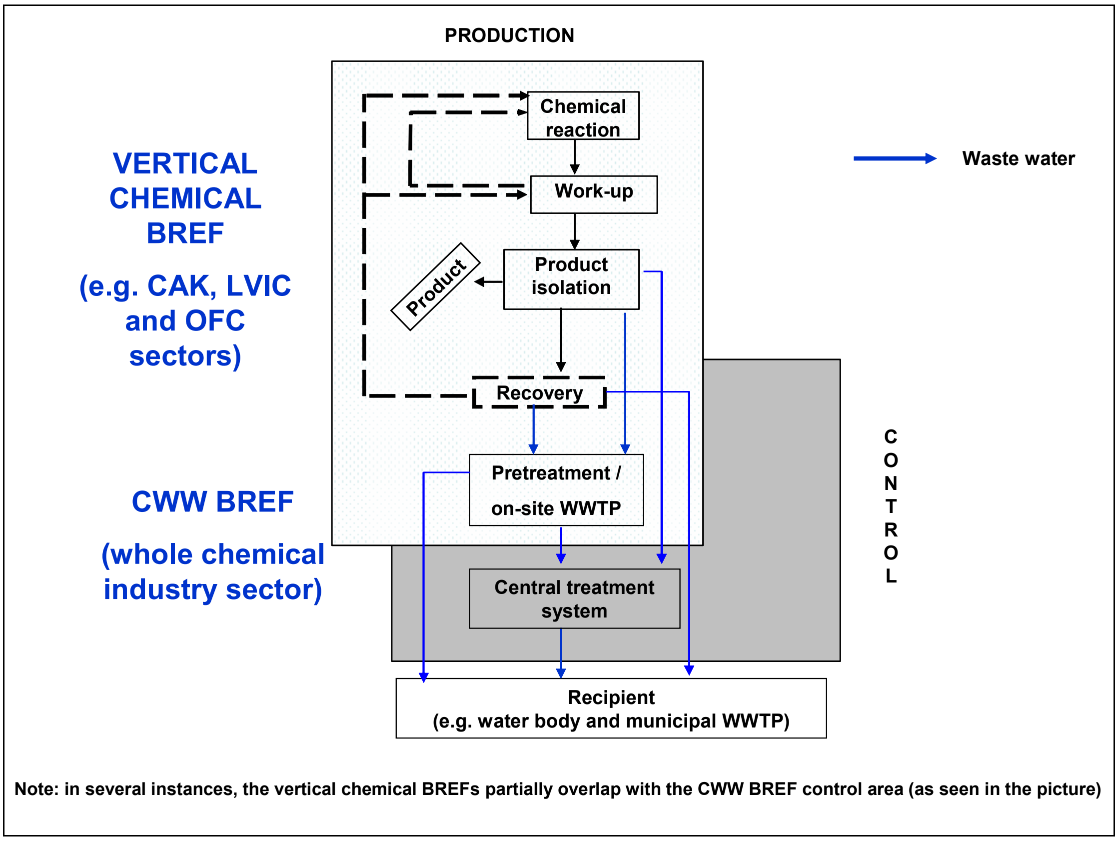

Figure 1.1: Borderline between vertical and horizontal chemical BREFs: waste water example [1, European Commission, 2003]

1.2 The series of chemical BREFs

[13, European Commission, 2007, 14, CEFIC, 2007]

Since the beginning of the decade the European chemical sector alone has represented 2/3 of the entire manufacturing trade surplus of the EU. The chemical sector also accounts for 12 % of the EU manufacturing industry's added value. Thus, the regulations for this sector are a very important and influential part of EU legislation. The industry is currently undergoing a process of rapid structural change primarily caused by a sharp rise in competition from emerging economies in Asia, e.g. China, India and the Gulf States.

The chemical sector covers a wide range of enterprises and its output covers numerous chemical products, and supplies virtually all sectors of the economy. The EU chemical sector (excluding pharmaceuticals) comprises about 27000 enterprises.

In order to regulate this large and important industry under the IPPC Directive, Annex I to the Directive includes several chemical industrial activities, i.e.

4. Chemical industry

Production within the meaning of the categories of activities contained in this section means the production on an industrial scale by chemical processing of substances or groups of substances listed in Sections 4.1 to 4.6.

4.1. Chemical installations for the production of basic organic chemicals, such as:

(b) oxygen-containing hydrocarbons such as alcohols, aldehydes, ketones, carboxylic acids, esters, acetates, ethers, peroxides, epoxy resins

(c) sulphurous hydrocarbons

(d) nitrogenous hydrocarbons such as amines, amides, nitrous compounds, nitro compounds or nitrate compounds, nitriles, cyanates, isocyanates

(e) phosphorus-containing hydrocarbons

(f) halogenic hydrocarbons

(g) organometallic compounds

(h) basic plastic materials (polymers, synthetic fibres and cellulose-based fibres)

(i) synthetic rubbers

(j) dyes and pigments

4.2. Chemical installations for the production of basic inorganic chemicals, such as:

(b) acids, such as chromic acid, hydrofluoric acid, phosphoric acid, nitric acid, hydrochloric acid, sulphuric acid, oleum, sulphurous acids

(c) bases, such as ammonium hydroxide, potassium hydroxide, sodium hydroxide

(d) salts, such as ammonium chloride, potassium chlorate, potassium carbonate, sodium carbonate, perborate, silver nitrate

4.3. Chemical installations for the production of phosphorous-, nitrogen- or potassium-based fertilisers (simple or compound fertilisers)

4.4. Chemical installations for the production of basic plant health products and of biocides

4.5. Installations using a chemical or biological process for the production of basic pharmaceutical products

4.6. Chemical installations for the production of explosives.

These industrial sectors are covered by eight chemical BREFs:

- one horizontal BREF: Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW)
- seven vertical BREFs. Four related to the production of inorganic products, i.e. Chlor-Alkali (CAK), Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers (LVIC-AAF), Large Volume Inorganic Chemicals – Solids and Others (LVIC-S) and Speciality Inorganic Chemicals (SIC). Three related to the production of organic products, i.e. Large Volume Organic Chemicals (LVOC), Organic Fine Chemicals (OFC) and Polymers (POL).

All these BREFs have been formally adopted by the European Commission.

It is important to notice that although the scope is defined in each vertical chemical BREF, there are no exact borderlines between them, e.g. there are some interrelations between the inorganic chemical BREFs and also between the organic chemical BREFs. Furthermore, there are substances that can be produced using both an inorganic and an organic process (e.g. HCN, methanol and its derivatives, and potassium sulphate). In addition, some chemical sites produce a wide range of products (multi-purpose/integrated plants) covered by several vertical chemical BREFs and their waste water discharges contain a complex variety of chemicals.

With regard to waste water and waste gas streams and associated treatment systems, the chemical sector covers a wide range of enterprises:

- at one end, the one-process-few-products small enterprises with one or just a few waste water/waste gas streams
- at the other, the multi-production-mix enterprises with many complex waste water/waste gas streams.

Table 1.1 gives an overview of the main characteristics of the first series of chemical BREFs. The table specifies general issues such as:

- duration of the project
- number of pages
- the products covered by each BREF
- the structure followed (i.e. a general approach covering all products together or an approach which covers each product/process independently of the others, which will be called "product approach" for the purpose of this document only)
- if the BAT conclusions include cross-references to the chapter on techniques to consider
- if the BREF author followed the BREF outline and guide when describing the techniques to consider in the determination of BAT (as the BREF outline and guide was completed in November 2000, it was not available at the time of writing of some of the BREFs).

Table 1.2 shows the main waste water and waste gas pollutants covered by the series of chemical BREFs. Note that the list is applicable to the sectors as a whole. Other pollutants may be emitted and may be dealt with in the vertical BREFs, especially when describing specific products.

Table 1.3 shows the main issues reported in the concluding remarks of the series of chemical BREFs.

Sections 1.2.1, 1.2.2, 1.2.3, 1.2.4, 1.2.5, 1.2.6 and 1.2.7 give general descriptions of the industries covered in the series of chemical BREFs.

BREF	Date KOM/ final draft/ adoption	Number of pages[a]	Products/processes	Structure	Cross-references in BAT chapter	Outline and guide format (Nov 2000)
CWW	1999/ 2001/ 2003	341/472	Applies to the whole chemical sector	General approach	Yes*	Yes
CAK	1997/ 2000/ 2000	137/180	Mercury cell Membrane cell Diaphragm cell	General approach	Yes*	No
LVIC-AAF	2001/ 2006/ 2007	431/448	Ammonia Nitric acid Sulphuric acid Phosphoric acid Hydrofluoric acid NPK and CN Urea and UAN AN and CAN Superphosphates	Product approach	Yes	Yes
LVIC-S	2003/ 2006/ 2007	690/712	Soda ash Titanium dioxide Carbon black Synthetic amorphous silica Inorganic phosphates 17 illustrative processes[b]	Product approach	Yes	Yes
SIC	2003/ 2006/ 2007	328/348	Speciality inorganic pigments Phosphorus compounds Silicones SIC explosives Cyanides	Product approach	Yes	Yes
LVOC	1999/ 2001/ 2003	397/478	Lower olefins Aromatics Ethylene oxide and ethylene glycols Formaldehyde Acrylonitrile Ethylene dichloride and vinyl chloride monomer Toluene diisocyanate	Product approach	No	No
OFC	2003/ 2005 2006	437/456	Covers the sector as a whole	General approach	Yes	Yes
POL	2003/ 2006/ 2007	308/317	Polyolefins Polystyrene Polyvinyl chloride Unsaturated polyester Emulsion polymerised styrene butadiene rubber Solution polymerised rubber containing butadiene Polyamides Polyethylene terephthalate fibres Viscose fibres	Product approach[c]	Yes	Yes

a. X/Y, where X is the number of pages up to and including the concluding remarks and Y is the total number of pages (i.e. including also the Annexes, Glossary and References)
b. the following 17 so-called selected illustrative products were addressed at a lesser level of detail: aluminium fluoride, calcium carbide, carbon disulphide, ferrous chloride, copperas and related products, lead oxide, magnesium compounds, sodium silicate, silicon carbide, zeolites, calcium chloride, precipitated calcium carbonate, sodium chlorate, sodium perborate, sodium percarbonate, sodium sulphite and related products, and zinc oxide
c. the techniques to consider and BAT sections are covered together for all the processes
*not all BAT conclusions include cross-references to the chapter on techniques to consider in the determination of BAT

Table 1.1: Overview of the main characteristics of the series of chemical BREFs

Parameter	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Air emissions							
NH_3			X				
NO_X	X	X	X	X	X		
N_2O		X					
H_2	X		X				
F_2			X				
HF		X	X				
Cl_2	X		X				
HCl			X				
H_2S			X		X		
SO_2		X	X		X		
Heavy metals				X			
Hg	X						
VOC			X		X	X	X
CO			X				
CO_2			X				
Dust		X	X	X			
Asbestos	X						
Water emissions							
NH_3			X				
Nitrate				X			
Phosphate			X		X		
Sulphate	X		X	X			
Bromate	X						
Chlorate	X						
Chloride	X		X	X			
Fluoride			X				
Free oxidants	X						
Chlorinated hydrocarbons	X						
Metals	X						
Heavy metals			X		X	X	
Hg	X						
BOD					X		
COD				X	X		X
TOC			X		X	X	
AOX					X	X	
EOX					X		
Non-biodegradable organics						X	
Spent solvents					X	X	X
Volatile organics					X		
Oil					X		
Suspended solids	X		X		X		
Asbestos	X						

Table 1.2: Pollutants reported as main environmental issues for the vertical chemical BREFs

	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Data shortage on								
Performance/ operational conditions (at installation level)	X	X	X		X	X		
Comparable data				X		X		
Energy consumption	X				X	X		
Cross-media effects	X					X		
Costs	X	X	X	X	X	X	X	X
Best performers	X							
Emissions of chlorinated substances and free oxidants to water		X				X		
Diffuse/fugitive air emissions						X	X	
Releases of the sector as a whole						X	X	
VOC emissions						X	X	
Common pre-treatment options for WW						X	X	
Sludge treatment						X	X	
Heavy metals in waste water	X				X	X		
Water consumption					X	X		
Monitoring			X	X	X	X		
Generic BAT				X[(a)]		X		
Decommissioning	X	X	X	X[(a)]	X	X	X	X
Measurement of N total	X					X		
Toxicity/WEA						X	X	
Consensus								
High degree	X	X	X	X	X	X	X	X
Split views	X		X					X
a) good environmental practices (GEP) for the use of technology, plant design, maintenance, operation, environmental protection and plant decommissioning in the LVIC-S industry were developed and are included in the annexes of the document								

Table 1.3: Main issues reported in the concluding remarks of the series of chemical BREFs

1.2.1 Common Waste Water and Waste Gas Treatment/Management in the Chemical Sector BREF

[1, European Commission, 2003, 12, UMWELTBUNDESAMT, 2000]

Only commonly applied or applicable techniques for the chemical sector are dealt with in the document, leaving process-specific techniques or process-integrated techniques (e.g. water re-use, water saving and pollution prevention) to the vertical process BREFs. However, as this BREF applies to the chemical sector as a whole, it provides information and data useful when a relevant environmental issue is not specifically dealt with/addressed in the vertical chemical BREFs.

Although developed to apply to the chemical sector, it is recognised that the document also contains valuable information for other sectors (e.g. the refineries and the surface treatment using organic solvents sectors).

1.2.2 Chlor-Alkali (CAK) BREF

[4, European Commission, 2000]

The chlor-alkali industry is the industry that produces chlorine (Cl_2) and alkali, i.e. sodium hydroxide (NaOH) or potassium hydroxide (KOH), by the electrolysis of a salt solution. The main technologies applied for chlor-alkali production are mercury, diaphragm and membrane cell electrolysis, mainly using sodium chloride (NaCl) as the feed or, to a lesser extent, using potassium chloride (KCl) for the production of potassium hydroxide.

1.2.3 Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers (LVIC-AAF) BREF

[7, European Commission, 2006]

The fertiliser industry is essentially concerned with the provision of three major plant nutrients – nitrogen, phosphorus and potassium – in plant available forms. Often, a suitable combination of productions (and not only fertiliser production) is carried out on one integrated site, typically focused on the production of nitrogen-based fertilisers or phosphate fertilisers.

Although the main use of ammonia, nitric acid, sulphuric acid and phosphoric acid is the downstream production of fertilisers, the scope of the LVIC-AAF BREF is not restricted to the manufacture of fertiliser grade products. It also includes the production of synthesis gas for the production of ammonia and the production of sulphuric acid based on SO_2 gases from various processes.

1.2.4 Large Volume Inorganic Chemicals – Solids and Others (LVIC-S) BREF

[3, European Commission, 2006]

The BREF on the LVIC-S industry is a sister to the Chlor-Alkali (CAK), the Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers (LVIC-AAF), and the Speciality Inorganic Chemicals (SIC) BREFs.

A homogeneous and strictly defined LVIC-S industry does not really exist, and there are no clear borderlines between the above-mentioned four inorganic chemical sector groups and the four associated BREFs. However, the most typical characteristics of the LVIC-S industry are:

- medium to high levels of installed capacities and substantial production outlets of commodity products
- capital intensive, highly subject to the economies of scale
- substantial infrastructure involved
- diversified chains of production processes used jointly in integrated inorganic chemical complexes, thus allowing a heterogeneity of products and viability of production which is highly dependent on an integrated approach and economic outlets for co- and by-products to be obtained
- linkage to SIC installations. Small scale SIC installations are often offshoots of LVIC-S installations, the boundary being usually located in the product purification section of an LVIC-S installation.

The LVIC-S BREF gives a general illustration of the industry from the perspective of the EU chemical industry sector, and describes thoroughly the production of five cornerstone products (i.e. soda ash, titanium dioxide, carbon black, synthetic amorphous silica and inorganic phosphates). Due to the diversity of the LVIC-S processes, the BREF also addresses 17 selected illustrative products at a lesser level of detail (see Table 1.1).

1.2.5 Speciality Inorganic Chemicals (SIC) BREF

[6, European Commission, 2006]

The term "speciality inorganic chemical" is taken to mean an inorganic substance manufactured industrially by chemical processing, generally in relatively small quantities, according to specifications (i.e. purity) tailored to meet the particular requirements of a user or industry sector (e.g. pharmaceutical).

The SIC sector is characterised by its diversity and by its fragmentation. Thousands of SIC products are manufactured all over Europe using an immense range of raw materials and production processes. SIC installations are generally small to medium sized installations using mainly batch modes of operation, but also continuous modes of operation for parts of the process. Some SIC installations produce only one type of SIC while others are multipurpose plants capable of producing many different SIC. Companies of all sizes (from very large to very small) produce SIC at standalone installations or at installations that are part of a larger industrial complex.

The BREF examines the SIC sector as a whole as well as several chosen illustrative processes (see Table 1.1).

1.2.6 Large Volume Organic Chemicals (LVOC) BREF

[8, European Commission, 2002]

LVOC encompasses a large range of chemicals and processes. In very simplified terms it can be described as taking refinery products and transforming them, by a complex combination of physico-chemical operations, into a variety of "commodity" or "bulk" chemicals; normally in continuously operated plants. LVOC products are more commonly used in large quantities as raw materials in the further synthesis of higher value chemicals (e.g. solvents, plastics, drugs).

Due to the diversity of LVOC processes, the BREF does not give a very detailed examination of the whole LVOC sector. It does, however, make a good first attempt at defining BAT for the sector as a whole and for the chosen illustrative processes (see Table 1.1).

Figure 1.2 shows the relationship between the LVOC and the other vertical organic chemical BREFs (i.e. OFC and POL). It is worth noting that there are no absolute boundaries between these three BREFs.

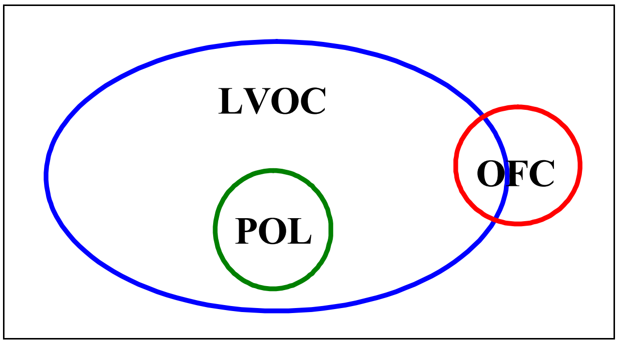

Figure 1.2: Boundaries between the LVOC and the other two vertical organic chemical BREFs
[15, Consultation group, 2007]

1.2.7 Organic Fine Chemicals (OFC) BREF

[2, European Commission, 2005]

Organic fine chemical manufacturers produce a range of chemical substances, which are typically of a high added value and produced in low volumes, mainly by batch processes in multipurpose plants. The organic fine chemicals covered in the OFC BREF include (this list is not exhaustive), e.g. dyes and pigments, plant health products and biocides, pharmaceutical products (chemical and biological processes), organic explosives, organic intermediates, specialised surfactants, flavours, fragrances, pheromones, plasticisers, vitamins, optical brighteners and flame-retardants.

These products are sold to companies, mostly other chemical companies, serving an immense range of end-user markets, on either a specification of purity or on their ability to deliver a particular effect.

1.2.8 Polymers (POL) BREF

[5, European Commission, 2006]

The POL BREF focuses on the principal products of the European polymer industry. The products are mainly produced in dedicated installations for the production of one specific polymer. The list of products covered is not exhaustive but includes polyolefins, polystyrene, polyvinyl chloride, unsaturated polyesters, emulsion polymerised styrene butadiene rubbers, solution polymerised rubbers containing butadiene, polyamides, polyethylene terephthalate fibres and viscose fibres (see Table 1.1).

Polymer companies produce a variety of basic products, which range from commodities to high added value materials and are produced in both batch and continuous processes.

2 TECHNIQUES TO CONSIDER IN THE DETERMINATION OF BAT

Table 2.1 shows the types of techniques (given in percentages) described in each chemical BREF, i.e. process-integrated or end-of pipe (differentiating from waste gas, waste water and waste treatment techniques). This is important in order to notice that many chemical vertical BREFs contain a lot of information and data on end-of-pipe techniques.

BREF	Total number of techniques	Process-integrated techniques[(a)] (%)	Total end-of-pipe (%)	End-of-pipe techniques (%)		
				Waste gas	Waste water	Waste
CWW	62	14	86	36	45	5
CAK	33	33	67	40	12	15
LVIC-AAF	130	48	52	30	12	10
LVIC-S	150	28	72	40	17	15
SIC	129	54	46	21	17	8
LVOC	202	28	72	40	14	18
OFC	140	48	52	12	35	5
POL	52	64	36	18	15	3
a) production, prevention, horizontal issues (%). Techniques to consider in the determination of BAT that refer to change of production system, prevention of emissions and energy efficiency						

Table 2.1: Number and types of techniques to consider for the determination of BAT in each chemical BREF
[10, European IPPC Bureau, 2007]

Table 2.2 and Table 2.3 show the section numbers of the techniques to consider in the determination of BAT described for the abatement of air and water pollutants in each of the documents across the series of chemical BREFs. The term "none" used in the tables means that no techniques to consider were reported in the BREF in question.

2.1 Overview of the techniques to consider in the determination of BAT for waste gas treatment in the chemical BREFs

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Fugitive/diffuse emissions	2.2.2.4.2	3.1.2.1.1 3.1.2.2.1 3.1.2.4.2.1 3.1.2.4.3 3.1.2.4.3.3 4.1.1 4.3.1	5.4.8 10.4.1	7.3.4.1 7.16.4.1 8.2.4	4.3.1 6.3.4.1 6.3.4.4 6.3.4.14 6.3.4.16	5.1.4 5.2.4 5.3.1.3 7.4.2 7.4.2.5 7.4.2.7 8.4.1.3 8.4.4.1.2 9.4.4.5 10.4.2 10.4.5.3 10.4.5.5 11.4.2.5 12.4.2.1 12.4.2.4 12.4.5 13.4.2.4 8.5.2	4.2.1 4.2.3 4.2.14 4.2.15 4.2.16 4.2.19 4.3.1.4 4.3.5.10	12.1.2 12.1.3 12.1.4 12.1.18 12.4.7 12.6
Dust/particulate matter (PM)	3.3.1.5 3.4.3 3.5.1.4 3.5.2.1 3.5.2.4 3.5.2.5 3.5.3.1 3.5.3.2	None	1.4.6 4.2.3.5 4.4.10 4.4.11 4.4.12 5.4.8 5.4.15 6.4.8	3.2.4.1.2 3.2.4.8 3.3.4.2 3.3.4.9 3.3.4.10.2 3.3.4.13 4.4.5 4.4.7	4.4.2.1 4.4.2.1.1 4.4.2.1.2 4.4.2.1.3 4.4.2.1.4 4.4.2.1.5 4.4.2.1.6 4.4.2.1.7	5.3 5.3.2 5.3.3 5.3.4 7.4.2.2 13.4.2	4.2.3 4.3.5.7 4.3.5.22	12.1.5 12.1.6 12.1.7 12.3.1 12.3.2 12.4.5 12.6

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Dust/particulate matter (PM) (continued)	3.5.3.3 3.5.3.4 3.5.3.5 3.5.3.6 3.5.3.7 3.5.3.8 3.5.3.9 3.5.3.10 3.5.4.1		7.4.2 7.4.3 7.4.4 7.4.6 7.4.10 8.4.6 8.4.11 9.4.6 10.4.2	5.4.2.2 5.4.3 6.2.4.4 6.4.4.1.1 6.4.4.1.2 6.4.4.2.2 6.4.4.2.4 7.1.4.1.3 7.2.4.1 7.2.4.2 7.2.4.3 7.2.4.5 7.2.4.6 7.2.4.7 7.4.4.1 7.5.3.4.1 7.6.4.1 7.7.4.1 7.7.4.2 7.8.4.1 7.9.4.5 7.10.4.2 7.11.4.2 7.11.4.3 7.13.4.5.1 7.14.4.6 7.15.4.3 7.16.4.3 7.17.4.1 7.17.4.2.1 7.17.4.2.2 7.17.4.2.3 7.17.4.2.4 7.17.4.2.5 7.17.4.3 8.2.3.7 8.2.4	4.4.2.1.8 4.4.2.1.9 4.4.2.2.4 6.3.4.1 6.3.4.3 6.3.4.17			

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Odour	3.3.4.3.1 3.3.4.3.2 3.3.4.3.3 3.4.1 3.4.2 3.4.3 3.5.1.2 3.5.1.3 3.5.1.4 3.5.2.1 3.5.2.2 3.5.2.3 3.5.2.5	3.12	1.1.2.5 5.4.9 7.4.1	6.4.4.2.2	4.4.2.2.2 4.4.2.2.3 4.4.2.2.4	5.1.5 5.1.8 5.2.4 5.3 5.3.1.1 5.4.2 10.4.5.3	4.1.3 4.3.5.14 4.3.5.15	12.5.3
Flaring	3.5.2.6	None	2.4.25 5.4.15	4.4.1 4.4.3 7.2.4.5 8.6.2	2.5.2	5.1.4 5.3.1.1 5.3.1.2 5.3.1.3.1 5.3.1.3.7 5.3.1.4 5.3.4 5.8 7.4.2 7.4.2.3 7.4.2.4 7.4.2.6 7.4.3.2 8.4.1.2 8.4.4.1.1 8.4.4.1.2 8.4.4.2 8.4.4.4 9.4.4.2 9.4.4.4 9.4.4.6 11.4.2.4 11.4.5 13.4.2.3	None	12.1.9 12.1.10 12.2.1 12.2.3.2 12.2.3.5 12.3.3
Choice of waste gas treatment system(s)	2.2.2.3.2	None	None	3.3.4.7 3.3.4.11 6.2.4.4	4.4.1.1	5.3	None	None

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Collection system	2.2.2.4.2	None	7.4.8	3.2.4.1.2 4.4.7 5.4.2.2 6.2.4.4 7.2.4.1 7.2.4.6 7.7.4.1 7.9.4.2 7.9.4.3 7.13.4.5.1 7.16.4.1 7.16.4.3	3 4.4.2.1.7	3.6 4.1.1 5.3.1.3.7 5.4 6.3 7.5.2 8.4.2 12.4.2.1	4.3.1.8 4.3.5.7 4.3.5.18	2.3.2.1 2.3.7 2.4.1
Minimisation of exhaust gas volume flows and loads	2.2.2.4.2	None	1.4.4 2.4.2 2.4.4 6.4.6 7.4.6 9.4.5	None	None	None	4.2.16 4.2.17 4.2.18 4.2.20 4.3.1.7 4.3.5.16 4.3.5.17 4.3.5.18	None
Organic pollutants								
Dioxins (chlorinated/halogenated organic compounds)	3.5.1.3 3.5.3.6	4.1.1	4.4.11	None	3.1 4.4.2.2.7 6.3.4.8 7.2	5.3.1.1 5.3.5 12.4.1.2 12.4.2 12.4.2.3 12.4.2.4	4.3.2.5 4.3.2.10 4.3.5.7 4.3.5.8 4.3.7.2	12.1.9

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
VOCs (recovery/abatement)	3.3.4.1.6 3.3.4.2.15 3.5.1.1 3.5.1.2 3.5.1.3 3.5.1.4 3.5.2.1 3.5.2.2 3.5.2.3 3.5.2.4 3.5.2.5 3.5.2.6 3.5.3.4 3.5.3.6 3.5.3.9	None	3.4.8 4.4.11	4.4.3	4.4.2.1.3 4.4.2.1.8 4.4.2.2.1 4.4.2.2.2 4.4.2.2.3 4.4.2.2.6 4.4.2.2.7 4.4.2.2.8 6.3.4.4 6.3.4.8 6.5.4.2	5.3 5.3.1 7.4.2 7.4.2.4 8.4.1.2 8.4.1.3 9.4.4.1 9.4.4.3 9.4.4.4 9.4.4.5 9.4.4.6 10.4.5.1 10.4.5.3 10.4.5.4 13.4.2	4.1.3 4.1.4.7 4.1.4.9 4.1.4.10 4.1.5.1 4.2.1 4.2.4 4.2.13 4.2.14 4.2.15 4.2.19 4.2.20 4.2.24 4.3.1.4 4.3.1.8 4.3.2.1 4.3.2.2 4.3.2.3 4.3.2.5 4.3.2.6 4.3.2.7 4.3.2.8 4.3.2.9 4.3.2.10 4.3.5.2 4.3.5.6 4.3.5.7 4.3.5.10 4.3.5.13 4.3.5.14 4.3.5.15 4.3.5.17 4.3.5.18 4.3.5.19	12.1.2 12.1.3 12.1.5 12.1.6 12.1.9 12.2.1 12.2.2 12.2.3.1 12.2.3.4 12.4.8 12.5.1

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Inorganic pollutants								
HCN (hydrogen cyanide)	None	None	None	4.4.1 4.4.3	4.4.2.2.5 4.4.3.1 6.5.4.1 6.5.4.4	5.3.4 11.4.1.2 11.4.1.3 11.4.1.4 11.4.2.4 11.4.2.5	4.3.5.17 4.3.6.1 4.3.6.2	None
NH_3 (ammonia)	3.5.1.2 3.5.1.4 3.5.2.2 3.5.2.3 3.5.3.4 3.5.4.2	4.1.1	1.4.2 1.4.6 2.4.10 2.4.22 7.4.2 7.4.3 7.4.4 7.4.10 8.4.5 8.4.9 8.4.10 8.4.11 8.4.13 9.4.1	2.4.1 2.4.6 4.4.1 4.4.3 8.2.3.5	4.4.2.1.3 4.4.2.2.4 4.4.2.2.5 6.5.4.4	7.4.2.1.1 7.5.4.1	4.2.30 4.3.1.8 4.3.5.7 4.3.5.17 4.3.5.20	None

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
NO_x/NO_2 (nitrogen oxides)	3.5.2.6 3.5.4.2	4.1.4	1.4.7 2.4.1 2.4.2 2.4.3 2.4.4 2.4.5 2.4.10 2.4.13 2.4.22 2.4.23 3.4.4 3.4.7 3.4.8 3.4.9 3.4.10 3.4.11 4.4.17 5.4.15 7.4.1 7.4.2 7.4.9 7.4.10 7.4.11	2.4.2 2.4.5 3.2.4.12 3.3.4.2 3.3.4.10.2 3.3.4.13 4.4.1 4.4.4 4.4.5 5.4.2.2 7.5.4.4.1 7.7.4.3 7.8.4.3 7.9.4.4 7.13.4.1 7.13.4.2 7.17.4.1 7.17.4.2.1 7.17.4.2.2 7.17.4.2.3 7.17.4.2.4 7.17.4.2.5 7.17.4.3 8.2.3.4	4.4.2.3.2	5.3 5.3.2 5.3.4 7.4.2 7.4.2.1 7.4.2.1.1 8.4.1.1 8.4.4.1.1 8.4.4.2 9.4.4.2 10.4.5.1 12.4.2.3 13.4.2	4.2.4 4.3.2.5 4.3.2.6 4.3.5.1 4.3.5.2 4.3.5.7 4.3.5.17 4.3.5.19	None
HF (hydrogen fluoride)	3.5.1.4 3.5.3.4 3.5.4.1	None	4.4.11 6.4.6 6.4.7 7.4.9 7.4.10	6.2.4.2 6.2.4.3 7.1.4.2 7.1.4.3 7.8.4.5	4.4.2.1.3 4.4.2.2.4 4.4.2.3.1 6.1.4.3	None	None	None

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
HCl (hydrogen chloride)	3.5.3.4 3.5.4.1	4.2.2	4.4.11	3.2.4.2 3.2.4.5 5.4.1.1 5.4.1.2 5.4.1.3 5.4.1.4 7.7.4.1 7.7.4.2 7.8.4.4 7.8.4.5 7.11.4.3 8.2.3.2	4.4.2.1.3 4.4.2.2.4 4.4.2.2.7 4.4.2.3.1 6.2.4.5 6.2.4.6	5.3.4 12.4.1.2 12.4.2.1 12.4.2.3 12.4.2.4 13.4.2	4.3.18 4.3.2.4 4.3.2.5 4.3.2.8 4.3.2.10 4.3.5.2 4.3.5.3 4.3.5.7 4.3.5.14 4.3.5.17	None
Cl_2 (gaseous chlorine)	3.5.1.4 3.5.2.2 3.5.2.3	3.1.2 3.1.2.2.1 3.1.2.4.3.1 4.1.1 (safety measures) 4.1.2 4.1.6 4.2.1 4.2.2	None	3.2.4.1.4 3.2.4.5 3.2.4.7 3.2.4.9 5.4.1.1 5.4.1.2 5.4.1.3 7.5.5.4.1 7.13.4.3 7.13.4.5.1 8.2.3.1	4.4.2.2.4 6.4.4.2	12.4.2.4	4.3.2.5 4.3.2.10 4.3.5.2 4.3.5.7 4.3.5.17	None
HBr/Br_2 (hydrogen bromide)	None	None	None	None	None	None	4.3.2.5 4.3.5.4 4.3.5.7 4.3.5.17	None
H_2S (hydrogen sulphide)	3.5.2.2	None	2.4.9 2.4.18	3.3.4.3 3.3.4.10.1 4.4.3 7.3.4.1 7.9.4.1 7.9.4.2 7.16.4.1 7.16.4.2 7.16.4.4	4.4.2.2.3 4.4.2.2.4 6.1.4.6	5.3 5.4.2 7.4.2.6 7.4.3.2 7.4.3.3 8.4.4.2	4.3.5.17	12.7.2 12.7.3.1 12.7.3.2 12.7.4.1

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Sulphur oxides, e.g. SO_2 (sulphur dioxide), SO_3 (sulphur trioxide)	3.5.1.4 3.5.2.6 3.5.3.4 3.5.4.1 3.5.4.2	None	4.4.1 4.4.2 4.4.3 4.4.4 4.4.5 4.4.6 4.4.8 4.4.9 4.4.10 4.4.12 4.4.13 4.4.14 4.4.16 4.4.19 4.4.20 4.4.21 4.4.22 5.4.15 6.4.6 6.4.7	2.4.2 2.4.5 3.2.4.1.3 3.2.4.5 3.2.4.12 3.3.4.2 3.3.4.10.1 3.3.4.10.2 3.3.4.13 4.4.2 4.4.3 4.4.5 5.4.2.2 7.3.4.1 7.5.6.4.1 7.5.6.4.2 7.7.4.1 7.7.4.2 7.8.4.2 7.8.4.5 7.9.4.1 7.9.4.2 7.13.4.1 7.13.4.2 7.16.4.1 7.16.4.2 7.16.4.4 7.17.4.1 7.17.4.2.1 7.17.4.2.2 7.17.4.2.3 7.17.4.2.4 7.17.4.2.5 7.17.4.3 8.2.3.3	4.4.2.1.3 4.4.2.2.4 4.4.2.3.1 4.4.2.3.3	5.3 5.3.4 7.4.2 7.4.2.1 7.4.2.1.4 7.4.2.6 7.4.3.2 8.4.1.1 13.4.2	4.2.4 4.3.2.6 4.3.2.8 4.3.2.9 4.3.2.10 4.3.5.2 4.3.5.7 4.3.5.17 4.3.5.21	12.7.4.2

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
CO (carbon monoxide)	3.5.2.4 3.5.2.5 3.5.2.6	None	2.4.3 2.4.19 2.4.25 3.4.8 4.4.11 5.4.15	3.2.4.2 3.2.4.5 7.2.4.1 7.2.4.2 7.2.4.3 7.2.4.5 7.7.4.3 7.9.4.2 8.2.3.8	4.4.2.2.8	7.4.2.1.2 7.4.2.2 8.4.1.1 10.4.4 10.4.5.1 11.4.2.1 12.4.2.4 13.4.2 13.4.2.1 13.4.5	4.3.5.2 4.3.5.7	None
Mercury (Hg)	3.5.1.3 3.5.1.4	3.1.2.1 3.1.2.1.1 3.1.2.1.5 4.2.1 4.2.1.1 4.2.2 4.2.3	4.4.11 4.4.23	None	4.4.2.2.3 4.4.2.2.4 6.5.4.10	None	4.3.5.17	None
Asbestos (including replacement of asbestos)	None	3.1.2.2.1 4.3.1 4.3.2 4.3.3	None	None	None	None	None	None

Table 2.2: Overview of the section numbers of the techniques to consider in the determination of BAT for waste gas treatment across the series of chemical BREFs

2.2 Overview of the techniques to consider in the determination of BAT for waste water treatment in the chemical BREFs

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Minimisation of water consumption	2.2.1.2.2 2.2.1.3 2.2.2.3.1	None	1.4.1 8.4.7 8.4.12	2.4.7.3 8.3.4.1	6.2.4.1 6.2.4.3 6.4.4.2	5.4.1 7.4.3.5	4.2.22	12.2.6 12.6
Minimisation of volume and load of waste water	3.3.1.2	None	7.4.11 8.4.1 10.4.4	2.4.6 2.4.7.1 2.4.7.3 2.4.7.4 2.4.7.5 3.2.4.10.3 3.3.4.11 7.14.4.7 7.15.4.4 8.3.4.2 8.8.3.1	4.3.3 4.4.1.1 4.4.1.2 6.3.4.10	5.4	4.2.4 4.2.9 4.3.5.9	12.1.16 12.4.1 12.6.1
Diffuse emissions (including avoidance/prevention)	3.3.4.4.1	3.1.2.1.2 4.2.1 4.2.1.2	5.4.8 8.2.2 10.4.1	2.4.7.4 7.6.2.3 7.3.4.1 7.2.3.1 7.3.5 8.2.4 11.3.5	4.7.4	5.1.4 5.2.4	4.3.7.18 4.3.7.19 4.3.7.20	None
Total suspended solids (TSS)	3.3.4.1.2 3.3.4.1.3 3.3.4.1.4 3.3.4.1.5 3.3.4.2.9 3.3.4.3.3 3.3.4.3.5 3.3.4.4.2 3.4.3	3.1.2.4.5	5.4.2	2.4.4 2.4.7.1 2.4.7.2 2.4.7.3 2.4.7.4 2.4.7.5 3.2.4.5 3.3.4.11.1 3.3.4.11.2 7.10.4.1 7.12.4.4 7.16.4.4 8.3.4.4.2	4.4.1	5.4.1 12.4.3	4.3.7.4 4.3.8.7 4.3.8.21	4.3.1 4.3.2 5.3 5.3.4 7.2

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Collection and treatment of rainwater	3.3.3 3.3.4.1.1 3.3.4.1.2 3.3.4.4.1 3.3.4.4.2	3.1.2.1.2	5.4.13	2.4.7.4 7.6.4.2 8.3.4.1 8.3.4.2 8.3.4.3.2	4.4.1.1.1 4.7.4	5.2.4 5.3.1.2 5.4.1 5.4.2 8.4.2 8.4.4.2 10.4.6	4.2.28 4.3.7.5	5.1
Segregation, collection and allocation of waste water streams	2.2.2.3.1 2.2.2.4.1	4.1.1	5.4.13 7.4.8	2.4.7.4 3.3.4.7 7.1.4.2 7.9.4.6 7.12.4.4 7.13.4.5.2 8.3.4.1 8.3.4.2 8.3.4.3	4.4.1.2.5 4.7.1 4.7.4 6.4.4.3 6.4.4.5 6.5.4.3	5.4	4.2.21 4.3.1.2	12.1.8 12.4.1
Biological treatment	3.3.4.3.1 3.3.4.3.2 3.3.4.3.3 3.3.4.3.4 3.3.4.3.5	None	5.4.15 7.4.12 8.4.12 9.4.4	8.3.4.4.3	4.4.1 4.7.4 6.1.4.8 6.3.4.9	5.4.2 5.4.3 7.4.3.1 7.4.3.2 7.4.3.5 8.4.2 8.4.4.4 9.4.5.1 10.4.6 11.4.3 12.4.3 13.4.3	4.2.3 4.2.21 4.2.24 4.3.1.3 4.3.2.1 4.3.2.2 4.3.2.3 4.3.2.4 4.3.2.5 4.3.2.7 4.3.2.8 4.3.2.9 4.3.2.10 4.3.2.11 4.3.5.9 4.3.5.11 4.3.5.15 4.3.6.2 4.3.7.1 4.3.7.2 4.3.7.3 4.3.7.4 4.3.7.5 4.3.7.6 4.3.7.7	12.1.18 12.5.2 12.5.3 12.7.9

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Biological treatment (continued)							4.3.7.8 4.3.7.9 4.3.7.14 4.3.7.15 4.3.7.16 4.3.7.18 4.3.7.19 4.3.7.20 4.3.7.22 4.3.7.24 4.3.8.2 4.3.8.3 4.3.8.4 4.3.8.6 4.3.8.7 4.3.8.8 4.3.8.9 4.3.8.10 4.3.8.11 4.3.8.12 4.3.8.13 4.3.8.14 4.3.8.15 4.3.8.16 4.3.8.17 4.3.8.18 4.3.8.19 4.3.8.20 4.3.8.21	

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Sludge treatment	3.4.1 3.4.2 3.4.3	3.1.2.4.4	4.2.3.6	6.4.4.2.5 7.2.4.4 7.2.4.7 7.12.4.2 7.13.4.6	4.4.4.1 4.4.4.2 4.4.4.3 6.1.4.5 6.1.4.7 6.1.4.9 6.1.4.10 6.3.4.9	3.4.1 3.5.2 3.5.4 3.7 3.9 4.2.1 4.3 4.3.2 5.2.4 5.4 5.4.2 5.5.1 6.5 7.2.5 7.3.3 7.3.4 7.3.6.2 7.4.4 7.5.6 8.2 8.3.5 8.4.4.1.2 8.5.4 10.3.4 11.3.3.3 11.3.4 11.3.5 11.4.3 12.2.8 12.3.5 12.4.3 12.4.4 12.5.6 13.4.3	4.3.7.4 4.3.7.22 4.3.8.4	12.1.18 12.7.6
Waste water discharge to surface water	3.3.2 3.3.4.3.4	3.1.2.4.1	6.4.3 9.4.4	2.4.7.4 7.13.4.5.2	3.2	10.4.6	None	None

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Organic pollutants								
Sum parameters – organic traces (BOD/COD/TOC)	3.3.4.1.2 3.3.4.1.3 3.3.4.2.3 3.3.4.2.4 3.3.4.2.7 3.3.4.2.8 3.3.4.2.9 3.3.4.2.14 3.3.4.2.15 3.3.4.3.1 3.3.4.3.2 3.3.4.3.3 3.3.4.3.4 3.3.4.3.5 3.3.4.4.2 3.4.3 3.5.4.1	4.1.5 4.2.1.2 4.3.2	6.4.7	8.3.4.4.3	4.4.1.2.3 4.4.1.2.6 6.1.4.10 6.3.4.9 6.3.4.10 6.4.4.3	5.4 5.4.2 11.4.3 12.4.3 12.4.3.1 12.4.7 13.4.3	4.2.4 4.2.5 4.2.23 4.2.24 4.2.26 4.2.28 4.3.1.1 4.3.1.2 4.3.1.3 4.3.1.5 4.3.2.1 4.3.2.2 4.3.2.3 4.3.2.4 4.3.2.5 4.3.2.6 4.3.2.7 4.3.2.8 4.3.2.9 4.3.2.10 4.3.2.11 4.3.5.2 4.3.5.9 4.3.6.1 4.3.6.2 4.3.7.1 4.3.7.2 4.3.7.3 4.3.7.4 4.3.7.5 4.3.7.6 4.3.7.7 4.3.7.8 4.3.7.9 4.3.7.10 4.3.7.11 4.3.7.12	12.1.18 12.5.2 12.5.3 12.7.9

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Sum parameters – organic traces (BOD/COD/TOC) (continued)							4.3.7.13 4.3.7.16 4.3.7.18 4.3.8.2 4.3.8.3 4.3.8.5 4.3.8.8 4.3.8.9 4.3.8.10 4.3.8.11 4.3.8.20 4.3.8.21	
Hydrocarbons (e.g. PAH)	3.3.4.2.3 3.3.4.2.14	3.1.2.4.2.2 3.2	2.3.4 2.4.14 3.4.8 4.2.3.6	3.2.4.6	3.2 4.4.2.2.6 6.3.2.5 6.3.3.2 6.3.3.3 6.3.3.4.2 6.3.4.4 6.3.4.8 6.3.5 7.2	5.4.2	4.3.7.18 4.3.7.19	12.5.2 12.5.3
Halogenated organic compounds (halides)	3.3.4.2.3 3.3.4.2.5 3.3.4.2.15	3.1.2.4.2.2	None	2.4.7 2.4.7.1 2.4.7.2 2.4.7.4 2.4.7.5 3.2.4.10.3 3.6 5.3.4 6.4.4.2.1 6.4.4.2.3 7.1.4.2 7.4.4.1 7.11.4.1 12.4.3.1 12.5.6	None	12.4.3 12.4.3.1	4.3.1.6 4.3.2.4 4.3.2.5 4.3.2.7 4.3.7.1 4.3.7.2 4.3.7.9 4.3.7.14 4.3.7.15 4.3.7.16 4.3.7.17	12.4.1 12.4.2 12.4.3 12.4.4 12.4.6 12.4.7 12.4.8

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
AOX (absorbable organic halogen)	3.3.1.7 3.3.4.2.3 3.3.4.2.4 3.3.4.2.9 3.3.4.2.11 3.3.4.3.3 3.3.4.3.5	4.2.1.2	None	3.2 3.3 3.4.9 3.5.6 3.6 4.2.2 5.4 5.4.2 6.5 12.3.3 12.4.2.4 12.4.3.1 12.4.7	4.4.3.1 6.5.4.1	5.4 5.4.2 12.4.3.1	4.2.3 4.3.1.1 4.3.1.2 4.3.1.6 4.3.2.1 4.3.2.3 4.3.2.4 4.3.2.5 4.3.2.7 4.3.2.8 4.3.2.10 4.3.5.2 4.3.6.1 4.3.6.2 4.3.7.1 4.3.7.2 4.3.7.3 4.3.7.4 4.3.7.5 4.3.7.6 4.3.7.8 4.3.7.9 4.3.7.14 4.3.7.15 4.3.7.16 4.3.7.17 4.3.8.5 4.3.8.6 4.3.8.12 4.3.8.21	11.3 13.4
Phenols and benzene	3.3.4.2.3 3.3.4.2.4 3.3.4.2.5 3.3.4.2.8 3.3.4.2.9 3.3.4.2.10 3.3.4.2.11 3.3.4.2.12 3.3.4.2.14 3.3.4.3.3 3.3.4.3.4 3.3.4.3.5	None	None	None	None	7.4.2.4 7.4.3.1 7.4.3.2	4.3.2.6 4.3.5.2 4.3.5.17 4.3.7.1	None

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Solvents	3.3.4.2.11	4.1.1	2.3.3 2.4.11	3.3.3.6	2.6.7 3.3 4.4.2.2.4 4.4.2.2.6 6.3.2.1 6.3.2.8.2 6.3.3.1	4.3.1 2.1.4	4.3.7.4 4.3.7.18 4.3.7.19 4.3.8.2 4.3.8.10	3.2.3.1.2 8.2 12.1.3 12.1.4 12.1.6 13.7 12.1.7 12.2.3 12.2.3.1 12.2.3.4 12.2.3.5
Separation of solvents from WW Re-use, recovery and disposal of solvents	3.3.1.4 3.3.1.6 3.3.4.2.11 3.3.4.2.12 3.3.4.2.14	None	2.3.3	3.3.3.6 3.2.3.1	2.6.7 4.4.2.2.4 4.4.2.1.3	7.4.3.2 13.4.3	4.2.1 4.2.5 4.2.7 4.2.12 4.2.13 4.3.1.4 4.3.2.5 4.3.3 4.3.4 4.3.5.7 4.3.5.8 4.3.5.15 4.3.7.6	3.2.3.1.2 3.2.3.1.2.2 8.2 12.1.3 12.1.4 12.1.6 12.1.7 12.2.3 12.2.3.1 12.2.3.4 12.2.3.5 13.7
Inorganic pollutants								
Cyanides (e.g. HCN/CN)	3.3.4.2.3 3.3.4.2.7 3.3.4.3.3 3.3.4.3.4	None	None	4.4.3 4.4.1	4.4.1.2.3 4.4.3.1 6.5.4.1 6.5.4.3 6.5.4.7	11.4.3 11.4.5	4.3.6.1 4.3.6.2 4.3.7.3 4.3.7.4 4.3.7.5	None
Ammonia (NH_3)	3.3.4.2.9 3.3.4.2.14 3.3.4.3.4	4.1.1	2.4.16 8.4.12 8.4.13 9.4.4	2.4.6	4.4.1.2.9	5.4.2 11.4.3 12.4.3	4.3.5.11	None
Nitrates (NO_3^-)/nitrites (NO_2^-)	3.3.4.2.4 3.3.4.2.6 3.3.4.2.10 3.3.4.3.2 3.3.4.3.3 3.3.4.3.4	None	9.4.1	None	6.1.4.8	None	4.3.5.2 4.3.7.4 4.3.8.8 4.3.8.14 4.3.8.21	None

Achieved environmental benefit/pollutant abated/removed	CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Phosphates	3.3.4.2.1 3.3.4.2.2 3.3.4.2.7 3.3.4.2.9 3.3.4.3.5 3.3.4.4.2	None	5.4.9 5.4.10 5.4.12 5.4.15	6.4.3 6.4.4 6.4.4.1.1 8.3.3.3 8.3.4.4.3	4.4.1.2.1 4.4.1.2.6	None	4.1.4.3 4.3.1.2 4.3.5.2 4.3.7.24 4.3.8.5 4.3.8.6 4.3.8.16 4.3.8.17 4.3.8.21	None
Sulphates (SO_4^{2-})	3.3.4.2.1 3.3.4.2.2 3.3.4.2.10 3.3.4.3.2	4.1.5 4.3.3	None	3.3.3.4 3.3.3.6 3.3.4.7 3.3.4.11 5.4.2.1 8.3	4.4.1.2.1	7.4.2.6 7.4.3.2 13.4.3	None	12.7.5 12.7.7 12.7.9
Bromides and chlorides	3.3.1.5 3.3.4.2.1	3.1.2.4.2.2 4.1.5	9.4.1	2.4.7.2 2.4.7.3 3.2.4.10.3 7.13.4.5.2 7.17.4.3 8.3.3.1 8.3.4.2 8.3.4.3.1	6.3.4.10	None	4.1.4.3 4.3.1.2 4.3.7.2 4.3.7.4	None
Chlorine (dissolved gas Cl_2)	3.3.1.6 3.3.4.2.6	3.1.2.4.2.2 4.1.5	None	3.2.4.1.4	4.4.1.2.4	None	None	None
Other inorganic salts and/or acids (except heavy metal salts, ammonium salts and other salts mentioned separately)	None	None	6.4.9	2.4.7.2	None	7.4.3.5	4.2.1 4.2.4 4.2.24 4.2.26 4.3.2.4 4.3.2.8 4.3.6.1 4.3.7.2	12.7.4.1 12.7.5
Asbestos	None	3.1.2.2.2 4.3.1 4.3.2 4.3.3	None	None	None	None	None	None

Achieved environmental benefit/pollutant abated/removed		CWW	CAK	LVIC-AAF	LVIC-S	SIC	LVOC	OFC	POL
Metals	Heavy metals (as a whole)	5.2.4 5.4 5.4.2 12.4.6	3.1.2.4.2.2 4.1.5	5.4.14 5.4.15 9.4.1	2.4.7.1 2.4.7.2 2.4.7.4 3.2.4.10.3 6.3.4.1 6.4.4.2.5 8.3.3.6 8.3.4.4.1	4.3.3 4.4.1.1.1 4.4.1.1.2 4.4.1.1.3 4.4.1.1.4 4.4.1.2.1 4.4.1.2.2 4.4.1.2.5 4.4.1.2.6 4.4.1.2.7 4.4.1.2.8 4.4.1.2.10 6.1.4.8 6.1.4.9 6.1.4.10 6.3.4.9 6.4.4.1 6.5.4.10	4.3.1.4 4.3.2.4 4.3.7.3 4.3.7.4 4.3.7.7 4.3.7.21 4.3.7.22 4.3.8.1	None	3.3.4.2.9
	Chromium (Cr)	5.4.1	None	9.4.1	None	6.1.4.5 6.1.4.10	4.3.2.4 4.3.1.2 4.3.7.22 4.3.8.1	None	3.3.4.2.1 3.3.4.2.6 3.3.4.2.10
	Mercury (Hg)	None	3.1.2.1.2 3.1.2.1.5 4.2.1 4.2.1.2 4.2.2 4.2.3	5.4.14 5.4.15 9.4.1	3.3.4.11.1 3.3.4.11.2	4.4.1.2 6.5.4.10	4.3.7.22	None	3.3.4.1.2 3.3.4.2.1 3.3.4.2.8 3.3.4.2.10 3.3.4.3.4
Note: the list of techniques used for the reduction of the emissions of halides, chlorides and inorganic salts may partially overlap									

Table 2.3: Overview of the section numbers of the techniques to consider in the determination of BAT for waste water treatment across the series of chemical BREFs

3 BEST AVAILABLE TECHNIQUES FOR WASTE WATER AND WASTE GAS TREATEMENT

The BAT chapters are described differently in each BREF. The most recent documents number the conclusions and even have subsections for the diverse processes/products described. This makes conclusions easier to locate. Older documents tend to list the conclusions with no further structural division within the chapter.

Table 3.1 and Table 3.2 show the section numbers of the BAT described for the abatement of air and water pollutants in each of the documents across the series of chemical BREFs. The term "none" used in the tables means that no BAT was determined by the TWG during the development of the BREF in question.

Section 3.3 shows specific information on the BAT described for waste water and waste gas abatement in each BREF.

3.1 Overview of the BAT conclusions for waste gas treatment in the chemical BREFs

Achieved environmental benefit/pollutant abated/removed	CWW	CAK[(b)]	LVIC-AAF	LVIC-S[(c)]	SIC[(d)]	LVOC	OFC	POL[(c)]
Fugitive/diffuse emissions	None	None	None	7.3.5(1) 7.16.5	5.12 5.13 6.1.4 6.1.5 6.1.6 6.3.1	6.3 7.5.2 7.5.3 7.5.4.6 8.5.2 9.5.3 9.5.4 10.5.3 11.5.3 12.5.3	5.1.2.1	13.1(2) 13.1(3) 13.2(6) 13.4(8) 13.6(2)
Dust/particulate matter (PM)	4.3.2 Table 4.9* Table 4.11*	None	5.5* 6.5*[(a)] 7.5* 8.5* 9.5* 10.5	2.5* 3.5.1(10,12,14*) 3.5.2(3,14,16,18*) 4.5(6*) 5.5.1(4*) 5.5.2(1-2*) 6.5.1(4*) 6.5.2(3*) 6.5.3.1(4*) 6.5.3.2(4*) 7.1.5* 7.2.5(3*,4*,5*,6*) 7.4.5(1*) 7.5.3.5* 7.5.4.5(2*) 7.5.6.5(4*) 7.6.5(1*) 7.7.5(1*) 7.8.5(1*) 7.9.5* 7.10.5* 7.11.5* 7.12.5 7.13.5* 7.14.5* 7.15.5* 7.16.5* 7.17.5*	5.6* 5.12 6.1.4 6.1.5 6.1.6 6.1.8* 6.3.1 6.3.3* 6.4.4	6.4* 7.5.4.2	5.2.3.6*	13.1(5) 13.2(6*) 13.3(6*) 13.4(6)
Odour	4.3.1 Table 4.10*	None	None	6.5.3.2 7.16.5	None	6.4*	5.2.3.1.3	None

Achieved environmental benefit/pollutant abated/removed	CWW	CAK[b]	LVIC-AAF	LVIC-S[c]	SIC[d]	LVOC	OFC	POL[e]
Flaring	4.3.2	None	None	4.5(4,5) 7.2.5(3)	None	6.3 6.4* 7.5.2 7.5.4.3* 7.5.4.4 7.5.5.2 8.5.2 9.5.3* 9.5.4* 11.5.2 11.5.3 11.5.5	None	13.1(11/12)
Choice of waste gas treatment system(s)	4.2	None	None	None	6.1.7 6.1.9 6.1.10	6.4*	None	None
Collection system	4.2	III	None	4.5(6) 5.5.2(1) 7.2.5(3) 7.9.5	None	None	5.1.2.4.1	None
Minimisation of exhaust gas volume flows and loads	4.3.2	None	9.5	None	6.2.7 6.5.5	None	5.1.2.4 5.2.1.1.5	None
Organic pollutants								
VOCs (recovery/abatement)	4.3.2 Table 4.9* Table 4.10*	None	None	None	6.3.12 6.5.2* 6.5.3	6.4* 8.5.2 9.5.3 11.5.3 12.5.3 13.5*	5.1.2.1 5.1.2.3 5.2.1.1.1 5.2.3.1*	13.2(2/6*) 13.3(6*) 13.5(3*) 13.6(8*)
Dioxins (chlorinated/halogenated organic compounds)	Table 4.10* Table 4.11*	None	None	None	5.6	6.4* 12.5.2* 12.5.3*	None	None

Achieved environmental benefit/pollutant abated/removed	CWW	CAK[(b)]	LVIC-AAF	LVIC-S[(c)]	SIC[(d)]	LVOC	OFC	POL[(c)]
Inorganic pollutants								
HCN (hydrogen cyanide)	4.3.2	None	None	None	5.7 6.5.2* 6.5.4	11.5.2 11.5.3	5.2.3.7*	None
NH_3 (ammonia)	4.3.2 Table 4.10 Table 4.11*	None	2.5 7.5* 8.5* 10.5*	2.4.6 7.16.5(1*)	5.8* 6.5.2* 6.5.4	6.4*	5.2.3.4.1* 5.2.3.4.2*	None
NO_x/NO_2 (nitrogen oxides)	4.3.2 Table 4.11*	None	2.5* 3.5* 4.5 7.5*	3.5.2(18) 4.5(5*) 7.6.5* 7.7.5* 7.8.5* 7.15.5*	6.5.2* 6.5.5	6.4* 7.5.4.1* 8.5.2 10.5.3* 12.5.2 13.5	5.2.3.1.3 5.2.3.2*	13.5(3*)
HF (hydrogen fluoride)	4.3.2 Table 4.10* Table 4.11*	None	5.5* 6.5* 7.5* 10.5*	6.5.1(4*) 6.5.2(3*) 7.1.5(1*) 7.8.5 (4*,5*)	6.1.7	None	None	None
HCl (hydrogen chloride)	4.3.2 Table 4.10* Table 4.11*	None	7.5* 10.5*	3.5.1(14*) 5.5.1(2*) 6.5.3.2(5*) 7.7.5 7.8.5(4*) 7.11.5(1*)	5.9* 6.1.7 6.1.9 6.2.7*	6.4* 12.5.2* 12.5.3* 13.5*	5.2.3.1.3 5.2.3.3*	None
Cl_2 (gaseous chlorine)	4.3.2	II*	None	3.5.1(11) 5.5.1(1*) 7.5.5.5* 7.8.5(4) 7.13.5(5*)	6.4.4.2	12.5.3	5.2.3.3*	None
HBr/Br_2 (hydrogen bromide)	None	None	None	None	None	None	5.2.3.3*	None
H_2S (hydrogen sulphide)	4.3.2 Table 4.10*	None	None	3.5.2(18*) 7.3.5(2*) 7.9.5 7.16.5*	6.1.7 6.1.9	6.4* 7.5.4.5	None	13.10(3)

Achieved environmental benefit/pollutant abated/removed	CWW	CAK[b]	LVIC-AAF	LVIC-S[c]	SIC[d]	LVOC	OFC	POL[c]
Sulphur oxides, e.g. SO_2 (sulphur dioxide), SO_3 (sulphur trioxide)	4.3.2 Table 4.10* Table 4.11*	None	4.5* 6.5*	2.5(3) 3.5.1(3) 3.5.1(14*) 3.5.2(14) 3.5.2(18*) 4.5(1*) 7.3.5(2) 7.5.6.5(3*) 7.7.5(2*) 7.8.5(2*) 7.8.5(5) 7.9.5(3) 7.9.5(4*) 7.16.5* 7.17.5*	6.1.7 6.1.9	6.4* 7.5.4.1	5.2.3.5*	13.5(3*)
CO (carbon monoxide)	4.3.2 Table 4.10*	None	None	7.2.5(2,3*) 7.7.5(3*)	None	7.5.4.1 10.5.3* 12.5.3	None	13.5(3*)
Mercury (Hg)	4.3.2 Table 4.10*	IV	None	None	None	6.4*	None	None
Asbestos (including replacement of asbestos)	None	I V	None	None	None	None	None	None

a) a split view was recorded
b) as the CAK BREF does not have its BAT conclusions structured and/or numbered, the following numbers are proposed for the purpose of identifying the conclusions:

- I. process technology selection
- II. all cell plants
- III. membrane cell plants
- IV. mercury cell plants
- V. diaphragm cell plants

c) the POL and LVIC-S BREFs number each BAT conclusion within each section (see the number in brackets)
d) the numbers refer to the BAT conclusion, not to the Section in the BREF, i.e:

- Chapter 5 includes BAT 5.1 to 5.22
- Section 6.1.5 includes BAT 6.1.1 to 6.1.15
- Section 6.2.5 includes BAT 6.2.1 to 6.2.10
- Section 6.3.5 includes BAT 6.3.1 to 6.3.16
- Section 6.4.5 includes BAT 6.4.1 to 6.1.10
- Section 6.5.5 includes BAT 6.5.1 to 6.5.19

*includes BAT AELs and/or performance levels

Table 3.1: Overview of BAT conclusions for waste gas treatment across the chemical BREFs

3.2 Overview of the BAT conclusions for waste water treatment in the chemical BREFs

Achieved environmental benefit/pollutant abated/removed	CWW	CAK[b]	LVIC-AAF	LVIC-S[c]	SIC[d]	LVOC	OFC	POL[c]
Minimisation of water consumption	4.2 4.3.1	None	None	8.3.4	5.11 6.5.13	6.3 6.5 7.5.5.1 10.5.2 10.5.4	5.1.2.5.2 5.1.2.5.3 5.1.2.5.5	13.3 (6*) 13.5 (3*) 13.6 (4) 13.10 (9*)
Minimisation of volume and load of waste water	4.3.1	None	1.5.1 7.5 10.5	2.5(8*) 2.5(9*) 2.5 (10) 3.5.2(10) 7.3.5(3-4) 7.7.5(1*) 7.9.5(8) 7.10.5(1*) 7.13.5(7*) 7.16.5(8*) 7.17.5 8.3.4.2 8.8.3.1	None	None	5.1.2.5	13.4(1) 13.6(1)
Diffuse emissions	None	IV	10.5	8.3.4	5.11 5.13	None	None	None
Total suspended solids (TSS)	4.3.1 Table 4.1* Table 4.3* Table 4.7* Table 4.8*	None	None	2.5(9*) 2.5(10) 3.5.1(15*) 3.5.2(19*) 7.10.5 7.12.5(3*) 7.16.5(8*)	None	None	5.2.4.7.2*	13.3(6*) 13.4(10*)
Collection and treatment of rainwater	4.3.1	None	None	7.6.5(2)	5.11	None	None	None
Segregation, collection and allocation of waste water streams	4.2 4.3.1	None	None	4.5(8)	5.10 6.4.4	6.3 7.5.2 9.5.5 11.5.4 12.5.4	5.2.4	13.1(9-10)

Achieved environmental benefit/pollutant abated/removed	CWW	CAK[(b)]	LVIC-AAF	LVIC-S[(c)]	SIC[(d)]	LVOC	OFC	POL[(c)]
Biological treatment	4.3.1	None	8.5 9.5	None	6.1.13 6.1.14 6.2.8 6.3.15 6.4.9	6.5 7.5.5 7.5.5.3* 9.5.5 10.5.4 11.5.4 12.5.4.2 13.5	5.2.1.1.3 5.2.4.3 5.2.4.4.1 5.2.4.4.2 5.2.4.5 5.2.4.6 5.2.4.7* 5.2.4.8	13.4(5) 13.6(5)
Sludge treatment	4.3.1	None	None	7.13.5	6.3.14	None	5.2.4.5	None
Waste water discharge to surface water	4.3.1	None	None	7.13.5	6.1.13	None	10.5.4	None
Organic pollutants								
Sum parameters – organic traces (BOD/COD/TOC)	4.2 4.3.1* Table 4.2* Table 4.6* Table 4.7* Table 4.8*	None	None	None	6.1.5 6.1.5.13 6.3.15 6.5.6*	6.5* 7.5.5.3* 9.5.5* 11.5.4 12.5.4.2* 13.5*	5.2.1.1.1 5.2.1.1.3 5.2.4.2 5.2.4.2.1* 5.2.4.2.3* 5.2.4.6 5.2.4.7.2* 5.2.4.8.2	13.2(6*) 13.3(6*) 13.4(10*) 13.6(8*) 13.10(9*)
Hydrocarbons (e.g. CHC, PAH)	4.3.1 Table 4.2* Table 4.10	None	None	None	None	7.5.5.3[2] 11.5.4 12.5.4.2	5.2.4.4.1*	13.3(6*)
Halogenated organic compounds	None	None	None	12.4.3.1 12.5.6	None	12.5.4.2*	5.2.4.1.1 5.2.4.4*	None
AOX (absorbable organic halogen)	Table 4.7* Table 4.8[(a)]	None	None	None	6.5.5 6.5.7	6.5*	5.2.1.1.1 5.2.1.1.3 5.2.3.3 5.2.4.4.2* 5.2.4.7.2* 5.2.4.8	13.4(10*)
Phenols and benzene	Table 4.7*	None	None	None	None	7.5.5.3*	5.2.4.1.2	None
Solvents	None	None	None	None	6.5.2 6.5.3 6.5.4 6.5.5	13.5	5.2.1.1.3 5.2.4.3 5.2.4.7.2	13.7
Separation of solvents from WW Re-use, recovery and disposal of solvents	None	None	None	None	6.5.2 6.5.3 6.5.4 6.5.5	None	5.2.1.1.1(b) 5.1.2.1(d) 5.1.2.3.1 5.1.2.3.2 5.1.2.5.6 5.2.2	None

Achieved environmental benefit/pollutant abated/removed	CWW	CAK[b]	LVIC-AAF	LVIC-S[c]	SIC[d]	LVOC	OFC	POL[c]
Inorganic pollutants								
Cyanides (e.g. HCN/CN)	None	None	None	4.4.1	6.5.7* 6.5.8	11.5.2	5.2.4.6*	None
Ammonia (NH_3)	4.3.1	None	2.5 8.5* 9.5	2.5(7*)	6.5.2	12.5.4.1	None	None
Nitrates (NO_3^-)/nitrites (NO_2^-)	4.3.1 Table 4.8	None	None	None	6.1.14	6.5* 7.5.5.3* 7.5	None	None
Phosphates	Table 4.8	None	None	6.5.3.1(3*) 6.5.3.2(3*)	5.17 6.2.8*	7.5.5.3* 12.5.4.1	5.2.1.1.3 5.2.4.7.2*	None
Sulphates	4.3.1 Table 4.5*	None	None	3.5.2 2.3.4 Table 2.13 3.5.2(19*) 5.4.2.1 7.16.5(8*)	None	13.5	None	13.10
Bromides and chlorides	4.3.1	None	None	3.5.1(15*) 7.7.5(1*) 7.17.5(3)	6.2.8*	None	5.2.1.1.3	13.10(5) 13.10(7)
Chlorine (dissolved gas Cl_2)	Table 4.6	II*	None	None	None	12.5.4	None	None
Other inorganic salts and/or acids (except heavy metal salts, ammonium salts and other salts mentioned separately)	4.3.1	None	None	7.1.5(2*-4*) 7.6.5(2*) 7.14.5(3*) 7.15.5(1*)	None	7.5.5 7.5.5.2	5.1.2.5.1 5.2.4.1.3	13.10
Asbestos	None	I V	None	None	None	None	None	None

Achieved environmental benefit/pollutant abated/removed		CWW	CAK[b]	LVIC-AAF	LVIC-S[c]	SIC[d]	LVOC	OFC	POL[c]
Metals	Heavy metals (as a whole)	None	None	2.5(3) 2.5(10) 7.4.5	6.1.12* 6.5.1	6.5*	5.2.1.1.1 5.2.4.5* 5.2.4.7.2* 5.2.4.8	None	None
	Chromium (Cr)	None	None	2.5(3)	6.1.11 6.1.12*	6.5*	5.2.4.5* 5.2.4.7.2*	None	None
	Mercury (Hg)	None	IV*	2.5(3) 3.5.2(19*) 3.5.1(1) 3.5.2(7)	6.5.1 6.5.5	6.5*	None	None	None

a) a split view was recorded
b) as the CAK BREF does not have its BAT conclusions structured and/or numbered, the following numbers are proposed for the purpose of identifying the conclusions:

- I. process technology selection
- II. all cell plants
- III. membrane cell plants
- IV. mercury cell plants
- V. diaphragm cell plants

c) the POL and LVIC-S BREFs number each BAT conclusion within each section (see the number in brackets)
d) the numbers refer to the BAT conclusion, not to the Section in the BREF, i.e:

- Chapter 5 includes BAT 5.1 to 5.22
- Section 6.1.5 includes BAT 6.1.1 to 6.1.15
- Section 6.2.5 includes BAT 6.2.1 to 6.2.10
- Section 6.3.5 includes BAT 6.3.1 to 6.3.16
- Section 6.4.5 includes BAT 6.4.1 to 6.1.10
- Section 6.5.5 includes BAT 6.5.1 to 6.5.19

*includes BAT AELs and/or performance levels

Table 3.2: Overview of BAT conclusions for waste water treatment across the chemical BREFs

3.3 BAT conclusions for waste water and waste gas treatment in each chemical BREF

3.3.1 Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector BREF

[European Commission, 2003 #1]

The CWW BREF is a horizontal document. In this sense, the term "best available techniques" (BAT) is assessed in the document for the entire chemical sector, independently of the particular production process and the kind or size of the chemical enterprise(s) involved. The scope of the document comprises:

- the application of environmental management systems and tools
- the application of the treatment technology for waste water and waste gas as it is commonly used or applicable in the chemical sector, including the treatment technology for waste water sludge, as long as it is operated on the site
- the identification of, or conclusion on, best available techniques based on the two preceding items, resulting in a strategy of optimum pollution reduction and, under appropriate conditions, in BAT associated emission levels at the discharge point to the environment.

Figure 3.1 shows the different treatment techniques described in the CWW BREF.

The approach to reaching specific BAT conclusions for waste water and waste gas treatment follows the pathway of pollutants as shown in Figure 3.2 and Figure 3.3.

The document sets BAT AELs for the final discharge of waste water pollutants into receiving water (see Table 3.3). However, no BAT AEL was set for heavy metals or AOX (see Section 4.1 for details on the split views recorded).

Parameter	Performance rates (%)	Emission levels[a] (mg/l)
TSS		10 - 20[b]
BOD_5		2 - 20[b]
COD	76 - 96[c]	30 - 250
Total inorganic N[d]		5 - 25
Total P		0.5 - 1.5[e]
a) daily average, exception TSS and BOD_5 b) monthly average c) the lower end of the range refers to waste water with low contaminant concentrations d) sum of NH_4-N, NO_2-N and NO_3-N (a more recommendable parameter would be total N. Because of the lack of information on total N, total inorganic N is used here) e) lower range from nutrient feed in biological WWTP, upper range from production processes		

Table 3.3: BAT associated emission levels for final waste water discharge into a receiving water

According to treatment, the sources for waste gases are distinguished as:

- low temperature sources: such as production processes, handling of chemicals (including storage activities causing emissions) and work-up of products
- high temperature sources: such as combustion processes, which include facilities such as boilers, power plants, process incinerators, and thermal and catalytic oxidisers.

The releases of both groups have special contaminants to consider. The first group can consist of dust, VOC, inorganic volatile compounds and mists. The second group consists of a mixture of particulate matter, halogen compounds (mainly HCl, HF and Cl_2), carbon monoxide, sulphur oxides (mainly SO_2), NO_X and possibly dioxins.

The CWW BREF defines BAT AELs for high temperature sources (i.e. combustion exhaust gas treatment). These are listed in Table 3.4.

Parameter	Emission levels[(a)] (mg/Nm^3)
Dust	<5 - 15[(b)]
HCl[(g)]	<10
HF[(g)]	<1
SO_2[(g)]	<40 - 150[(c)]
NO_x (gas boilers/heaters)	20 - 150[(d)]
NO_x (liquid boilers/heaters)	55 - 300[(d)]
NH_3[(e)]	<5[(f)]
Dioxins	0.1 ng/Nm^3 TEQ
a) ½ hourly average, reference oxygen content 3 % b) by using ESPs, bag filters, catalytic filtration or wet scrubbers c) lower end of the range refers to gaseous fuel, the upper end of the range to liquid fuel d) the upper end of the range refers to small installations using SNCR e) NH_3 slip with SCR f) value for new catalysts, but higher NH_3 emissions occur as the catalyst ages g) by using wet scrubbers	

Table 3.4: BAT AELs for combustion exhaust gas treatment in the chemical sector

For low temperature sources, no BAT AELs were set since these are expected to be reported in the vertical BREFs. However, the BAT chapter of the CWW BREF reports performance levels related to the application of several waste gas treatment techniques.

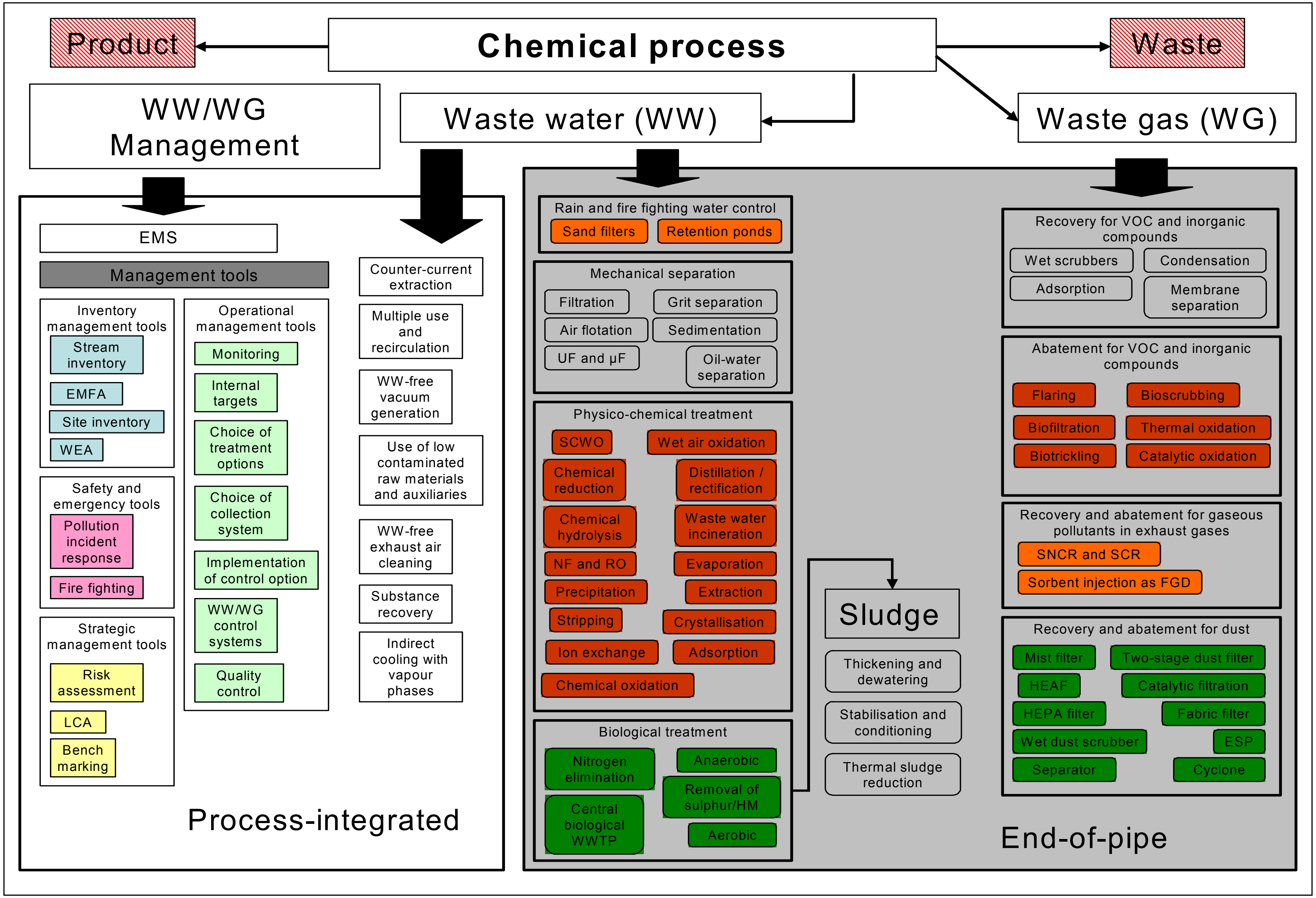

Figure 3.1: Treatment techniques described in the CWW BREF

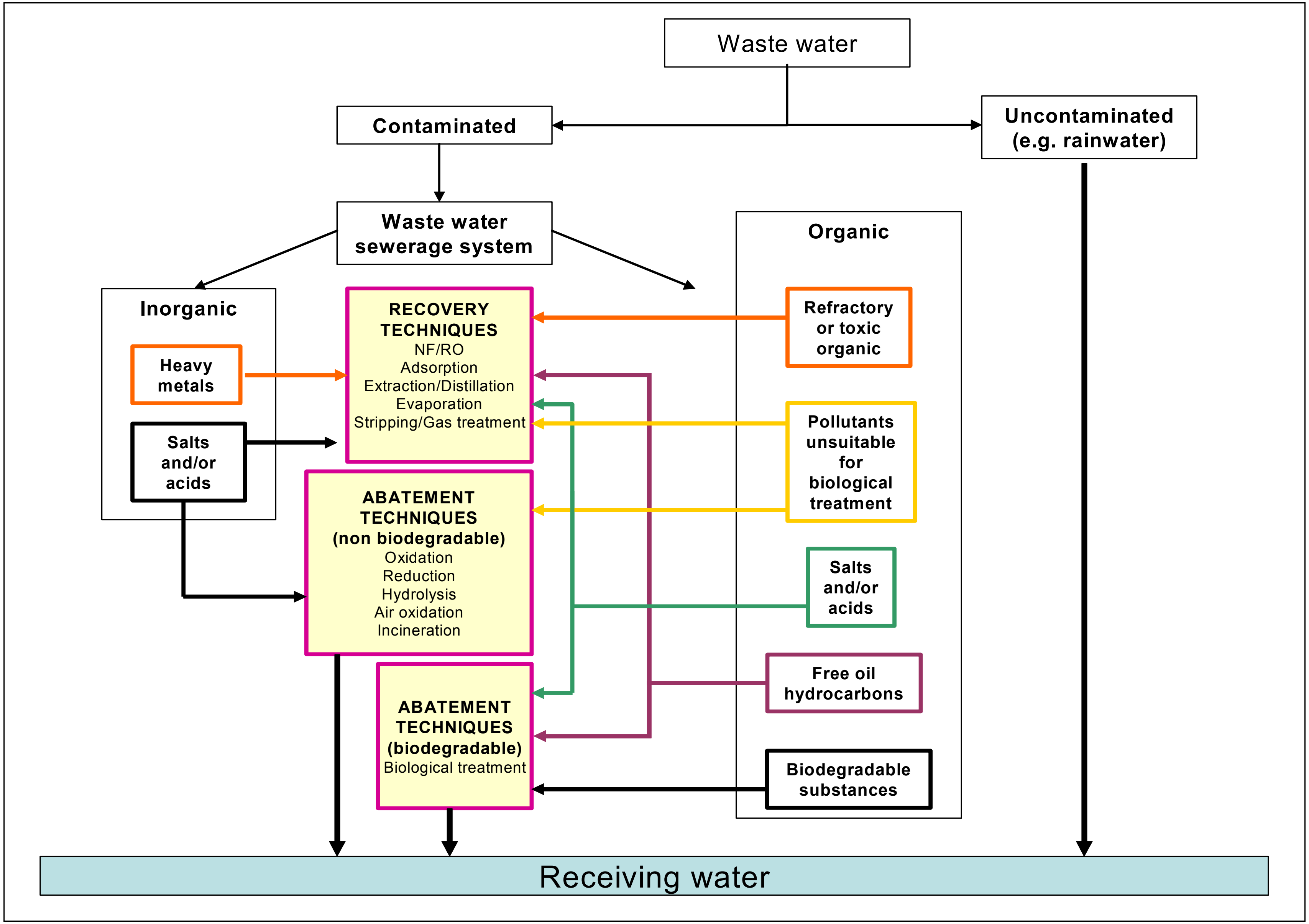

Figure 3.2: Decision pathway for waste water treatment: basis for BAT conclusions

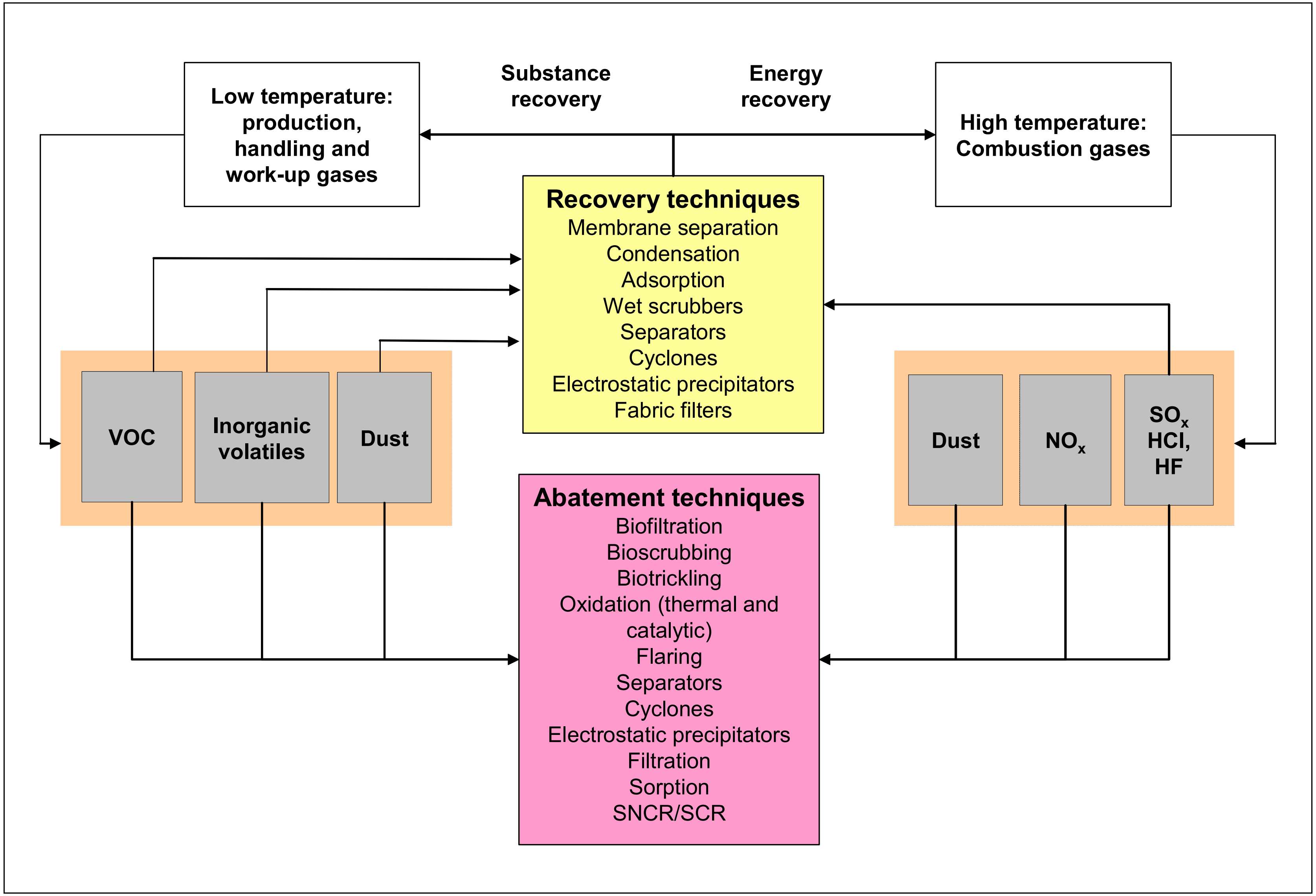

Figure 3.3: Decision pathway for waste gas treatment: basis for BAT conclusions
Note that some techniques are listed both as recovery and abatement measures

3.3.2 Chlor-Alkali (CAK) BREF

[European Commission, 2000 #4]

Most of the waste water and waste gas treatment techniques are described in a general way in the consumption and emission levels chapter. However, they are not included in the techniques to consider chapter. The CAK BREF is a very process-integrated document, which, in the BAT chapter, does not describe the application of any end-of-pipe technique in order to achieve the BAT AELs set for the main waste water and waste gas pollutants.

The BAT AELs set are shown in Table 3.5 and Table 3.6.

Parameter	BAT AEL
Chlorate[(a)]	1 - 5 g/l
Bromate[(a)]	2 - 10 mg/l
Asbestos[(b)]	0.1 g/t chlorine capacity*
Free oxidants[(c)]	<10 mg/l
* as yearly averages a) membrane cell plants b) diaphragm cell plants c) all cell plants	

Table 3.5: BAT AELs for emissions to water in CAK processes

Parameter	BAT AEL	Technique
Chlorine gas[(a)]	<1 mg/m^3 (partial liquefaction) <3 mg/m^3 (total liquefaction)	Chlorine absorption unit
a) all cell plants		

Table 3.6: BAT AELs for emissions to air in CAK processes

With regard to mercury cell plants, the BAT determined are the conversion to membrane cell technology and no BAT AELs for mercury were set. However, it is reported in the document that the best performing mercury cell plants achieve total mercury losses to air, water and with products in the range of 0.2 – 0.5 g/t of chlorine capacity as a yearly average.

3.3.3 Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers (LVIC-AAF) BREF

[European Commission, 2006 #7]

The BAT for waste water and waste gas are described for each product in the LVIC-AAF BREF.

The BAT AELs set for NO_X emissions in ammonia production are shown in Table 3.7.

Plant concept	NO_x emission as NO_2 mg/Nm^3	Technique
Advanced conventional reforming processes and processes with reduced primary reforming	90 - 230 [(a)]	• SNCR at the primary reformer, if the furnace allows the required temperature/retention time windows and/or • low NOX burners and/or • ammonia removal from purge and flash gases and/or • low temperature desulphurisation for autothermal heat exchange reforming
Heat exchange autothermal reforming	80[(b)] 20[(c)]	
a) low end of the range: best existing performers and new installations b) process air heater c) auxiliary boiler		
Note: no direct correlation between concentration levels and emission factors could be established		

Table 3.7: BAT AELs for NO_x emissions for the production of ammonia

The BAT AELs set for nitric acid production are shown in Table 3.8 and Table 3.9.

	N_2O emission level	ppmv	Technique
	kg/tonne 100 % HNO_3		
New plants	0.12 - 0.6	20 – 100	By applying a combination of the following techniques: • process-integrated measures • catalytic N_2O decomposition in the reactor chamber • combined NO_X and N_2O abatement in tail gases
Existing plants	0.12 - 1.85[(a)]	20 – 300	
a) a split view was recorded			

Table 3.8: BAT AELs for N_2O emissions for the production of HNO_3

	NO_x emission level as NO_2	
	ppmv	Technique
New plants	5 - 75	By applying one or a combination of the following techniques: • optimisation of the absorption stage • combined NO_X and N_2O abatement in tail gases • SCR • addition of H_2O_2 to the last absorption stage
Existing plants	5 - 90[(a)]	
NH_3 slip from SCR	<5	
a) up to 150 ppmv, where safety aspects due to deposits of AN restrict the effect of SCR or with the addition of H_2O_2 instead of applying SCR		

Table 3.9: BAT AELs for NO_X emissions for the production of HNO_3

The BAT AELs set for sulphuric acid production are shown in Table 3.10 and Table 3.11.

Technique	BAT AEL as H_2SO_4
By applying a combination of the following techniques: • in-process techniques, e.g. use of sulphur with a low impurity content, adequate drying of inlet gas and combustion air, use of a larger condensation area, and control the concentration and temperature of the absorber acid • recovery/abatement techniques in wet processes, such as ESP, WESP, wet scrubbing	10 - 35 mg/Nm^3 (as yearly averages)

Table 3.10: BAT AEL for SO_3/H_2SO_4 emissions for the production of sulphuric acid

<table>
<tr><th rowspan="2">Conversion process type</th><th rowspan="2">Technique (includes many in-process techniques)</th><th>Conversion rate(a)</th><th>SO_2 in mg/Nm3(b)</th></tr>
<tr><th colspan="2">Daily averages</th></tr>
<tr><td rowspan="2">Sulphur burning, double contact/double absorption</td><td rowspan="5">Apply a combination of the following techniques:
• in-process techniques
• improve raw gas cleaning (metallurgical plants)
• improve air filtration, e.g. by two stage filtration (sulphur burning)
• improve sulphur filtration, e.g. by applying polishing filters (sulphur burning)
• tail gas scrubbing, provided that by-products can be recycled on-site</td><td>99.8 - 99.92 %</td><td>30 - 680 (c)</td></tr>
<tr><td>99.9 - 99.92 %</td><td>30 - 340 (d)</td></tr>
<tr><td>Other double contact/double absorption plants</td><td>99.7 - 99.92 %</td><td>200 - 680</td></tr>
<tr><td>Single contact/single absorption</td><td></td><td>100 - 450</td></tr>
<tr><td>Other</td><td></td><td>15 - 170</td></tr>
<tr><td colspan="4">a) conversion rates relate to the conversion including the absorption tower, they do not include the effect of tail gas scrubbing
b) these levels can include the effect of tail gas scrubbing
c) existing installations
d) new installations</td></tr>
</table>

Table 3.11: Conversion rates and BAT AELs for SO_2 emissions for the production of sulphuric acid

The BAT and BAT AELs set for phosphoric acid production are shown in Table 3.12 and Table 3.13.

Parameter	BAT AEL	Technique
Emissions of P_2O_5	None	By applying one or a combination of the following techniques: • entrainment separators, where vacuum flash coolers and/or vacuum evaporators are used • liquid ring pumps with the recycling of the ring liquid to the process • scrubbing with the recycling of the scrubbing liquid
Dust emissions from rock grinding	2.5 - 10 mg/Nm^3	By applying fabric filters or ceramic filters
Fluoride emissions	1 - 5 mg/Nm^3 (expressed as HF)	By applying scrubbers with suitable scrubbing liquids

Table 3.12: BAT AELs for air emission from the production of phosphoric acid

Parameter	Technique
Waste water treatment	By applying a combination of the following techniques: • neutralisation with lime • filtration and optionally sedimentation • recycling of solids to the phosphogypsum pile
Fluoride emissions to water	By applying an indirect condensation system or by a scrubbing with recycling or marketing the scrubbing liquid

Table 3.13: BAT for waste water treatment for the production of phosphoric acid

The BAT and BAT AELs set for hydrofluoric acid (HF) production are shown in Table 3.14 and Table 3.15.

Parameter	kg/tonne HF	mg/Nm^3	Technique
SO_2	0.001 - 0.01[(a)]		By applying, e.g. water scrubbing and/or alkaline scrubbing
Fluorides as HF		0.6 - 5[(a)]	
Dust emissions from fluorspar drying, transfer and storage		3 - 19[(b)]	
a) yearly averages b) a split view was recorded, see Chapter 4 for details			

Table 3.14: BAT AELs for air emissions for the production of hydrofluoric acid

Parameter	Technique
Waste water from wet scrubbing	By applying a combination of the following techniques: • neutralisation with lime • addition of coagulation agents • filtration and optionally sedimentation

Table 3.15: BAT for waste water treatment for the production of hydrofluoric acid

The BAT and BAT AELs set for air emissions on NPK production are shown in Table 3.16.

Parameter	BAT AEL	Technique
Dust from rock grinding	2.5 – 10 mg/Nm^3	By applying fabric filters or ceramic filters
NO_X load in exhaust gases from phosphate rock digestion	None	By applying one or a combination of the following in-process techniques: • accurate temperature control • proper rock/acid ratio • phosphate rock selection • by controlling other relevant process parameters
Emission levels to air from neutralisation, granulation, drying, coating and cooling	None	By applying the following techniques: • dust removal, such as cyclones and/or fabric filters • wet scrubbing, e.g. combined scrubbing
Emissions to air from phosphate rock digestion, sand washing and CNTH filtration	None	By applying, e.g. multistage scrubbing

Table 3.16: BAT and BAT AELs for air emissions for the production of NPK

The BAT AELs set for UREA/UAN production are shown in Table 3.17 and Table 3.18.

Parameter	Level	Technique
Dust	15 - 55 mg/Nm^3	Scrubbing
Ammonia	3 - 35 mg/Nm^3	

Table 3.17: BAT AELs for dust and ammonia emissions from prilling or granulation in UREA/UAN production

	NH_3 ppm wt-%	Urea ppm wt-%	Technique
New plants	1	1	By applying, e.g. desorption and hydrolysation
Existing plants[(a)]	<10	<5	
a) if, in existing plants, these levels cannot be achieved, it is BAT to apply subsequent biological waste water treatment			

Table 3.18: BAT AELs for the treatment of process water from UREA/UAN production

The BAT AELs set for AN/CAN production are shown in Table 3.19.

Parameter	BAT AEL	Technique
Dust emissions from dolomite grinding	<10 mg/Nm^3	Fabric filters

Table 3.19: BAT AELs for dust emissions for the production of AN/CAN production

The BAT AELs set for superphosphates production are shown in Table 3.20 and Table 3.21.

Parameter	BAT AEL	Technique
Fluoride	1 - 5 mg/Nm^3 (expressed as HF)	Scrubbers with suitable scrubbing liquids
Dust	2.5 - 10 mg/Nm^3	Fabric filters or ceramic filters

Table 3.20: BAT AELs for air emissions from superphosphates production

	BAT AEL (mg/Nm^3)	Removal efficiency (in %)	Technique
NH_3	5 - 30 [(a)]		By applying the following techniques: • cyclones and/or fabric filters • wet scrubbing, e.g. combined scrubbing
Fluoride as HF	1 - 5 [(b)]		
Dust	10 - 25	>80	
HCl	4 - 23		
a) the lower end of the range is achieved with nitric acid as the scrubbing medium, the upper end of the range is achieved with other acids as the scrubbing medium. Depending on the actual NPK grade produced (e.g. DAP), even by applying multistage scrubbing, higher emission levels might be expected b) in the case of DAP production with multistage scrubbing with H_3PO_4, levels of up to 10 mg/Nm^3 might be expected			

Table 3.21: BAT AELs for air emissions from neutralisation, granulation, drying, coating and cooling in superphosphates production

3.3.4 Large Volume Inorganic Chemicals – Solids and Others (LVIC-S) BREF

[European Commission, 2006 #3]

Even though there is information on common techniques available for reducing emissions to air and water for the LVIC-S industry as a whole, during the exchange of information, no general BAT or BAT AELs could be derived. However, Annex 3 of the document contains Good Environmental Practices (GEP) for the use of technology, plant design, maintenance, operation environmental protection, and plant decommissioning in the LVIC-S industry.

BAT are described at product/process level. Table 3.22 and Table 3.23 show the BAT AELs set for air and water emissions, respectively.

Parameter	Technique	BAT AEL (products in brackets)
Chlorine	Alkaline scrubbing, leading to a hypochlorite solution	3 – 10 mg/Nm^3 (synthetic amorphous pyrogenic silica) 0.05 - 1 g/t $NaClO_3$ (sodium chlorate)
Hydrogen chloride	Water scrubbing or alkaline scrubbing, or the combination of both	0.03 - 0.1 kg/t TiO_2 pigment (titanium dioxide – chloride process route) <10 mg/Nm^3(synthetic amorphous pyrogenic silica) 10 - 30 mg/Nm_3 (feed phosphates – hydrochloric acid route) <0.1 kg/t $CaCl_2$ 100 % as 36 wt-% (calcium chloride liquor – acid-limestone route)
Sulphur oxides (SO_2, SO_X)	Use of low sulphur feedstock, alkaline scrubbing or catalytic conversion to sulphuric acid or sulphur	1.3 - 1.7 kg/t TiO_2 pigment (titanium dioxide – chloride process route) 1 - 6 kg//t TiO_2 pigment (titanium dioxide - sulphate process route) 10 - 50 kg/t rubber grade CB (carbon black) <0.6 kg/t (dead-burned magnesia) 100 - 200 mg/Nm^3 (sodium silicate) 6.4 - 11 kg/t 100 % product (silicon carbide) <20 - 150 mg/Nm^3 (sodium sulphite)
Nitrogen oxides	NO_X emissions can be reduced by applying both primary and secondary end-of-pipe measures. In some cases, control measures are taken to minimise their production and no further abatement is provided	0.6 - 1 g/Nm^3 (carbon black) <2.6 kg/t iron oxide pigment or 150 mg/Nm^3 (copperas) <2.1 - 4.4 kg/t (dead-burned magnesia) 400 - 640 mg/Nm^3 (sodium silicate)
Ammonia	Scrubbing (e.g. water, brine and acidic water)	5 mg NH_3/Nm^3 (sodium sulphite)
VOC	Thermal/catalytic oxidation, absorption and adsorption	None
Dust	Cyclones, bag filters and scrubbers	<5 - 50 mg/Nm^3 (soda ash) 0.1 - 0.2 kg/t TiO_2 pigment (titanium dioxide – chloride process route) 0.004 - 0.45 kg/t TiO_2 pigment (titanium dioxide – sulphate process route) <5 - 20 mg/Nm^3 (titanium dioxide – sulphate process route) 10 - 30 mg/Nm^3(carbon black) <20 - 50 mg/Nm^3 (synthetic amorphous pyrogenic silica) <10 - 20 mg/Nm^3 (synthetic amorphous precipitated silica) 0.9 kg dust/t STPP dry or < 20 mg/Nm^3 (detergent-grade STPP, for dry airstreams) <20 mg/Nm^3 (feed phosphates via the phosphoric acid route, for dry airstreams) 10 - 50 mg/Nm^3 (feed phosphates via the hydrochloric acid route exhaust gases, for dry air streams) 0.05 - 0.1 kg/t AlF_3 (aluminium fluoride) 10 – 60 mg/Nm^3 (sodium silicate) <20 mg/Nm^3 (sodium sulphite)
Carbon dioxide	Optimisation of the process to avoid excessive CO_2 emissions	02 - 0.4 t of 100 % CO_2/t (soda ash)
Carbon monoxide	Control of the combustion conditions	3.5 - 14.5 kg/t (dead-burned magnesia)

Table 3.22: BAT AELs for air emissions in LVIC-S processes

Parameter	Technique	BAT AEL (product/process in brackets)
Chlorides	Generally not abated, but released into the environment	38 - 330 kg/t TiO_2 pigment (titanium dioxide – chloride route)
Hydrochloric acid	Recovery in the acid scrubber for re-use or production of sodium hypochlorite at the site	10 - 14 kg/t TiO_2 pigment (titanium dioxide – chloride route)
Sulphates	Precipitation with lime	100 - 550 kg/t TiO_2 pigment (titanium dioxide – sulphate route)
Phosphates	Precipitation (e.g. with lime or $FeCl_3$)	1 - 8 g P/m^3 of waste water (feed phosphates, by purifying waters in the process and by liquid effluent treatment)
Ammonia	Steam stripping under controlled pH conditions	<0.9 kg N-NH_3/t (soda ash)
Fluorides	Precipitation with, e.g. lime	0.1 kg F/t AlF_3 (aluminium fluoride –wet process) 5 kg F/t AlF_3 (aluminium fluoride – dry process)
Metals and heavy metals	Precipitating and separating insoluble metal hydroxides, sulphides or phosphates	Hg 0.32 mg - 1.5 g/t TiO_2 pigment (titanium dioxide – sulphate route) Cd 1.0 mg - 2.0 g/t TiO_2 pigment (titanium dioxide – sulphate route)
Suspended solids	Flocculation, natural or mechanically-aided decantation, air-flotation and filtration	0.5 - 2.5 kg/t TiO_2 pigment (titanium dioxide – chloride route) 1.0 - 40 kg/t TiO_2 pigment (titanium dioxide – sulphate route) 0.09 - 0.24 t/t (soda ash)*
*at the outlet of the distillation unit, i.e. before separation of the suspended solids		

Table 3.23: BAT AELs for water emissions in LVIC-S processes

3.3.5 Speciality Inorganic Chemicals (SIC) BREF

[European Commission, 2006 #6]

Waste water and waste gas treatment techniques are described briefly in the generic section of the SIC BREF following the structure of the CWW BREF.

The generic (i.e. those that are generally applicable to the whole SIC sector) BAT AELs for air emissions set are shown in Table 3.24.

Parameter	BAT AEL	Technique
Total dust[(a)]	1 – 10 mg/Nm^3	Cyclone, fabric or ceramic filter, wet dust scrubber and ESP
HCN	<1 mg/m^3	Scrubbing with an alkaline solution
NH_3	<1.2 mg/m^3	Scrubbing with an acidic solution
HCl	3 – 10 mg/Nm^3	Wet gas scrubbing under alkaline conditions
NO_X	150 mg/Nm^3	Wet gas scrubbing under alkaline conditions
SO_X total	200 mg/Nm^3	Wet gas scrubbing under alkaline conditions
a) the lower end of the range may be achieved by using fabric filters in combination with other abatement techniques. However, the range may be higher, depending on the carrier gas and particle characteristics. Using fabric filters is not always possible, e.g. when other pollutants have to be abated (e.g. SO_X) or when the off-gases present humid conditions (e.g. presence of liquid acid)		

Table 3.24: Generic BAT AELs for air emissions in SIC processes

The specific BAT AELs for air emissions from the production of cyanides are shown in Table 3.25.

Parameter	BAT AEL[(a)] g/t 100 % NaCN or KCN	Technique
HCN	0.5 - 2	Alkaline scrubber with NaOH solution
NH_3	0.7 - 3	Acidic scrubber with H_2SO_4 solution
NO_X	100 - 500	
VOC	0 - 0.01	
a) the values were developed from measurements of emissions in different cyanide production plants. The ranges give a best practice depending on the process and technology used and on site-specific conditions which vary from site to site (i.e. waste water treatment)		

Table 3.25: BAT AELs for air emissions from the production of cyanides

As a general measure, BAT is to allocate contaminated waste water streams according to their pollutant load. Inorganic waste water without relevant organic components is segregated from organic waste water and ducted to special treatment facilities. No generic BAT AELs were set for emissions to water. However, the discharge levels to water at the inlet of the WWTP associated with BAT for the production of speciality inorganic pigments, phosphorus compounds and cyanides are shown in Table 3.26.

Parameter	BAT AEL	Technique
Cr(VI)	<0.1 mg/l(a)	Pretreatment, flow buffering and reduction of Cr(VI) to Cr(III) e.g. by sulphite, iron(II) sulphate
Cd	50 g/t end-product(a)	Precipitation, flocculation, sedimentation and filtration
Cr_{total}	5 - 10 g/t end-product(a) ≤ 0.1 mg/l(a)	
Pb	20 - 40 g/t end-product(a) <0.5 mg/l(a)	
P	0.5 – 2 kg/t of raw elemental P(b)	WWTP equipped with biological treatment
Cl	5 – 10 kg/t of raw elemental P(b)	WWTP equipped with biological treatment
$NH_4^{(+)}$-N	400 - 2000 g/t 100 % NaCN or KCN(c)	
COD	800 - 4000 g/t 100 % NaCN or KCN(c)	
CN^-	0.4 - 6 g/t 100 % NaCN or KCN(c)	
TOC	300 - 1500 g/t 100 % NaCN or KCN(c)	
a) speciality inorganic pigments b) phosphorus compounds c) cyanides		

Table 3.26: BAT AELs to water at the inlet of the WWTP for the production of speciality inorganic pigments, phosphorus compounds and cyanides

3.3.6 Large Volume Organic Chemicals (LVOC) BREF

[European Commission, 2002 #8]

Waste gas treatment systems are described in detail using a pollutant approach. Table 3.27 and Table 3.28 show the BAT AELs set for the abatement of air emissions for the sector as a whole. The data reported include reference conditions and averaging times.

Technique	BAT AEL(b)
Selective membrane separation	90 – >99.9 % recovery VOC <20 mg/m³
Condensation	Condensation: 50 – 98 % recovery + additional abatement Cryo-condensation: (a) 95 – 99.95 % recovery
Adsorption (a)	95 - 99.99 % recovery
Scrubber (a)	95 - 99.9 % reduction
Thermal incineration	95 - 99.9 % reduction VOC (b) <1 - 20 mg/m³
Catalytic oxidation	95 – 99 % reduction VOC <1 - 20 mg/m³
Flaring	Elevated flares >99 % Ground flares >99.5 %
a) the technique has cross-media issues that require consideration b) concentrations relate to half hourly/daily averages for reference conditions of dry exhaust gas at 0 °C, 101.3 kPa and an oxygen content of 3 vol-% (11 vol-% oxygen content in the case of catalytic/thermal oxidation)	

Table 3.27: BAT AELs for the recovery/abatement of VOCs in LVOC processes

Pollutant	Technique	BAT AEL[(a)]
Particulates	Cyclone	Up to 95 % reduction
	Electrostatic precipitator	5 - 15 mg/Nm³ 99 - 99.9 % reduction
	Fabric filter	<5 mg/Nm³
	Two stage dust filter	~1 mg/Nm³
	Ceramic filter	<1 mg/Nm³
	Absolute filter	<0.1 mg/Nm³
	HEAF filter	Droplets and aerosols up to 99 % reduction
	Mist filter	Dust and aerosols up to 99 % reduction
Odour	Adsorption and biofilter	95 – 99 % reduction for odour and some VOCs
Sulphur dioxide and acid gases	Wet limestone scrubbing	90 - 97 % reduction SO_2 <50 mg/Nm³
	Scrubbers	HCl [(b)] <10 mg/Nm³ HBr [(b)] <5 mg/Nm³
	Semi dry sorbent injection	SO_2 <100 mg/Nm³ HCl <10 – 20 mg/Nm³ HF <1 – 5 mg/Nm³
Nitrogen oxides	SNCR	50 - 80 % NO_x reduction
	SCR	85 to 95 % reduction NO_x <50 mg/m³ Ammonia <5 mg/m³
Dioxins	Primary measures and adsorption 3-bed catalyst	<0.1 ng TEQ/Nm³
Mercury	Adsorption	0.05 mg/Nm³
Ammonia and amines	Scrubber	<1 - 10 mgNm³
Hydrogen sulphide	Absorption (alkaline scrubber)	1 - 5 mg/Nm³
a) concentrations relate to half hourly/daily averages for reference conditions of dry exhaust gas at 0 °C, 101.3 kPa and an oxygen content of 3 vol-% b) daily mean value at standard conditions. The half hourly values are HCl <30 mg/m³ and HBr <10 mg/m³		

Table 3.28: BAT AELs for the abatement of air pollutants in LVOC processes

Waste water treatment systems are also described using a pollutant approach. Most waste water components of LVOC processes are biodegradable and are often biologically treated at centralised waste water treatment plants. This is dependent on first treating or recovering any waste water streams containing heavy metals or toxic or non-biodegradable organic compounds using, for example, (chemical) oxidation, adsorption, filtration, extraction, (steam) stripping, hydrolysis (to improve biodegradability) or anaerobic pretreatment. The BAT AELs for waste water emissions for the whole LVOC sector are shown in Table 3.29.

Parameter	BAT AEL (as daily averages)
COD	30 - 125 mg/l [(a)]
AOX	<1 mg/l [(b)]
Total nitrogen	10 - 25 mg/l [(c)]
Hg	0.05 mg/l [(d)]
Cd	0.2 mg/l [(d)]
Cu, Cr, Ni, Pb	0.5 mg/l [(d)]
Zn, Sn	2 mg/l [(d)]
a) the lower end of this range is determined by values of 30 - 45 mg/l for lower olefin effluents b) most LVOC processes can achieve an AOX value of below 1 mg/l c) the exact figure largely depends on the applied processes and type of biological treatment system (N removal) d) as daily averages	

Table 3.29: BAT AELs for wastewater emissions from LVOC processes

BAT AELs after combined biological treatment are shown in Table 3.30.

Pollutant	BAT AEL
BOD	<20 mg/l (as a daily average)
A typical design for this treatment plant is a lowly loaded biological treatment plant, which in the case of an activated sludge plant is a COD load of ≤ 0.25 kg COD/kg sludge (as dry solids) per day	

Table 3.30: BAT AELs of waste water pollutants from LVOC processes after combined biological treatment

The LVOC BREF also defines BAT AELs for the illustrative processes. The levels set for waste gas pollutants are shown in Table 3.31. The levels set for waste water pollutants are shown in Table 3.32.

Illustrative process	Parameter	BAT AEL		Technique
		(mg/Nm^3)	(kg/t)	
Lower olefins[a]	NO_X (as NO_2)	75 - 100 60 - 80		Ultra low NO_X burners SCR
	CO	20		Advanced combustion control
Formaldehyde[b]	NO_X (as NO_2)	150[c]	0.3[c]	Gas engines and dedicated thermal oxidation with steam generation[c] Dedicated catalytic oxidation system, preferably with steam generation[d]
		<10[d]		
	CO	50[c]	0.1[c]	
		20[d]	0.05[d]	
Ethylene dichloride/vinyl chloride monomer[e]	VOC (EDC and VCM)	<1		Use efficient combustion techniques (either thermal or catalytic) to further reduce the off-gas concentrations of chlorinated compounds and ethylene, and to recover energy as steam
	Dioxin	0.1 ng/Nm^3		
	HCl	<10		Absorption in water/hydrochloric acid for recovery and/or an alkaline solution
Toluene diisocyanate[f]	Phosgene	<0.5		Incineration techniques
	HCl	<10		
	Total carbon	<20		
a) BAT AELs for gas fired furnaces b) specific figures relate to tonne of formaldehyde 100 %. Note that techniques to reduce CO may have an adverse effect on NO_X emissions c) silver process d) oxide process. Levels as daily averages e) from point sources. Levels as daily averages f) levels as hourly averages				

Table 3.31: BAT AELs for the abatement of air pollutants in LVOC illustrative processes

Illustrative process	Parameter	BAT AEL	Technique
Lower olefins[(a)]	COD	30 - 45 mg/l	Physical separation (e.g. API separator, corrugated plate separator), followed by a polishing treatment (e.g. hydrogen peroxide oxidation or biological treatment)
	TOC	10 - 15 mg/l (2 - 10 g/t ethylene)	
	Sulphide ions	0.6 mg/l	
	Phosphate	1.5 mg/l	
	Nitrogen	25 mg/l	
	Phenols	0.15 mg/l	
	Benzene	0.05 mg/l	
	Total hydrocarbon content	1.5 mg/l	
Ethylene oxide and ethylene glycols	TOC	10 - 15 g/t EO	Dedicated central or external waste water biological treatment plant
Acrylonitrile	TOC	0.4 kg/t acrylonitrile	Dedicated central or external waste water biological treatment plant
Ethylene dichloride/vinyl chloride monomer	Chlorinated organic compounds	<1 mg/l	Pretreatment: steam or hot air stripping
	Copper	<1 mg/l	Pretreatment: alkaline precipitation and separation by settling or, where the effluent contains ammonia, by electrolysis
	Dioxins	0.1 ng/l	Pretreated effluent after biological treatment
	Total chlorinated hydrocarbons	1 mg/l	
	Copper total	1 mg/l	
	Hexachlorobutadiene	1 µg/l	
	COD	125 mg/l	
		50 - 100 mg/l	Dual nitrification-de-nitrification waste water treatment plant (not BAT for a EDC/VCM unit that stands isolated from PVC production)
Toluene diisocyanate	TOC	<1 kg/t DNT	Biological treatment BAT for the waste water from nitration
	TOC	0.5 kg/t TDI	Optimisation of processes (level prior to biological treatment) BAT for the waste water from phosgenation
a) the levels do not include cooling waters as these are not normally treated and refer to daily averages. The values for TOC assume a COD:TOC ratio of 3:1 and may have been calculated from the percentage contribution to a central WWTP			

Table 3.32: BAT AELs for the abatement of waste water pollutants in LVOC illustrative processes

3.3.7 Organic Fine Chemicals (OFC) BREF

[European Commission, 2005 #2]

For OFC processes, the management of waste water and waste gas streams includes process-integrated techniques for the assessment of waste stream properties and the understanding and monitoring of emissions. However, a wide range of recovery/abatement techniques for the treatment of waste gases, the pretreatment of waste water streams and the biological treatment of the total waste water are also described in the BREF. The description of abatement systems follows the pathway of pollutants. The data reported include reference conditions and averaging times.

The BAT AEL set for VOC abatement is shown in Table 3.33.

Parameter	Average mass flow kg C/hour	Average concentration mg C/m^3	Technique
Total organic carbon (TOC)	<0.05	<5	Thermal oxidation/incineration or catalytic oxidation
	<1	<20	Non-oxidative techniques
Note: levels relate to dry gas and Nm^3			

Table 3.33: BAT AELs for total organic carbon after thermal oxidation/incineration or catalytic oxidation in OFC processes

The BAT AELs derived for NO_X emissions are shown in Table 3.29.

Source	Average mass flow kg/hour[(a)]	Average concentration mg/m^{3}[(a)]	Technique
Chemical production processes, e.g. nitration, recovery of spent acids	0.03 - 1.7	7 - 220[(b)]	The lower end of the range relates to low inputs to the scrubbing system and scrubbing with H_2O. With high input levels, the lower end of the range is not achievable even with H_2O_2 as the scrubbing medium
Thermal oxidation/incineration, catalytic oxidation	0.1 - 0.3	13 - 50[(b)]	
Thermal oxidation/incineration, catalytic oxidation, input of nitrogenous organic compounds	None	25 - 150[(b)]	Lower range with SCR, upper range with SNCR
a) NO_X expressed as NO_2 b) levels relate to dry gas and Nm^3			

Table 3.34: BAT AELs for the abatement of NO_X emissions in OFC processes

The BAT AELs set for the abatement of other air pollutants from OFC processes are shown in Table 3.35.

Parameter	BAT AEL	Technique
HCl	0.2 - 7.5 mg/m^3 0.001 - 0.08 kg/h	Scrubbers (scrubbing media, e.g. H_2O or NaOH)
Cl_2	0.1 - 1 mg/m^3	Absorption of the excess chlorine and/or scrubbing with scrubbing media such as $NaHSO_3$
HBr	<1 mg/m^3	Scrubbing (scrubbing media, e.g. H_2O or NaOH)
NH_3	0.1 - 10 mg/m^3 0.001 - 0.1 kg/h	Scrubbing (scrubbing media, e.g. H_2O or acid)
NH_3	<2 mg/m^3 <0.02 kg/hour	Slip levels from SCR or SNCR
SO_X	1 - 15 mg/m^3 0.001 - 0.1 kg/h	Scrubbing (scrubbing media, e.g. H_2O or NaOH)
Particulates	0.05 - 5 mg/m^3 0.001 - 0.1 kg/h	Bag filters, fabric filters, cyclones, scrubbing, or wet electrostatic precipitation (WESP)
Free cyanides (as HCN)	1 mg/m^3 3 g/h	

Table 3.35: BAT AELs for air pollutants in OFC processes

In OFC processes, BAT is to segregate and pretreat waste water containing relevant recalcitrant (heavily biodegradable) organic loadings. Recalcitrant (heavily biodegradable) organic loading is not relevant if the waste water stream shows a bioeliminability of greater than about 80 – 90 %. In cases with lower bioeliminability, the recalcitrant (heavily biodegradable) organic loading is not relevant if it is lower than the range of about 7.5 – 40 kg TOC per batch or per day. Table 3.36 shows the BAT AELs set for waste water pretreatment options.

Parameter	BAT AEL	Technique
COD	>95 % reduction	Combination of pretreatment and biological treatment
Purgeable CHCs	<1 mg/l$^{(a)}$ <0.1 mg/l$^{(b)}$	Stripping, rectification or extraction
AOX	0.5 - 8.5 mg/l$^{(b)}$	The upper end of the range relates to cases where halogenated compounds are processed in numerous procedures and the corresponding waste water streams are pretreated, and/or where the AOX is very bioeliminable
Cu	0.03 - 0.4 mg/l$^{(b)}$	The upper end of the ranges result from the deliberate use of heavy metals or heavy metal compounds in numerous processes and the pretreatment of waste water streams from such use
Cr	0.04 - 0.3 mg/l$^{(b)}$	
Ni	0.03 - 0.3 mg/l$^{(b)}$	
Zn	0.1 - 0.5 mg/l$^{(b)}$	
Solvents	Recover from waste water streams for on-site or off-site re-use, using techniques such as stripping, distillation/rectification, extraction or combinations of such techniques$^{(c)}$	
a) in the outlet from pretreatment b) in the inlet to the on-site biological WWTP or in the inlet to the municipal sewerage system c) where the costs for biological treatment and purchase of fresh solvents are higher than the costs for recovery and purification		

Table 3.36: BAT AELs for waste water pretreatment options in OFC processes

After pretreatment, BAT is to take full advantage of the biological degradation potential of the total effluent. The BAT AELs set for emissions from the biological WWTP are shown in Table 3.37.

Parameter	BAT AEL[(a)] (yearly averages)	Unit	Comment
BOD	1 - 18	mg/l	BOD elimination rates above 99 % Yearly average BOD level
COD	12 - 250	mg/l	
Total P	0.2 - 1.5	mg/l	The upper end of the range results from the production of compounds containing phosphorus
Inorganic N	2 - 20	mg/l	The upper end of the range results from production of organic compounds containing nitrogen or from, e.g. fermentation processes
AOX	0.1 - 1.7	mg/l	The upper end of the range results from numerous AOX relevant productions and pretreatment of waste water streams with significant AOX loads
Cu	0.007 - 0.1	mg/l	The upper end of the range results from the deliberate use of heavy metals or heavy metal compounds in numerous processes and the pretreatment of waste water streams from such use
Cr	0.004 - 0.05	mg/l	
Ni	0.01 - 0.05	mg/l	
Zn	<0.1	mg/l	
Suspended solids	10 - 20	mg/l	
LID_F	1 - 2	Dilution factor	Lowest ineffective dilution (LID) Refers to toxicity levels
LID_D	2 - 4	Dilution factor	
LID_A	1 - 8	Dilution factor	
LID_L	3 - 16	Dilution factor	
LID_{EU}	1.5	Dilution factor	
a) the levels relate to the effluent after biological treatment without dilution, e.g. by mixing with cooling water			

Table 3.37: BAT AELs after treatment in a biological WWTP in OFC processes

3.3.8 Polymers (POL) BREF

[European Commission, 2006 #5]

All BAT AELs relate to total emissions including both point sources and fugitive emissions in the POL BREF.

Waste water treatment can be carried out in a central plant or in a plant dedicated to a special activity. Depending on the waste water quality, additional dedicated pretreatment is required. The generic BAT for waste water treatment also includes:

- preventing water pollution by appropriate piping design and materials
- using separate effluent collection systems
- using a buffer for waste water upstream of the waste water treatment plant to achieve a constant quality of the waste water.

The document contains BAT AELs for waste water and waste gas emissions for each of the production processes described.

The BAT AELs set for the production of polyethylene are shown in Table 3.38. The techniques described for achieving these levels are primarily process-integrated.

Emissions to air	
Dust emissions	17 g/t product
VOC emissions[a] • new installations • existing installations	 700 – 1100 g/t product 1100 – 2100 g
Emissions to water	
COD emissions	19 – 30 g/t product
a) VOC includes all hydrocarbon and other organic compounds including fugitive emissions	

Table 3.38: BAT AELs for air and water emissions for the production of low density polyethylene (LDPE) in POL processes

The BAT AELs set for the production of polystyrene are shown in Table 3.39.

Emissions to air[a]	
Dust	20 g/t product
VOC total	85 g/t product
Emissions to water [b]	
COD	30 g/t product
Suspended solids	10 g/t product
Hydrocarbons total	1.5 g/t product
a) the techniques described for achieving the air emission levels are primarily process-integrated b) the emission values in the water are measured after treatment. The waste water treatment facility can be inside the plant or at a centralised location	

Table 3.39: BAT AELs for the production of general purpose polystyrene (GPPS) in POL processes

The BAT AELs set for the production of polyvinyl chloride (PVC) are shown in Table 3.40.

Parameter	S-PVC	E-PVC	Technique
Emissions to air			
Total VCM[a]	18 – 45 g/t product	100 – 500 g/t product	By using one or more of the following: • absorption • adsorption • catalytic oxidation • incineration
PVC dust	10 – 40 g/t product	50 – 200 g/t product	By using, e.g. cyclones and bag filters
Emissions to water			
VCM[b]	0.3 – 1.5 g/t product	1 – 8 g/t product	By using a combination of: • stripping • flocculation • biological waste water treatment
COD[c]	50 – 480 g/t product		
Suspended solids[d]	10 g/t product		
a) a split view was recorded b) before WWT c) in the final effluent d) after pretreatment, in this way AOX values from 1 – 12 g/t PVCM in the final effluent are achieved for PVC production sites or combined EDC, VCM and PVC production			

Table 3.40: BAT AELs for the production of polyvinyl chloride (PVC) in POL processes

The BAT AELs for air emissions set for the production of unsaturated polyester (UP) are shown in Table 3.41.

Parameter	BAT AEL	Technique
VOC	40 - 100 g/t	By using, e.g. thermal oxidation, active carbon, glycol scrubbers and sublimation boxes
CO	50 g/t	
CO_2	50 - 150 kg/t	
NO_X	60 - 150 g/t	
SO_2	~ 0 - 100 g/t	
Particles	5 - 30 g/t	

Table 3.41: BAT AELs for air emissions from the production of unsaturated polyester (UP) in POL processes

The BAT AELs set for the production of emulsion styrene-butadiene rubber (ESBR) are shown in Table 3.42.

Parameter	BAT AEL
Emissions to air[(a)]	
Total VOC	170 – 370 g/t of solid product
Emissions to water[(b)]	
COD	150 – 200 g/t product
a) the techniques described for achieving these air emission levels are primarily process-integrated b) after biological treatment or equivalent techniques	

Table 3.42: BAT AELs for emissions to air and water from the production of emulsion styrene-butadiene rubber (ESBR) in POL processes

The BAT set for the production of solution polymerised rubbers containing butadiene is shown in Table 3.43. No BAT AELs were set for waste water or waste gas abatement.

Parameter	Technique
Solvent removal	By devolatilisation extrusion and/or steam stripping

Table 3.43: BAT for the removal of solvent from waste water for the production of solution polymerised rubbers containing butadiene in POL processes

The BAT set for the production of polyamides is shown in Table 3.44. No BAT AELs were set for waste water or waste gas abatement.

Parameter	Technique
Flue-gas treatment	By wet scrubbing

Table 3.44: BAT for flue-gas treatment for the production of polyamides in POL processes

The BAT set for the production of polyethylene terephthalate fibres are shown in Table 3.45. No BAT AELs were set for waste water or waste gas abatement.

Parameter	Technique
Flue-gas treatment	Catalytic oxidation or equivalent techniques
Waste water treatment	Stripping, recycling or equivalent as pretreatment, before WWTP

Table 3.45: BAT for waste water and waste gas treatment for the production of polyethylene terephthalate fibres in POL processes

The BAT AELs set for the production of viscose staple fibres are shown in Table 3.46. The techniques described for achieving the air emission levels are primarily process-integrated.

Parameter	BAT AEL
Emissions to air	
S_2	12 - 20 kg/t product
Emissions to water	
SO_4^{2-}	200 - 300 kg/t product
Zn	10 - 50 g/t product
COD	3000 - 5000 g/t product

Table 3.46: BAT AELs for the production of viscose staple fibres in POL processes

4 CASE STUDIES

The case studies for waste water treatment were chosen from two of the split views recorded during the exchange of information for the development of the CWW BREF. The case studies for waste gas treatment were chosen because of the importance of these pollutants across most of the IPPC sectors.

The possible contributions from the other vertical chemical BREF documents which could help resolve the split views recorded are presented in this chapter.

There are four case studies. The first two are related to waste water treatment, i.e. heavy metals removal and AOX abatement (see Sections 4.1.1 and 4.1.2). The last two relate to waste gas treatment, i.e. NO_X abatement and dust removal (see Sections 4.2.1 and 4.2.2).

4.1 Waste water treatment

4.1.1 Heavy metals

Important characteristics of heavy metals which influence waste water treatment are:

- heavy metals are not degradable and almost all of them are adsorbed to the sludge or passed through the biological WWTP
- heavy metals cannot be destroyed
- excessive heavy metal loadings in sewage sludge cause problems for disposal and, therefore, the increased costs of disposal or treatment have to be taken into account
- once discharged to water, heavy metals from sediment can remobilise in the watercourse (river or sea).

During the exchange of information for the development of the CWW BREF, the TWG members concluded that BAT AELs for heavy metal control techniques, covering the whole chemical sector, did not exist, because these levels depend strongly on the source process. A Member State presented a split view stating that following the strategy of prevention, pretreatment and central treatment, it was possible to name BAT AELs for heavy metals which are valid for many chemical sites. The Member State referred to the levels presented in Annex 7.6.4 of the CWW BREF as examples (these levels are shown in Annex I of this document) and stated that long term mean values (yearly of 24 hour composite samples – flow proportional) in some examples of chemical sites at the discharge point/last waste water treatment stage could be reached (without dilution of the waste water with rain and cooling water). These levels are shown in Table 4.1. The majority of the TWG did not follow this proposal.

Cd	Hg	Pb	Cr	Cu	Ni	Zn
0.02 - 0.833	0.01 - 0.84	10 - 100	10 - 30	20 - 60	10 - 80	4 - 174
The values refer to µg/l						

Table 4.1: Long term mean values from some examples chemical sites at the discharge point/last waste water treatment as stated in the split view

During the development of four of the vertical chemical BREFs, i.e. LVIC-S, LVIC-AAF, LVOC and OFC, BAT AELs for heavy metals in waste water were derived. These are shown in Table 4.2.

<table>
<tr><th rowspan="2">Heavy metal</th><th rowspan="2">CAK</th><th rowspan="2">LVIC-AAF</th><th>LVIC-S (titanium dioxide)</th><th colspan="2">SIC (speciality inorganic pigments)</th><th rowspan="2">LVOC (µg/l)</th><th colspan="2">OFC</th><th rowspan="2">POL</th></tr>
<tr><th>(mg/t product)</th><th>g/t product</th><th>µg/l</th><th>mg/l</th><th>µg/l</th></tr>
<tr><td>Hg</td><td>None</td><td>None</td><td>0.32 - 1500</td><td>None</td><td>None</td><td>50</td><td>None</td><td>None</td><td>None</td></tr>
<tr><td>Cd</td><td>None</td><td>None</td><td>1.0 - 2000</td><td>50</td><td>None</td><td>200</td><td>None</td><td>None</td><td>None</td></tr>
<tr><td>Cu</td><td>None</td><td>None</td><td>None</td><td>None</td><td>None</td><td rowspan="4">500</td><td>0.03 - 0.4 (PT)</td><td>7 - 10 (BT)</td><td>None</td></tr>
<tr><td>Cr</td><td>None</td><td>None</td><td>None</td><td>5 - 10</td><td>≤100</td><td>0.04 - 0.3 (PT)</td><td>4 - 50 (BT)</td><td>None</td></tr>
<tr><td>Ni</td><td>None</td><td>None</td><td>None</td><td>None</td><td>None</td><td>0.03 - 0.3 (PT)</td><td>10 - 50 (BT)</td><td>None</td></tr>
<tr><td>Pb</td><td>None</td><td>None</td><td>None</td><td>20 - 40</td><td><500</td><td>None</td><td>None</td><td>None</td></tr>
<tr><td>Zn</td><td>None</td><td>None</td><td>None</td><td>None</td><td>None</td><td rowspan="2">2000</td><td>0.1 - 0.5 (PT)</td><td><100 (BT)</td><td>None</td></tr>
<tr><td>Sn</td><td>None</td><td>None</td><td>None</td><td>None</td><td>None</td><td>None</td><td>None</td><td>None</td></tr>
<tr><td colspan="10">PT – after pretreatment and before biological treatment
BT – after biological treatment
None means no level was reported in the BREF in question</td></tr>
</table>

Table 4.2: BAT AELs for heavy metals in waste water reported in the vertical chemical BREFs
[European Commission, 2000 #4; European Commission, 2002 #8; European Commission, 2003 #1; European Commission, 2005 #2; European Commission, 2006 #3; European Commission, 2006 #6]

Comparative notes to Table 4.1 and Table 4.2:

- the levels set in the SIC BREF are closer to the higher ends of the ranges set in Table 4.1, however, outside the ranges reported
- the levels set in the OFC BREF are closer to the lower ends of the ranges set in Table 4.1
- the levels set in the LVOC BREF are much higher than the ones set in Table 4.1
- as the values set in the LVIC-S BREFs are specific figures, it is not possible to make a comparison with the values set in Table 4.1. In these cases, the equivalent concentrations would have been very useful.

Specific information regarding heavy metals removal presented in the vertical BREFs is discussed in the following paragraphs. The OFC, SIC, LVOC and LVIC-S BREFs have several techniques described in order to reduce the content of heavy metals in the waste water. Table 2.3 and Table 3.2 show the section numbers of the techniques and BAT described for heavy metals removal, respectively.

The CAK BREF covers mainly the abatement of mercury from mercury cell plants. Historical mercury contamination of land and waterways from mercury cell plants is reported as a major environmental problem at some sites. Considerable emissions of mercury can also occur with run-off water. Mercury emitted to water from mercury cell facilities mainly arises from:

- bleed from brine purification and condensates
- the wash water from the cell cleaning operations
- rain water from the electrolysis hall
- the rinsing water from maintenance areas.

In CAK processes, waste water contaminated with mercury is collected from all sources and generally treated in a waste water treatment plant. The amount of waste water can be reduced by filtration and washing of the sludges to remove mercury before feeding the condensate back into the brine. The use of process-integrated techniques, e.g. monitoring of possible leakages and recovery of mercury, good housekeeping and the use of salt with low impurity content are reported. End-of-pipe measures include precipitation as sulphide and mercury removal from hydrogen gas and caustic soda. No BAT AELs for mercury were set; however, it is reported in the document that the best performing mercury cell plants achieve total mercury losses to air and water, with products in the range of 0.2 – 0.5 g/t chlorine capacity as a yearly average.

In LVIC-AAF processes, heavy metals such as nickel and vanadium (introduced with the feedstock) are suspended as oxides and are also partially present as salts in the soot water circuit. To prevent an accumulation of these compounds in the water circuit, some of the extracted water has to be drained. The waste water is treated by flocculation, applying settlers and/or filters, and being finally discharged of after a biological treatment. Heavy metal emissions occur during phosphoric acid and AN/CAN production. The use of raw materials (coke, gypsum) with lower heavy metal content is reported as essential. No BAT AELs were derived.

Heavy metals are regarded as major contaminants for LVIC-S processes. The problem arises as heavy metals naturally occur in the main raw materials (e.g. limestone, coke, brine, feedstock and scrap iron).

In soda ash production, heavy metals are not retained in the product, but pass through the process to be finally released mainly with suspended solids in the waste waters from distillation. No BAT AELs were defined for soda ash production. The main reason was that 90 % of the heavy metals emissions originate from the use of raw materials (limestone and salt brine), and the operators have little influence on changing the currently exploited limestone or brine deposit. However, the emissions of heavy metals in the production of soda ash were thoroughly investigated in the LVIC-S BREF and detailed data from examples plants were reported. Also, the management of waste waters from the production of soda ash was illustrated in detail.

In titanium dioxide and food phosphates production, heavy metals are also passed to the waste waters. BAT AELs were set only for titanium dioxide production using the sulphate route (see Table 4.2). However, techniques are described in order to reduce the presence of heavy metals in the waste waters, i.e:

- the selection of raw materials which contain a lower content of heavy metals, e.g. quality limestone, salt brine, coke, feedstock and scrap iron
- deposition and dispersion
- separation of solids and filtration
- sedimentation using settling ponds.

In SIC processes, the use of catalysts creates waste water contaminated with heavy metals. Heavy metals could be carried by the waste water from plants producing pigments, explosives, silicones and nickel salts. Segregation and separation of the waste water containing heavy metals is essential. The techniques used for their removal are sedimentation, air flotation, filtration, precipitation, crystallisation, chemical reduction, nanofiltration/reverse osmosis, adsorption, ion exchange, evaporation, and anaerobic biological digestion. No generic BAT conclusions on the abatement of heavy metals in waste water were derived. The BAT AELs set for speciality inorganic pigments are shown in Table 4.2.

For LVOC processes, heavy metals are also regarded as major water pollutants. The main source is the use of catalysts. The heavy metals (from catalysts) are treated or recovered separately, because they cannot be removed efficiently in biological treatment plants. The techniques used are chemical precipitation (creating a sludge that may allow metal recovery), ion exchange, electrolytic recovery or reverse osmosis. The treated waste water streams are discharged to a combined biological treatment plant for further treatment. The BAT AELs set can be seen in Table 4.2.

In OFC processes, heavy metals are involved in chemical processing, e.g. as feedstock, auxiliaries and catalysts. Mass balances for emissions inventories are considered essential for understanding on-site processes and the development of improvement strategies. The pretreatment of waste waters is needed prior to biological treatment. The BAT AELs set are shown in Table 4.2. It is important to notice that the OFC BREF with its diverse sectors shows systematic similarities with the CWW BREF. In fact, the discussion on heavy metals was based on a similar set of reference plants.

In the POL BREF, there is little information reported on the presence of heavy metals on waste waters and/or their abatement.

Conclusions

- The waste waters of many chemical processes contain heavy metals, e.g. they are contained in the materials used for chemical processing (feedstock, auxiliaries and catalysts).

- As heavy metals cannot be destroyed, process-integrated options are essential in order to reduce the content of heavy metals in the production process and, consequently, in the waste water. However, end-of-pipe treatment (including pretreatment) is also necessary as heavy metals can pass through the process, to be finally released in the waste water.

- There have been difficulties during the development of many vertical chemical BREFs when determining BAT AELs for heavy metals in waste water. However, in five of them, BAT AELs were set (see Table 4.2). In the case of the LVOC and OFC BREFs, the BAT AELs were set for the sector as a whole.

- Even when there are differences in the ranges set by the vertical chemical BREFs, these contain enough information in order for the CWW TWG to re-assess the possibility of determining a BAT AEL (see Table 4.2). The TWG may need to gather further information, e.g. pretreatment options, input/output data of the pretreatment plant, mixing of waste water streams, input/output data of the final or central WWTP (if existent) and output data of the final discharge.

4.1.2 Adsorbable organic halogen (AOX)

AOX is a sum parameter which indicates the overall level of organohalogen compounds (chlorine, bromine and iodine) in water samples. It is important as many organic halogens are toxic. However, it gives no information on the chemical structure of organohalogen compounds present nor on their toxicity. The AOX method has the advantage that it is quite a simple measurement if it is compared to the alternative methods of measuring levels of individual compounds which are complex and require costly equipment.

During the exchange of information for the development of the CWW BREF, the TWG members concluded that they could not derive BAT AELs for AOX. A Member State asked for levels to be set based on the information detailed in Annex 7.6.2 of the CWW BREF (see Table 4.3). The other TWG members stated that these levels consisted of different statistical data sets which did not allow the deriving of BAT AELs. The majority of the TWG did not follow this proposal.

Production of	Input (mg/l)	Output (mg/l)	Performance (%)
Vitamins and intermediates	1.1	0.13	88
Organic dyes, intermediates, optical brighteners antimicrobica and municipal waste water (50 %)	8.5	1.7	80
Textile dyes, intermediates, plastics and resins	None	1.2	None
Organic and inorganic speciality chemicals	None	0.3	None
Pharmaceutical ingredients, vitamins and OFC	None	0.4	None
Polymers, fibres, optical brighteners, detergents and pharmaceutical ingredients	0.4	0.16	60
Light stabilisers, antioxidants, corrosion inhibitors, additives and stabilisers	1.5	0.25	83.3
Pharmaceutical ingredients, pesticides and dyes	1.1	0.16	85[(a)]
Range	0.4 - 8.5	0.13 - 1.7	60 - 88
a) 99 % when considering pretreatment			

Table 4.3: AOX discharges after treatment from different chemical plants as reported in the CWW BREF
[1, European Commission, 2003]

During the development of two of the vertical chemical BREFs, i.e. LVOC and OFC, BAT AELs for the abatement of AOX were derived. These are shown in Table 4.4.

CAK	LVIC-AAF	LVIC-S	SIC	LVOC (mg/l)	OFC (mg/l)	POL
None	None	None	None	<1	0.5 - 8.5 (PT) 0.1 - 1.7 (BT)	None
PT – after pretreatment and before biological treatment BT – after biological treatment The OFC and LVOC BAT AELs are within the range described in Table 4.3 None means no level was reported in the BREF in question						

Table 4.4: BAT AELs for AOX emissions reported in the vertical BREFs
[European Commission, 2002 #8; European Commission, 2005 #2]

Specific information regarding AOX abatement presented in the vertical chemical BREFs is discussed in the following paragraphs. The section numbers of the techniques and BAT described in order to reduce the content of AOX in the waste water are shown in Table 2.3 and Table 3.2, respectively. It is important to notice that this parameter is mainly associated with the production of organic chemicals and silicones.

In the CAK, LVIC-AAF and LVIC-S BREFs there is no information on AOX reported.

In SIC processes, AOX emissions are not regarded as a common general environmental issue for the sector as a whole. AOX could be carried by the waste water from plants producing silicones. The techniques reported for AOX abatement are chemical oxidation, nanofiltration/reverse osmosis, adsorption, stripping, incineration, anaerobic biological digestion and aerobic biological digestion. No BAT AELs were derived.

In some LVOC processes, i.e. the production of lower olefins, aromatics, oxygenated compounds, nitrogenated compounds and halogenated compounds, the waste waters contain AOX loads after pretreatment and prior to biological treatment. Waste water streams containing high AOX/EOX loads are preferably pretreated or recovered separately, e.g. by (chemical) oxidation, adsorption, filtration, extraction, (steam) stripping, hydrolysis (to improve bio-degradability) or anaerobic pretreatment.

The LVOC TWG acknowledged that it was difficult to describe AELs that were applicable for all LVOC processes as the waste water characteristics are strongly influenced by the applied processes, operational process variability, water consumption, source control measures and the extent of pretreatment. Nevertheless, based on their expert judgement, a general BAT AEL was set (see Table 4.4).

In OFC processes, the main sources for waste water streams with relevant AOX load are processes/operations involving halogenated solvents and halogenated intermediates, products and by-products. Mass balances for emissions inventories are mentioned as being essential for understanding on-site processes and the development of improvement strategies. Pretreatment includes, e.g. distillation, stripping, activated carbon adsorption, extraction and membrane processes. The pretreatment can also be done by oxidation, e.g. chemical oxidation, high pressure wet oxidation and low pressure wet oxidation, or disposal (incineration). After pretreatment, the effluent is sent to biological treatment. The BAT AELs set can be seen in Table 4.4. It is important to notice that the OFC BREF with its diverse sectors shows systematic similarities with the CWW BREF. In fact, the discussion on AOX was based on a similar set of reference plants.

In POL processes, AOX emissions occur during PVC production. Since AOX also covers solid compounds, the parameter is used to control overall PVC recovery/removal. Further, AOX emissions can occur during viscose fibre and viscose filament yarn production. However, no further information is reported. It is important to notice that AOX may not be a suitable parameter for the waste water of halogenated polymer production facilities. The reason being that an undefined part of the halogen bonded to the polymer particles present in the waste water may be included in AOX measurements, e.g. PVC particles.

Conclusions

- There is little information in most of the vertical chemical BREFs regarding AOX levels in the waste water. However, there are two BREFs (i.e. LVOC and OFC) that have BAT AELs for AOX for their sectors as a whole. The levels set are within the range described in Table 4.3. They also have plenty of information regarding the application of end-of-pipe techniques in order to reduce the levels of AOX, especially the OFC BREF.

- The information contained in the vertical chemical BREFs could be used as a starting point by the CWW TWG for the review of the sections on AOX abatement, including the BAT sections. However, further information on, e.g. pretreatment options, input/output data of the pretreatment plant, mixing of waste water streams, input/output data of the final or central WWTP (if existent) and output data of the final discharge, is needed.

4.2 Waste gas treatment

4.2.1 Nitrogen oxides (NO_X)

Nitrogen oxides form when fuel is burned at high temperatures, as in a combustion process. The two primary sources of NO_X in combustion processes are thermal and fuel NO_X. Thermal NO_X formation, which is highly temperature dependent, is recognised as the most relevant source when combusting natural gas. Fuel NO_X tends to dominate during the combustion of fuels, such as coal, which have significant nitrogen content.

NO_X causes a wide variety of environmental impacts because of various compounds and derivatives in the family of nitrogen oxides, including nitrogen dioxide, nitric acid, nitrous oxide, nitrates, and nitric oxide.

The section numbers of the techniques and BAT described in order to abate NO_X emissions in the series of chemical BREFs are shown in Table 2.2 and Table 3.1, respectively.

In the CWW BREF, there is little information reported for NO_X abatement. The end-of-pipe techniques reported are SCR and SNCR. It is also reported in the document that SCR is regarded as BAT instead of SCNR (at least for larger installations) because it has a better removal efficiency and better environmental performance. The BAT AEL set can be seen in Table 4.5.

In the CAK BREF, no information is reported.

In LVIC-AAF processes, NO_X emissions can occur during the production of ammonia, nitric acid, NPK and CN. NO_X can be recovered from exhaust gases from the reaction, feed tanks, centrifugation and buffers by scrubbing. The BAT AELs set can be seen in Table 4.5.

In ammonia production, the NO_X emitted originates from boilers, heaters and combustion chambers. Several process-integrated techniques (variations in the plant concepts) are reported, e.g. the use of low NO_X boilers and pre-reformers. End-of-pipe techniques include SNCR.

During nitric acid production, the tail gas, which contains NO_X and N_2O, is led through an abatement system and through a tail gas expander for energy recovery. The most common end-of-pipe treatment techniques for tail gases from nitric acid plants are SCR and SNCR. The BAT AELs set for NO_X by using a recently developed SCR-type catalyst applied in nitric acid plants are noteworthy (see Table 4.5). The recent development of SCR catalysts for NO_X abatement and its application in other chemical industries should be assessed during the review of the CWW BREF.

During NPK and CN production, NO_X (mainly NO and NO_2) is emitted with some nitric acid. The main source of NO_X is the dissolution of phosphate rock in nitric acid. Sand washing and CNTH filtration NO_X emissions also occur. The end-of-pipe techniques reported include multistage scrubbing, but mainly process-integrated techniques are used (e.g. proper operating conditions).

Emissions of NO_X are not considered a main environmental issue for the LVIC-S sector as a whole. During soda ash manufacture, NO_X are produced inside the kiln by the oxidation of nitrogen contained in the air used in the combustion process. However, emissions are low. During titanium dioxide production, if drying is required, NO_X emissions result. Emissions also arise from chlorination and finishing. In carbon black production, emissions occur during the oxidation of the feedstock and from driers, boilers and flares. During synthetic amorphous silica production, the NO_X emission points are primarily the off-gas leaving the absorption scrubber system and the venting of conveying air from storage silos to the air. In inorganic phosphates production, NO_X emissions occur during calcination (atomisation), ageing and cooling.

In LVIC-S processes, treatment includes the reduction of NO_X emissions during the combustion processes and the reduction of the input of fuel related nitrogen. End-of-pipe techniques include SCR and SNCR. The BAT AELs set can be seen in Table 4.5.

NO_X is regarded as a common environmental issue for the SIC sector as a whole. NO_X can be emitted to the air in the calcination process, as a product of decomposition. It can also be emitted from the combustion units for generating steam, heat and electricity (e.g. process heaters, furnaces) and from the incineration of waste water. Specifically, NO_X is emitted to the air during the production of pigments, cyanides, silicones and nickel salts. The end-of-pipe techniques reported for their abatement are SNCR, SCR and wet scrubbers. Process-integrated techniques are regarded as essential for reducing the production of NO_X emissions, e.g. optimisation of the construction of the burner, reduction of nitrogen components in the process gases. The BAT AEL set can be seen in Table 4.5.

In LVOC processes, the main sources of NO_X are related to catalyst preparation, catalyst regeneration and combustion units for raising steam, heat and electricity (e.g. process heaters, furnaces). Specifically, NO_X is emitted during methanol, phenol, aniline and nitrous compounds production. NO_2 emissions are most commonly reduced by combustion modifications that reduce temperatures and hence the formation of thermal NO_X. The techniques include low NO_X burners (up to 70 % NO_X reduction), flue-gas recirculation, and reduced preheating. End-of-pipe techniques include SNCR, which achieves removal rates of 60 – 80 %, and SCR, which can achieve up to 95 % reduction. Caustic scrubbing and recovery, via absorption in nitric acid, are also used. The BAT AELs set can be seen in Table 4.5.

In the OFC processes, the sources for exhaust gases containing NO_X are mainly chemical processes, e.g. nitrations, and thermal oxidation/incineration of exhaust gases (thermal oxidation of organic compounds containing nitrogen, e.g. acetonitrile or N_2 from air). The use of some oxidising agents, e.g. HNO_3 (benzoic acids), produce NO_X as their by-product. Process-integrated measures are essential for the reduction of NO_X emissions (e.g. oxidisers operated at lower temperatures). End-of-pipe techniques include SCR or SNCR, using NH_3 or urea as a reduction equivalent, thermal oxidation and scrubbing. The BAT AELs set can be seen in Table 4.5.

In POL processes, NO_X is emitted during the production of unsaturated polyesters (UP). Emissions arise from boilers and catalytic oxidisers. The BAT AEL set can be seen in Table 4.5.

Conclusions

- Process-integrated solutions are essential for reducing the content of NO_X in the waste gas. However, end-of-pipe treatment is necessary in order to reduce NO_X levels to the BAT AELs. SCR and SNCR are considered as the main end-of-pipe techniques used in order to reduce NO_X levels. Thermal oxidation and scrubbing are also used.
- The LVOC, OFC, LVIC-AAF and LVIC-S BREFs have plenty of information regarding the application of techniques (both end-of-pipe and process integrated) in order to reduce the levels of NO_X in the waste gases.
- Except for the values set in the LVIC-S BREF, the BAT AELs set in the vertical BREFs are within the range set in the CWW BREF (see Table 4.5).
- The TWG can greatly benefit from the information contained in the vertical chemical BREFs during the review process.

NO$_X$ emissions to air										
CWW	**CAK**	**LVIC-AAF**		**LVIC-S**	**SIC (cyanides)**	**LVOC**		**OFC**		**POL (UP)**
mg/Nm^3		**mg/Nm^3**	**ppmv**	**mg/Nm^3**	**g/t 100 % NaCN or KCN**	**% of NO$_X$ reduction**	**mg/m³**	**kg/h**	**mg/Nm^3**	**g/t**
20 - 150[(d)] (gas boilers/heaters) 55 - 300[(d)] (liquid boilers/heaters)	None	Ammonia 20 - 230 NPK/CN 100 - 425 (as NO_2)	Nitric acid 5 - 75 (new plants) 5 - 90 (existing plants)	Carbon black <600 (new plants) 600 - 1000 (existing plants) Sodium silicate 400 – 640 mg/Nm^3	100 - 500	50 – 80 (SNCR) 85 – 95 (SCR)	<50 (SCR)	0.03 - 1.7[(a)] 0.1 - 0.3[(b)] None[(c)]	7 - 220[(a)] 13 - 50[(b)] 25 – 150[(c)]	60 - 150

a) chemical production processes, e.g. nitration, recovery of spent acids
b) thermal oxidation/incineration, catalytic oxidation
c) thermal oxidation/incineration, catalytic oxidation, input of nitrogenous organic compounds
d) the upper end of the range refers to small installations using SNCR (for details see, Table 3.4)
As the values set in both the POL and the SIC BREFs are only reported in specific figures, it is not possible to make a comparison with the values set in the CWW BREF. In these cases, the equivalent concentrations would have been very useful
None means no level was reported in the BREF in question

Table 4.5: BAT AELs for NO$_X$ in the series of chemical BREFs
[European Commission, 2000 #4; European Commission, 2002 #8; European Commission, 2003 #1; European Commission, 2005 #2; European Commission, 2006 #3; European Commission, 2006 #6; European Commission, 2006 #5; European Commission, 2006 #7]

4.2.2 Dust

Dust refers to particulate matter emitted directly from the source. The size of particles is directly linked to their potential for causing health and environmental problems. Fine particles are more difficult to detect and remove and have a higher potential for causing health and environmental problems. Apart from the dust size, the parameters and nature of waste gas/air streams (wet streams or dry streams) are also of great importance for dust removal.

The section numbers of the techniques and BAT described in order to reduce the content of dust in waste gases are shown in Table 2.2 and Table 3.1, respectively.

The techniques described in the CWW BREF for the removal of dust are separators, cyclones, electrostatic precipitators (ESP), wet dust scrubbers, fabric filters, catalytic filtration, two-stage dust filters with metal gauze as filter material, absolute filters (HEPA filters), high efficiency air filters (HEAF) and mist filters. The BAT AEL derived can be seen in Table 4.6.

In the CAK BREF, no information is reported.

In LVIC-AAF processes, dust emissions occur during the production of urea/UAN, HF, TSP/SSP, AN/CAN, NPK and CN. The sources of dust are transfer, storage, grinding, milling, prilling, granulation and drying. The removal techniques used include cyclones, filters and wet scrubbers. The BAT AELs set can be seen in Table 4.6.

LVIC-S plants are typically equipped with storage and handling systems of solid substances which create dust emissions. During finishing dust emissions may also occur. Wet scrubbers, cyclones, ESPs and fabric filters are used for dust removal. For reducing fugitive emissions, enclosed systems are used. The BAT AELs set can be seen in Table 4.6. BAT AELs for dust have been also defined in most of the 17 illustrative products covered in the LVIC-S BREF. In general, the defined BAT AELs depend mostly on the nature and size of the dust particles (e.g. submicron dust fumes are very difficult to remove), the parameters of the off-gas/air dry or wet streams, and the techniques used for the reduction of dust emissions.

The emission of particulates to air (mainly dust and dust which contains heavy metals) are regarded as a common environmental issue for the SIC sector as a whole. Dust is emitted during the production of explosives, pigments, cyanides, silicones and nickel salts. The mixing of solid fine materials (powder) and the synthesis/reaction operations can generate dust emissions. Dust can also be emitted during combustion/calcination, drying, dry milling/grinding, sieving, storage and handling processes. Pretreatment techniques include separators and cyclones. Final treatment techniques include wet dust scrubbers, ESPs, fabric filters and ceramic filters. Polishing treatment includes two-stage dust filters with metal gauze as the filter material, absolute (HEPA) filters, HEAF and mist filters. The BAT AELs set can be seen in Table 4.6.

In LVOC processes, dust emissions are usually not a major issue, but they may derive from activities such as the conditioning of solid raw materials, the drying of solid products, catalyst regeneration and the handling of wastes. The end-of-pipe treatment techniques reported are multi-cyclones, fabric filters, electrostatic precipitators and wet scrubbers. The BAT AEL set can be seen in Table 4.6.

In the OFC BREF there is little information reported for dust removal. The techniques described are the use of dust collection systems (e.g. cyclones, filters and scrubbers) and closed systems to prevent non ducted emissions (diffuse or fugitive). The BAT AEL set can be seen in Table 4.6.

In POL processes, dust emissions occur during the production of LDPE, GPPS, HIPS, EPS, PVC, UP and polyamides. Dust is emitted while floss ends up in the product or is collected as waste polymer. Dust emissions can also occur from drying processes. Process-integrated techniques are considered essential for the reduction of dust emissions, e.g. enclosure. End-of-pipe measures include cyclones, wet scrubbers and filters. The BAT AELs set can be seen in Table 4.6.

Conclusions

- Process-integrated solutions are essential for reducing the content of dust in waste gases. However, end-of-pipe treatment is also necessary in order to reduce dust levels to the BAT values. The techniques applied for dust removal across the chemical sectors are similar, e.g. filters, ESPs, cyclones and scrubbers.

- The CWW TWG can greatly benefit from the information contained in the vertical chemical BREFs during the review process, especially in order to understand the reason for the higher values of dust emissions in sectors such as LVIC-S, POL and LVIC-AAF, e.g. dusty operations and poor maintenance of equipment.

Dust emissions to air									
CWW	**CAK**	**LVIC-AAF**	**LVIC-S**		**SIC**	**LVOC**		**OFC**	**POL**
mg/Nm^3		**mg/Nm^3**	**mg/Nm^3**	**kg/t product**	**mg/Nm^3**	**% reduction**	**mg/Nm^3**	**mg/Nm^3**	**g/t product**
<5 - 15	None	UREA/UAN 3 - 35 HF 3 - 19[d] TSP/SSP 2.5 - 25 AN/CAN <10 NPK/CN 2.5 - 25	Soda ash <5 - 20 (FF) <25 - 50 (WS) Titanium dioxide <5 - 20 (SR) Carbon black 10 - 30 Synthetic amorphous silica 10 - 50 Inorganic phosphates <20	Titanium dioxide 0.1 - 0.2 (CR) 0.004 - 0.45 (SR)	General 1 - 10[c] Silicones 5 - 20	95 - 99.9[a]	<5 - 15[b]	0.05 - 5	LDPE 17 LDPE copolymers 20 HDPE 56 GPPS 20 HIPS 20 EPS 30 S-PVC 10 - 40 E-PVC 50 - 200

a) depending on the technique used. For details see Table 3.28
b) depending on the technique used. Two stage, ceramic and absolute filters can achieve the lowest emission levels. For details see Table 3.28
c) the range may be higher depending on the carrier gas and particle characteristics. For details see Table 3.24
d) split view: part of industry claimed that the dust emission levels are not achievable, because changing the bags in the applied fabric filters more than once a year would not be economically viable
FF – fabric filter
WS – wet scrubber
CR – chloride route
SR – sulphate route
As the values set in the POL BREF are only reported in specific figures, it is not possible to make a comparison with the values set in the CWW BREF. In this case, the equivalent concentrations would have been very useful
None means no level was reported in the BREF in question

Table 4.6: BAT AELs for dust in the series of chemical BREFs
[European Commission, 2002 #8; European Commission, 2003 #1; European Commission, 2006 #3; European Commission, 2006 #6; European Commission, 2006 #5; European Commission, 2006 #7]

5 GUIDELINES AND RECOMMENDATIONS FOR THE REVIEW OF THE CWW BREF

The following guidelines and recommendations are based on the findings of the chapters before, especially on the comparative tables shown in Chapter 2 and Chapter 3 and the case studies shown in Chapter 4.

Section 5.1 and Section 5.2 below describe general and specific gaps that should be filled by the CWW TWG. Section 5.3 describes the data collection opportunities and challenges for the CWW review. Finally, Section 5.4 discusses the terminology used in the whole series of chemical BREFs. These issues should be looked at during the review of the CWW BREF in order to minimise possible inconsistencies and to improve the BAT conclusions.

Even though this document has been written for the purpose of the revision of the CWW BREF, these guidelines and recommendations may also be useful when revising the vertical chemical BREFs.

At the end of each section, a concluding statement is presented in a text box.

5.1 General gaps

This section discusses general issues to consider during the review of the CWW BREF which have arisen during the development of the whole series of chemical BREFs.

Each chemical BREF document describes waste water and waste gas abatement techniques in different ways, i.e. in diverse levels of detail and within several production processes. The BAT chapters of the different chemical BREFs examined are also not consistent (e.g. organisation, structure, style and level of detail). The inconsistencies concerning the structure of the series of chemical BREFs are mainly due to the fact that the process of writing BREFs has been dynamic and has evolved over the last 10 years. Minimising these variations is the basis for strengthening the concept of having a "series" of chemical BREFs, e.g. there is a need for streamlining the "series" by introducing structural and conceptual improvements. However, this should be done without undermining the specificities of the different processes described in the vertical chemical BREFs. Some of these differences are detailed in Section 3.3.

Regarding the BAT chapters, BAT AEL ranges are sometimes wide (e.g. consumption and emission factors), and also include whole ranges of possible emissions and not the best performers. The lower end of the ranges is sometimes <XX, therefore not specifying real emission levels which are possible to achieve when implementing BAT. The inclusion of cross-references in the BAT chapters which guide the reader to the technique(s) to consider which led to the definition of the conclusion is essential but has not always been done during the development of the series of chemical BREFs (see Table 1.1).

Regarding the CWW BREF, the following are examples of structural issues that should be improved in order to make the BREF more user-friendly:

- update the CWW BREF according to the most recent standards developed in the European IPPC Bureau for writing BREFs, e.g. to follow the BREF outline and guide when describing the techniques to consider in the determination of BAT
- consider a structural modification of the chapter on techniques to consider in the determination of BAT and/or cross-reference the techniques to the appropriate pollutants. This is important as many techniques can abate more than one pollutant
- complete or delete the empty tables presented in the document
- re-assess the information contained in the annexes. There is information, e.g. monitoring reports and data on emissions of heavy metals and AOX, which might be useful for the reader but loses its importance within the document because it is in the annex (for details see Sections 4.1.1 and 4.1.2). This information should be updated and moved to the appropriate sections within the document. Furthermore, the annex containing information on national legislation should be removed as it is not relevant for determining BAT. Furthermore, following a decision made at the IPPC IEF meeting on 21 and 22 April 2004, national legislation should no longer be included in a BREF
- avoid presenting data and information with high levels of aggregation
- number the BAT conclusions
- include cross-references in all the BAT conclusions to the chapter on techniques to consider.

<u>Scope of the CWW BREF</u>
The interface between the horizontal and the vertical chemical BREFs is not defined at length in the scope of the CWW BREF, yet it is a key issue for the end-user as many times it is necessary to take both vertical and horizontal BREFs into account in order to put together a permit. As the whole series of chemical BREFs has been finalised, the CWW TWG should reassess this interface, further describing the concept of "common" waste water and waste gas treatment systems and its applicability within the chemical industry, taking in consideration the "horizontal" characteristics of the chemical industry, e.g:

- the chemical industry is very diverse and sometimes includes chemical sites which produce a wide range of products (multi-purpose/integrated plants) which may be covered by several vertical chemical BREFs, and their waste water discharges contain a complex variety of chemicals (see Section 1.1)
- there are no exact borderlines between the scopes of the vertical chemical BREFs, e.g. there is some overlapping with regard to the products/processes that could be covered in each of them (see Sections 1.2.4 and 1.2.6)
- there are substances that can be generated using both an inorganic and an organic process (e.g. HCN, methanol and its derivatives, and potassium sulphate).

In these cases, the CWW BREF should provide key concepts and contain information and data which allow the users, e.g. operators and permit writers, to understand such complex cases.

In addition, the CWW BREF should not aim to replace the lack of "sector specific" information in the vertical chemical BREFs, but to supplement the data/information contained in them especially when waste water and waste gas treatment issues are not extensively covered or are not described at all.

The most recent horizontal BREF, i.e. the Energy Efficiency (ENE) BREF, has described the interface between horizontal and vertical BREFs, guiding the user in situations when more than one BREF applies. This document could be used as a guideline when discussing the scope of the CWW BREF.

For the review of the CWW BREF, it is recommended that the TWG members:

1. Fill the general gaps described in this section (see also Section 5.3).

2. Set a precedent in order to streamline the whole series of chemical BREFs with regard to, e.g. organisation, structure and style (see also Sections 5.3 and 5.4).

3. Complete the chapters on consumption and emission levels and on techniques to consider for determining BAT with quantified data at installation level (see also Section 5.3).

4. Determine BAT conclusions based on techniques which contain data from example plants, installations or whole sites as references. In this sense, the use of cross-references in the BAT chapter is essential (see also Section 5.3).

5.2 Specific gaps

This section describes the main technical gaps found specifically in the CWW BREF. These are issues related to waste gas and waste water treatment not sufficiently discussed or not addressed at all.

Regarding waste gas treatment systems, the following issues should be looked at by the TWG with the aim of updating and strengthening the information contained in the CWW BREF:

- measures for the minimisation of waste gas volume flows and loads
- the use of combined treatment (application of more than one technique in order to achieve a specific environmental benefit), especially for VOC emissions
- treatment of waste gases containing a combination of pollutants
- the use of modular recovery/abatement systems
- measures for the elimination and/or minimisation of fugitive and diffuse emissions (e.g. dust and VOC)
- measures for the removal of fine and ultrafine particulates (e.g. $PM_{2.5}$ or PM_{10})
- measures to reduce odorous emissions
- measures to reduce toxic pollutants.

Regarding waste water treatment systems, the following issues should be looked at by the TWG with the aim of updating and strengthening the information contained in the CWW BREF:

- water saving measures
- the application of pretreatment options
- combined treatment platforms, e.g. the combination of pretreatment and biological treatment and chemical-mechanical treatment stages in a central WWTP
- measures for the removal/recovery of solvents
- measures for the treatment of recalcitrant (heavily biodegradable) organic loads.

The general section on EMS is also a key element that needs further improvement, e.g. include information on inventories, mass balances and IPPC concepts. This is especially important for waste water treatment.

Also, the CWW BREF contains little information regarding energy efficiency measures respective to waste water and waste gas treatment operations. In this sense, the ENE BREF could be used as a starting point during the review of the CWW BREF. For example, the ENE BREF provides information and BAT on identifying the opportunities for energy efficiency which are applicable to many systems using industrial energy. It also includes tools or methodologies to assist and quantify energy optimisation. The proposal is not to repeat the information contained in the ENE BREF but to complement it with waste water and waste gas specific data.

It is also important to consider novel integrated processes and concepts that allow for more efficient recovery/abatement approaches or even the prevention of emissions, e.g. recent developments of SCR catalysts for NO_X abatement (see Section 4.2.1) and advanced oxidation processes for COD elimination by direct oxidation or oxidation via formation of *OH radicals, e.g. advanced oxidation process (AOP). This is also related to the need for a careful exploration of the emerging techniques, e.g. current research projects data/information could lead to techniques to consider for determining BAT or even BAT.

There are some generic aspects that would better fit the CWW BREF and, when appropriate, could be cross-referenced or even removed from the sector-specific documents, e.g:

- rainwater collection and treatment
- energy efficiency measures respective to waste water and waste gas treatment operations
- safety and security aspects respective to waste water and waste gas treatment operations.

Finally, there are technical gaps which are specific to the BAT chapter, which should be looked at in order to improve the conclusions presented, e.g:

- there are large numbers of options with an individual BAT, e.g. for VOC abatement
- there are no BAT AELs for some major pollutants, e.g. heavy metals and AOX (see also Sections 4.1.1and 4.1.2).

The vertical BREFs can supply information regarding these and other issues. However, there is also a need to update and complete the information in the CWW BREF via the provision of data by the TWG (for details see Section 5.3 on data collection).

5. It is suggested that the CWW TWG fill the technical gaps described in this section (see also Section 5.3).

6 The TWG should provide information on generic aspects, e.g. rainwater collection/treatment, energy efficiency measures and EMS (e.g. inventories and mass balances). If these issues are properly covered in the CWW BREF during the review process, the TWGs of the vertical BREFs could consider the cross-referencing and the possible removal of generic information and focus on issues which are specific to their sectors.

5.3 Data collection: provision and transfer of information for the review of the CWW BREF

This section gives examples of information contained in the vertical BREFs which could help improve the CWW BREF during the review process. However, it also emphasises that further collection and provision of data is needed in order to update the data sets made available for the development of the original CWW BREF with special attention being made to data from best performing plants, installations and/or whole sites.

Overall, during the development of the chemical BREFs, there has been a lack of quantified (non-aggregated) performance/operational data and information on costs of techniques, which are reliable and comparable. The data collection difficulties that have arisen during the development of most of the chemical BREFs have led to insufficient data which did not allow BAT AELs for many waste water and waste gas pollutants to be derived. This is very important as the reliance on data from example plants, installations and/or whole sites is essential for determining useful BAT conclusions. Many of these issues have been raised in the concluding remarks chapters of the chemical BREFs (see Table 1.3 for further details).

Due to the data collection difficulties (which are not only related to the chemical BREFs), an IEF working group has been discussing a position paper in order to improve the collection and submission of data for the review of the BREFs. The main conclusion of the group has been that complete and coherent data sets at installation level (i.e. including both the environmental performance achieved and the techniques used to achieve it) are essential to ensure comparability and for determining useful BAT conclusions. The CWW TWG should use this position paper as a starting point when defining the data collection needs for the review of the CWW BREF.

The following paragraphs analyse the opportunities for the use of information/data from the vertical chemical BREFs in the review of the CWW BREF. The proposal is to base the data collection needs for the CWW review on the experience gained during the development of the vertical chemical BREFs.

Further information could be derived from Table 2.2, Table 2.3, Table 3.1 and Table 3.2, which list the section numbers of the techniques to consider in the determination of BAT and the BAT conclusions for waste water and waste gas treatment across the series of chemical BREFs.

<u>General issues</u>
Regarding consumption and emission data, the LVOC, OFC and LVIC-S BREFs contain a lot of qualified data on pollutant emissions. However, the data in the LVOC BREF are aggregated and not related to specific techniques or BAT conclusions. On the other hand, the OFC BREF contains data related to the application of specific techniques and as a consequence of the application of diverse OFC unit operations. The LVIC-S BREF contains data both as specific loads and also in concentrations.

When reporting data for the chemical industry, it is important to take into account the purity of chemical products, e.g. the different content of impurities in the products influence the comparability of data, making it difficult to properly quantify BAT AELs, even in terms of specific consumption and emission factors.

The Annex 3 of the LVIC-S BREF contains good environmental practices (GEP) for the use of technology, plant design, maintenance, operation, environmental protection and plant decommissioning. These GEP are generally applicable to large volume chemical industries and, therefore, could be an important source of information for the CWW review.

Fugitive and diffuse emissions
As seen in Section 5.2, the CWW BREF contains little information and no BAT conclusions on fugitive and diffuse emissions. These emissions can account for about one third of the total organic emissions from chemical plants. The sources of these emissions include pumps and compressors, storage and processing vessels, loading facilities, flow control and pressure relief valves, and leakage from pipelines carrying materials from one process to another. Process-integrated solutions are the best options of preventing or minimising them, e.g. engineering controls, maintenance of plant equipment and regular monitoring.

The specific process-integrated techniques should be dealt with in the vertical documents. However, there are common grounds which can be dealt with in the CWW BREF. There are two vertical chemical BREFs which contain useful data on this subject, i.e. the LVIC-S and the LVOC BREFs. In both cases, attention is paid to avoid fugitive emissions of gases contained in the vessels and pipes. The OFC, POL, CAK and SIC BREFs also describe the application of techniques for the reduction of fugitive and diffuse emissions.

Carbon dioxide emissions
Carbon dioxide process emissions are important in the chemical industry but are not included in the CWW BREF. Two vertical chemical BREFs, i.e. LVIC-S and LVIC-AAF, contain data on CO_2 process emissions. Even though these emissions are dealt with in the Emission Trading Scheme (Directive 2003/87/EC), process emissions of CO_2 (non-combustion or non-GHG emitting processes) could be included in the CWW review. If this is to be carried out, the relationship and borderline between the CWW BREF and the Emission Trading Scheme should be described.

Particulate matter
As dust is an important issue in the LVIC-S sector, it is widely covered. The LVIC-AAF and SIC BREFs also describe the application of techniques for dust abatement in their sectors. However, in general there is little information on ultrafine (UFP) or fine particulates (e.g. $PM_{2.5}$ or PM_{10}) and unless otherwise stated dust or particulate matter mean total PM. One of the areas where information could be improved in future is in the monitoring and emissions prevention of ultrafine and fine particulates, especially in the case of hazardous compounds.

Odour
Odour is discussed in the vertical BREFs. However, only the LVOC BREF deals with this issue in greater detail. The CWW BREF should contain more information on the abatement of odorous pollutants.

Removal/recovery of solvents
Unfortunately, although solvents are widely used in the LVOC, OFC and LVIC-AAF sectors, there is not a lot of information on the removal of solvents from waste waters, although it is recognised that many processes consist of various recovery approaches that are intrinsic to these processes. Even after process-integrated solutions are applied, as described in the LVOC and OFC BREFs, some solvents are transferred to the waste waters and their removal is needed. Process-integrated measures described include their decreased usage, re-use and, if they cannot be recovered, their disposal, incineration or anaerobic biodegradation.

Regarding the use solvents and the emissions of VOC, the BREF on BAT on Surface Treatment using Organic Solvents (STS) includes an annex (Annex 24.9) which is a compilation of data reviewing the applicability of waste gas treatment techniques and the removal efficiencies of various combinations of VOCs. The annex contains information applicable to all industrial sectors. It could be a source of information for the revision of the CWW BREF.

The BREFs dealing with the production of organic products cover the abatement of VOC emissions in detail, i.e. the LVOC, OFC and POL BREFs. The SIC BREF also covers the abatement of VOC emissions in silicones and cyanides production.

<u>Waste water treatment</u>
The LVIC-AAF and OFC BREFs describe the application of combined treatment for the reduction of waste water and waste gas pollutants. With regard to waste water treatment, the OFC BREF widely discusses pretreatment options. Also, it includes information on the treatment of biodegradable water pollutants and recalcitrant (heavily biodegradable) organic loads. The LVOC BREF also extensively discusses the treatment of biodegradable water pollutants.

The LVIC-S BREF contains valuable information on sulphates, e.g. these are the most important pollutants in titanium dioxide production via the sulphate route. Also, large emissions of sulphates are discussed in other LVIC-S processes, e.g. soda ash and silica production. This BREF also contains a lot of data and information on techniques and best available techniques (including BAT AELs) for the treatment of ammonia and suspended solids emissions in the soda ash process.

The use of Whole Effluent Assessment (WEA) is described in the CWW BREF but it is not included as a parameter in the data sets reported. This parameter has been used mainly in the OFC BREF (see Table 3.37), but is also described in the LVOC BREF. The TWG should consider the use of WEA for assessing the effectiveness of the treatment of waste water streams as it increases the understanding of the combined effects of all known and unknown substances within effluents, especially in complex mixtures.

7. When considering the collection of information/data for the CWW review, it is important to take in consideration the following issues (these have been already raised in Section 5.1 and Section 5.2):

- the removal of aggregated data (except when making an overview of the sector as a whole)
- the use of example plants, installations and/or whole sites as references (this is essential for defining useful BAT conclusions). Special attention should be given to the inclusion of information from best performers.

8. The TWG should use the vertical BREFs as a source of information for completing and improving the CWW BREF.

5.4 Terminology used

Consistency of the terms used in the series of chemical BREFs is essential. The revision of the CWW BREF can set a precedent in this respect and should, therefore, be careful in its use and definition of terms. Examples of the lack of consistency are included in this section.

Important issues that should be looked at regarding terminology include:

- some terms should be avoided because they are ambiguous (e.g. expressions such as "when possible", "when technically and economically viable", "appropriate combination", "suitable combination" and "when feasible"). These are used in the descriptions of many BAT in several of the chemical BREFs and also in other BREFs
- the use of chemical formulas in titles and text should also be avoided (e.g. use ammonia instead of NH_3 and phosphorus instead of P).

Examples of diverse terms used to describe similar issues are listed below. As the documents do not clearly explain the definitions, it is not obvious if they refer to the same issue or not. This can create confusion for the reader, especially if the reader is not an expert in the subject. In order to enhance clarity and consistency, some definitions are proposed. As this list is not exhaustive, creating a common glossary for the series of chemical BREFs is strongly advised.

Biodegradation and bio-elimination
Biodegradation is a biological process where bacteria or other micro-organisms break down organic molecules, for example, in an activated sludge plant. Several factors determine whether an organic compound is biodegradable or not but this is primarily not a property of chemical compounds but rather the conditions in the biological system.

In a biological treatment plant, different mechanisms cause the reduction of organic compounds and load respectively. The ultimate biodegradation is to form, e.g. water, carbon dioxide, ammonia/nitrate and sulphate, as the final products. In an activated sludge plant, adsorption, stripping by air and flocculation also occur. Therefore, the term "bio-elimination" includes all of these elimination mechanisms. As a result, this term needs to be distinguished from the term "biodegradation".
The most common testing method to determine bio-elimination is the so called Modified Zahn-Wellens Test which has been standardised as OECD 302B (described in the OECD Guidelines for Testing of Chemicals). The results of this test can be reliably transferred to biological treatment plants.

Data measured in m^3 and Nm^3
The N (in Nm^3) stands for normal conditions. It means the data were measured at standard temperature and pressure. Because the volumes of gases change with temperature or pressure, it is necessary to specify the temperature and pressure the flowrate was measured at. Standard pressure is 1 atmosphere. Standard temperature varies between industries, but is usually 0 or 20 °C.

If only m^3 is used, the reference conditions should be specified.

Diffuse and fugitive emissions
Diffuse emissions refer to pollution infiltrating the atmosphere from non-point sources. For example, in the case of emissions to air, it is any emission not in waste gases. They can result from:

- the inherent design of the equipment (e.g. filters and driers)
- operating conditions (e.g. during transfer of material between containers)
- the type of operation
- a gradual release to other media (e.g. to cooling water or waste water).

Fugitive emissions are a subset of diffuse emissions. They are emissions caused by non-tight equipment leak (gaseous or liquid).

The term "incidental emission" is also used. It is recommended that this term should be avoided.

Effluent and waste water
An effluent is any substance, particularly a liquid that enters the environment from a point source. The term generally refers to waste water from a sewage treatment or industrial plant.

Particulate matter (also called particulates/particles in some documents) and dust
Particulate matter is a mixture of particles and liquid droplets. The size of the particulate matter can vary from coarse to fine particles. Particle pollution is made up of a number of components, including acids (such as nitrates and sulphates), organic chemicals, metals and dust particles.

Dust is a solid, mechanically produced particle with a size ranging from submicroscopic to macroscopic.

Pinch technology, pinch methodology and pinch analysis

Pinch analysis is a methodology for minimising energy consumption of chemical processes by calculating thermodynamically feasible energy targets and achieving them by optimising heat recovery systems, energy supply methods and process operating conditions. It is also known as process integration, heat integration, energy integration or pinch technology.

The concept was first developed in the late 1970s by teams led by Bodo Linnhoff at ICI and UMIST (now Manchester University).

It is recommended that the original term, "pinch analysis" is used.

Suspended solids (SS) and total suspended solids (TSS)

The term "suspended solids" refers to small solid particles which remain in suspension in water (e.g. surface water and waste water) as a colloid or due to the motion of the water. It is used as one indicator of water quality. Suspended solids are important as pollutants and pathogens are carried on the surface of particles. The smaller the particle size, the greater the surface area per unit mass of particle, and so the greater the pollutant load that is likely to be carried.

The term "total suspended solids" refers to a water quality measurement, i.e. the dry-weight of particles trapped by a filter, typically of a specified pore size. TSS of a water sample (e.g. surface water and waste water) is determined by pouring a carefully measured volume of water through a pre-weighed filter of a specified pore size, then weighing the filter again after drying to remove all water. The gain in weight is a dry weight measure of the particulates present in the water sample expressed in units derived or calculated from the volume of water filtered (typically mg/l).

Thermal treatment, incineration and oxidation

Thermal treatment of waste gases is the oxidation at high temperatures. It could be done through thermal oxidation and catalytic oxidation. The latter is a process similar to thermal oxidation with the fundamental difference being that the oxidation reaction takes place in the presence of a catalyst and at lower temperature.

The terms "thermal incineration" and "catalytic incineration" can also be used, however, it is recommended that oxidation is used instead.

Waste gas and flue-gas

A waste gas is the final gaseous discharge into the air (containing pollutants) from a stack or from abatement equipment.

A flue-gas is a waste gas generated by incineration/combustion processes.

The term "vent" is also used. It is recommended that this term should be avoided.

9. The TWG should be careful in the use and definition of terms in order to ensure consistency. Creating a common glossary for the series of chemical BREFs is strongly advised. Care should be taken to avoid confusion with existing definitions, e.g. in legislation.

REFERENCES

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14 CEFIC (2007). "Chemicals trend report".

15 Consultation group (2007). "Comments to the draft".

GLOSSARY

Abbreviations/acronyms

AN	Ammonium nitrate (LVIC-AAF process)
AOX	Adsorbable organic halogens
API	American petroleum institute
BAT	Best available techniques
BAT AEL	BAT associated emission level
BOD	Biological oxygen demand
BREF	BAT reference document
CAN	Calcium ammonium nitrate (LVIC-AAF process)
CHC	Chlorinated hydrocarbon
CN	Calcium nitrate fertiliser (LVIC-AAF process)
CNTH	Calcium nitrate crystallised as tetrahydrate (LVIC-AAF process)
COD	Chemical oxygen demand
DAP	Diammonium phosphate fertiliser (LVIC-AAF process)
DNT	Dinitrotoluene
EC50	Median effective concentration: concentration of a toxicant that can be expected to cause a defined non-lethal effect in 50 % of the given population of organisms under defined conditions
EDC	Ethylene dichloride (POL process). Also 1,2-Dichloroethane
EMS	Environmental management system
EMFA	Energy and material flow analysis
EO	Ethylene oxide
EOX	Extractable organic halogens
EPS	Expandable polystyrene (POL process)
E-PVC	Emulsion PVC (POL process)
ESBR	Emulsion styrene-butadiene rubber (POL process)
ESP	Electrostatic precipitator
FGD	Flue-gas desulphurisation
GHG	Greenhouse gas
GPPS	General purpose polystyrene (POL process)
HDPE	High density polyethylene (POL process)
HEAF	High efficiency air filter
HEPA	High efficiency particulate air filter (also called absolute filter)
HF	Hydrofluoric acid (LVIC-AAF process)
HIPS	High impact polystyrene (POL process)
HM	Heavy metal
IEF	Information exchange forum
IPPC	Integrated pollution prevention and control
KOM	Kick-off meeting
LCA	Life cycle assessment
LDPE	Low density polyethylene (POL process)
LID	Lowest ineffective dilution. Dilution of the total effluent is carried out until no effects on the test organisms are observed. Test organisms are usually fish (F), daphnia (D), algae (A), luminescent bacteria (L), genotoxicity (EU)
NF	Nanofiltration
NPK	Fertiliser containing nitrogen, phosphorus and potassium (LVIC-AAF process)
PAH	Polycyclic aromatic hydrocarbons
PM	Particulate matter PM2.5: particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometre PM10: particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometre
ppm	Parts per million (by weight)
ppmv	Parts per million (by volume)
PVC	Polyvinyl chloride (POL process)
PVCM	Poly VCM (POL process)
RO	Reverse osmosis

SCR	Selective catalytic reduction
SCWO	Super critical water oxidation
SNCR	Selective non-catalytic reduction
S-PVC	Raw suspension PVC (POL process)
SS	Suspended solids
SSP	Single superphosphate (LVIC-AAF process)
STPP	Sodium tripolyphosphate (LVIC-S process)
TDI	Toluene diisocyanate
TEQ	Toxic Equivalency (combined toxicity of all 29 dioxins)
TOC	Total organic carbon
TSP	Triple superphosphate (LVIC-AAF process)
TSS	Total suspended solids
TWG	Technical working group
UAN	Urea ammonium nitrate (LVIC-AAF process)
µF	Microfiltration. Also abbreviated as MF
UF	Ultrafiltration
UFP	Ultrafine particulates
UP	Unsaturated polyester (POL process)
VCM	Vinyl chloride monomer (POL process)
VOC	Volatile organic compound
WEA	Whole effluent assessment
WESP	Wet electrostatic precipitator
WWT	Waste water treatment
WWTP	Waste water treatment plant

Chemical symbols

B^-	Bromide ion
Br_2	Bromine
Cd	Cadmium
Cl^-	Chloride ion
Cl_2	Chlorine
CN^-	Cyanide ion
CO	Carbon monoxide
CO_2	Carbon dioxide
Cr	Chromium
Cr(VI)	Hexavalent chromium
Cu	Copper
F_2	Fluorine
H_2S	Hydrogen sulphide
H_2SO_4	Sulphuric acid
H_3PO_4	Phosphoric acid
HBr	Hydrogen bromide/hydrobromic acid
HCl	Hydrogen chloride/hydrochloric acid
HCN	Hydrogen cyanide/hydrocyanic acid
HF	Hydrogen fluoride/hydrofluoric acid
Hg	Mercury
N_2	Nitrogen
N_2O	Nitrous oxide
Na_2CO_3	Soda ash
NH_3/NH_4^+	Ammonia
NH_4-N	Ammonium nitrogen
Ni	Nickel
NO_2	Nitrogen dioxide
NO_2^-	Nitrite ion
NO_3^-	Nitrate ion
NO_X	Nitrogen oxides
P	Phosphorus
P_2O_5	Phosphorus pentoxide
Pb	Lead
PO_4^{3-}	Phosphate ion
S_2	Sulphur
SiO_2	Silicon dioxide
SO_2	Sulphur dioxide
SO_3	Sulphur trioxide
SO_4^{2-}	Sulphate ion
SO_X	Sulphur oxides
TiO_2	Titanium dioxide
Zn	Zinc

6 ANNEXES

6.1 Annex I

The following table shows emission levels of heavy metals from 23 German installations at the final discharge point after biological treatment as reported in Annex 7.6.4 of the CWW BREF [1, European Commission, 2003].

	Hg	Cr	Ni	Zn	Cu	Cd	Pb	As
Plant 1	0.32 - 1.96		20	4 - 27		0.057 - 0.4	7	1
Plant 2	1.01 - 2.82	10	30 - 180	54 - 230	50 - 100	0.395 - 1.2	32	4 - 28
Plant 3	0.23 - 0.7	40	60 - 180	145 - 470	20 - 180	0.276 - 3.8		
Plant 4	0.50 - 3.6	60		158 – 540			100	
Plant 5	0.84 - 2.95	20	10 - 20					
Plant 6	0.10 - 0.3		40 - 60			0.2 - 0.6	6	
Plant 7			20	74 - 380	30 - 180	0.083 - 1.0	10 - 36	
Plant 8		30 - 120	80 - 190	174 - 490	60 - 280	0.833 - 8.2	10 - 16	
Plant 9	0.02 - 0.35	10 - 60	10 - 90	111 - 230	20 - 90	0.031 - 0.8	20 - 110	
Plant 10	0.11 - 2.3	10	20 - 95	18 - 40	10 - 20	0.042 - 0.3	18	3 - 9
Plant 11	0.1		8	4 - 20	50	0.012 - 0.1	10	
Plant 12	0.01 - 0.1	20 - 50	50 - 85	117 - 360	30 - 70	0.212 - 1.3	16	
Plant 13	0.1	5	13	13 - 390	30	0.006 - 0.1	10	1
Plant 14	0.09 - 1.3		13		20 - 70	0.018 - 0.3	7	
Plant 15	0.01 - 0.1					0.16 - 0.8		
Plant 16	0.45 - 1.2			64 - 150				
Plant 17	0.49 - 1.6			4 - 29		0.064 - 1.61	7	
Plant 18	0.05 - 0.3		50 - 130	23 - 60	20	0.017 - 0.4		
Plant 19	0.01 - 0.2			5 - 70			7	
Plant 20	0.2	20	10 - 40	61 - 190	20 - 50	0.023 - 1.0	12	
Plant 21		20	10	30 - 70	20		38	
Plant 22			10 - 30	613 - 1350	50	0.106 - 0.6	10 - 34	
Plant 23	<0.17	2.7	34	39	38	<0.3	<2.6	
Notes: The unit of measurement is µg/l. The values given are yearly averages of 24 hours mixed samples. The concentrations are achieved at the final discharge point, after treatment at source, without dilution with rainwater or cooling water. They depend on the share of heavy metals in the total waste water mix								