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Integrated Pollution Prevention and Control

Reference Document on
Best Available Techniques for the Manufacture of

Large Volume Inorganic Chemicals – Solids and Others industry

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EXECUTIVE SUMMARY

Introduction

The BAT (Best Available Techniques) Reference Document (BREF) entitled Large Volume Inorganic Chemicals – Solids and Others (LVIC-S) industry reflects an information exchange carried out under Article 16(2) of Council Directive 96/61/EC (IPPC Directive). This Executive Summary describes the main findings, a summary of the principal BAT conclusions and the associated consumption and emission levels. It should be read in conjunction with the preface, which explains this document's objectives; how it is intended to be used and legal terms. It can be read and understood as a standalone document but, as a summary, it does not represent all the complexities of this full document. It is therefore not intended as a substitute for this full document as a tool in BAT decision making.

Scope of this document

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

A homogeneous and strictly defined LVIC-S industry does not really exist, and there no clear borderlines between the above-mentioned four inorganic chemical industry groups and the four associated BREFs.

The scope of this document is, in principle, relevant to industrial activities covered in Annex I to the IPPC Directive (96/61/EC) Section 4.2. 'Chemical installations for the production of basic inorganic chemicals', in particular to activities covered in points 4.2.d and 4.2.e.

Annex I to the IPPC Directive does not give any threshold value of the capacity for chemical industry plants, neither does it define the concepts of 'large volume', 'cornerstone' and 'selected illustrative' LVIC-S products used in this document, however, the following criteria were adopted for the selection of the processes covered in this document:

- scale and economic importance of the production
- number of plants and their distribution in different Member States
- impact of a given industry on the environment
- accordance of the industrial activities with the structure of Annex I to the Directive
- representativeness for a wide range of technologies applied in the LVIC-S industry
- validated data and information on LVIC-S products sufficient to formulate 'Techniques to consider in the determination of BAT' and to draw BAT conclusions for the manufacture of these products.

The LVIC-S products addressed in this document include:

I. <u>Five products at the so-called 'cornerstone' level, addressed in Chapters 2 through to 6:</u>

- soda ash (sodium carbonate, including sodium bicarbonate)
- titanium dioxide (chloride and sulphate process routes)
- carbon black (rubber and speciality grades)
- synthetic amorphous silica (pyrogenic silica, precipitated silica, and silica gel)
- inorganic phosphates (detergent, food and feed phosphates).

II. 17 LVIC-S products at the so-called ‘selected illustrative’ level, addressed at a lesser level of detail in Chapter 7 (Sections 7.1 to 7.17):

- aluminium fluoride (two process routes: starting from fluorspar and from fluosilicic acid)
- calcium carbide (a high temperature electrothermic process, starting from lime and carbon)
- carbon disulphide (the methane process, based on the reaction of sulphur with natural gas)
- ferrous chloride (the process-integrated with the production of TiO_2 by the chloride route)
- copperas and related products (co-products in the manufacture of TiO_2 by the sulphate route)
- lead oxide (production processes for the manufacture of red lead and litharge, from pure lead)
- magnesium compounds (produced by the wet process route to magnesium chloride and oxide)
- sodium silicate (covering the production of water glass by the melting and hydrothermal routes)
- silicon carbide (a high temperature electrochemical process starting from silica and carbon)
- zeolites (production processes to synthetic aluminosilicates, including zeolites A and Y)
- calcium chloride (processes routes related to soda ash and magnesia, and the $HCl\text{-}CaCO_3$ route)
- precipitated calcium carbonate (production by the reaction of calcium hydroxide with CO_2)
- sodium chlorate (produced by the electrolysis of an aqueous solution of sodium chloride)
- sodium perborate (produced by the reaction of borax and NaOH, and the reaction with H_2O_2)
- sodium percarbonate (produced by the crystallisation and the spray-granulation process routes)
- sodium sulphite and related products (the family of sodium products obtained by the reaction of SO_2 with an alkali)
- zinc oxide (obtained by the direct process, the five indirect processes, and the chemical process).

The following points indicate the main structure of this document:

- the executive Summary gives concise information on the main findings from the chapters in this document
- the preface explains the status and objectives of this document, and how to use it
- the scope gives details on the scope of the TWG work and the structure of this document
- Chapter 1 gives a general description of the LVIC-S industry, its potential and characteristics
- Chapters 2, 3, 4, 5 and 6 give description of five cornerstone LVIC-S products, including a BAT chapter for each cornerstone product
- Chapter 7 gives descriptions of 17 selected illustrative LVIC-S groups of processes, including a BAT chapter for each illustrative process
- Chapter 8 illustrates common abatement measures applied in the LVIC-S industry
- Chapter 9 gives description of Emerging Techniques in the LVIC-S industry
- Chapter 10 gives the Concluding Remarks relevant to this document
- the references detail the main sources of information used in developing this document
- the glossary of terms and abbreviations is meant to help the user understand this document
- the annexes provide additional information relevant to this document and, in particular:
    - Annex 3 – includes ‘good environmental practices (GEP) in the LVIC-S industry’.

As it was considered important not to lose even partial or incomplete information on the LVIC-S products, an 'Additional information submitted during the information exchange on LVIC-S industry' document, accessible through the EIPPCB website http://eippcb.jrc.es, contains partial data and information related to nine 'selected illustrative' LVIC-S products, which could not have been used to draw BAT conclusions. These are: 1. Aluminium chloride; 2. Aluminium sulphate; 3. Chromium compounds; 4. Ferric chloride; 5. Potassium carbonate; 6. Sodium sulphate; 7. Zinc chloride; 8. Zinc sulphate; and 9. Sodium bisulphate.

The 'Additional Information…' document was not peer reviewed and information within it was neither validated nor endorsed by the TWG or the European Commission, however, it is hoped that this partial information may be used for the revision of the four inorganic chemical industry BREFs.

Chapter 1 – General information on LVIC-S industry

The EU chemical industry has a growth rate about 50 % higher than that of the EU economy, and when the growth of the EU chemical industry (3.1 %) is compared by sector, the production growth of basic inorganic chemicals is the least dynamic (0.2 %).

The share of the EU in global production of chemicals is dropping, the dynamism of the chemical industry derives not only from its growth but also from rapid technological change that is one of the industry's outstanding features.

The chemical industry supplies all sectors of the economy, and the EU chemical industry is both its own principal supplier and customer. This is due to the processing chains that involve many intermediate steps in the transformation of chemicals. The manufacture of large volume chemicals is not only the subject of the economy of scale, but is also much more efficient in highly integrated industrial complexes than in isolated plants.

The LVIC-S industry is one of the main pillars of the whole EU chemical industry sector and, without this somewhat mature industry characterised by a relatively slow production growth, it would be impossible to meet the basic needs of the whole economy.

The following table shows the production scale in the European LVIC-S 'cornerstone' industry:

LVIC-S product	EU capacity	World share	Number of plants	Range of capacities
Soda ash	7700 kt/year	18 %	14	160 – 1020 kt/year
Titanium dioxide	1500 kt/year	37 %	20	30 – 130 kt/year
Carbon black	1700 kt/year	21 %	22	10 – 120 kt/year
Synthetic amorphous silica	620 kt/year	30 %	18	12 – 100 kt/year
Inorganic phosphates	3000 kt/year (*)	48 %	26 (**)	30 – 165 kt/year (***)
(*) Approximate data; (**) Detergent, food, and feed-grade phosphate plants; (***) For detergent-grade phosphates				

Out of the total of 100 LVIC-S cornerstone plants identified, 21 plants are located in Germany, 10 plants in the UK, nine plants in France, seven plants in Spain, six plants in the Netherlands, and five cornerstone plants respectively in Belgium, Italy and Poland. Austria, the Czech Republic, Finland, Hungary, Norway, Portugal, Slovenia and Sweden each have less than five cornerstone plants. Denmark, Greece, Ireland, Luxembourg, Slovakia, Lithuania, Latvia and Estonia are not represented at the LVIC-S industry cornerstone level.

In addition, over 300 installations are reported to exist in the EU-25 for the production of the 'selected illustrative' LVIC-S products, but it can be assumed that ~ 400 installations, with a broad range of capacities and using many production processes, are associated with the LVIC-S industry in the EU.

Chapter 2 – Soda ash

Soda ash is a fundamental raw material to the glass, detergent and chemical industries and, as such, is of strategic importance in the European and global manufacturing framework.

As trona deposits are not available in Europe, soda ash in the EU is almost entirely manufactured by the Solvay process, using the locally available salt brine and limestone of the required quality. The Solvay process was developed in the 19th century and the first soda ash plants in Europe date from that period. All the plants have been modernised and revamped several times to implement technology upgrades and their capacities have been increased to follow market demand.

The European soda ash capacities amount to over 15 million tonnes per year, half of which are in the EU-25. At several sites, soda ash plants have associated refined sodium bicarbonate plants.

The quality of the selected raw materials and geographical location of the production plants have a direct influence on composition, volume and treatment of effluents. The key environmental impacts of the Solvay process are the atmospheric emissions of CO_2, and aqueous emissions associated with the waste waters from the ‘distillation’ stage of the process.

In some locations – due to long term soda ash operations and the volume and composition of the post-distillation slurry (inorganic chlorides, carbonates, sulphates, alkali, ammonia and suspended solids, including heavy metals derived from the raw materials) – the disposal of the post-distillation effluent is a significant environmental issue, if not managed properly.

The post-distillation slurry is either directed to the aquatic environment for total dispersion (mostly the soda ash plants located at the seaside) or – after liquid/solid separation (mostly from land-locked soda ash plants) – the outgoing clear liquid is directed to the aquatic receptor.

When concluding on BAT for the production of soda ash by the Solvay process, the following key environmental issues have been identified for the sector:

- limited material efficiency of the Solvay process, due to intractable chemical equilibrium limitations, which has a direct impact of the production of soda ash on the environment
- the influence of the quality of the raw materials used (including the heavy metals content), in particular limestone, for the overall impact of the production of soda ash on the environment
- the relatively high volume of the waste waters discharged from the process to the aquatic environment
- the load of suspended solids in the waste waters, including heavy metals derived from the raw materials, and the limited possibilities to separate them from the waste waters in all soda ash producing sites. The best management option depends on local conditions, however, in several locations total dispersion is used without any separation of suspended solids.

13 BAT conclusions have been drawn for soda ash plants in the EU-25 based on the Solvay process, and the following are examples of accepted BAT conclusions which illustrate the drivers for environmental improvement in the soda ash industry sector (all BAT figures relate to yearly average).

BAT 2
Total consumption of limestone at the plant inlet in the range of 1.1 – 1.5 tonne per tonne of soda ash, although the consumption of up to 1.8 tonne limestone per tonne of soda ash produced may be justifiable for plants where good quality limestone is not available (i.e. limestone of lower carbonate content, poor burning characteristics and stone friability).

BAT 3
Selection of appropriate quality limestone, including:

- high $CaCO_3$ content, preferably in the range between 95 – 99 % (low $MgCO_3$, SiO_2, SO_3, and Al_2O_3+Fe_2O_3 content)
- appropriate physical limestone characteristics required in the process (particle size, hardness, porosity, burning properties)
- limited content of heavy metals (As, Cd, Cr, Cu, Hg, Ni, Pb and Zn) in either the purchased limestone or limestone from the currently exploited own deposit.

In cases where the limestone deposit of lower grade, with a content of 85 to 95 % $CaCO_3$, is used, and where other limestone of better quality are not readily available, low $MgCO_3$, SiO_2, SO_3, and Al_2O_3+Fe_2O_3 content is not achievable.

BAT 5
Optimised operation of the soda ash plant, to maintain the emissions of CO_2 from the process in the range of 0.2 – 0.4 tonne of 100 % CO_2 per tonne of soda ash produced (integrated production of soda ash with refined sodium bicarbonate at the site can lead to much lower emission levels).

BAT 8
The quantity of waste waters discharged from the distillation unit to a local watercourse, in the range of 8.5 – 10.7 m^3 per tonne of soda ash produced.

BAT 10
With regard to the impact of waste waters (containing suspended solids and associated heavy metals) discharged from the production of soda ash to the aquatic environment:

A. Where the final discharge is made to the marine environment (to the sea or into an estuary of a river under tidal influence, depending on local considerations), to ensure dispersion of the solids avoiding localised build-up of deposited solids and in any case to minimise the discharge of heavy metals using feedstock selection.

B. Where the final discharge is made to a fresh water body, to:

minimise the emission of heavy metals by the application of at least one of the following techniques:

- selection of appropriate feedstocks
- removal of coarse solids from waste waters
- deposition/dispersion – settling ponds
- deposition/dispersion – underground disposal.

minimise the emission of suspended solids by the application of at least one of the following techniques, depending on the characteristics of the receiving water body:

- selection of appropriate feedstocks
- removal of coarse solids from waste waters
- deposition/dispersion – settling ponds
- deposition/dispersion – underground disposal.

Chapter 3 – Titanium dioxide

Chapter 3 on Titanium dioxide covers two totally different process routes used for the manufacture of TiO_2 pigments, namely:

- the chloride process (continuous process operations, chlorine inventory involved); and
- the sulphate process (batch process operations, utilisation of spent sulphuric acid involved).

Therefore, Chapter 3 covers the following main issues in an integrated way:

- Section 3.1 – General information on the titanium dioxide industry
- Section 3.2 – Titanium dioxide – the chloride process
- Section 3.3 – Titanium dioxide – the sulphate process
- Section 3.4 – Comparison of the chloride and sulphate processes; and
- Section 3.5 – Best Available Techniques for the production of titanium dioxide.

The titanium dioxide industry has developed dynamically over the past few decades. It is a global industry in which about 1.5 million tonnes of titanium dioxide per year is produced in the EU. Approximately 30 % of this is produced by the chloride process, and the remainder is made by the sulphate process.

Over the past 20 years, the European TiO_2 industry has invested as much as EUR 1400 million in environmental improvement. This expenditure was initiated in the 1970s and was boosted as a result of the TiO_2 Harmonisation Directives: 78/176/EEC; 82/883/EEC and 92/112/EEC, prescribing minimum environmental performance standards for the TiO_2 industry, to which the industry is required to comply. Most of this investment has been put into the sulphate process, and the EU TiO_2 industry believes that environmentally there is little difference between a modern sulphate and chloride process.

However, following the analysis of 12 ‘Techniques to consider in the determination of BAT’ for the chloride process, and 13 ‘Techniques to consider in the determination of BAT’ for the sulphate process, the findings of this document are that the new TiO_2 plants in the EU are more likely to adopt the chloride process route, as it offers better energy efficiency.

Subject to maintaining low chlorine inventory and measures to reduce the environmental risks associated with chlorine and titanium tetrachloride handling (the SEVESO II Directive – Council Directive 96/82/EC on the control of major accident hazards involving dangerous substances), the chloride process is preferable from the point of view of overall environmental impact in the EU. However, given the availability of the TiO_2 feedstock and the findings of the Life Cycle Analysis, neither process route is de facto selected as BAT, and conclusions for both processes are presented in this document in parallel.

When concluding on BAT for the production of titanium dioxide, the following key environmental issues have been identified for the sector:

- the environmental impact outside of the EU due to the upgrading of titanium ores prior to the production of titanium dioxide
- precautions regarding chlorine inventory in the chloride process route
- measures adopted to utilise spent post-hydrolytic sulphuric acid in the sulphate process route
- substantial energy use involved in both routes, in particular in the sulphate process.

Different feedstocks, within a range of 44 – 96 % TiO_2 content, are used for the production of titanium dioxide. For the chloride process, natural TiO_2 ores or synthetic TiO_2 feedstocks are selected, while for the sulphate process, titanium slag and ilmenite can be chosen and used either separately or in blends. Therefore, the principal BAT conclusion for the TiO_2 industry, in both the chloride and sulphate process, relate to cost-effective choice of feedstock, based on, e.g. LCA considerations, with a low as practical level of harmful impurities, in order to reduce consumption of raw materials and energy, to reduce waste generation, and to provide the lowest environmental burden at the TiO_2 plant site.

The application of this principal BAT is connected with environmental impacts upstream of the TiO_2 plant site (ore mining and upgrading), therefore, an integrated approach and good industrial practice should be applied in each case of TiO_2 feedstock selection, in order to achieve a high general level of protection of the environment as a whole.

The reported consumption and emission figures are given in terms of 1 tonne of TiO_2 pigment, but as the TiO_2 content in the produced pigments varies and no data per 1 tonne of 100 % pure TiO_2 are available, it is difficult to draw quantitative BAT conclusions on the production of titanium dioxide. However, two quantitative BAT conclusions on the consumption of energy in both process routes have been drawn, as quoted below.

Chloride process, BAT 13
Improve the overall energy efficiency in the chloride process to the range of 17 – 25 GJ/t TiO_2 pigment (for plants operated at full capacity level), noting that the finishing section consumes majority of the total energy (in the range of 10 – 15 GJ/t TiO_2 pigment), the energy use being highly dependent on the characteristics of the final product. An increase of energy required in the wet treatment and finishing operations is foreseen if customer specifications call for a finer particle size in the final pigment product.

Sulphate process, BAT 17
Improve the overall energy efficiency in the sulphate process (for plants operated at full capacity level) to the range of 23 – 41 GJ/t TiO_2 pigment, and from this:

1) 23 – 29 GJ/t TiO_2 pigment in the process with sulphuric acid neutralisation
2) 33 – 41 GJ/t TiO_2 pigment in the process with sulphuric acid re-concentration.

Given different combinations of systems used across the EU TiO_2 industry for acid neutralisation and/or acid reconcentration, the extreme ranges as in 1) and 2) above apply only as indicative levels for the estimation of the overall energy efficiency in the TiO_2 plant in question.

Note also that the finishing section consumes a large share of the total energy (in the range of 10 – 15 GJ/t TiO_2 pigment), the energy use being highly dependent on the characteristics of the final product. An increase of energy required in the finishing operations is foreseen if customer specifications call for finer particle size in the final pigment product. Increased sulphate removal from liquid effluent streams requires higher energy usage.

Finally, the reader should note that for both process routes, BAT AELs to air and water, in particular the BAT AELs relevant to the emissions of heavy metals to water, have been drawn in this document.

Chapter 4 – Carbon black

About 65 % of the world's consumption of carbon black is used in the production of tyres and tyre products for automobiles and other vehicles. Roughly 30 % goes into other rubber products, with the remainder being used in plastics, printing ink, paint, paper and miscellaneous applications.

Today, the global installed capacity is approximately eight million tonnes per year, with a worldwide demand for carbon black in the order of six million tonnes per year. This quantity is produced by more than 150 carbon black plants situated in 35 countries, of that 1.7 million tonnes per year in 22 plants situated in 12 Member States of the EU-25.

Mixtures of gaseous or liquid hydrocarbons represent the raw materials preferable for the industrial production of carbon black. Since aliphatic hydrocarbons give lower yields than aromatic hydrocarbons, the latter are primarily used.

The sulphur content in the carbon black feedstock is of key importance for the assessment of the environmental impact of the European carbon black plants.

The most important process today is the furnace black process. It accounts for more than 95 % of the total worldwide carbon black production. Nearly all rubber grades and a significant part of pigment-grade carbon blacks are now manufactured by the furnace black process. It is a continuous process, and its advantages are its great flexibility and its better economy compared to other processes. The typical production rate is approximately 2000 kg/h for a modern furnace black reactor.

When concluding on BAT for the carbon black industry, the following key environmental issues have been taken into consideration:

- dependence of the European carbon black industry on the availability of petrochemical and carbochemical feedstocks with a high carbon to hydrogen ratio and high aromatic content, which result in the highest yields and reduced impact on the environment
- the sulphur content in the feedstock used in the production of carbon black and its influence on the emissions of SO_X to air
- the modern furnace process used in the European carbon black industry which allows high plant throughput, the most characteristic environmental features of this process being high energy intensity, and the emissions of NO_X, SO_X and dust to air
- process-integrated measures, including primary NO_X and SO_X reduction, and tail-gas combustion with energy recovery, followed by possible end-of-pipe measures with the aim to reduce the emissions of NO_X, SO_X and dust to air, in order to lessen the impact of the production of carbon black in the EU-25 on the environment.

Several distinct BAT conclusions have been drawn for carbon black plants in the EU-25 based on the furnace process, including the usage of low sulphur feedstock, the carbon black content in the filtered tail-gas, flaring, NO_X emissions, and dust emissions.

Of these, the most illustrative is the sequence of actions in concluding on BAT for sulphur content in the carbon black feedstock, to finally come to the following BAT conclusion:

BAT 1
Use low sulphur feedstock: The use of low sulphur primary feedstock with a sulphur content in the range of 0.5 – 1.5 % as a yearly average. The corresponding specific emission level associated with BAT is 10 – 50 kg SO_X (as SO_2) per tonne of rubber-grade carbon black produced, as a yearly average. These levels are achieved assuming that the secondary feedstock is natural gas. Other liquid or gaseous hydrocarbons can be used as well.

In the production of speciality grade carbon black (high surface pigment blacks), higher emission levels are expected.

Chapter 5 – Synthetic amorphous silica

Synthetic amorphous silica is produced either by the thermal process (a high temperature hydrolysis of chlorosilanes – pyrogenic silica) or by the wet process (precipitation of a water glass solution with acids – precipitated silica and silica gel) and is used in a wide range of applications, such as synthetic resins, plastics, rubbers, cosmetics, nutritional products and drugs, fillers or anti-caking agents.

When concluding on BAT for the synthetic amorphous silica industry, the following key environmental issues have been taken into consideration:

- for the production of synthetic amorphous pyrogenic silica, the key environmental issue is to reduce the chlorine emission by applying process-integrated measures (hydrogen injection, methane and hydrogen injection, incineration), followed by the removal of hydrogen chloride from the off-gas and, finally, by using the end-of-pipe technique of scrubbing residual chlorine from the off-gas and treatment of the resulting sodium hypochlorite stream either with hydrogen peroxide or by catalytic conversion to obtain sodium chloride
- for the production of synthetic amorphous precipitated silica and silica gel, the most important environmental issue is proper selection and integration of liquid/solid separation and silica drying techniques in order to save energy and reduce the associated emissions of CO_2, SO_X and NO_X to air.

Chapter 6 – Inorganic phosphates

This document covers the production of three groups of inorganic phosphates:

- detergent phosphates, in particular sodium tripolyphosphate (STPP)
- food phosphates (human food or pharmaceutical ingredients), in particular sodium tripolyphosphate (STPP)
- feed phosphates (animal feed supplements), in particular dicalcium phosphate (DCP).

When concluding on BAT for the inorganic phosphates industry sector, the following key environmental issues have been taken into consideration:

- inorganic phosphates are derived from phosphate rock and, depending on the quality of the rock and the pretreatment (purification) of the intermediate phosphoric acid used, the impact on the environment varies, with the cross-media effects also varying to a large degree. Detailed comparisons are difficult as the data on the purification of non-fertiliser grade wet phosphoric acid are very limited (this process stage is situated outside of the scope of this document)
- for detergent-grade STPP, based on the ‘green’ phosphoric acid route, two main environmental process-related issues can be identified: in the wet stage of the process – the cakes of gypsum and other impurities originating from the raw materials used, and in the dry stage of the process – emissions of fluorine, P_2O_5 droplets and STPP dust are produced
- for food and detergent-grade STPP, based on the purified non-fertiliser grade wet phosphoric acid, the main environmental impact is located upstream in the wet stage of acid purification. In the dry stage of the STPP process, the main issues are again the emissions of fluorine, P_2O_5 droplets and dust
- for feed-grade DCP, in the phosphoric acid route, based on the purified non-fertiliser grade wet phosphoric acid, the main environmental impact is located upstream in the wet stage of acid purification. In the dry stage of the DCP process, the key issues are the emissions of dust to air and phosphorus to water. In turn, in the hydrochloric acid route, the key issues are the emissions of dust and HCl to air, phosphorus to water, and solids waste to land.

Chapter 7 – ‘Selected illustrative’ LVIC-S products

Chapter 7 covers in total 17 ‘selected illustrative’ LVIC-S products, addressed in this document at a lesser level of detail than the ‘cornerstone’ LVIC-S products.

Given the limitations of the text in the Executive Summary, and the size of Chapter 7, which exceeds 240 pages, it is impossible to even briefly comment on all the process routes applied in the production of ‘selected illustrative’ LVIC-S products, the ‘Techniques to consider in the determination of BAT’ analysed, and the detailed BAT conclusions drawn in this chapter.
However, it should be noted that, when concluding on BAT for the ‘selected illustrative’ products, a total of 126 Best Available Techniques were identified.

An attempt had been made to look for the commonalities in the BAT proposals for these 17 LVIC-S products, but apart from some similarities regarding abatement techniques for dust collection, no other common BAT conclusions in this group were drawn.

Chapter 8 – Common abatement measures applied in the LVIC-S industry

Following IPPC Directive Annex IV considerations, which need to be taken into account when determining BAT, Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** gives information on the sources of emissions to air, techniques available for reducing emissions to air, as well as on the emissions to water and emissions of solid waste in the LVIC-S industry. The description of the environmental management tools and, finally, the conclusion on Best Available Technique for the environmental management follows. Closely related to Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** is Annex 3, 'good environmental practices (GEP) for the use of technology, plant design, maintenance, operation, environmental protection, and decommissioning in the LVIC-S industry'.

Chapter 9 – Emerging Techniques in the LVIC-S industry

The review of techniques currently available in the LVIC-S industry indicates that there is little information on emerging techniques. Innovations and emerging techniques defined in this document are relevant to the production of soda ash, titanium dioxide, carbon black, and silicon carbide.

Chapter 10 – Concluding Remarks

The Concluding Remarks chapter contains background information on the kick-off meeting on LVIC-S, the milestones in developing this document, and the degree of consensus reached on BAT proposals for the process Chapters 2 through to 7, and on generic BAT proposals for the LVIC-S industry. Recommendations for further research and information gathering on LVIC-S are given and, finally, recommendations for updating this document.

The EC is launching and supporting, through its RTD programmes, a series of projects dealing with clean technologies and management strategies. Potentially these projects could provide a useful contribution to future BREF reviews. Readers are therefore invited to inform the EIPPCB of any research results which are relevant to the scope of this document (see also the preface of this document).