



EUROPEAN COMMISSION

**Integrated Pollution Prevention and Control (IPPC)
Reference Document on Best Available Techniques for
Mineral Oil and Gas Refineries**

February 2003

EXECUTIVE SUMMARY

The BREF (Best Available Techniques reference document) on Mineral Oil and Gas Refineries reflects an information exchange carried out according to Article 16(2) of Council Directive 96/61/EC. This Executive Summary – which is intended to be read in conjunction with the BREF preface’s explanations of objectives, usage and legal terms – describes the main findings, the principal BAT conclusions and the associated emission levels. It can be read and understood as a stand-alone document but, as a summary, it does not present all the complexities of the full BREF text. It is therefore not intended as a substitute for the full BREF text as a tool in BAT decision making. In this information exchange more than 40 people have participated directly. Oil companies are typically international companies, so people from outside the EU have also been involved in the process.

Scope

The scope of this BREF for the Mineral Oil and Gas Refinery Industry is based on Section 2.1 of Annex I of the IPPC Directive 96/61/EC, from which it also takes its title. This document addresses the mineral oil refining industry as well as the natural gas plants. Other related activities such as exploration, production, transportation or marketing of products are not included here. All types of mineral oil refineries regardless of capacity and all types of process activities typically found there are covered in this document. Some activities that are or may be found in refineries are not covered here because they are covered in other BREFs (e.g. low olefins and solvent production, generation of power with natural gas). Other activities have not been fully covered in this document because they are partially covered in other BREFs (e.g. cooling, storage, waste water and waste gas). Thus, when implementing IPPC permits for a specific site, other BREFs should also be considered. Soil remediation is not included in this BREF because it is not a contamination prevention or control technique.

The European Refinery industry

The mineral oil and gas refinery industry is an important and strategic industry. Mineral oil refineries alone provide 42% of EU energy requirements and 95% of the fuels required for transport. About 100 mineral oil refineries have been identified in EU, Switzerland and Norway and together they process around 700 million tonnes per year. Installations are well spread around the European geography, generally located near the coast. Estimations show that the mineral oil refinery sector has 55000 direct employees and some 35000 indirect employees. 4 on-shore natural gas plants have been identified.

Refinery processes and the most important environmental issues

The document provides an updated picture of the technical and environmental situation of the two industrial sectors. It contains a brief technical description of the major activities and processes found in the sectors complemented by the actual emissions and consumptions found in European installations.

Refinery installations are typically big and fully integrated. Refineries are industrial sites that manage huge amounts of raw materials and products and they are also intensive consumers of energy and water. In their storage and refining processes, refineries generate emissions to the atmosphere, to the water and to the soil, to the extent that environmental management has become a major factor for refineries. The type and quantity of refinery emissions to the environment are typically well known. Oxides of carbon, nitrogen and sulphur, particulates (mainly generated from combustion processes), and volatile organic carbons are the main air pollutants generated by both sectors. Water is used intensively in a refinery as process water and for cooling purposes. Its use contaminates the water with oil products. The main water contaminants are hydrocarbons, sulphides, ammonia and some metals. In the context of the huge amount of raw material that they process, refineries do not generate substantial quantities of waste. Currently, waste generated by refineries are dominated by sludges, non-specific refinery waste (domestic, demolition, etc.), and spent chemicals (e.g. acids, amines, catalysts).

Emissions to air are the main pollutants generated by mineral oil refineries and, to a much lesser extent, natural gas plants (i.e. number of emission points, tonnes emitted, number of BAT developed). For every million tonnes of crude oil processed (European refineries range from 0.5 to more than 20 million tonnes), refineries emit from 20000 – 820000 t of carbon dioxide, 60 - 700 t of nitrogen oxides, 10 – 3000 t of particulate matter, 30 – 6000 t of sulphur oxides and 50 – 6000 t of volatile organic chemicals. They generate, per million tonnes of crude oil refined, from 0.1 – 5 million tonnes of waste water and from 10 – 2000 tonnes of solid waste. Those big differences in emissions from European refineries can be partially explained by the differences in integration and type of refineries (e.g. simple vs. complex). However, the main differences are related to different environmental legislation schemes in Europe. Main air emissions from natural gas plants are CO₂, NO_x, SO_x, and VOC. Water and waste are typically less important than for mineral oil refineries.

Given the progress that refineries have made in the abatement of sulphur emissions to air, the focus has started to shift towards VOC (including odour), particulates (size and composition) and NO_x, as it has in the environmental debate generally. When the carbon dioxide emissions debate gathers momentum, it will also strongly affect refineries. Refinery waste water treatment techniques are mature techniques, and emphasis has now shifted to prevention and reduction. Reduction of water use and/or the concentration of pollutants in the water can have effects in reducing the final emission of pollutants.

Techniques to consider in the determination of BAT

Close to 600 techniques have been considered in the determination of BAT. Those techniques have been analysed following a consistent scheme. That analysis is reported for each technique with a brief description, the environmental benefits, the cross-media effects, the operational data, the applicability and economics. In some cases the driving force for implementation has been explored and references to the number of installations containing the technique have been included. The description of the techniques ends with the reference literature supporting the data in Chapter 4. Those techniques have been put into in 25 sections as shown in the following table.

Chapter section	Activity/Process	Techniques applied to				TOTAL
		production and prevention	gases and waste gas	waste water	solid waste	
1	General					
2	Alkylation	3	0	0	0	3
3	Base oil production	14	4	2	1	21
4	Bitumen production	2	5	1	2	10
5	Catalytic cracking	17	13	2	5	37
6	Catalytic reforming	3	3	0	0	6
7	Coking processes	9	19	8	3	39
8	Cooling	3	-	-	-	3
9	Desalting	13	0	4	1	18
10	Energy system	56	22	2	0	80
11	Etherification	1	0	1	1	3
12	Gas separation processes	3	2	0	0	5
13	Hydrogen-consuming processes	8	0	0	2	10
14	Hydrogen production	6	0	0	0	6
15	Integrated refinery management	33	0	24	6	63
16	Isomerisation	3	0	0	0	3
17	Natural gas plants	0	12	5	3	20
18	Polymerisation	1	0	0	2	3
19	Primary distillation units	3	2	3	3	11
20	Product treatments	5	2	4	0	11
21	Storage and handling of refinery materials	21	19	2	12	54
22	Visbreaking	3	1	1	1	6
23	Waste gas treatments	-	76	-	1	77
24	Waste water treatments	-	-	41	-	41
25	Waste management	-	-	-	58	58
	TOTAL	207	180	100	101	588

As can be calculated from the above table, 35 % of the techniques included in Chapter 4 are techniques dedicated to production and to the prevention of contamination, 31 % are air abatement techniques and 17 % are for techniques to reduce water pollution and to reduce waste or to prevent soil contamination. Those figures again reflect the fact that air emissions are the most important environmental issue in the refinery sector.

Best Available Techniques for Mineral Oil and Gas Refineries

The conclusions on Best Available Techniques for both sectors as a whole are considered the most important part of this document and are included in Chapter 5. Where possible, the associated emission, consumption and efficiency levels have been included. Once again, this BAT chapter reflects that emissions to air are the most important environmental concern of refineries. More than 200 BAT have been reported in Chapter 5 that relate to all environmental issues found in refineries. Because of the complexity of the sector, the different raw materials used, the great number of cross-media issues and the different environmental perceptions, it has not been easy to define a structure for Chapter 5. For example, this chapter does not prioritise the environmental goals or the steps towards achieving them, because of the differences of opinion within the TWG and the different site-specific possibilities to reach the same environmental goal.

This section of the executive summary highlights the most relevant environmental issues and the key findings that are given in Chapter 5. During the discussion of the information exchanged by the TWG, many issues were raised and discussed. Only some of them are highlighted in this summary.

Unit-based BAT approach vs. generic BAT approach

A most controversial issue during the preparation of the BREF, given its bearing on most of the conclusions on BAT in Chapter 5, has been the issue of process integration within the refinery as a whole, notably on the basis of the bubble approach, versus an integrated multi-media approach per individual process unit, i.e. the unit-by-unit approach. An important conclusion has been that both approaches should be respected as having their own merits in the permitting procedure and can complement each other rather than opposing each other. Chapter 5 has therefore been divided into two sections (generic and process BAT). So, BAT for any specific refinery is the combination of the non-unit-specific elements, i.e. those applicable to refineries as a whole (generic BAT), and the unit-specific-BAT applicable to that particular case.

Implementation of IPPC permits based on BAT

As totally new refineries are unlikely to be built in Europe, the application of the BAT concept is most relevant to the permitting of new process units in existing refineries or the update and renewal of permits for existing facilities. Implementation of some concepts or techniques related to BAT in those existing refineries may be very difficult. This difficulty is related to the complex nature of the refinery sector, its diversity, the high degree of process integration or its technical complexity.

Emission or consumption levels “associated with best available techniques” are presented where relevant within BAT chapter. BREFs do not set legally binding standards, they are meant to give information for the guidance of industry, Member States and the public on achievable emission and consumption levels when using specified techniques. Those levels are neither emission nor consumption limit values and should not be understood as such. The appropriate limit values for any specific case will need to be determined taking into account the objectives of the IPPC Directive and the local considerations.

It was acknowledged that the implementation of BAT in each refinery needs to be addressed in each case and that multiple technical solutions exist. That is why prevention or control techniques are given in the BAT as a group of possibilities.

Amongst the many environmental issues addressed in the BREF, the five that are dealt with below are probably the most important:

- increase the energy efficiency
- reduce the nitrogen oxide emissions
- reduce the sulphur oxide emissions
- reduce the volatile organic compounds emissions
- reduce the contamination of water

BAT is to increase refinery energy efficiency

It was recognised during the exchange of information that one of the most important BAT for the sector is to increase energy efficiency, the principal benefit of which would be a reduction in the emissions of all air pollutants. Techniques to increase energy efficiency within refineries were identified (~32) and data were provided, but it was not possible, with any of the several methods available, to quantify what constitutes an energy efficient refinery. Only some reported figures on the Solomon index for ten European refineries were included. It is recognised in the BAT chapter that an increase in energy efficiency should be tackled on two fronts: increasing the energy efficiency of the various processes/activities and enhancing energy integration throughout the refinery.

BAT is to reduce nitrogen oxides emissions

NO_x emissions from refineries were also identified as an issue that should be analysed from two perspectives: that of the refinery as a whole and that of specific processes/activities, notably the energy system (furnaces, boilers, gas turbines) and catalytic cracker regenerators, because that is where they are mainly generated. The TWG has therefore tried to reach consensus using both the bubble concept and scrutiny of the individual processes that generate NO_x emissions. The TWG has not been able to identify a single range of emissions associated with the application of

BAT under the bubble concept. Five different ranges or values were provided by the TWG for the concentration bubble approach (three based on different scenarios when implementing BAT) and two for the load bubble approach (one based on the scenario of implementation of BAT). BAT related to NO_x emissions (~17) typically contain associated emission values.

BAT is to reduce sulphur oxides emissions

The third area identified as an issue that should be examined from those two perspectives is SO_x emissions, which are typically generated in the energy system (from fuels containing sulphur compounds), catalytic cracker regenerators, bitumen production, coking processes, amine treating, sulphur recovery units and flares. An additional difficulty here is that sulphur appears in the products manufactured by the refinery. A sulphur balance has therefore been included as a technique to consider as part of the Environmental Management System. As a consequence of all that, the TWG tried to reach consensus using the bubble concept and by examining the individual processes that generate SO_x emissions. The TWG was not able to identify a single range of emissions associated with the application of BAT under the bubble concept. Five different ranges or values were provided by the TWG for the concentration bubble approach (two based on different scenarios when implementing BAT) and two for the load bubble approach (one based on the scenario of implementation of BAT). BAT related to SO_x emissions (~38) typically contain associated emission values.

The Commission has noted the divergent views of the TWG concerning the average sulphur dioxide emission levels when burning liquid fuels, associated with the use of BAT. The Commission further notes that Council Directive 1999/32/EC on the sulphur content of certain liquid fuels prescribes a maximum emission limit value of 1700 mg/Nm³, which equates to 1 % sulphur in heavy fuel oil, as a monthly mean value averaged over all plants in the refinery from 1 January 2003. In addition, the more recently adopted Directive 2001/80/EC on large combustion plants provides for emission limit values in the range of 200 to 1700 mg/Nm³ depending on the characteristics of plants covered by that directive.

In this perspective, the Commission believes the range of 50 to 850 mg/Nm³, as average sulphur dioxide emission levels when burning liquid fuels to be consistent with BAT. In many cases, achieving the lower end of this range would incur costs and cause other environmental effects which outweigh the environmental benefit of the lower sulphur dioxide emission (reference in Section 4.10.2.3). A driver towards the lower end could be the national emission ceiling for sulphur dioxide as fixed in Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants or if the installation is located in a sulphur sensitive area.

BAT is to reduce VOC emissions

VOC emissions from refineries were identified more as a global issue than a process/activity issue, because VOC emissions in the sector come from fugitives, for which the point of emission is not identified. However, those processes/activities with a high potential for VOC emissions are identified in the Specific BAT for processes/activities. Because of this difficulty in identifying points of emission, the TWG concluded that one important BAT is to quantify the VOC emissions. One method is mentioned in Chapter 5 as an example. In this case the implementation of a LDAR programme or equivalent is also recognised as very important. The TWG was not able to identify any range of emissions associated with the application of BAT, mainly because of a lack of information. Many (~19) BAT related to VOC emissions have been identified.

BAT is to reduce contamination to water

As mentioned repeatedly in the document, air emissions are the most important environmental issues that appear within a refinery. However, because refineries are extensive consumers of water, they also generate great quantities of contaminated waste water. The (~37) BAT related to water are on two levels. One deals with water management and waste water management in the refinery as a whole and the other deals with specific actions to reduce contamination or reduce water consumption. In this case, benchmarks for fresh water usage and process effluent volume are included in Chapter 5 as well as water parameters for the effluent of the waste water treatment. Chapter 5 contains many (~21) BAT related to the possibility of recycling of waste water from one process to another.

Emerging techniques

This brief chapter includes the techniques that have not yet been commercially applied and are still in the research or development phase. However, because of the implications they may have in the refinery sector, they have been included here to raise awareness during any future revision of the document.

Concluding remarks

The environmental situation of European refineries varies greatly across the European Community, so the starting point for each case is very different. Different environmental perceptions and priorities are also evident.

Level of consensus

The refineries sector is a large and complex one, spread across all Member States except Luxembourg. This size and complexity are reflected in the number of processes / activities addressed in the BREF and the number (200+) of BAT it contains. The fact that agreement has been reached on all but 27 of those 200+ BAT is a measure of the broad commitment of TWG members to the conclusions reached. Those 27 split views can be summarised and classified in the following three ways:

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- One relates to the general introduction to Chapter 5
 - eleven relate to the Generic BAT
 - fifteen relate to Specific BAT.
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- Nineteen relate to the figures in the ranges given in Chapter 5. They represent two points of view; the first is that control techniques are almost always applicable in all cases and the second is that control techniques are hardly applicable
 - four relate to the structure of the parts of Chapter 5 that relate to SO_x and NO_x emissions and are driven by the bubble concept approach
 - two relate to the water emissions table; one to the average time period given in the concentration column and the other to how the metal content should be expressed within the table
 - one is addressed to the introduction to Chapter 5 and relates to the way in which the upper value of the ranges in Chapter 5 is selected
 - only one split view relates fundamentally to a technique; base oil production.
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- Nine relate to the water emissions table
 - eight relate to SO_x emissions
 - eight relate to NO_x emissions
 - two relate to particulates emissions.
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Recommendations for future work

In preparation for future BREF reviews, all TWG members and interested parties should continue to collect data on the current emission and consumption levels and on the performance of techniques to be considered in the determination of BAT. For the review, it is also important to collect more data on the achievable emission and consumption levels and the economics of all production processes under analysis. It is also important to continue collecting information on energy efficiency. Apart from these general areas, some techniques in Chapter 4 need more information in order to be complete. Other complementary data missing in the document is about characteristics of particulates, noise and odour. It is also recognised that other organisations such as technology providers, may enhance the appearance and validation of data within the document.

Recommendations for future R&D work

The previous paragraph highlights many areas for attention in future work. Much of the future work concerns the collecting of information to be used in reviewing this BREF. Proposals for future R&D work focus on the techniques that are identified in this BREF, but are too expensive or cannot be used yet in the sector.

The EC is launching and supporting, through its RTD programmes, a series of projects dealing with clean technologies, emerging effluent treatment and recycling 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).