BAT Guidance Note on
Best Available Techniques for
Oil and Gas Refineries

(1st Edition)

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Acknowledgements

The Environmental Protection Agency would like to acknowledge the assistance provided by Byrne Ó Cléirigh in preparing the consultation draft document. A public consultation process was carried out as part of the preparation of this document. The comments/constructive criticism on the consultation draft guidance note offered by individuals and organisations particularly IBEC staff and representatives of the relevant sectoral groups, Office of Environmental Enforcement and Office of Climate, Licensing & Resource Use staff are gratefully acknowledged.

The Environmental Protection Agency would also like to acknowledge the assistance provided by Mr John Doheny, Office of Environmental Enforcement, for the use of the cover photograph from his personal portfolio.

ISBN: 1-84095-291-1 08/08/50

Price: Free

Contents

1. INTRODUCTION

1.1 GENERAL

This Guidance Note is one of a series issued by the Environmental Protection Agency (EPA), which provides guidance on the determination of Best Available Techniques (BAT) in relation to:

- applicants seeking Integrated Pollution Prevention and Control (IPPC) licenses under Part IV of the Environmental Protection Agency Acts 1992 to 2007,
- existing Integrated Pollution Prevention and Control (IPPC) Licensees, whose licence is to be reviewed under the Environmental Protection Agency Acts 1992 to 2007,
- applicants seeking Waste Licenses under Part V of the Waste Management Acts 1996 to 2008,
- existing Waste Licensees, whose licence is to be reviewed under Waste Management Acts 1996 to 2008.

This Guidance Note shall not be construed as negating the installation/facility statutory obligations or requirements under any other enactments or regulations.

1.2 BAT GUIDANCE NOTE STRUCTURE

This Guidance Note has been structured as follows:

Section	Details
1	Introduction
2	Interpretation of BAT
3	Sector(s) Covered by this Guidance Note
4	Process Description, Risk to the Environment and Control Techniques
5	Best Available Techniques
6	BAT Associated Emission Levels
7	Compliance Monitoring

Where relevant, references are made to other detailed guidance; such as the reference documents (BREF) published by the European Commission, Agency Guidance Notes for *Noise in Relation to Scheduled Activities*, and the determination of BAT should be made giving regard to these.

The information contained in this Guidance Note is intended for use as a tool to assist in determining BAT for the specified activities.

2. INTERPRETATION OF BAT

2.1 STATUS OF THIS GUIDANCE NOTE

This Guidance Note will be periodically reviewed and updated as required to reflect any changes in legislation and in order to incorporate advances as they arise.

Techniques identified in these Guidance Notes are considered to be current best practice at the time of writing. The EPA encourages the development and introduction of new and innovative technologies and techniques, which meet BAT criteria and look for continuous improvement in the overall environmental performance of the sectors activities as part of sustainable development. Operators should therefore continue to keep up to date with the best available techniques relevant to the activity and discuss appropriate innovations with the EPA.

2.2 INTERPRETATION OF BAT

BAT was introduced as a key principle in the IPPC Directive, 96/61/EC. This Directive has been incorporated into Irish law by the Protection of the Environment Act 2003. To meet the requirements of this Directive, relevant Sections of the Environmental Protection Agency Act 1992 and the Waste Management Act 1996 have been amended to replace BATNEEC (Best Available Technology Not Entailing Excessive Costs) with BAT.

Best available techniques (BAT) is defined in Section 5 of the Environmental Protection Agency Acts 1992 to 2007 and Section 5(2) of the Waste Management Acts 1996 to 2008 as the “most effective and advanced stage in the development of an activity and its methods of operation, which indicate the practical suitability of particular techniques for providing, in principle, the basis for emission values designed to prevent or eliminate or where that is not practicable, generally to reduce an emission and its impacts on the environment as a whole” where:

B ***‘best’*** in relation to techniques means the most effective in achieving a high general level of protection of the environment as a whole.

A ***‘available techniques’*** means those techniques developed on a scale which allows implementation in the relevant class of activity under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced within the State, as long as they are reasonably accessible to the person carrying on the activity.

T ***‘techniques’*** includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

The range of BAT associated emission level values specified in Section 6 indicate those that are achievable through the use of a combination of the process techniques and abatement technologies specified as BAT in Section 5. The licensee must demonstrate to the satisfaction of the Agency, during the licensing process, that the installation/facility will be operated in such a way that all the appropriate preventative measures are taken against pollution through the application of BAT and justify the application of other than the most stringent ELV in the range.

At the installation/facility level the most appropriate techniques will depend on local factors. A local assessment of the costs and benefits of available options may be needed to establish the best option. The choice may be justified on:

- technical characteristics of the installation/facility;
- its geographical location;
- local environmental considerations;
- the economic and technical viability of upgrading existing installation/ facility;

The overall objective of ensuring a high level of protection for the environment as a whole will often involve making a judgment between different types of environmental impact, and these judgements will often be influenced by local considerations. On the other hand, the obligation to ensure a high level of environmental protection including the minimisation of long-distance or transboundary pollution implies that the most appropriate techniques cannot be set on the basis of purely local considerations.

The guidance issued in this Note in respect of the use of any technology, technique or standard does not preclude the use of any other similar technology, technique or standard that may achieve the required emission standards and is demonstrated to the Agency to satisfy the requirement of BAT.

2.3 BAT HIERARCHY

In the identification of BAT, emphasis is placed on pollution prevention techniques rather than end-of-pipe treatment.

The IPPC Directive 96/61/EC and the Environmental Protection Agency Acts 1992 to 2007 (section 5(3)), require the determination of BAT to consider in particular the following, giving regard to the likely costs and advantages of measures and to the principles of precaution and prevention:

(i) the use of low-waste technology,
(ii) the use of less hazardous substances,
(iii) the furthering of recovery and recycling of substances generated and used in the process and of waste, where appropriate,
(iv) comparable processes, facilities or methods of operation, which have been tried with success on an industrial scale,
(v) technological advances and changes in scientific knowledge and understanding,
(vi) the nature, effects and volume of the emissions concerned,
(vii) the commissioning dates for new or existing activities,
(viii) the length of time needed to introduce the best available techniques,
(ix) the consumption and nature of raw materials (including water) used in the process and their energy efficiency,
(x) the need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it,
(xi) the need to prevent accidents and to minimise the consequences for the environment, and
(xii) the information published by the Commission of the European Communities pursuant to any exchange of information between Member States and the industries concerned on best available techniques, associated monitoring, and developments in them, or by international organisations, and such other matters as may be prescribed.

3. SECTOR COVERED BY THIS GUIDANCE NOTE

This Guidance Note covers the following activities under the First Schedule of the Environmental Protection Agency Acts 1992 to 2007:

9.2 The handling or storage of crude petroleum, not included in paragraph 9.3.1 or 9.3.2.

9.3.1 The operation of mineral oil and gas refineries.

9.3.2 The refining of petroleum or gas, not included in paragraph 9.3.1.

4. PROCESS DESCRIPTION, RISK TO THE ENVIRONMENT AND CONTROL TECHNIQUES

4.1 INTRODUCTION

(Note: any reference to BREF in this document means the reference document on *Best Available Techniques for Mineral Oil and Gas Refineries*, published by the European Commission, February, 2003).

The refining of crude oil and natural gas is the process of converting naturally occurring hydrocarbons into saleable products. The products of refining include:

- Fuel for cars, ships, aircraft and other forms of transport;
- Combustion fuels for use in electricity generation, process heating and space heating in households and commercial enterprises;
- Raw materials for the chemical and petrochemical industries.

This Section describes the process unit-operations that are normally employed in a Configuration 1 type oil refinery. It also provides details of the consumption of raw materials and utilities as well as the emissions associated with this type of refinery.

The unit operations typically employed in the refining of natural gas as well as the emissions associated with these operations, are also described.

4.1.1 Crude Oil Refining

Technical descriptions of the activities and unit operations associated with other refinery configuration types or base oil and bitumen refineries are given in Chapter 2 of the BREF.

The principal process steps involved in a hydroskimming and isomerisation refinery are:

- Desalting
- Distillation
- Isomerisation
- Reforming
- Hydrotreating
- Blending
- Sulphur removal
- Utilities.

A schematic of the hydroskimming and isomerisation refining process is given in Figure 1. The above unit operations are described in the following paragraphs as well as a number of ancillary processes.

4.1.2 Desalting

Crude oil refining involves heating crude oil so that its various fractions vaporise. The process of heating is known as distillation and the capture of the fractions is called fractionating.

Crude oil contains inorganic compounds such as salts, metals and other sediments. These substances can cause fouling and corrosion and are removed by desalting which involves adding water (fresh and/or recycled) at high temperature and pressure. The incoming crude oil is passed through a series of heat exchangers until its temperature reaches between 115 and 150°C. At this point, it enters the desalter.

A demulsifier is added and the resulting crude/water mix is placed in an electric field. The demulsifier and the electric field encourage coalescence of the impurities. The water and crude then separate (see BREF Section 2.9). The crude enters another series of heat exchangers before distillation. The treatment of the water is further discussed in BREF Section 4.4.2.1.

4.1.3 Distillation

After desalting, the crude passes through another series of heat exchangers where it is gradually heated using reflux streams from the subsequent unit operations. It then enters one or more furnaces, where it is heated to approximately 380°C. The heated feedstock enters a vertical distillation column (the Pipestill Unit). The lighter fractions of crude vaporise and are collected on trays within the distillation column, known as fractionation trays, each corresponding to a different condensation temperature. The heavier fractions may not be vaporised at all. Steam is added to assist distillation.

The overheads from the Pipestill pass to a naphtha splitter. Splitting is similar in principle to distillation and is used to separate the lighter fractions of naphtha from LPG and to separate LPG into Propane and Butane. Caustic soda is added to the LPG to remove any H_2S present.

Pipestill distillation is carried out at atmospheric pressure (Atmospheric Distillation). The atmospheric residue remaining after this process is known as SRAR (straight-run atmospheric residue). The products from atmospheric distillation are referred to as ‘virgin’ naphtha, ‘virgin’ gasoline, ‘virgin’ kerosene, etc. Atmospheric residue can be sold as heavy fuel oil but this may represent a downgrading of the material1. Atmospheric residue can be further distilled under low pressure (Vacuum Distillation) to produce Vacuum Gas Oil (VGO) which is, in turn, is the feedstock for a catalytic- or hydro-cracking process on a more complex refinery. The long-chained hydrocarbon molecules in the VGO are cracked to form ‘cracked’ naphtha, ‘cracked’ gasoline, ‘cracked’ kerosene, etc. [2] (see BREF Section 2.19).

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[1] Depending on the market

[2] There is currently no vacuum distillation in Ireland

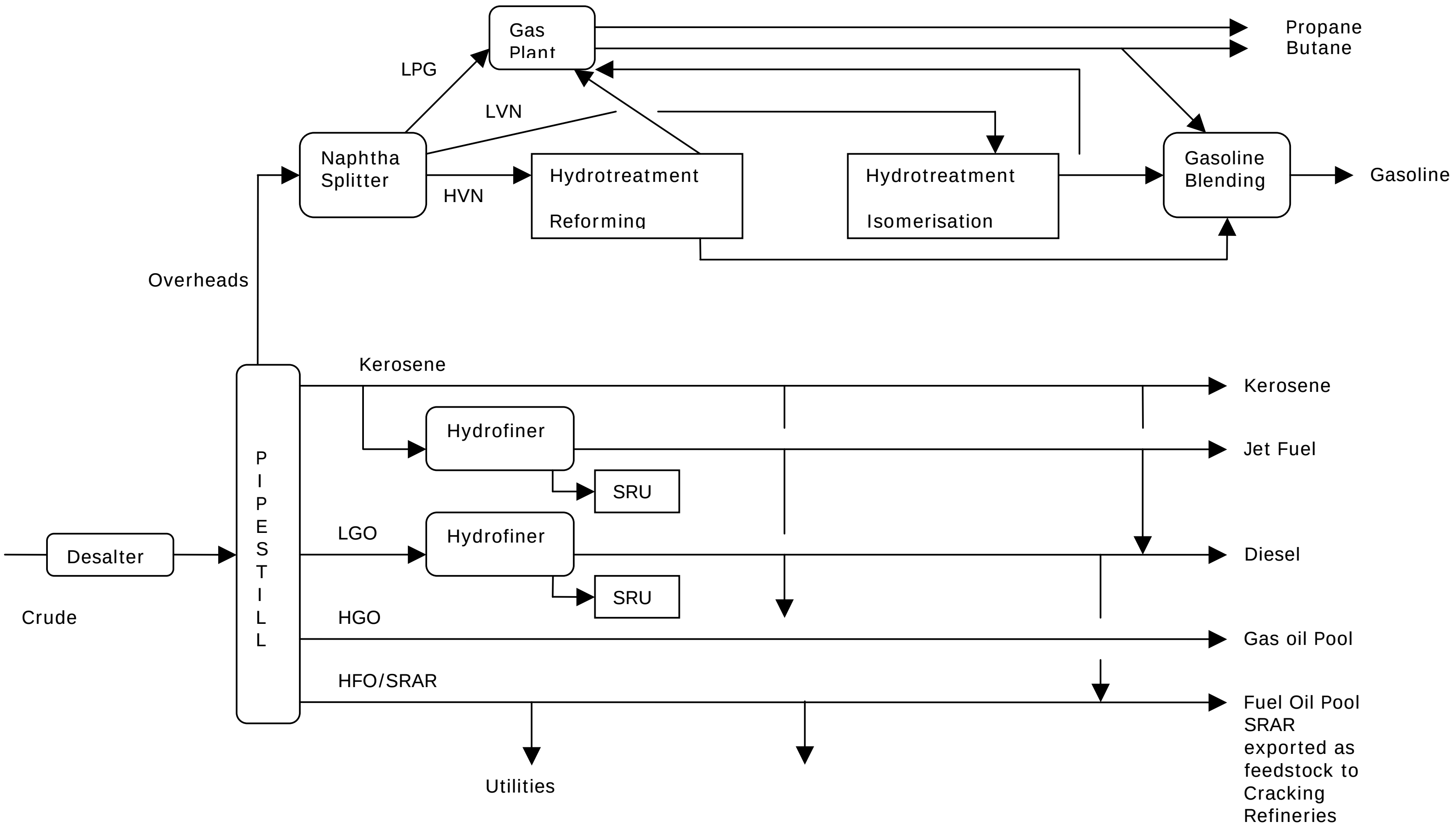

Figure 1: Refinery Process Schematic

4.1.4 Isomerisation

Isomerisation is the alteration of the arrangement of a molecule by converting from straight chain to branch chain without adding or removing anything from the original. It is used to convert low octane molecules to high-octane molecules prior to blending into gasoline. Light Virgin Naphtha (LVN) is fed to the Isomerisation Unit after fractionation in the splitter. The LVN is passed over hydrogen in the presence of a platinum catalyst. Most of the isomerised product goes into gasoline blending; however a small amount is used in the LPG splitter. Sulphur, nitrogen and metals are removed from the feedstock prior to isomerisation (see BREF Section 2.16).

4.1.5 Reforming

Reforming, or catalytic reforming, has the same purpose as isomerisation, i.e. the improvement of the octane rating of naphtha. Sulphur, nitrogen and metals are removed from the feedstock prior to reforming. There are three types of catalytic reforming process (see BREF Section 2.6):

- Continuous catalytic reforming
- Cyclic catalytic reforming
- Semi-regenerative catalytic reforming.

Hydrogen for use in the other processes in a refinery, such as isomerisation and hydrotreating, is produced by reforming.

4.1.6 Hydrotreating

The purpose of hydrotreating is to upgrade the quality of the fractions distilled. Two types of hydrotreater are described here; a naphtha hydrotreater and a diesel oil deep desulphurization unit.

A naphtha hydrotreater has three purposes: removal of sulphur, removal of nitrogen and stabilising the naphtha stream before it enters the isomerisation and reformer units. Sulphur and nitrogen can impair the performance of the catalysts and hence have to be removed. Stabilisation involves converting unsaturated long-chain hydrocarbons (alkanes) into paraffins. Naphtha is mixed with a hydrogen-rich gas stream, heated and vaporised and then fed into the hydrotreater unit in the presence of a catalyst. The resulting effluent is cooled and sent to the isomerisation or reforming units. Any un-reacted hydrogen is recycled.

Heating and diesel oils are hydrofined in a process known as diesel oil, deep desulphurization to remove sulphur in order to meet product specifications. It may also improve colour and sediment stability. Hydrogen-rich gas from the reformer is heated with gas oil over the catalyst. The sulphur in the gas oil reacts with the hydrogen to form hydrogen sulphide. The clean gas oil then goes to storage (see BREF Section 2.13).

4.1.7 Sulphur Removal

Hydrogen sulphide (H_2S) is produced across a refinery, e.g. hydrofining process. The H_2S abatement system typically consists of an amine scrubbing system and a sulphur recovery unit (SRU). A refinery gas containing the H_2S (sour gas) is treated to remove the sulphur. The gas is dissolved in a chemical solvent, usually an amine. The amine-hydrogen solution is steam-stripped and heated to remove the H_2S. The H_2S-rich gas stream is treated in a Sulphur Recovery Unit, where the H_2S is oxidised to form elemental sulphur.

Sour Water (containing ammonia, hydrogen sulphide, hydrocarbons) arises from steam injection processes. Sour water is in the main stripped in a sour water stripper prior to further treatment or reuse as wash water. Sour off-gases from a stripper unit can be routed to a sulphur recovery unit or incinerator or sour flare. Routing to the SRU is preferred and now commonly practiced (see BREF Sections 4.23.5 & 4.24.2).

4.1.8 Blending

Product blending is used to produce the optimum mix of finished refinery products. It involves mixing the products in different proportions to meet various specifications, such as vapour pressure, specific gravity, octane rating (gasoline), Cetane number and cloud point (diesel), and sulphur content. Blending can be carried out in-line or in batch blending tanks. A blending system consists of a manifold where streams are blended on flow control. The blend ratio is optimised and controlled by a computer. In-line analysis of various properties, such as flash point, RVP, boiling point and specific gravity is carried out to ensure that the product meets industry specifications. Batch blending involves mixing the feed streams in a blend tank, from where the process units are fed. Intermediate product streams are sent to intermediate storage tanks and batch blended into the final product tanks.

4.1.9 Transfer and Storage of Crude Oil

The primary method of transferring crude oil to refineries is via pipeline only or through a combination of pipelines and crude-oil tankers loading and unloading at marine terminals. Crude oil is stored above ground in external floating roof tanks. The roof of the tank floats on the surface of the liquid, and rises and falls with the level of the oil in the tank (see BREF Section 3.12).

4.1.10 Storage and Transfer of Intermediate and Refined Products

Following distillation and fractionation, intermediate products are transferred via a pipeline to undergo further processing or to storage. Finished and intermediate products are stored in fixed roof, internal floating roof or external floating roof tanks, depending on their volatility (see Storage BREF Section 3.1.2).

Propane and Butane are stored in pressure vessels [3] at approximately 4 and 10 bar respectively (see Storage BREF Section 3.1.7).

Finished products are transferred out of a refinery to smaller distribution terminals. This can be by direct pipeline, by marine tanker or by road or by rail (see Storage BREF Section 3.2).

4.1.11 Flaring

Flaring is an essential safety feature. In the event of process malfunction or power failure, the flare system is used to burn off any excess gases that are generated (see BREF Section 4.23.7).

Some refineries reduce the volume of gas being flared by using excess gas to generate electricity in a gas-turbine generation plant.

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[3] Spheres are usually used for larger quantities but smaller vessels may be of the bullet type.

4.1.12 Energy System

Combustion takes place in furnaces/boilers to provide heat to the various process operations directly (heaters) or indirectly (steam). Some refineries may also generate a portion of their electricity requirement on-site and, if so, combustion will also take place in that operation. On a hydro-skimming refinery, the fuel is atmospheric residue and Refinery Fuel Gases (RFG), such as ethane, methane and hydrogen (see BREF Section 2.10). Further information on combustion is given in the Large Combustion Plant BREF.

4.1.13 Reflux Heating, Cooling

Reflux streams from the unit operations are passed to heat exchangers where they used to heat the crude oil prior to distillation. These steams may then be cooled in a second set of heat exchangers by either air or water.

4.2 DESCRIPTION OF PROCESS

4.2.1 Natural Gas Refining

Natural gas refining is the process of removing chemicals and other contaminants in order to ensure it meets the standards for transmission.

The contaminants likely to be found in natural gas are:

- Gases, such as CO_2, and H_2S
- Liquids, such as water, hydrocarbons, and chemicals added at the well-head, to prevent corrosion
- Solids, such as sand, scale
- Water is likely to contain dissolved mineral salts from the rock in which the gas was formed.

The unit operations in a natural gas refinery are:

- Inlet and reception
- Gas conditioning
- Gas compression and export
- Condensate recovery and stabilisation
- Antifreeze recovery, regeneration and chemical injection.

In addition to these unit operations, ancillary processes such as combustion and water treatment take place.

4.2.1.1 Inlet and Reception

Liquids commonly found in natural gas are water, hydrocarbons and chemicals that have been added to aid delivery. When the natural gas arrives at a refinery, it is in the form of a fine mist with “slugs” of liquid. The liquid can be separated from the gas by passing the gas/liquid mix through a device called a slug catcher. The slug catcher is an arrangement of large pipes where the velocity incoming gas/liquid mix is reduced. The gas and liquid phases then separate out. The gas stream flows to an inlet separator where any fine drops of liquid present are separated out. It then goes on to the conditioning step.

The liquids must then be further separated into hydrocarbons and a water/chemical mix.

Separation may also be achieved by cooling to below the relevant dew points in a low temperature separator.

4.2.1.2 Gas Conditioning

Gas conditioning is the process of treating natural gas to meet transmission specifications. Any mercury present in the gas is removed as a first step. The mercury is absorbed onto an absorbent bed and converted into a stable chemical compound. The gas stream is then dried to remove any residual liquid hydrocarbons.

Natural gas may contain high quantities of H_2S and is known as "sour gas". H_2S must be removed prior to transmission in order to meet quality standards for sale to consumers. The most common method of H_2S removal is by absorption in an amine solution.

4.2.1.3 Gas Compression and Export

The conditioned gas is compressed to the pressure required by the transmission network operator. An odorant may be added at this point although in some transmission systems it is not added until much closer to the distribution network.

4.2.1.4 Condensate Recovery and Stabilisation

Stabilisation of the hydrocarbon condensate is the removal of light hydrocarbon fractions and is usually carried out by pressure reduction and heating. Any trace mercury present is removed and converted into a stable chemical compound. The condensate is then stored in storage tanks. It is usually used for on-site process heating.

4.2.1.5 Antifreeze Recovery, Regeneration and Chemical Injection

The water/chemical mix recovered in the slug catcher contains antifreeze (methanol or glycol) that was added to the gas at the wellhead to aid delivery on-shore. The antifreeze/water mix is distilled and the antifreeze recovered for re-use. A corrosion inhibitor is added to the methanol before it is piped to the wellhead.

The water is likely to contain traces of antifreeze, hydrocarbon and corrosion inhibitors and will need treatment prior to discharge.

4.2.1.6 Energy System

Combustion of natural gas and recovered hydrocarbons is likely to be carried out on site to meet a refinery's own energy demands. Natural gas may be burned in gas turbines to generate electricity. The recovered condensate may be used to provide heating for gas conditioning.

4.2.1.7 Water Treatment

Water treatment processes are discussed in more detail in BREF Section 4.4.2.1.

4.3 RISK TO THE ENVIRONMENT

4.3.1 Crude Oil Refineries

Crude oil refineries are complex industrial sites that process large amounts of raw materials and consume substantial amounts of energy. Depending on the method of cooling employed, they may also use large quantities of water. Refining of crude oil results in emissions to air and water, as well as generation of various solid and liquid waste streams (see BREF Sections 4.3.1.1 to 4.3.1.6).

4.3.1.1 Emissions to Air

Emissions to air from a crude oil refinery can include:

- Carbon dioxide (CO_2)
- Carbon monoxide (CO)
- Oxides of sulphur (SOx)
- Oxides of nitrogen (NOx)
- Particulates (PM)
- Volatile Organic Compounds (VOCs)
- Ammonia (NH_3).

The main sources of these emissions are listed in Table 1 below.

Table 1: Main Sources of Emissions to Air from a Crude Oil Refinery (see BREF Table 1.10)

	CO_2	**CO**	**NO_x**	**PM**	**SO_x**	**VOCs**	**NH_3**
Process furnaces, boilers, gas turbines, internal combustion engines	X	X	X	X	X		
Flare systems	X	X	X		X	X	
Sulphur Recovery Units		X	X		X		X
Storage and Handling Facilities						X	
Oil/water separation systems						X	
Fugitive emissions (valves, flanges, etc.)						X	

Other emissions to the atmosphere can include the following; H_2S, NH_3, BTX, CS_2, Carbonyl sulphide, HF, and metals as constituents of particulates (V, Ni and others).

4.3.1.2 Emissions to Water

Emissions to water from a crude oil refinery can include:

- Water generated as a result of desalting
- Ballast water from tankers and other vessels
- Surface water run-off, i.e. rainwater that may have come into contact with hydrocarbons
- Steam condensate
- Utility water.
-

Common monitoring parameters in wastewaters include:

- pH
- Flow
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Suspended Solids
- Oil
- Hydrocarbons
- Ammonia
- Phenols
- Heavy Metals.

The main sources of some of these parameters are listed in Table 2.

Table 2: Main Water Pollutants Generated by Crude Oil Refineries (see BREF Table 1.11)

	Oil	**H_2S**	**NH_3 (NH_4^+)**	**Phenols**	**Organic Chemicals (BOD, COD, TOC)**	**CN^- (CNS^-)**	**Total Suspended Solids**
Distillation	X	X	X	X	X		X
Hydrotreatment	X	X	X		X		
Spent Caustic	X	X		X	X	X	X
Ballast Water	X			X	X	X	X
Rain (surface water run-off)	X				X		X
Sanitary/Domestic			X		X		X
Desalting	X		X	X	X		X
Lube Oil	X	X	X				

Contamination of groundwater may also arise as a result of a refinery's activities. Hydrocarbons may be lost to the ground from crude, refined products or water containing hydrocarbons as a result of storage and transfer activities.

4.3.1.3 Waste

In addition to emitting to air and water, refineries can produce significant amounts of solid waste. Types of solid waste generated include:

- Oily sludge from tank bottoms and desalters
- Spent catalysts
- "Sulphur cake" from the SRU.

Any waste oils generated are recovered and recycled on site. Waste from ancillary operations, such as packaging, domestic waste and food waste may also be generated. In some circumstances, recovered sulphur may be sold as a by-product, where a demand exists.

4.3.1.4 Noise & Vibration

The use of heavy, rotating machinery such as pumps, compressors and turbines may give rise to noise and vibration. Other sources of noise include Pressure Relief Valves, air-fin coolers, furnaces and truck movements within the site.

4.3.1.5 Odour

Emissions of VOCs and sulphur compounds may cause odour problems.

4.3.1.6 Resource Consumption

Crude oil refineries consume large amounts energy; both thermal and electrical. They may also consume large quantities of water in desalting, steam generation and cooling. Some refineries have installed Combined Heat and Power (CHP) plants for the purposes of generating steam and electricity.

Installed combustion capacity in European refineries varies from several hundred MWhth to more than 1500 MWhth. This equates to between 1.7 GJ and 5.4 GJ installed capacity per tonne of crude oil processed.

The amount of water used will depend on the type of refinery and the cooling system in place. For European refineries, it is between 0.01 and 5 tonnes per tonne of crude oil processed.

4.3.2 Natural Gas Refineries

4.3.2.1 Emissions to Air

The following substances may be emitted to air as a result of natural gas treatment processes:

- H_2S
- NOx
- Carbon monoxide
- Carbon dioxide
- Organic compounds (natural gas).

Table 3: Potential Sources of Emissions to Air from Natural Gas Refineries.

	H_2S	**NO_x**	**CO**	**CO_2**	**Organic Compounds**
Reception	X*				X
Gas conditioning	X*	X	X	X	X
Hydrocarbon removal					X
Gas compression			X	X	X
Condensate treatment			X	X	X
Water treatment					

* Applies only where “sour” gas is being processed.

4.3.2.2 Emissions to Water

Natural gas treatment processes may result in the emission of the following substances to water:

- Organic compounds
- Oils
- Trace salts and minerals.

Untreated natural gas contains water, which, in turn, may contain hydrocarbons, natural salts and minerals leached from rock surrounding the gas. This water is removed from the natural gas stream and is treated prior to discharge. Rainwater that may have come into contact with hydrocarbons is also treated.

Table 4: Potential Sources of Emissions to Water from Natural Gas Refineries

	Organic Compounds	**Oils**	**Acids/alkalis/salts, etc.**
Reception	X	X	
Gas conditioning	X	X	
Hydrocarbon removal	X	X	
Condensate treatment	X		X
Water treatment	X	X	

Rain (surface water run-off) can impact on total suspended solids.

4.3.2.3 Waste

In general, natural gas refining produces relatively small amounts of solid waste. Examples of the waste streams include scale and salt deposits that have been removed from the pipeline, spent mercury absorbents and spent corrosion inhibitors.

4.3.2.4 Noise & Vibration

The use of heavy, rotating machinery such as pumps, compressors and turbines may give rise to noise and vibration. Other sources of noise include Pressure Relief Valves and truck movements.

4.3.2.5 Odour

Odour problems may arise at a natural gas refinery as a result of the injection of mercaptans into the gas before transmission. These malodorous substances provide warning of a leak of gas in the transmission or distribution systems. Odours may also arise if the gas contains H_2S.

4.3.2.6 Resource Consumption

Natural gas refineries consume water and energy. The energy source may be the liquid hydrocarbons recovered from the raw gas as well as the treated gas. Treated natural gas may be used in an on-site generator to provide electricity for the installation.

There is no significant water consumption involved in natural gas refining.

4.4 CONTROL TECHNIQUES

Existing and possible measures for the elimination, reduction and control of emissions are described in this section. Table 5 lists the sections of the BREF where further information is given on control techniques for the various crude oil refinery unit operations as described in BREF Sections 4.1.2 to 4.1.13 (see also BREF Sections 4.4.2.1 and 4.4.2.2).

Table 5: Techniques to Consider when Determining BAT for the Oil Refineries Sector

Process	BREF Section
Desalting	Section 4.9
Distillation	Section 4.19
Isomerisation	Section 4.16
Reforming	Section 4.6
Hydrotreating	Section 4.13
Blending	Sections 4.21.14 & 4.21.15
Storage and Transfer of Crude Oil	Section 4.21 Note 1
Energy system	Section 4.10.
Storage and Transfer of Refined Products	Section 4.21 Note 1
Flares	Section 4.23.7
Cooling system	Section 4.8 Note 2

Note 1: Further information on techniques to consider when determining BAT for storage and transfer of both crude oil and refined products is given in the *Storag*e BREF Section 4.

Note 2: Further information on techniques to consider when determining BAT for cooling systems is given in the *Cooling Systems* BREF.

Techniques to consider in the determination of BAT for natural gas refineries (see BREF Section 4.17):

- Sulphur recovery
- Re-use of carbon dioxide
- Techniques to reduce VOC emissions
- Techniques to reduce NOx emissions
- Techniques to reduce water emissions
- Techniques to reduce waste generation.

4.4.1 Techniques for Prevention and Minimisation of Resource Consumption

4.4.1.1 Process Selection

There is no specific crude oil refining “process”. The configuration of each refinery is unique and the unit operations present will depend, *inter alia*, on the properties of the crude(s) used as feedstock and the product slate required by the market into which the refiner is selling. When determining what is BAT for crude oil refining, it is necessary to look at each unit operation individually and select BAT for that operation (see BREF Section 4.4). Techniques to be considered BAT for general refinery management are described below.

4.4.1.2 Refinery Management

Techniques to consider when examining BAT for general refinery management include environmental management tools such as the development of an Environmental Management System, scheduling of maintenance, training and safety management (see BREF Section 4.15).

4.4.1.3 Use of Energy

Information on energy management and the use of energy in Refineries is given in BREF Section 4.10. Reference should also be made to the EPA's Guidance Note on *Energy Efficiency Auditing* and any BAT Guidance Note on the Energy Sector.

4.4.1.4 Raw Materials

Refineries are designed to process specific raw materials and there would be little flexibility in changing raw material without changing the configuration of a refinery's process units. With regard to an oil refinery, the principal raw material is crude oil. This is a naturally occurring material and its properties and composition can vary very significantly, depending on the source. North Sea crude tend to be light and sweet, that is to say, they may yield approximately 65% as petroleum products and 35% as atmospheric residue. They are also low in Sulphur content. Crude sources from the Middle East tend to be heavier and sourer. Condensate recovered from natural gas processing may also be used as a feedstock.

Occasionally, a Configuration 1 refinery may also import intermediate products such as LVN for isomeriser feedstock or components for blending with its own products to achieve the required specifications.

Information on the prevention and minimisation/optimisation of raw material and water and chemical use for each unit operation contained, where applicable, in the sections of the BREF listed in Table 5 and in section 4.15 of the BREF.

4.4.2 Techniques for Prevention and Minimisation of Emissions

4.4.2.1 Waste Water Management

The wastewaters generated by a refinery that may require treatment prior to discharge are:

- Process water generated by the various unit operations that has been in direct contact with hydrocarbons
- Water/Brine from natural gas fluid
- Contaminated rainwater (surface water run-off)
- Tank water bottoms
- Ballast water
- Cooling water blow down.

Techniques to consider for integrating the wastewater streams from the various unit operations are:

- Use of process water (H_2S removed) as desalter wash water
- Use of equalising tanks to store waste water
- Cover equalising tanks with floating roofs to minimise VOC emissions
- Control the temperature of the waste water to reduce volatilization and to secure the performance of the biological treatment
- Contaminated storm water or potentially contaminated storm water should be collected and routed to a treatment plant. This may be an oil/water separation system and/or a bio-treatment unit
- Control the surfactants entering the waste water
- Using a high pressure power washer instead of a chlorinated solvent degreaser
- Use non-hazardous degreasers.

Techniques that are described in more detail in Sections 4.24.2 to 4.24.6 of the BREF are:

- Sour water stripping
- Reduction and recovery of hydrocarbons from water
- Primary treatments (separation of oil and water)
- Secondary treatments (air flotation)
- Tertiary treatments (bio-treatment).

Methods for use in treating effluent prior to recycling are described in Section 4.24.7 of the BREF.

Information on reduction to emissions to water and reduction of consumption of water for each unit operation are described, where applicable, in the sections of the BREF listed in Table 5. However, general end-of-pipe wastewater treatment, i.e. non-process specific, will be described in this section. More detailed information on end-of-pipe wastewater treatments is given in Section 4.24 of the BREF and in the WW/WG BREF. Table 6 contains a summary of wastewater treatment techniques and their applications.

Techniques to consider when controlling releases to water from natural gas refineries include,

- use of a three phase separator on the liquids from the slug catcher
- if possible the quantity and contamination of waste water needs to be controlled at source, i.e. waste water coming from off-shore
- separation of the process effluent from methanol/glycol regeneration from the other waste water streams.

Table 6: Major Waste Water Contaminants and their Respective Treatment Techniques.

	Total Suspended Solids	**BOD COD TOC**	**NH_4-N (NH_3)**	**Heavy Metals**	**Phenols**	**Oil**
Sedimentation	X	(X)^1		(X)^2		
Air Floatation	X	X^3		(X)^2		X
Filtration	X	(X)^1		(X)^2		
MF/UF	(X)^4	(X)^1				
Oil Separation		X				X
Precipitation					X	
Crystallisation					X	
Chemical Oxidation		X				
Wet air Oxidation		X			X	
NF/RO		X			X	
Adsorption		X			X	
Ion Exchange		(X)^5			X	
Extraction		X				
Distillation/Rectification		X				
Evaporation		(X)^6			X	
Stripping		(X)^7	X			
Anaerobic biological		X		X^8		
Aerobic biological		X			X	X
Nitri/de-nitrification			X			

Note 1: Only solid

Note 2: Undissolved heavy metal compounds
Note 3: Undissolved organic content
Note 4: Finely dispersed and low concentration
Note 5: Ionic organic species
Note 6: Non-volatile organic content
Note 7: Volatile organic content
Note 8: In combination with sulphate precipitated as sulphides

4.4.2.2 Waste Gas Management

Information on the treatment of waste gases emitted by each process is contained in the relevant section of the BREF (see Table 5). The WW/WG BREF gives detailed information on common waste gas treatment techniques. A summary table for waste gas treatment is given in Table 7 below.

Table 7: Selection of Techniques for Waste Gas Emission Reduction.

Technique	**Dry Matter**	**Wet Matter**	**Inorganic Particulates**	**Organic Particulates**	**Inorganic Gaseous or Vaporous Components**	**Organic Gaseous or Vaporous Components**	**Odour**
Dust Recovery and abatement							
Separator (pre)	X	X	X	X			
Cyclone (pre)	X	X	X	X			
Wet dust scrubber (FT)	X	X	X	X			
Electrostatic Precipitator (FT)	X	X	X	X	(X)	(X)	
Fabric Filter (incl. ceramic filter) (FT)	X		X	X			
Catalytic Filtration	X	X	X	X			
Two-stage Dust Filter (pol)	X		X	X			
Absolute (HEA) filter (pol)	X		X	X			
HEAF (pol)		X					
Mist filter (pre, pol)		X					
Gas Recovery							
Membrane separation (pre)						X	
Condenser (pre)					(X)	X	
Cryo-condensation (pre, FT)					(X)	X	(X)
Adsorption (FT)					X	X	X
Wet gas scrubber (water) (FT)	(X)	(X)	(X)	(X)	X	X	X
Wet gas scrubber (alkaline) (FT)	(X)	(X)	(X)	(X)	X	X	X
Wet gas scrubber (alkaline-oxidation) (FT)	(X)	(X)	(X)	(X)			X
Wet gas scrubber (acidic) (FT)	(X)	(X)	(X)	(X)	X	X	X
Gas abatement							
Biofiltration (FT)					X	X	X
Bio-scrubbing (FT)					X	X	X
Bio-trickling (FT)					X	X	X
Thermal oxidation (FT)				X		X	X
Catalytic oxidation (FT)						X	X
Flaring (FT)						X	X
Combustion Gas Treatment							
Dry alkali injection (FT)					X		
Semi-dry alkali injection (FT)					X		

Wet lime injection (FT)					X		
SNCR (FT)					X		
SCR (FT)					X	(X)	

X	Primary application
(X)	Secondary application
(pre):	mainly as pre-treatment facility
(FT):	treatment technique used as final treatment technique
(pol):	mainly as polishing technique after standard technique

4.4.3 Specific Techniques for NO_X Emissions

The term NO_x is used to describe emissions of NO (nitrogen monoxide) and NO_2 (nitrogen dioxide). Combustion processes are the main source of NO_x.

4.4.3.1 Minimisation of NO_X Formation

The emissions of NOx from a crude oil or natural gas refinery depend on the fuels used, the operation of a refinery and the abatement techniques in place. When examining how NOx formation can be reduced or eliminated, it is necessary to quantify each NOx source.

4.4.3.2 Abatement of NO_X Formation

Primary and secondary measures to control and abate NOx emissions from combustion are set out in Table 8. Table 9 lists the techniques that can be used to reduce/eliminate NOx emissions and the section of the BREF where information on that technique may be found.

Table 8: NO_x Control and Abatement Techniques to be considered in Energy Systems (Table 4.23 of the BREF)

Type of Technique	Fired Heaters	Boilers
Primary Measures (control techniques)	Low-NO_x Burners Ultra-Low-NO_x Burners Re-burning	Flue Gas Recirculation Ultra-Low-NO_x Burners Low-NO_x Burners Re-burning
Secondary Measures (abatement techniques)	SCR SNCR	SCR SNCR

Table 9: NO_x Abatement Techniques

Name	Section
Low-temperature NOx oxidation	4.23.3.1
Selective Non-Catalytic Reduction (SNCR)	4.23.3.2
Selective Catalytic Reduction (SCR)	4.23.3.3

Refer to Section 6.1.10.3 of the LCP BREF for a description of measures to reduce NOx emissions from internal combustion engines.

4.4.4 Specific Techniques for Sulphur Emissions

The sulphur contained in crude oil may leave a refinery in products, be emitted to the atmosphere as part of the refining process or be recovered. When examining sulphur emissions from a refinery, the following should be taken into consideration:

- Atmospheric emissions from processes generating SO_x, such as boilers
- Atmospheric emissions from SRUs or of gases containing sulphur in H_2S before incineration

- Atmospheric emissions generated by sulphur contained in products for which specifications on sulphur exist, such as heavy fuel oil (Directive 1999/32/EC specifies that the sulphur content of heavy fuel to be less than 1%)
- Atmospheric emissions generated by products with less specific specifications, such as other oils.

4.4.4.1 Minimisation of SO_2 Formation

Refinery operators can use a combination of the following to reduce the SO_2 emissions of a refinery:

- Increase the use of gases that do not contain sulphur (LPG, natural gas)
- Decrease the sulphur content of the fuels used
- Use low sulphur crudes where feasible; however a specific refinery may not have this option
- Increase the efficiency of the SRU
- Use end-of-pipe techniques, such as flue gas desulphurization, to capture SO_2
- Reduce SO_2 from small contributors fired on liquid fuel where they become significant part of total emission.

4.4.4.2 Sulphur Recovery Techniques

Sulphur Recovery is described in Section 4.1.7. Hydrogen sulphide from various processes ends up as contaminant in a refinery fuel gas and off-gas streams. Information on amine treatment of refinery fuel gas to H_2S is given in Section 4.23.5.1 of the BREF. H_2S rich gas streams from amine treatment units and sour water strippers are treated in the Sulphur Recovery Unit, which is normally a Claus process. Tail Gas Treatment Units may be used to remove or treat the sulphur not removed in the SRU. There are over twenty types of Tail Gas Treatment Unit processes. These can be divided as follows:

- Dry bed processes
- Liquid Phase Sub-Dew Point Processes
- Liquid Scrubbing Processes
- Liquid Redox Processes.

Further information on sulphur management is given in Section 4.23.5 of the BREF.

Sulphur dioxide (SO_2) is removed from flue gases or other waste gases by flue gas desulphurisation (FGD). Various methods of FGD exist with varying SO_2 removal efficiencies. Information on types of FGD can be found in Section 3.3.7 of the Large Combustion Plant BREF.

4.4.5 Specific Techniques for Particulate Matter

The main source of particulate emissions are process furnaces/ boilers (mainly those fired with (liquid) heavy fuel oil), catalytic cracker regenerators, decoking and sootblowing of furnaces and the flare. Particulate matter removal techniques can be divided into either wet or dry techniques, or a combination of the two. Dry techniques are cyclones, electro-filters and filtration. Wet techniques are scrubbers and washers. The techniques usually found in refineries are:

- Cyclones
- Electro-filters
- Filtration
- Wet scrubbers

- Washers.

Combinations of some of the above techniques can also be used. Further information on these is given in Sections 4.23.4.1 to 4.23.4.6 of the BREF and in Section 3.5.3 of the WW/WG BREF.

A method for the combined removal of SOx, NO_x and particulates is the SNOX process. This is described in Sections 4.23.5.4 and 4.23.8 of the BREF.

4.4.5.1 Minimisation of VOC Emissions

When transferring liquids to vessels at atmospheric pressure, the mixture of vapour and gas in the receiving vessel may be emitted to atmosphere. EU Directive 94/63/EC lists a number of options to control/minimise these vapours escaping to the atmosphere. S.I. 374 of 1997 transposed Directive 94/63/EC into Irish legislation.

Another source of VOC emissions to air is fugitive emissions from the storage tanks. Emissions from floating roof tanks are as a result of the emission of petroleum vapours through the rim seals and deck fittings of tanks. As a floating roof is lowered, product that has adhered to the tank wall is exposed to atmosphere and evaporates.

VOCs are emitted from fixed roof tanks as a result of an increase in the temperature of the tank's contents. The vapours in the tank expand and are then emitted to atmosphere through the tank vent. In addition, when material is loaded into the tank it displaces an equal volume to air saturated with petroleum vapour.

Techniques that may be considered in order to reduce VOC emissions are given in Table 10.

Table 10: Techniques to Reduce VOC emissions

Name	Section in Refineries BREF
Establishing a programme to prevent, reduce, detect and control fugitive emissions	4.23.6.1
Vapour Recovery Units	4.23.6.2
Vapour Destruction	4.23.6.3

The following sections of the Storage BREF also provide information on techniques to consider when reducing gaseous emissions from a refinery.

Table 11: Techniques to reduce Gaseous Emissions from Storage

Name	Section in Storage BREF
Gaseous emissions from storage tanks	4.1.3
Transfer and handling of liquids and liquefied gases	4.2

VOCs may cause an odour problem in a refinery. Using a scrubber with hypochlorite ion can abate this. Use of the scrubber may also slightly reduce VOC emissions.

4.4.6 Waste Management Techniques

The following waste management techniques are described in the BREF are:

- Establishing a waste management programme (see BREF Section 4.25.1)
- Sludge management (see BREF Section 4.25.2)
- Spent Solid Catalyst Management (see BREF Section 4.25.3).

Recycling and recovery of wastes minimises the quantity for disposal. Techniques for recycling and recovery of wastes that could be used in a refinery are listed in Table 12.

Table 12: Recycling and Recovery Techniques at a Refinery

Technique	Section in BREF
Treatment of heavy residues	4.25.4.1
Recovery of oils from oily sludge	4.25.4.2
Regeneration or elimination of filter clay	4.25.4.3
Reprocessing off-specification products	4.25.4.4
Recycle or re-use of waste outside a refinery	4.25.4.5
Re-use of waste lubricants	4.25.4.6
Recycling of laboratory samples to the oil recovery system	4.25.4.7

4.4.7 Noise

Noise prevention and control techniques are described in Section 4.23.10 of BREF.

5. BEST AVAILABLE TECHNIQUES FOR OIL AND GAS REFINERIES

5.1 INTRODUCTION

As explained in Section 2, this Guidance Note identifies BAT but obviously does so in the absence of site-specific information. Accordingly, it represents the requirements expected of any new activity covered by the Note, and ultimately the requirement expected of existing facilities, but exclude additional requirements, which may form part of the granting of a licence for a specific site.

The technical feasibility of the measures listed below has been demonstrated by various sources. Used singly, or in combination, the measures represent BAT solutions when implemented in the appropriate circumstances. These circumstances depend on nature of process, plant scale, fuels used, etc.

5.2 PROCESS SELECTION

As described in Section 4.4.1.1 the refining of crude oil consists of various unit operations. BAT for any refinery will be a combination of BAT for each unit operation and general refinery BAT. General refinery BAT is described in Section 5.3.

The table below lists the sections of the BREF where information on BAT for the processes described in Section 4.4.1are found.

Table13: BAT for Refinery Unit Operations

Process	Section of BREF
Desalting	5.2.9
Distillation	5.2.19
Isomerisation	5.2.16
Reforming	5.2,6
Hydrotreating	5.2.13
Blending	5.2.21
Sulphur Recovery	5.2.23
Flaring	5.2.23
Storage and Transfer of Crude Oil and petroleum products	5.2.21
Truck loading and dispatch	5.2.21
Cooling systems	5.2.8

The techniques that are considered BAT for combustion will depend on the type of fuel used. BAT for the combustion of liquid fuels is described in Section 6.5 of the Large Combustion Plant BREF and BAT for the combustion of gaseous fuels is described in Section 7.5 of the same document.

BAT for the energy system of a refinery is described in Section 5.2.10 of the BREF. The techniques described in this section include:

- Energy Management Systems
- Improvement of refinery efficiency
- Use of clean refinery fuel gas
- An increase in the proportion of clean fuels used.

Further information on BAT for storage, transfer of crude oil and petroleum products, and truck loading and dispatch is given in the Storage BREF. BAT for the storage of liquids and liquefied gases is described in Section 5.1, and BAT for the transfer and handling of refinery materials is described in Section 5.2.21.

Reduction of emissions of a specific pollutant is achieved by a combination of improving the performance of the unit operation emitting that pollutant and general refinery management. Abatement techniques that are considered BAT for specific pollutants, such as NO_X and SO_2 are described in Sections 5.3.1 to 5.3.4.

BAT for natural gas treatment plants is described in Section 5.2.17 of the BREF. Generic refinery BAT (see BREF Section 5.3) also applies to a natural gas treatment plant. BAT for energy systems, as described above and for waste gas treatments (see BREF Section 5.3.6) apply to natural gas treatment facilities.

The following, more specific techniques are considered BAT for a natural gas refinery:

- Use as fuel gas that is of a saleable quality (H_2S content is less than 5 mg/Nm^3)
- Consider alternatives to direct releases of carbon dioxide
- Environmentally-friendly disposal of mercury from raw natural gas.

5.3 GENERAL PRIMARY MEASURES

General BAT for the operation of a refinery includes the following:

- Implementation of an Environmental Management System (see BREF Section 4.15.1)
- Improve stability of the unit operations by applying advanced process control (see BREF Section 4.15.5)
- Apply good practices for maintenance and cleaning (see BREF Section 4.15.3)
- Including environmental awareness in training programmes (see BREF Section 4.15.4)
- Implement a monitoring system that allows adequate processing and emission control (see BREF Section 3.26 and the Monitoring BREF).

5.3.1 Nitrogen Oxides

The main sources of NO_x in a refinery are the furnace, boilers, gas turbines and flaring systems. In order to determine BAT to reduce NO_x emissions, it is necessary to examine the techniques that are considered BAT for each unit operation that contributes to the NO_x emission as well as examining general techniques to reduce NO_x emissions.

BAT for NO_x abatement can be grouped into three main areas:

- Ensure the fuel is as “clean” as possible (upstream abatement)
- Ensure combustion is as complete as possible
- End-of-pipe abatement techniques.

BAT for NO_x reduction is described in Section 5.2.10 of the BREF.

BAT for the reduction of NOx from combustion is described in the *Large Combustion Plant* BREF. The specific techniques depend on the fuel type.

5.3.2 Sulphur Dioxide

The main sources of SO_2 are combustion processes, the SRU and flaring. A technique similar to that used to establish BAT for NOx emissions can also be used for SO_2 emissions, that is to look at BAT for the processes emitting SO_2.

BAT for sulphur removal is described Section 5.2.23 of the BREF. BAT is to apply a staged SRU including tail gas treatment with a recovery efficiency of 99.5% to 99.9%. In addition, the operator should carry out a mass balance of sulphur within a refinery. BAT is to have an SRU configuration with sufficient capacity for the H_2S feed to the unit.

5.3.3 Particulate Matter

The main source of particulate emissions are process furnaces/boilers (mainly those fired with (liquid) heavy fuel oil), catalytic cracker regenerators, decoking and sootblowing of furnaces and the flare. BAT for combustion is described in *Large Combustion Plant* BREF. The actual techniques themselves will depend on the fuel used.
BAT for particulate abatement depends on the aims of the abatement. If both SO_2 and particulates require abatement, BAT is wet scrubbing technology. If only particulates need to be abated, then cyclones followed by an ESP represent BAT. The approach described in Section 5.3.1 of grouping BAT for NOx abatement into three main areas can also applied to SO_2 and particulate emissions.

5.3.4 VOC

Volatile Organic Compounds (VOCs) are emitted as fugitive emissions from storage tanks, pipes, flanges, valves and other fittings, as well as from oil/water separation systems and flares.

BAT to reduce VOC emissions will depend on BAT for storage and handling processes. These are described in Sections 5.1 and 5.2.21 of the BREF and Sections 5.1 and 5.2 of the Storage BREF. The BREF specifies a VRU recovery rate between 95% and 99%.

5.3.5 Waste Water

BAT for the reduction of discharges to waste water is to reduce the volume of water used in a refinery and to reduce the contamination of the water. Techniques to do this are described in Section 5.1 of the BREF.

BAT for the treatment of spent caustic is pre-treatment prior to releasing to an effluent treatment plant. More general BAT includes the provision of a slops system for oily wastes and the use of skimmers on separators and storm water ponds. BAT for wastewater treatment in general is described in Section 4.3.1 of the WW/WG BREF.

5.3.6 Waste Gas

BAT for the treatment of specific pollutant gases was described in Sections 5.3.1 to 5.3.4. This section describes general BAT for emissions to air from a refinery.

An overall reduction in emissions to air can be achieved by improving the performance of each unit operation and of a refinery as a whole. Some of the techniques that are considered BAT to reduce emissions to air are (see BREF Section 5.1):

- Improve a refinery's energy efficiency
- Use clean RFG
- Reduce SO_2 emissions
- Reduce NOx emissions
- Reduce particulate emissions
- Reduce VOC emissions.

Information on BAT for waste gas treatments is given in Section 4.3.2 of the WW/WG BREF.

5.3.7 Solid Waste

BAT for solid waste management is to (see BREF Section 5.1):

- Implement a solid waste management system
- Minimise oil spills and exclude oil spills that contaminate the soil
- Apply techniques to reduce the solid waste generated by each unit operation.

Further information on a number of waste gas and wastewater treatment techniques can be found in the BREF document on *Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector*, EIPPCB, February 2003.

6. BAT ASSOCIATED EMISSION LEVELS

6.1 EMISSION LEVELS FOR DISCHARGES TO AIR

The main sources of emissions to air from a refinery are combustion processes (including flaring), the SRU and fugitive emissions of VOCs from storage or truck loading. Refer also to Council Directive 1999/32/EC.

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The BAT-Associated emission levels for emissions to air are as follows:

Table 6.1: BAT-Associated Emission Levels for Discharges to Air

Constituent Group or Parameter		**Emission Level (mg/m^3)**	**Mass Flow Threshold (g/hr)** Note 1
Particulate Matter	Gas fuels	5 - 20	-
	Liquid fuels	100 - 150	-
Hydrogen sulphide		3 - 5	-
Hydrogen fluoride		5	
Ammonia		30	150

Note 1: The Mass Flow Threshold is calculated in g/hr or kg/hr and is determined to be the maximum emission, which can occur over any one-hour period of plant operation. Where the Mass Flow in the raw gas exceeds the mass flow threshold given in the Table, abatement will be required to reduce the emission to below the appropriate emission level or mass flow threshold.

6.2 EMISSION LEVELS FOR DISCHARGES TO WATER

The BAT-Associated emission levels for emissions to waters are as shown in Table 6.1.

Other parameters may be relevant to a refinery and will depend on the raw materials and processes in use, and other site specific factors.

Establishing ELVs for direct discharges to surface water from wastewater treatment plant and stormwater discharges must ensure that the quality of the receiving is not impaired or that current Environmental Quality Standards (EQS) are not exceeded.

Table 6.2: BAT-Associated Discharge levels for Emissions to Water*

Constituent Group or Parameter	**Emission Levels**	**Percentage Reduction**[3]	**Notes**
pH	6 - 9	-	
Toxicity	5 TU		1
BOD_5	20mg/l	>91 - 99%	
COD	30 - 125mg/l	>75%	
Suspended Solids	2 - 50mg/l		
Total Ammonia (as N)	0.25 - 10mg/l		
Total Nitrogen (as N)	5 - 25mg/l	>80%	2, 4
Total Phosphorus (as P)	2mg/l	>80%	4
Oils Fats and Greases	10mg/l		

Hydrocarbons (to include petroleum and diesel range organics)	0.05 - 5mg/l		
Mineral Oil (from interceptor)	20mg/l		
Mineral Oil (from biological treatment)	1.0 mg/l		
Phenols			5
Metals			5
Priority Substances (as per Water Framework Directive)			5
Other			6

* All values refer to daily averages based on a 24-hour flow proportional composite sample, except where stated to the contrary and for pH, which refers to continuous values. Levels apply to effluent prior to dilution by uncontaminated streams, e.g. storm water, cooling water, etc.

* Temperature measured downstream of a point of thermal discharge must not exceed the unaffected temperature by more than 1.5^{o}C in salmonid waters and 3^{o}C in cyprinid waters (Freshwater Fish Directive 79/659/EEC).

Note 1: The number of toxic units (TU) = 100/x hour EC/LC50 in percentage vol/vol so that higher TU values reflect greater levels of toxicity. For test regimes where species death is not easily detected, immobilisation is considered equivalent to death.

Note 2: Total Nitrogen means the sum of Kjeldahl Nitrogen, Nitrate N and Nitrite N.

Note 3: Reduction in relation to influent load.

Note 4: Limits will depend on the sensitivity of the receiving waterbody.

Note 5: BAT associated emissions levels are highly dependent on production process, wastewater matrix and treatment. These parameters shall be considered on a site-specific basis when setting emission limit values.

Note 6: Any relevant polluting substances as specified in Schedule to S.I. No. 394 of 2004: EPA (Licensing)(Amendment) Regulations, 2004.

7. COMPLIANCE MONITORING

The methods proposed for monitoring the emissions from the sector are set out below. Licence requirements may vary from those stated below due to site-specific considerations, sensitivity of receiving media, and scale of the operations.

7.1. MONITORING OF EMISSIONS TO AIR

- Monitoring of minor boiler stack emissions for SOx, NOx, CO and particulates, as required by the licence, taking account of the nature, magnitude and variability of the emission and the reliability of the controls.
- Monitoring of boiler combustion efficiency in accordance with the manufacturer's instructions at a frequency determined by the Agency.
- Continuous monitoring on main emissions where technically feasible (e.g. TOC, HCl, Particulates, CO, SO_2, NOx).
- Periodic monitoring of stacks for other parameters as determined by the Agency.
- Monitor solvent / VOC usage by annual mass balance reports and use to determine fugitive emissions.
- Olfactory (sniff) assessment for odours should be carried out daily or as directed by the Agency at a minimum at four boundary locations and at the nearest odour sensitive locations to be agreed with the Agency.

7.2. MONITORING OF AQUEOUS EMISSIONS

- For uncontaminated cooling waters, continuous monitoring of temperature and flow.
- Continuous monitoring of flow, volume, pH, temperature and any other relevant parameters deemed necessary by the Agency, taking account of the nature, magnitude and variability of the emissions and the reliability of the control technique.
- Establish existing conditions prior to start-up of key emission constituents and salient flora and fauna.
- Monitoring of influent and effluent for the wastewater treatment plant to establish % BOD and COD reduction and early warning of any difficulties in waste water treatment, or unusual loads.
- The potential for the treated effluent to have tainting and toxic effects should be assessed and if necessary measured by established laboratory techniques.
- Periodic biodegradability checks where appropriate on effluents to municipal waste treatment plants, both prior to start-up and thereafter.
- BAT is to carry out regular biomonitoring of the total effluent after the biological WWTP where substances with ecotoxicological potential are handled or produced with or without intention. BAT is also to apply online toxicity monitoring in combination with online TOC measurement if residual acute toxicity is identified as a concern.
- BAT is to monitor regularly the total effluent from and to the biological WWTP for appropriate parameters. The monitoring frequencies should reflect the operational mode of the production and the frequency of product changes as well as the ratio of buffer volume and residence time in the biological WWTP.

7.3. MONITORING OF EMISSIONS TO GROUNDWATER

There should be no direct emissions to groundwater, including during extraction and treatment of groundwater.

7.4 MONITORING OF SOLID WASTE

- The recording in a register of the types, quantities, date and manner of disposal/recovery of all wastes.
- Leachate testing of sludges and other material as appropriate being sent for landfilling.
- Annual waste minimisation report showing efforts made to reduce specific consumption together with material balance and fate of all waste materials.

Appendix 1

PRINCIPAL REFERENCES

BREF on Best Available Techniques for Mineral Oil and Gas Refineries, EIPPCB, February 2003.

Modern Petroleum Technology (Institute of Petroleum, 5th Edition 1984, Wiley).

Large Combustion Plant BREF (BREF on Best Available Techniques for Large Combustion Plants, EIPPCB, May 2005).

Storage BREF (Reference Document on Best Available Techniques on Emissions from Storage, EIPPCB, January 2005).

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Appendix 2

GLOSSARY OF TERMS AND ABBREVIATIONS

Aromatics	The group of hydrocarbon products, so-called because of their sweet smell, which include benzene, toluene and provide feedstock for many of the main petrochemical processes, as well as improving the octane rating of gasoline.
Barrel	Traditional measurement unit of oil volume. Equal to 42 US gallons or approximately 35 Imperial gallons. Depending on specific gravity, there are roughly 7.5 barrels to a metric tonne of oil.
Benzene	A colourless liquid hydrocarbon use to manufacture a wide range of everyday products by the petrochemical industry.
Catalyst	A substance that alters, accelerates or instigates chemical reactions without itself being affected.
Cetane Number	A measure of the refining process which uses heat and/or catalyst to break down large chemical compounds into smaller compounds.
Crude Oil	An unrefined mixture of naturally occurring hydrocarbons, whose density and properties vary widely. Crude oils may also contain sulphur, nitrogen, oxygen and traces of metals such as vanadium and nickel.
Diesel Fuel	Light hydrocarbon mixture slightly heavier than kerosene. In a diesel engine, air is drawn into the cylinders and compressed to very high pressures; ignition occurs as fuel is injected into the compressed and heated air.
Distillation	Process of driving off gas or vapour from liquids or solids, usually by heating, and condensing the liquid back to purity.
Fraction	Hydrocarbon substance, or group of substances, extracted from crude oil or natural gas, usually by distillation in a fractionating tower.
Gasoline	Gasoline, or petrol as it is called in Ireland, is a volatile, flammable liquid hydrocarbon refined from crude oil and used to fuel internal combustion, spark ignition engines.
Hydrocarbons	Organic compounds of hydrogen and carbon whose densities, boiling points and freezing points increase as their molecular weights increase. The smallest molecules of hydrocarbon are gaseous, the largest solids.
Isomerisation	The process of altering the arrangement of atoms in a molecule without adding or removing anything from the original material.
Kerosene	Light flammable hydrocarbon product used as aviation fuel and in oil-fired central heating boilers, commonly known as paraffin oil.
LPG	Liquefied petroleum gases (LPG), principally butane and propane, have the characteristic of being gaseous in atmospheric conditions, but easily liquefied under pressure, enabling them to be transported as liquids and converted to gases on release of pressure.
Naphtha	A volatile, flammable liquid hydrocarbon distilled from crude oil and used as a solvent, petrochemical feedstock or in the manufacture of petrol.
Octane Rating	A classification of the gasoline according to its anti-knock

	properties. The higher the octane number, the less prone the fuel is to knocking. "Knocking" or "pinking" is a tendency for gasoline to detonate under compression in an engine instead of burning evenly.
Olefins	The group of hydrocarbons known as alkenes. In a refinery olefin units produce ethylene and propylene to make polyethylene and polypropylene, used by the petrochemical industry to make plastic, synthetic fibres and adhesives.
Paraffins	Alkane hydrocarbons, such as methane, ethane, propane, butane and pentane.
Petrol	See gasoline.
Petroleum	Literally, "rock oil". A natural organic material compound composed mainly of hydrocarbons – chemical compounds of hydrogen and carbon – that may be in a gaseous, liquid or solid state.
Reforming	Refining process used to change the molecular structure of a naphtha feedstock.
Sulphur	Pale yellow non-metallic chemical element. Sulphur reduction in fuels is desirable for corrosion control and for health and safety reasons.
Toluene (Methylbenzene)	A colourless aromatic hydrocarbon liquid used as a solvent.
°C	Degree Celsius
BOD	Biochemical Oxygen Demand
CHP	Combined Heat and Power
CN^-	Cyanide ion
CNS	Thiocyanate
CO	Carbon monoxide
CO_2	Carbon dioxide
COD	Chemical Oxygen Demand
FGD	Flue-Gas Desulphurisation
Flash point	The temperature to which an oil must be heated, under specified conditions, to produce sufficient vapour to yield a flammable mixture with air
H_2S	Hydrogen sulphide
HFO	Heavy Fuel Oil
HGO	Heavy Gas Oil
HVN	Heavy Virgin Naphtha
LGO	Light Gas Oil
LVN	Light Virgin Naphtha
N_2O	Nitrous oxide
NF	Nanofiltration
NH_3	Ammonia
NH_4	Ammonium

NH_4-N	Ammonium (calculated as N)
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
PM	Particulate Matter
PSA	Pressure Swing Adsorption
RO	Reverse Osmosis
RVP	Reid Vapour Pressure. The Reid Vapour Pressure is a measure of the volatility of a petroleum product. The Reid test measures the vapour evolution characteristics of a petroleum product.
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
SRU	Sulphur Removal Unit
TOC	Total Organic Carbon
TSS	Total Suspended Solids
Vapour pressure	The pressure at which a liquid and its vapour are in equilibrium at any given temperature
VOC	Volatile Organic Compounds
VRU	Vapour Recovery Unit
Waxing point	The temperature at which wax begins to crystallise from a distillate fuel