Environment Agency

Review of an Environmental Permit for an Installation subject to Chapter II of the Industrial Emissions Directive under the Environmental Permitting (England & Wales) Regulations 2016

Decision document recording our decision-making process following review of a permit

The Permit number is: EPR/UP3230LR
The Operator is: Phillips 66 Limited
The Installation is: Humber Refinery
This Variation Notice number is: EPR/UP3230LR/V014

What this document is about

Article 21(3) of the Industrial Emissions Directive (IED) requires the Environment Agency to review conditions in permits that it has issued and to ensure that the permit delivers compliance with relevant standards, within four years of the publication of updated decisions on BAT conclusions.

We have reviewed the permit for this installation against the revised BAT Conclusions for the refining of mineral oil and gas industry sector published on 28th October 2014. This is our decision document, which explains the reasoning for the consolidated variation notice that we are issuing.

It explains how we have reviewed and considered the techniques used by the Operator in the operation and control of the plant and activities of the installation. This review has been undertaken with reference to the decision made by the European Commission establishing best available techniques (BAT) conclusions ('BAT Conclusions') for the refining of mineral oil and gas as detailed in document reference IEDC-7-1. It is our record of our decision-making process and shows how we have taken into account all relevant factors in reaching our position. It also provides a justification for the inclusion of any specific conditions in the permit that are in addition to those included in our generic permit template.

As well as considering the review of the operating techniques used by the Operator for the operation of the plant and activities of the installation, the consolidated variation notice takes into account and brings together in a single document all previous variations that relate to the original permit issued. It also modernises the entire permit to reflect the conditions contained in our current generic permit template.

The introduction of new template conditions makes the Permit consistent with our current general approach and philosophy and with other permits issued to installations in this sector. Although the wording of some conditions has changed, while others have been removed because of the new regulatory approach, it does not reduce the level of environmental protection achieved by the Permit in any way. In this document we therefore address only our determination of substantive issues relating to the new BAT Conclusions.

This is our record of our decision-making process and shows how we have taken into account all relevant factors in reaching our position.

Throughout this document we will use a number of expressions. These are as referred to in the glossary and have the same meaning as described in “Schedule 6 Interpretation” of the Permit.

We try to explain our decision as accurately, comprehensively and plainly as possible. We would welcome any feedback as to how we might improve our decision documents in future. A lot of technical terms and acronyms are inevitable in a document of this nature: we provide a glossary of acronyms near the front of the document, for ease of reference.

How this document is structured

Glossary of acronyms used in this document

(Please note that this glossary is standard for our decision documents and therefore not all these acronyms are necessarily used in this document.)

AAD	Ambient Air Directive (2008/50/EC)
APC	Air Pollution Control
BAT	Best Available Technique(s)
BAT-AEL	BAT Associated Emission Level
BATc	BAT conclusion
BREF	Best available techniques reference document
CEM	Continuous emissions monitor
CHP	Combined heat and power
COMEAP	Committee on the Medical Effects of Air Pollutants
CROW	Countryside and rights of way Act 2000
CV	Calorific value
DAA	Directly associated activity – Additional activities necessary to be carried out to allow the principal activity to be carried out
DD	Decision document
Derogation	from BAT AELs stated in BAT Conclusions under specific circumstances as detailed under Article 15(4) of IED where an assessment shows that the achievement of emission levels associated with the best available techniques as described in BAT conclusions would lead to disproportionately higher costs
EAL	Environmental assessment level
EIONET	European environment information and observation network is a partnership network of the European Environment Agency
ELV	Emission limit value derived under BAT or an emission limit value set out in IED
EMS	Environmental Management System
EPR	Environmental Permitting (England and Wales) Regulations 2016 (SI 2010 No. 1154)
EQS	Environmental quality standard
EU-EQS	European Union Environmental Quality Standard
Eunomia	Ballinger, Holland & Hogg (2011) Use of Damage Cost Data for BAT Decision Making: Report for the Environment Agency of England & Wales
EWC	European waste catalogue
FGD	Flue Gas Desulphurisation
FSA	Food Standards Agency
GWP	Global Warming Potential
HMT GB	Her Majesty's Treasury The Green Book - Appraisal and Evaluation in Central Government
HW	Hazardous waste
IED	Industrial Emissions Directive (2010/75/EU)
IPPCD	Integrated Pollution Prevention and Control Directive (2008/1/EC) – now superseded by IED
I-TEF	Toxic Equivalent Factors set out in Annex VI Part 2 of IED
I-TEQ	Toxic Equivalent Quotient calculated using I-TEF
LADPH	Local Authority Director(s) of Public Health
LCP	Large Combustion Plant subject to Chapter III of IED

LCPD	Large Combustion Plant Directive (2001/80/EC) – now superseded by IED
MSUL/MSDL	Minimum start up load/minimum shut-down load
NOx	Oxides of nitrogen (NO plus NO_2 expressed as NO_2)
NPV	Net Present Value
PAH	Polycyclic Aromatic Hydrocarbons
PC	Process Contribution
PEC	Predicted Environmental Concentration
PHE	Public Health England
POP(s)	Persistent organic pollutant(s)
PPS	Public participation statement
PR	Public register
PXDD	Poly-halogenated di-benzo-p-dioxins
PXB	Poly-halogenated biphenyls
PXDF	Poly-halogenated di-benzo furans
RGS	Regulatory Guidance Series
SAC	Special Area of Conservation
SGN	Sector guidance note
SHPI(s)	Site(s) of High Public Interest
SPA(s)	Special Protection Area(s)
SSSI(s)	Site(s) of Special Scientific Interest
TDI	Tolerable daily intake
TEF	Toxic Equivalent Factors
TGN	Technical guidance note
TOC	Total Organic Carbon
US EPA	United States Environmental Protection Agency
WFD	Water Framework Directive (2000/60/EC)
WHO	World Health Organisation

1 Our decision

We have decided to issue the Consolidated Variation Notice to the Operator. This will allow it to continue to operate the Installation, subject to the conditions in the Consolidated Variation Notice.

We consider that, in reaching that decision, we have taken into account all relevant considerations and legal requirements and that the varied permit will ensure that a high level of protection is provided for the environment and human health.

The Consolidated Variation Notice contains many conditions taken from our standard Environmental Permit template including the relevant Annexes. We developed these conditions in consultation with industry, having regard to the legal requirements of the Environmental Permitting Regulations and other relevant legislation. This document does not therefore include an explanation for these standard conditions. Where they are included in the Notice, we have considered the techniques identified by the operator for the operation of their installation, and have accepted that the details are sufficient and satisfactory to make those standard conditions appropriate. This document does, however, provide an explanation of our use of “tailor-made” or installation-specific conditions, or where our Permit template provides two or more options.

2 How we reached our decision

2.1 Requesting information to demonstrate compliance with BAT Conclusions for the refining of mineral oil and gas.

We issued a Notice under Regulation 60(1) of the Environmental Permitting (England and Wales) Regulations 2010 (a Regulation 60 Notice) on 05/08/15 requiring the Operator to provide information to demonstrate how the operation of their installation currently meets, or will subsequently meet, the revised standards described in the relevant BAT Conclusions document. The Notice also required that where the revised standards are not currently met, the operator should provide information that:

- Describes the techniques that will be implemented before 28/10/18, which will then ensure that operations meet the revised standard, or
- Justifies why standards will not be met by 28/10/18, and confirmation of the date when the operation of those processes will cease within the installation or an explanation of why the revised BAT standard is not applicable to those processes, or
- Justifies why an alternative technique will achieve the same level of environmental protection equivalent to the revised standard described in the BAT Conclusions.

Where the Operator proposed that they were not intending to meet a BAT standard that also included a BAT Associated Emission Level (BAT AEL) described in the BAT Conclusions Document, the Regulation 60 Notice requested that the Operator make a formal request for derogation from compliance with that AEL (as provisioned by Article 15(4) of IED). In this circumstance, the Notice identified that any such request for derogation must be supported and justified by sufficient technical and commercial information that would enable us to determine acceptability of the derogation request.

The Regulation 60 Notice response from the Operator was received on 05/02/16.

We considered that the response did not contain sufficient information for us to commence the permit review. Suitable further information was provided by the Operator on the following dates;

03/07/17	Compliance and operating techniques identified in response to the BAT Conclusions 20,22,25,45,47 and 54.
06/10/17	Compliance and operating techniques identified in response to the BAT Conclusions 3,15,29,49 and 56.
16/11/17	Compliance and operating techniques identified in response to the BAT Conclusions 32,44,46 and 52.
13/02/18	Compliance and operating techniques identified in response to BAT Conclusion 19.

We considered it was in the correct form and contained sufficient information for us to begin our determination of the permit review but not that it necessarily contained all the information we would need to complete that review.

We have not received any information in relation to the Regulation 60 Notice listed in the permit status log response that appears to be confidential in relation to any party.

2.2 Review of our own information in respect to the capability of the installation to meet revised standards included in the BAT Conclusions document

Based on our records and previous regulatory activities with the facility we have no reason to consider that the operator will not be able to comply with the conditions that we include in the permit.

In relation to BAT Conclusion(s) 6 and 52 we agree with the operator in respect to their current stated capability as recorded in their Regulation 60 Notice response that improvements are required.

We have therefore included improvement conditions IC25, IC26 and IC27 in the Consolidated Variation Notice, which requires them to upgrade their operational techniques so that the requirements of the BAT Conclusion are delivered. This is discussed in more detail in Annex 1.

3 The legal framework

The Consolidated Variation Notice will be issued under Regulation 20 of the EPR. The Environmental Permitting regime is a legal vehicle which delivers most of the relevant legal requirements for activities falling within its scope. In particular, the regulated facility is:

- an *installation* as described by the IED;
- subject to aspects of other relevant legislation which also have to be addressed.

We consider that the Consolidated Variation Notice will ensure that the operation of the Installation complies with all relevant legal requirements and that a high level of protection will be delivered for the environment and human health.

We explain how we have addressed specific statutory requirements more fully in the rest of this document.

In line with Defra IED Guidance, where the BAT AELs are expressed as a range, the ELV has been set on the basis of the top of the relevant BAT-AEL range (the highest associated emission level) unless compliance with a lower ELV has been demonstrated and has been retained to ensure no deterioration. The emission limits and monitoring tables have been incorporated into Schedule 3.

4 Key Issues

The key issues arising during this permit review are:

- Emission to water particularly in the setting of tighter water quality limits to minimise waste water discharge to controlled waters in line with BAT 12
- BATs 57 and 58 Integrated Emissions Management Technique for NOx and SO_2.

We therefore describe how we determined these issues in more detail in the relevant sections of this document.

5 Decision checklist regarding relevant BAT Conclusions

BAT Conclusions for the refining of mineral oil and gas, were published by the European Commission on 28th October 2014. There are 58 BAT Conclusions.

This annex provides a record of decisions made in relation to each relevant BAT Conclusion applicable to the installation. This annex should be read in conjunction with the Consolidated Variation Notice.

The overall status of compliance with the BAT conclusion is indicated in the table as:

NA	Not Applicable
CC	Currently Compliant
FC	Compliant in the future (within 4 years of publication of BAT conclusions)
NC	Not Compliant
PC	Partially Compliant

BAT Conclusion Number	**Summary of BAT Conclusion requirement**	**Status NA/ CC / FC / NC**	**Assessment of the installation capability and any alternative techniques proposed by the operator to demonstrate compliance with the BAT Conclusion requirement**	**Relevant permit condition(s)**
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General				
1	**In order to improve the overall environmental performance of the plants for the refining of mineral oil and gas, BAT is to implement and adhere to an environmental management system (EMS) that incorporates all of the following features:** i. commitment of the management, including senior management; ii. definition of an environmental policy that includes the continuous improvement of the installation by the management; iii. planning and establishing the necessary procedures, objectives and targets, in conjunction with financial planning and investment; iv. implementation of procedures (a) Structure and responsibility (b) Training (c) Communication (d) Employee involvement (e) Documentation (f) Efficient process control (g) Maintenance programmes (h) Emergency preparedness and response (i) Safeguarding compliance with environmental legislation v. checking performance and taking corrective action, paying particular attention to: (a) monitoring and measurement (see also the Reference Document on the General Principles of Monitoring) (b) corrective and preventive action (c) maintenance of records (d) independent (where practicable) internal and external auditing in order to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained; vi. review of the EMS and its continuing suitability, adequacy and effectiveness by senior management;	CC	Environmental Management System has ISO14001 certification, and uses all techniques (i) - (ix), including sub-parts.	1.1

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	vii. following the development of cleaner technologies; viii. consideration for the environmental impacts from the eventual decommissioning of the installation at the stage of designing a new plant, and throughout its operating life; viii. consideration for the environmental impacts from the eventual decommissioning of the installation at the stage of designing a new plant, and throughout its operating life; ix. application of sectoral benchmarking on a regular basis. **Applicability**. The scope (e.g. level of detail) and nature of the EMS (e.g. standardised or non-standardised) will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.			
2	**In order to use energy efficiently, BAT is to use an appropriate combination of the techniques given below.**	CC	Techniques (i) including all sub-parts, (ii) including all sub-parts and (iii)(a) are used.	1.2

Technique	Description
i. Design techniques	
a. Pinch analysis	Methodology based on a systematic calculation of thermodynamic targets for minimising energy consumption of processes. Used as a tool for the evaluation of total systems designs
b. Heat integration	Heat integration of process systems ensures that a substantial proportion of the heat required in various processes is provided by exchanging heat between streams to be heated and streams to be cooled
c. Heat and power recovery	Use of energy recovery devices e.g. • waste heat boilers • expanders/power recovery in the FCC unit

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<table>
<tr><td></td><td>• use of waste heat in district heating</td></tr>
<tr><td colspan="2">ii. Process control and maintenance techniques</td></tr>
<tr><td>a. Process optimisation</td><td>Process optimisation. Automated controlled combustion in order to lower the fuel consumption per tonne of feed processed, often combined with heat integration for improving furnace efficiency</td></tr>
<tr><td>b. Management and reduction of steam consumption</td><td>Management and reduction of steam consumption. Systematic mapping of drain valve systems in order to reduce steam consumption and optimise its use</td></tr>
<tr><td>c. Use of energy benchmarking</td><td>Use of energy benchmark. Participation in ranking and benchmarking activities in order to achieve continuous improvement by learning from best practice</td></tr>
<tr><td colspan="2">iii. Energy efficient production techniques and description</td></tr>
<tr><td>a. Use of combined heat and power.</td><td>System designed for the co-production (or the cogeneration) of heat (e.g. steam) and electric power from the same fuel</td></tr>
<tr><td>b. Integrated gasification combined cycle (IGCC).</td><td>Technique whose purpose is to produce steam, hydrogen (optional) and electric power from a variety of fuel types (e.g. heavy fuel oil or coke) with a high conversion efficiency</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
</table>

3	**In order to prevent or, where that is not practicable, to reduce dust emissions from the storage and handling of dusty materials, BAT is to use one or a combination of the techniques given below:** i. store bulk powder materials in enclosed silos equipped with a dust abatement system (e.g. fabric filter); ii. store fine materials in enclosed containers or sealed bags; iii. keep stockpiles of coarse dusty material wetted, stabilise the surface with crusting agents, or store under cover in stockpiles; iv. use road cleaning vehicles	CC	Techniques (i), (ii), (iii) and (iv) are used. BAT 3 applies to the 'storage and handling of dusty materials'. Green coke (straight from the coke drums and before calcining) is steam stripped and quenched before drilling and is therefore inherently wet. It is not a 'dusty material'. Techniques (i) to (iv) do apply to calcined coke, however, and are used at the Humber Refinery where appropriate. Bulk calcined petroleum coke is not stored outdoors in stockpiles [technique (iii) is therefore not applicable]. Instead, calcined coke product is stored within large concrete enclosed Product Silos equipped with fabric filters [technique (i)]. Coke fines collected by the calciners' high-efficiency boiler and cooler gas cyclones are routed to dedicated Fines Silos, that also exhaust through fabric filters. Boiler fines may be recycled back to the process. Conveying systems transporting calcined coke are fully enclosed and employ a dust extraction system, fabric filters are fitted at all exhaust points. Both the Product and Fines Silos employ a 'Dust Free Loading system' whereby road vehicles accepting bulk material for sale are loaded via a fully enclosed chute and dust extraction system. Loaded coke lorries are double-sheeted before leaving site. Fines collected by the fabric filters are collected and stored in sealed bags [technique (ii)] prior to sale. A road sweeping vehicle is dedicated to the calciner production area [technique (iv)].	3.2
4	**BAT is to monitor emissions to air by using the monitoring techniques with at least the minimum frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.**	FC	Technique (i) is applied, with installation pending for CEMc for NOx on LCP 262 and LCP 263 by 1st October 2023. RPS/UP3230LR/11/10/2018 covers this position.	3.5.1

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<tr><th>Description</th><th>Unit</th><th>Minimum frequency</th><th>Monitoring technique</th></tr>
<tr><td rowspan="5">SO_X, NO_X and dust emissions</td><td>Catalytic cracking</td><td>continuous</td><td>Direct measurement</td></tr>
<tr><td>Combustion units ≥ 100MW (3) and calcining units</td><td>continuous</td><td>Direct measurement (4)</td></tr>
<tr><td>Combustion units of 50 to 100 MW (3)</td><td>continuous</td><td>Direct measurement or indirect monitoring</td></tr>
<tr><td>Combustion units < 50 MW (3)</td><td>once a year and after significant fuel changes</td><td>Direct measurement or indirect monitoring</td></tr>
<tr><td>Sulphur recovery units (SRU)</td><td>continuous for SO2 only</td><td>Direct measurement or indirect monitoring (6)</td></tr>
<tr><td>NH_3 emissions</td><td>All units equipped with SCR or SNCR</td><td>continuous</td><td>Direct measurement</td></tr>
<tr><td>CO emissions</td><td>Catalytic Cracking and combustion units >= 100MW (3)</td><td>continuous</td><td>Direct measurement</td></tr>
</table>
</td><td></td><td>Dust emissions are measured continuously through the use of an agreed factor. Technique (ii) is not applicable. Technique (iii) is used for continuous monitoring of CO on the FCC. Continuous monitoring of CO on combustion units >100MW is not currently carried out, issue being addressed with permitting for Chapter III and Annex V requirements of the Directive 2010/75/EU. Technique (iv) monitoring is not currently undertaken on the FCC, Phillips 66 will review the sampling and take action for measurements to be started on the FCC to align with BAT. Techniques (iv) monitoring for metals is not relevant to gas fired LCP and is therefore not relevant to the Humber Refinery combustion plant which fires on a multifuel mixture of natural gas and RFG. Monitoring as per (v) is not currently undertaken, Phillips 66 will review the sampling and take action for measurements to be started on the catalytic reformers to align with BAT.

Continuous measurement of dust is not required if the operator can demonstrate that the emissions from firing refinery fuel gas (RFG) or mixtures of RFG and natural gas are consistently no worse than those from natural gas firing (i.e. < 5mg/m^3). This demonstration must comprise at least 5 consecutive historic measurements where the emissions have been less than 3mg/Nm^3 (to allow for uncertainty and variability) .

Periodic monitoring at 6-monthly intervals will continue to be required to demonstrate that the emissions remain below 5 mg/m^3.</td><td></td></tr>
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<tr><td></td><td>Other combustion units</td><td>once every 6 months (5)</td><td>Direct measurement</td></tr>
<tr><td>Metal emissions:
Nickel (Ni)
Antimony (Sb)
Vanadium (V)</td><td>Catalytic cracking
Combustion units (8)</td><td>once every 6 months and after significant changes to the unit (5)</td><td>Direct measurement or analysis based on metals content in the catalyst fines and in the fuel</td></tr>
<tr><td>Polychlorinated dibenzodioxins / furans (PCDD/F) emissions</td><td>Catalytic reformer</td><td>once a year or once a regeneration, whichever is longer</td><td>Direct measurement</td></tr>
<tr><td colspan="4">(1) Continuous measurement of SO2 emissions may be replaced by calculations based on measurements of the sulphur content of the fuel or the feed; where it can be demonstrated that this leads to an equivalent level of accuracy
(2) Regarding SO$_X$, only SO$_2$ is continuously measured while SO$_3$ is only periodically measured (e.g. during calibration of the SO$_2$ monitoring system)
(3) Refers to the total rated thermal input of all combustion units connected to the stack where emissions occur.
(4) Or indirect monitoring of SO$_X$
(5) Monitoring frequencies may be adapted if, after a period of one year, the data series clearly demonstrate a sufficient stability.</td></tr>
</table>
</td><td></td><td>The reference conditions for emissions and flow data from combustion plants and FCC units is 3% oxygen and dry.

In determining compliance with the fixed concentration bubble ELVs referred to in the IEMT, measured/calculated emissions concentrations and flue gas flow rates for the FCC, sulphur plants and combustion plants are adjusted to combustion plant standard reference conditions of 3% oxygen and dry. Calciner emissions are adjusted to a reference condition for their operation of 9% oxygen and dry.

The 9% oxygen reference condition for calciners was determined based on operational evidence provided by the operator and precedent in other BREFs for similar types of process where higher oxygen reference conditions are allowed.</td><td></td></tr>
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<tr><td></td><td>(6) SO_2 emissions measurements from SRU may be replaced by continuous material balance or other relevant process parameter monitoring, provided appropriate measurements of SRU efficiency are based on periodic (e.g. once every 2 years) plant performance tests.
(7) Antimony (Sb) is monitored only in catalytic cracking units when Sb injection is used in the process (e.g. for metals passivation)
(8) With the exception of combustion units firing only gaseous fuel</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td>BAT is to monitor the relevant process parameters linked to pollutant emissions, at catalytic cracking and combustion units by using appropriate techniques and with at least the frequency given below.
<table>
<tr><th>Description</th><th>Minimum frequency</th></tr>
<tr><td>Monitoring of parameters linked to pollution emissions, e.g. O_2 content in flue-gas, N and S content in fuel or feed (1)</td><td>Continuous for O_2 content. For N and S content, periodic at a frequency based on significant fuel/feed changes.</td></tr>
<tr><td colspan="2">(1) N and S monitoring in fuel or feed may not be necessary when continuous emission measurement of NO_X and SO_2 are carried out at the stack.</td></tr>
</table></td><td>CC</td><td>Technique is applied. O_2 is measured continuously on FCC and combustion units >100MW (pending installation of continuous monitors on ST101 and ST301, as per BAT 4 and the permitting requirements of Chapter 3 and Annex V of the IED). Measurement for sulphur and nitrogen content of feed to FCC is not necessary, due to continuous measurement of emission's, although feed is sampled periodically. Sulphur and nitrogen content of RFG to combustion units is measured continuously.</td><td>3.5.1</td></tr>
<tr><td>6</td><td>BAT is to monitor diffuse VOC emissions to air from the entire site by using all of the following techniques:
i. sniffing methods associated with correlation curves for key equipment;
ii. optical gas imaging techniques;
iii. calculations of chronic emissions based on emissions factors periodically (e.g. once every two years) validated by measurements.</td><td>FC</td><td>Technique (i) is used - LDAR programme currently measures diffuse VOC emissions, overall emissions are calculated using emissions factors. Phillips 66 will review LDAR programme and take appropriate actions to align with BAT.</td><td>3.3.1</td></tr>
</table>

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	The screening and quantification of site emissions by periodic campaigns with optical absorption-based-techniques, such as differential absorption light detection and ranging (DIAL) or solar occultation flux (SOF) is a useful complementary technique. **Description**. See section 1.20.6, Annex 1.		Improvement condition IC25 has been set requiring the following; The Operator shall submit a diffuse VOC monitoring plan to the Environment Agency for written approval. This shall include but not be limited to: • The nature of the material handled; • The sources of emissions; • Justification of the monitoring techniques selected • How the monitoring data will be recorded and reviewed The plan shall take into account the appropriate techniques for VOC monitoring specified in BAT conclusion 6 for the Refining of Mineral Oil and Gas. The Operator shall implement the approved plan and produce and submit an annual report on the results of the monitoring undertaken under the plan.	
7	**In order to prevent or reduce emissions to air, BAT is to operate the acid gas removal units, sulphur recovery units and all other waste gas treatment systems with a high availability and at optimal capacity.** Special procedures can be defined for other than normal operating conditions, in particular: i. During start-up and shutdown operations.	CC	Techniques (i), (ii) and (iii) are used.	2.3.1

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<tr><td></td><td>ii. during other circumstances that could affect the proper functioning of the systems (e.g. regular and extraordinary maintenance work and cleaning operations of the units and/or of the waste gas treatment system);
iii. in case of insufficient waste gas flow or temperature which prevents the use of the waste gas treatment system at full capacity.</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td>In order to prevent and reduce ammonia (NH_3) emissions to air when applying selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) techniques, BAT is to maintain suitable operating conditions of the SCR or SNCR waste gas treatment systems, with the aim of limiting emissions of unreacted NH_3.
Table 2 BAT- associated emission levels for ammonia (NH_3) emissions to air for a combustion process unit where SCR or SNCR techniques are used.
<table>
<tr><th>Parameter</th><th>BAT-AEL (monthly average mg/m^3)</th></tr>
<tr><td>Ammonia expressed as NH_3</td><td><5 - 15mg/Nm^3 (1) (2)</td></tr>
<tr><td colspan="2">(1) the higher end of the range is associated with higher inlet NO_X concentrations, higher NO_X reduction rates and the ageing of the catalyst
(2) The lower end of the range is associated with the use of the SCR technique.</td></tr>
</table></td><td>NA</td><td>SCR and SNCR techniques are not used at the Humber Refinery.</td><td></td></tr>
<tr><td>9</td><td>In order to prevent and reduce emissions to air when using a sour water steam stripping unit, BAT is to route the acid off-gases from this unit to an SRU or any equivalent gas treatment system.</td><td>CC</td><td>Sour water stripper off-gas is treated in sulphur recovery units.</td><td>2.3.1</td></tr>
</table>

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<tr><td></td><td>It is not BAT to directly incinerate the untreated sour water stripping gases.</td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>BAT is to monitor emissions to water by using the monitoring techniques with at least the frequency given in Table 3 (as below) and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Table 3 BAT – associated emission levels for direct waste water discharges from the refining of mineral oil and gas monitoring frequencies associated with BAT (1)

<table>
<tr><th>Parameter</th><th>Unit</th><th>BAT – AEL (yearly average)</th><th>Monitoring (2) frequency and analytical method (standard)</th></tr>
<tr><td>Hydrocarbon oil index (HOI)</td><td>mg/l</td><td>0.1 – 2.5</td><td>Daily
EN 9377-2</td></tr>
<tr><td>Total suspended solids (TSS)</td><td>mg/l</td><td>5 - 25</td><td>Daily</td></tr>
<tr><td>Chemical oxygen demand (COD) (4)</td><td>mg/l</td><td>30 - 125</td><td>Daily</td></tr>
<tr><td>BOD 5</td><td>mg/l</td><td>No BAT - AEL</td><td>Weekly</td></tr>
<tr><td>Total nitrogen (5) expressed as N</td><td>mg/l</td><td>1 – 25 (6)</td><td>Daily</td></tr>
<tr><td>Lead, expressed as Pb</td><td>mg/l</td><td>0.005 – 0.030</td><td>Quarterly</td></tr>
<tr><td>Cadmium expressed as Cd</td><td>mg/l</td><td>0.002 – 0.008</td><td>Quarterly</td></tr>
</table>
</td><td>FC</td><td>All AELs are met based on current permit sampling requirements with the exception of new parameters required by the Bref. No data is currently available to determine compliance.

In order to meet the requirements of the BAT Conclusion, existing sampling equipment will need to be replaced in order to enable a 24 hour daily composite to be taken. RPS/UP3230LR/12/10/2018 covers this position.

The Bref requires some changes to the parameters sampled (and associated sampling methods) as summarised below.

<table>
<tr><th>Current parameter</th><th>Bref parameter</th></tr>
<tr><td>Oil in Water</td><td>Hydrocarbon Oil Index</td></tr>
<tr><td>Ammoniacal Nitrogen</td><td>Total Nitrogen</td></tr>
<tr><td>VOC (24 hour composite)</td><td>Benzene (spot)</td></tr>
</table>

Due to these changes, limited data using the new methods are available. Therefore, an accurate assessment of compliance with the BAT-AEL cannot currently be made. In order to obtain sufficient quality assurance of the level of compliance under the new test methods, we have agreed that a period of parallel monitoring, using both the current and Bref test</td><td>3.5.1</td></tr>
</table>

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<table>
<tr><td>Nickel, expressed as Ni</td><td>mg/l</td><td>0.005 – 0.100</td><td>Quarterly</td></tr>
<tr><td>Mercury, expressed as Hg</td><td>mg/l</td><td>0.0001 – 0.001</td><td>Quarterly</td></tr>
<tr><td>Vanadium</td><td>mg/l</td><td>No BAT - AEL</td><td>Quarterly</td></tr>
<tr><td>Phenol index</td><td>mg/l</td><td>No BAT - AEL</td><td>Monthly
EN 14402</td></tr>
<tr><td>Benzene, toluene, ethyl benzene, xylene (BTEX)</td><td>mg/l</td><td>Benzene
0.001 – 0.050
No BAT – AEL for T, E, X</td><td>Monthly</td></tr>
<tr><td colspan="4">(1) Not all parameters and sampling frequencies are applicable to effluent from gas refining sites
(2) Refers to a flow-proportional composite sample taken over period of 24 hours, or provided that sufficient flow stability is demonstrated, a time-proportional sample
(3) Moving from the current method to EN 9377-2 may require an adaptation period
(4) Where on-site correlation is available, COD may be replaced by TOC. The correlation between COD and TOC should be elaborated on a case-by-case basis. TOC monitoring would be the preferred option because it does not rely on the use of very toxic compounds
(5) Where total-nitrogen is the sum of the total Kjedahl nitrogen (TKN), nitrates and nitrites
(6) When nitrification/denitrification is used, levels below 15 mg/l can be achieved</td></tr>
</table>
</td><td></td><td>methods, can be undertaken for these parameters. During this period, compliance will be assessed against the Bref BAT-AEL using the current method. Upon completion of this period of monitoring, the Bref test method will be adopted and sufficient data will be available to determine the level of compliance with the BAT-AEL. Details are included in the footnotes to Table S3.2.

There is currently no requirement to monitor benzene however, samples are collected for Pollution Inventory reporting. The Bref requires 24-hour composite sampling for benzene on a monthly basis. We have reviewed the sampling methodology and because it is not technically feasible to analyse this parameter from a composite sample as VOCs will degas whilst sitting in the sample vessel over time, we have agreed spot sampling is appropriate and the relevant method included in Table S3.2.

The Bref requires phenol index monitoring which is not currently tested. A BAT-AEL is not set for this parameter and therefore does not require the parallel monitoring provision set out in the permit although the test method differs from the current one.

Arsenic and sulphide are currently monitored. Having reviewed monitoring returns, we have concluded that monitoring of these parameters is no longer required because measured levels have been consistently low</td><td></td></tr>
</table>

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<tr><td></td><td></td><td></td><td>since permit issue. Monitoring of these parameters is not required by the BAT Conclusion.

We have determined that monitoring of BOD is not required. Monitoring of COD is required and this is considered to provide sufficient control on effluent quality.

In addition to implementing the annual average BAT-AELs for all parameters except BOD, existing daily, monthly and quarterly limits will be retained in the permit to ensure there is no deterioration, unless justification for their removal has been demonstrated (see comments above).</td><td></td></tr>
<tr><td>11</td><td>In order to reduce water consumption and the volume of contaminated water, BAT is to use all of the techniques given below.

<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. water stream integration</td><td>Reduction of process water produced at the unit level prior to discharge by the internal reuse of water streams from e.g. cooling, condensates, especially for use in crude desalting</td><td>Generally applicable for new units. For existing units, applicability may require a complete rebuilding of the unit or the installation</td></tr>
<tr><td>ii. water and drainage system for</td><td>Design of an industrial site to optimise water management, where each stream is treated</td><td>Generally applicable for new units. For existing units,</td></tr>
</table></td><td>CC</td><td>Techniques (i), (ii), (iii) and (iv) are used.</td><td>1.3.1</td></tr>
</table>

<table>
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<tr><td>segregation of contaminated water streams</td><td>as appropriate, by e.g. routing generated sour water (from distillation, cracking, coking units, etc.) to appropriate pre-treatment, such as a stripping unit</td><td>applicability may require a complete rebuilding of the unit or the installation</td></tr>
<tr><td>iii. segregation of non-contaminated water streams (e.g. once-through cooling, rain water)</td><td>Design of a site in order to avoid sending non-contaminated water to general waste water treatment and to have a separate release after possible reuse for this type of stream</td><td>Generally applicable for new units.
For existing units, applicability may require a complete rebuilding of the unit or the installation</td></tr>
<tr><td>iv. prevention of spillages and leaks</td><td>Practices that include the utilisation of special procedures and/or temporary equipment to maintain performances when necessary to manage special circumstances such as spills, loss of containment, etc</td><td>Generally applicable</td></tr>
</table></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>In order to reduce the emission load of pollutants in the waste water discharge to the receiving water body, BAT is to remove insoluble and soluble polluting substances by using all of the techniques given below.<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Removal of insoluble</td><td>See Section 1.21.2, Annex 1.</td><td>Generally applicable</td></tr>
</table></td><td>CC</td><td>Techniques (i), (ii) and (iii) are used. Effluent Treatment Plant includes primary treatment for oil and solids removal, and biological treatment for removal of chemical contaminants.</td><td>2.3.1</td></tr>
</table>

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<tr><td>substances by recovering oil</td><td></td><td></td></tr>
<tr><td>ii. Removal of insoluble substances by recovering suspended solids and dispersed oil</td><td>See Section 1.21.2, Annex 1.</td><td>Generally applicable</td></tr>
<tr><td>iii. Removal of insoluble substances including biological treatment and clarification.</td><td>See Section 1.21.2, Annex 1.</td><td>Generally applicable</td></tr>
</table>
BAT – associated emission levels – see Table 3</td><td></td><td></td><td></td></tr>
<tr><td>13</td><td>**When further removal of organic substances or nitrogen is needed, BAT is to use an additional treatment step as described in Section 1.21.2 (see Annex 1).**</td><td>NA</td><td></td><td>2.3.1</td></tr>
<tr><td>14</td><td>**In order to prevent or, where that is not practicable, to reduce waste generation, BAT is to adopt and implement a waste management plan that, in order of priority, ensures that waste is prepared for reuse, recycling, recovery or disposal.**</td><td>CC</td><td>Phillips 66 takes measures needed to minimise, reuse, recycle or recover waste in accordance with the Waste Hierarchy of the Hazardous Waste Regulations.</td><td>1.4.1</td></tr>
</table>

<table>
<tr><th></th><th></th><th></th><th></th><th></th></tr>
<tr>
<td>15</td>
<td>In order to reduce the amount of sludge to be treated or disposed of, BAT is to use one or a combination of the techniques given below.
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i Sludge pretreatment</td><td>Prior to final treatment (e.g. in a fluidised bed incinerator), the sludges are dewatered and/or de-oiled (by e.g. centrifugal decanters of steam dryers) to reduce their volume and to recover oil from slop equipment.</td><td>Generally applicable</td></tr>
<tr><td>ii Reuse of sludge in process units</td><td>Certain types of sludge (e.g. oily sludge) can be processed in units (e.g. coking) as part of the feed due to their oil content.</td><td>Applicability is restricted to sludges that can fulfil the requirements to be processed in units with appropriate treatment</td></tr>
</table>
</td>
<td>CC</td>
<td>The Humber Refinery coking/calcining process produces speciality petroleum cokes that are an innovative, high-end product. The quality control of the feedstock to the coking process is a critical success factor. Although the re-use of oily sludge as part of the feed to the coking process would otherwise be desirable from a waste minimisation point of view, this technique cannot be applied at the Humber Refinery as it would impair coke quality to the extent that it would not meet customer specifications. Hence, the sludge is simply not suitable for re-processing in the one refinery process that could otherwise accept this as a feedstock. The restriction identified in the Applicability Statement to technique (ii) therefore applies: “Applicability is restricted to sludges that can fulfil the requirements to be processed in units with appropriate treatment”.

Instead technique (i) is used; Humber Refinery oily sludge is pre-treated on-site prior to offsite disposal. Typically sludges from smaller maintenance activities (such as holding pond forebay clean-outs) are accumulated and safely stored in concrete-walled sealed containment. A centrifuge is then brought to site, the sludge is processed in batches and the resultant de-watered sludge is sent for disposal (typically incineration) by the site waste management contractor. The separated oil/water stream is re-processed through the Refinery’s waste water treatment system, from where the oil content is recovered back to the process via an API (American Petroleum Institute) oil-water separator. Maintenance activities that produce a large amount of oily sludge as a one-time event, such as tank clean-outs, incorporate a dedicated sludge pre-treatment stage (e.g. by centrifuge) within that activity.</td>
<td>2.3.1</td>
</tr>
<tr>
<td>16</td>
<td>In order to reduce the generation of spent solid catalyst waste, BAT is to use one or a combination of the techniques given below.
<table>
<tr><th>Technique</th><th>Description</th></tr>
<tr><td>i. Spent solid catalyst management</td><td>Scheduled and safe handling of the materials used as catalyst (e.g. by</td></tr>
</table>
</td>
<td>CC</td>
<td>Techniques (i) and (ii) are used</td>
<td>1.4.1</td>
</tr>
</table>

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<tr><td></td><td>contractors) in order to recover or reuse them in off-site facilities. These operations depend on the type of catalyst and process</td></tr>
<tr><td>ii. Removal of catalyst from slurry decant oil</td><td>Decanted oil sludge from process units (e.g. FCC unit) can contain significant concentrations of catalyst fines. These fines can be separated prior to the reuse of decant oil as a feedstock.</td></tr>
</table></td><td></td><td></td><td></td></tr>
<tr><td>17</td><td>In order to prevent or reduce noise, BAT is to use one or a combination of the techniques given below:
i. Make an environmental noise assessment and formulate a noise management plan as appropriate to the local environment;
ii. Enclose noisy equipment/operation in a separate structure/unit;
iii. Use embankments to screen the source of noise;
iv. Use noise protection walls;</td><td>CC</td><td>Techniques (i) and (ii) are used. Noise management plan is in place and reviewed annually. The annual review is documented in the annual report submitted to the Agency, as required by UP3230LR.</td><td>3.4.1</td></tr>
<tr><td>18</td><td>In order to prevent or reduce diffuse VOC emissions, BAT is to apply the techniques given below.<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>I. Techniques related to plant design.</td><td>i. Limiting the number of potential emission sources
ii. Maximising inherent process containment features
iii. Selecting high integrity equipment</td><td>Applicability may be limited for existing units</td></tr>
</table></td><td>CC</td><td>Techniques (I), (II) and (III) are used. Use of an LDAR programme is required by UP3230LR.</td><td>3.2.1</td></tr>
</table>

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<table>
<tr><td></td><td>iv. Facilitating monitoring and maintenance activities by ensuring access to potentially leaking components</td><td></td></tr>
<tr><td>II. Techniques related to plant installation and commissioning</td><td>i. Well defined procedures for construction and assembly
ii. Robust commissioning and hand-over procedures to ensure that the plant is installed in line with the design requirements.</td><td>Applicability may be limited for existing units</td></tr>
<tr><td>III. Techniques related to plant operation</td><td>Use of a risk based leak detection and repair (LDAR) programme in order to identify leaking components, and to repair these leaks.
See table 1.20.6 under BAT 6</td><td>Generally applicable</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
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19	**In order to prevent hydrofluoric acid (HF) emissions to air from the hydrofluoric acid alkylation process, BAT is to use wet scrubbing with alkaline solution to treat incondensable gas streams prior to venting to flare.** **Description:** See section 1.20.3, Annex 1. **Applicability**: Generally applicable. Safety requirements, due to the hazardous nature of hydrofluoric acid, are to be considered.	CC	The Humber Refinery HF alkylation unit incorporates a dedicated flare system that collects incondensable gases from: • pressure relief valves; • venting of the Depropaniser Feed Settler drum; • de-pressuring of HF acid delivery road tankers; • equipment vents and drains; • sample points; and • venting of the KOH drain pots, associated with the propane and butane KOH treaters. In order to neutralise any trace amounts of HF acid present, these gases are treated in a Relief Gas Scrubber (W3635) prior to being routed to the Refinery's low pressure (No.3) Flare system. Scrubbing in W3635 is effected by a re-circulating stream of potassium hydroxide [KOH] solution. When the KOH strength drops, half of the inventory in W3635 is pumped to one of two 'regeneration' pits and fresh KOH solution is added to restore the strength. The spent KOH waste steam from the regeneration pits is removed from site periodically in road tankers and taken to a third party offsite treatment facility. A Relief Gas Scrubber that uses a re-circulating KOH stream to remove any trace amounts of HF acid from the HF alkylation unit flare gases meets the BAT 19 requirement of "wet scrubbing with alkaline solution".	2.3.1

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20	**In order to reduce emissions to water from the hydrofluoric acid alkylation process, BAT is to use a combination of the techniques given below.** **Technique** / **Description** / **Applicability** i. Precipitation / Neutralisation step — Precipitation (with e.g. calcium or aluminium-based additives) or neutralisation (where the effluent is indirectly neutralised with potassium hydroxide (KOH)) — Generally applicable. Safety requirements due to the hazardous nature of hydrofluoric acid (HF) are to be considered. ii Separation step — The insoluble compounds produced at the first step (e.g. CaF_2 or AlF_3) are separated in e.g. settlement basin. — Generally applicable	CC	In order to reduce emissions to water, surface drainage in the acid equipment area of the Humber Refinery HF Alkylation unit, and all acid equipment drains, are first routed to Neutralisation Pits located on the unit. In the first pit, there is the capability to add slaked lime – $Ca(OH)_2$ – to neutralise the water before it is routed to the main waste water treatment system. (This process is described in the Humber Refinery IPPC Application Document, FCC Area – Report No.5(c) – Alkylation Unit). Due to good unit design/operation, however, it has been found that is entirely possible to maintain good pH/fluoride control of the main refinery process effluent stream without the need to add lime to the Neutralisation Pits. This saves the additional time, expense and solids handling issues associated with the operation of the lime addition facility. Water from the neutralisation pits is routed to a large holding pond, or basin, dedicated to HF Alkylation unit effluent and located near the main waste water treatment system. This provides sufficient hold-up to allow the water to be fully tested before it is drained at a controllable rate to the effluent treatment plant. Thus technique (i) – a “precipitation/neutralisation step” – is not used. Technique (ii) – a “settlement basin” – is used but not as a means to separate insoluble compounds produced by step (i).	2.3.1
21	**In order to reduce the emissions to water from the sulphuric acid alkylation process, BAT is to reduce the use of sulphuric acid by regenerating the spent acid and to neutralise the waste water generated by this process before routing to waste water treatment.**	N/A	No sulphuric alkylation process on site.	2.3.1

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22	**In order to prevent and reduce the emissions of hazardous substances to air and water from base oil production processes, BAT is to use one or a combination of the techniques given below.**	NA	No base oil production.	2.3.1

Technique	Description	Applicability
i. Closed process with a solvent recovery	Process where the solvent, after being used during base oil manufacturing (e.g. in extraction, dewaxing units), is recovered through distillation and stripping steps. See Section 1.20.7, Annex 1.	Generally applicable
ii. Multi-effect extraction solvent-based process	Solvent extraction process including several stages of evaporation (e.g. double or triple effect) for a lower loss of containment	Generally applicable to new units. The use of a triple effect process may be restricted to non-fouling feed stocks
iii. Extraction unit processes using less hazardous substances	Design (new plants) or implement changes (into existing) so that the plant operates a solvent extraction process with the use of a less hazardous solvent: e.g. converting furfural or phenol extraction into the n-methylpyrrolidone (NMP) process	Generally applicable to new units. Converting existing units to another solvent-based process with different physico-chemical properties may require substantial modifications

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<tr><td></td><td><table><tr><td>iv. Catalytic processes based on hydrogenation</td><td>Processes based on conversion of undesired compounds via catalytic hydrogenation similar to hydrotreatment.</td><td>Generally applicable to new units</td></tr></table></td><td></td><td></td><td></td></tr>
<tr><td>23</td><td>In order to prevent and reduce emissions to air from the bitumen production process, BAT is to treat the gaseous overhead by using one of the techniques given below<table><tr><th>Technique</th><th>Description</th><th>Applicability</th></tr><tr><td>i. Thermal oxidation of gaseous overhead over 800 °C</td><td>See Section 1.20.6, Annex 1.</td><td>Generally applicable for the bitumen blowing unit</td></tr><tr><td>ii. Wet scrubbing of gaseous overhead</td><td>See Section 1.20.3, Annex 1.</td><td>Generally applicable for the bitumen blowing unit</td></tr></table></td><td>NA</td><td>No bitumen production.</td><td>2.3.1</td></tr>
<tr><td colspan="2">BAT conclusions for the fluid catalytic cracking process</td><td></td><td></td><td></td></tr>
<tr><td>24</td><td>In order to prevent or reduce NO_X emissions to air from the catalytic cracking process (regenerator), BAT is to use one or a combination of the techniques given below.
I. Primary or process-related techniques, such as:<table><tr><th>Technique</th><th>Description</th><th>Applicability</th></tr><tr><td colspan="3">Process optimisation and use of promoters or additives</td></tr></table></td><td>CC</td><td>FCC is an existing, full combustion mode unit. Techniques (I)(i) and (I)(ii) are used. Compliance with associated emissions level satisfies BAT. Trends of NOx emissions from the FCC are provided in the quarterly reports submitted to the EA as required by UP3230LR, see Form Air 6.</td><td>2.3.1</td></tr>
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<tr><td>i. Process optimisation</td><td>Combination of operating conditions or practices aimed at reducing NO_X formation, e.g. lowering the excess oxygen in the flue-gas in full combustion mode, air staging of the CO boiler in partial combustion mode, provided that the CO boiler is appropriately designed.</td><td>Generally applicable</td></tr>
<tr><td>ii. Low-NO_X CO oxidation promoters</td><td>Use of a substance that selectively promotes the combustion of CO only and prevents the oxidation of the nitrogen that contain intermediates to NO_X e.g. non-platinum promoters.</td><td>Applicable only in full combustion mode for the substitution of platinum-based CO promoters. Appropriate distribution of air in the regenerator may be required to obtain the maximum benefits</td></tr>
</table></td><td></td><td></td><td></td></tr>
</table>

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<tr><td></td><td>
<table>
<tr><td>iii. Specific additive for NO_X reduction</td><td>Use of specific catalyst additives for enhancing the reduction of NO by CO</td><td>Applicable only in full combustion mode for the substitution of platinum-based CO promoters. Appropriate distribution of air in the regenerator may be required to obtain the maximum benefits.</td></tr>
</table>
<p>II Secondary or end-of-pipe techniques such as:</p>
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Selective catalytic reduction (SCR)</td><td>See section 1.20.2, Annex 1.</td><td>To avoid potential fouling downstream, additional firing might be required upstream of the SCR. For existing units, the applicability may be limited by space availability.</td></tr>
<tr><td>ii. Selective non-catalytic reduction (SNCR)</td><td>See section 1.20.2, Annex 1.</td><td>For partial combustion FCCs with CO boilers, a sufficient residence time at the appropriate temperature is required. For full combustion FCCs without auxiliary boilers, additional fuel injection (e.g. hydrogen) may be required to match a lower temperature window.</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
</table>

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	See section 1.20.2, Annex 1.	Need for additional scrubbing capacity. Ozone generation and the associated risk management need to be properly addressed. The applicability may be limited by the need for additional waste water treatment and related cross-media effects (e.g. nitrate emissions) and by an insufficient supply of liquid oxygen (for ozone generation). The applicability of the technique may be limited by space availability.

Table 4 BAT- associated emission levels for NO_X emissions to air from the regenerators in the catalytic cracking process

Parameter	Type of unit/combustion mode	BAT-AEL (monthly average) Mg/Nm^3
NO_X expressed as NO_2	New unit/all combustion mode	<30 – 100
	Existing unit/full combustion mode	<100 – 300 (1)
	Existing unit/partial combustion mode	100 - 400 (1)

<table>
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<tr><td></td><td>When antimony (Sb) injection is used for metal passivation, NO_X levels up to 700 mg/Nm^3 may occur. The lower end of the range can be achieved by using the SCR technique.</td><td></td><td></td><td></td></tr>
<tr><td>25</td><td>In order to reduce dust and metals emissions to air from the catalytic cracking process (regenerator), BAT is to use one or a combination of the techniques given below.

I. Primary or process-related techniques, such as:

<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Use of an attrition-resistant catalyst</td><td>Selection of catalyst substance that is able to resist abrasion and fragmentation in order to reduce dust emissions.</td><td>Generally applicable provided the activity and selectivity of the catalyst are sufficient</td></tr>
<tr><td>ii. Use of low sulphur feedstock (e.g. by feedstock selection or hydrotreatment of feed)</td><td>Feedstock selection favours low sulphur feedstocks among the possible sources. Hydrotreatment aims at reducing the sulphur, nitrogen and metal contents of the feed.</td><td>Requires sufficient availability of low sulphur feedstocks, hydrogen production and hydrogen sulphide (H2S) treatment capacity (e.g. amine and Claus units)</td></tr>
</table>

II. secondary or end-of-pipe techniques, such as:

<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
</table></td><td>CC</td><td>(i) P66 installed a new extractive CEM system, taking its sample from the FCC ESP outlet duct, the FTIR analyser was installed in Q1 2018.

(ii) Humber Refinery has operated previously with an ammonia injection rate to the FCC ESP sufficient to keep Regenerator dust emissions below BAT 25 AEL of 50mg/Nm^3 (this period was April 2013 - February 2014, ending with the high ammonia concentration detected by our emissions monitoring consultants during the monthly stack test on 03.03.2014.). At present however, given that there is variability in the amount of ammonia ‘slip’ through to the FCC stack, ammonia must be injected at a lower rate to ensure compliance with the Regenerator flue gas ammonia concentration limit.

Utilisation of the FTIR analyser will, through continuously monitoring the impact on emissions, be able to manage the quantity of ammonia injected (e.g. in reaction to changing unit operation) to meet consistently both the Regenerator flue gas ammonia concentration limit and the BAT 25 AEL of 50mg/Nm^3.</td><td>2.3.1</td></tr>
</table>

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i. Electrostatic precipitator (ESP)	See section 1.20.1, Annex1.	For existing units, the applicability may be limited by space availability
ii. Multistage cyclone separators	See section 1.20.1, Annex1.	Generally applicable
iii. Third stage blowback filter	See section 1.20.1, Annex1.	Applicability may be restricted
iv. Wet scrubbing	See section 1.20.3, Annex1.	The applicability may be limited in arid areas and in the case where the by-products from treatment (including e.g. waste water with high level of salts) cannot be reused or appropriately disposed of. For existing units, the applicability may be limited by space availability.

Table 5 BAT – associated emission levels for dust emissions to air form the regenerator in the catalytic cracking process.

Parameter	Type of unit	BAT-AEL (monthly average) (1) Mg/Nm^3
Dust	New unit	10 – 25

<table>
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<tr><td></td><td><table><tr><td></td><td>Existing unit</td><td>10 – 50 (2)</td></tr><tr><td colspan="3">(1) Soot blowing in CO boiler and through the gas cooler is excluded
(2) The lower end of the range can be achieved with a 4-field ESP</td></tr></table>The associated monitoring is in BAT 4.</td><td></td><td></td><td></td></tr>
<tr><td>26</td><td>In order to prevent or reduce SO_X emissions to air from the catalytic cracking process (regenerator), BAT is to use one or a combination of the techniques given below.

I. Primary or process-related techniques such as:
<table><tr><th>Technique</th><th>Description</th><th>Applicability</th></tr><tr><td>i. Use of SO_X reducing catalyst additives</td><td>Use of a substance that transfers the sulphur associated with coke from the regenerator back to the reactor.</td><td>Applicability may be restricted by regenerator conditions design. Requires appropriate hydrogen sulphide abatement capacity (e.g. SRU)</td></tr><tr><td>ii. Use of low sulphur feedstock (e.g. by feedstock selection of by hydrotreatment of the feed)</td><td>Feedstock slelction favours low sulphur feedstocks among the possible sources to be processed at the unit. Hydrotreatment aims at reducing the</td><td>Requires sufficient availability of low sulphur feedstocks, hydrogen production anf hydrogen sulphide (H_2S) treatment capacity</td></tr></table></td><td>CC</td><td>Techniques used are (I)(i) and (I)(ii). Compliance with the AEL is achieved, which satisfies BAT. Trends of SOx emissions from the FCC are provided in the quarterly reports submitted to the EA as required by UP3230LR, see Form Air 6.</td><td>2.3.1</td></tr>
</table>

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	sulphur, nitrogen and metal contents of the feed. Section 1.20.3, Annex1	(e.g. amine and Claus units)

II. Secondary or end-of pipe techniques, such as:

Technique	Description	Applicability
i. Non-regenerative scrubbing	Wet scrubbing or seawater scrubbing	The applicability may be limited in arid areas and in the case where the by-products form the treatment (including e.g. waste water with high levels of salts) cannot be reused or appropriately disposed of.
ii. Regenerative scrubbing	Use of a specific SO_X absorbing reagent (e.g. absorbing solution) which generally enables the recovery of sulphur as a by-product during a regenerating cycle where the reagent is reused	The applicability is limited to the case where regenerated by-products can be sold. For existing units, the applicability may be limited by the existing sulphur recovery capacity as well as by space availability

<table>
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<table>
<tr><td></td><td>Section 1.20.3, Annex1</td><td></td></tr>
</table>
Table 6 BAT-associated emission levels for SO_2 emissions to air from the regenerator in the catalytic cracking process
<table>
<tr><th>Parameter</th><th>Type of units/mode</th><th>BAT-AEL (monthly average) mg/Nm^3</th></tr>
<tr><td>SO_2</td><td>New units</td><td>≤ 300</td></tr>
<tr><td></td><td>Existing units/full combustion</td><td><100 – 800(1)</td></tr>
<tr><td></td><td>Existing units/partial combustion</td><td>100 – 1 200 (1)</td></tr>
<tr><td colspan="3">(1) Where selection of low sulphur (e.g. < 0.5% w/w) feed (or hydrotreatment) and/or scrubbing is applicable, for all combustion modes, the upper end of the BAT-AEL range is ≤600 mg/Nm^3</td></tr>
</table>
The associated monitoring is in BAT 4.</td><td></td><td></td><td></td></tr>
<tr><td>27</td><td>In order to reduce carbon monoxide (CO) emissions to air from the catalytic cracking process (regenerator), BAT is to use one or a combination of the techniques given below.
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Combustion operation control</td><td>See section 1.20.5, Annex 1.</td><td>Generally applicable</td></tr>
<tr><td>ii. Catalysts with carbon</td><td>See section 1.20.5, Annex 1.</td><td>Generally applicable only for full combustion mode</td></tr>
</table></td><td>CC</td><td>Techniques (i) and (ii) are used. AEL is not applicable. Trends of CO emissions from the FCC are provided in the quarterly reports submitted to the EA as required by UP3230LR, see Form Air 6.</td><td>2.3.1</td></tr>
</table>

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<tr><td></td><td>
<table>
<tr><td>monoxide (CO) oxidation promoters</td><td></td><td></td></tr>
<tr><td>iii. Carbon monoxide (CO) boiler</td><td>See section 1.20.5, Annex 1.</td><td>Generally applicable only for partial combustion mode</td></tr>
</table>
Table 7 BAT- associated emission levels for carbon monoxide emissions to air from the regenerator in the catalytic cracking process for partial combustion mode.
<table>
<tr><th>Parameter</th><th>Combustion mode</th><th>BAT-AEL (monthly average) mg/Nm3</th></tr>
<tr><td>Carbon monoxide expressed as CO</td><td>Partial combustion mode</td><td>≤ 100 (1)</td></tr>
<tr><td colspan="3">(1) May not be achievable when not operating the CO boiler at full load.</td></tr>
</table>
The associated monitoring is in BAT 4</td><td></td><td></td><td></td></tr>
<tr><td>28</td><td>In order to reduce emissions of polychlorinated dibenzodioxins/furans (PCDD/F) to air from the catalytic reforming unit, BAT is to use one or a combination of the techniques given below
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Choice of the catalyst promoter</td><td>Use of catalyst promoter in order to minimise polychlorinated dibenzodioxins/furan</td><td>Generally applicable</td></tr>
</table></td><td>CC</td><td>Technique (i) is used. PCE catalyst promoter is used as per BAT. Technique (ii)(a) is not applicable for configuration of unit. Techniques (ii)(b) and (ii)(c) are not applicable for semi-regen reformers.</td><td>2.3.1</td></tr>
</table>

<table>
<tr><th>BAT Conclusion Number</th><th>Summary of BAT Conclusion requirement</th><th>Status NA/ CC / FC / NC</th><th>Assessment of the installation capability and any alternative techniques proposed by the operator to demonstrate compliance with the BAT Conclusion requirement</th><th>Relevant permit condition(s)</th></tr>
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<table>
<tr><td></td><td>s (PCDD/F) formation during regeneration. See section 1.20.7, Annex 1.</td><td></td></tr>
<tr><td colspan="3">ii Treatment of the regeneration flue-gas</td></tr>
<tr><td>a) Regeneration gas recycling loop with adsorption bed</td><td>Waste gas from the regeneration step is treated to remove chlorinated compounds (e.g. dioxins)</td><td>Generally applicable to new units. For existing units the applicability may depend of the current regeneration unit design</td></tr>
<tr><td>b) Wet scrubbing</td><td>See section 1.20.3, Annex 1.</td><td>Not applicable to semi-regenerative reformers</td></tr>
<tr><td>c) Electrostatic precipitator (ESP)</td><td>See section 1.20.1, Annex 1.</td><td>Not applicable to semi-regenerative reformers</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
<tr><td>29</td><td>In order to reduce emissions to air from the coking production processes, BAT is to use one or a combination of the techniques given below:
<table>
<tr><th>Applicability</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Collection and recycling of coke fines</td><td>Systematic collection and recycling of coke fines generated during the whole coking process (drilling, handling, crushing, cooling etc)</td><td>Generally applicable</td></tr>
</table>
</td><td>CC</td><td>All 4 techniques are applied at appropriate points in the Humber Refinery coke production process. Techniques (i) and (ii) are used throughout the calcining process to systematically collect and recycle coke fines; see BAT 3 above. Techniques (iii) and (iv) are also used as detailed below

The Humber Refinery has a closed blowdown (CBD) system that condenses and collects hydrocarbon and steam vapours generated by coking area operations [technique (iii)].</td><td>2.3.1</td></tr>
</table>

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<tr><td rowspan="3"></td><td>ii. Handling and storage of coke according to BAT 3</td><td>See BAT 3</td><td>Generally applicable</td><td rowspan="3"></td><td rowspan="3">In normal operation, incondensable process off-gases from the coking area process units are recovered as a component of refinery fuel gas [technique (iv)]. During start-up, shut-down and in some emergency relief situations, some product may also be sent to the CBD system.

Once coke has formed in the coke drums, the drums themselves are steam stripped, quenched and dewatered to remove volatile hydrocarbons prior to being finally opened and de-pressured to atmosphere at a pressure of 5 psig. Hydrocarbon and steam vapours from the stripping/quenching process are routed to the CBD system.

The CBD system recovers hydrocarbon (slop oil) and water back to the process. Some flaring of incondensable hydrocarbon vapours is unavoidable. These unrecovered gases are routed to the No.3 Flare, where product that would otherwise be background flaring is recovered to RFG by the flare gas recovery system compressors [technique (iv)].</td><td rowspan="3"></td></tr>
<tr><td>iii. Use of a closed blowdown system</td><td>Arrestment system for pressure relief from the coke drum</td><td>Generally applicable</td></tr>
<tr><td>iv. Recovery of gas (including the venting prior to the drum being opened to atmosphere) as a component of refiner fuel gas (RFG)</td><td>Carrying venting from the coke drum to the gas compressor to recover as RFG rather than flaring. For the flexicoking process, a conversion step (to convert the carbonyl sulphide (COS) into S_2S) is needed prior to treating the gas from the coking unit.</td><td>For existing units, the applicability of the techniques may be limited by space availability</td></tr>
</table>

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<tr><td>30</td><td>In order to reduce NO_X emissions to air from the calcining of green coke process, BAT is to use selective non-catalytic reduction (SNCR).
Description: See section 1.20.2, Annex 1.
Applicability: The applicability of the SNCR technique (especially with respect to residence time and temperature window) may be restricted due to the specificity of the calcining process.</td><td>NA and CC</td><td>We are satisfied that the calcining process precludes the use of SNCR on release point A11. The retro-fitting of SNCR to Release Point A11 was evaluated in a detailed study by Phillips 66 in March 2014. It concluded that SNCR was not a viable technique for this unit due to technical constraints. The process equipment configuration does not allow sufficient residence time in the requisite temperature window for this technique to be effective; the Environment Agency accepted the findings of this study.
Release point A9 is compliant by inclusion of that release point in the approved Integrated Emissions Management Technique Protocol.</td><td>2.3.1</td></tr>
<tr><td>31</td><td>In order to reduce SO_X emissions to air from the calcining of green coke process, BAT is to use one or a combination of the techniques given below.
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Non-regenerative scrubbing</td><td>Wet scrubbing or seawater scrubbing.
See Section 5.20.3</td><td>The applicability may be limited in arid areas and in the case where the by-products from treatment (including e.g. waste water with high level of salts) cannot be reused or appropriately disposed of. For existing units, the applicability may be limited by space availability</td></tr>
</table></td><td>CC</td><td>Compliance is achieved through the inclusion of the relevant release points (A9 and A11) in the approved Integrated Emissions Management Technique Protocol.
There are no BATAELs included in BAT31 for SO_2 emissions from calciners.</td><td>2.3.1</td></tr>
</table>

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<tr><td></td><td><table><tr><td>ii. Regenerative scrubbing</td><td>Use of a specific SO_X absorbing reagent (e.g. absorbing solution) which generally enables the recovery of sulphur as a by-product during a regenerating cycle where the reagent is reused. See Section 5.20.3, Annex 1.</td><td>The applicability is limited to the case where regenerated by-products can be sold.
For existing units, the applicability may be limited by the existing sulphur recovery capacity as well as by space availability</td></tr></table></td><td></td><td></td><td></td></tr>
<tr><td>32</td><td>In order to reduce dust emissions to air from the calcining of green coke process, BAT is to use a combination of the techniques given below.<table><tr><th>Technique</th><th>Description</th><th>Applicability</th></tr><tr><td>i. Electrostatic precipitator (ESP)</td><td>See section 1.20.1, Annex 1.</td><td>For existing units, the applicability may be limited by space availability.
For graphite and anode coke calcining production, the applicability may be restricted due to the high resistivity of the coke particles</td></tr><tr><td>ii. Multistage cyclone separators</td><td>See section 1.20.1, Annex 1.</td><td>Generally applicable</td></tr></table></td><td>CC</td><td>Technique (ii) is used. Technique (i) is not applicable. The Humber Refinery calciners process graphite and anode coke. The resistivity of coke particles is not compatible with an Electrostatic Precipitator, as stated in the applicability statement, therefore this technique does not apply to the Humber Refinery calciners. Trends of dust emissions from ST601 and ST5602 are provided in the quarterly reports submitted to the EA as required by UP3230LR.
BAT 32 technique (ii)
This technique is used comprehensively at the Humber Refinery to reduce dust emissions to air from the calcining of green coke process. Multi-stage high-efficiency cyclone separators remove coke fines from the process gases at both the boiler and cooler ends of the process on each of the three calciners before these gases are discharged to atmosphere via their respective stacks.</td><td>2.3.1</td></tr>
</table>

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<tr><td></td><td>Table 8 BAT- associated emission levels of dust emissions to air from a unit for the calcining of green coke
<table>
<tr><th>Parameter</th><th>BAT-AEL (monthly average) mg/Nm^3</th></tr>
<tr><td>Dust</td><td>10 - 50 ($^{1, 2}$)</td></tr>
<tr><td colspan="2">(1) The lower end of the range can be achieved with a 4-field ESP
(2) When an ESP is not applicable, values of up to 150 mg/Nm^3 may occur.</td></tr>
</table>
The associated monitoring is in BAT 4.</td><td></td><td>The use of these cyclone separators is described further in the Humber Refinery IPPC Application Document (Calcining Area – Report No. 7 – No. 1, No. 2 & No. 3 Calciner). The handing of the coke fines generated by the cyclones is in accordance with the information provided in relation to BAT 15.

BAT 32 technique (i)
Bulk graphite carbon is a good conductor of electricity and this is one of the characteristics that make this an excellent material from which to make the electrodes used by the aluminium and steel manufacturing industries. As particle size decreases, however, so does the number of conductive pathways per unit volume of material. Unlike the bulk material, small particles of graphite carbon therefore have low conductivity – or high resistivity – and the smaller the particle (e.g. dust) the higher the resistivity, or resistance to electrical charge. This is recognised in Section 5.20.1 of the BAT Reference Document for the Refining of Mineral Oil and Gas (the REF BREF): “<i>for the calcining of green coke, the ESP capture efficiency may be reduced due to the difficulty for coke particles to be electrically charged</i>”.

The Humber Refinery coking/calcining process produces speciality graphite and anode grade calcined petroleum cokes. As has been stated above, the high resistivity of the coke particles produced by this process is not compatible with an Electrostatic</td><td></td></tr>
</table>

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NC = Not complaint</td></tr>
<tr><td></td><td></td><td></td><td>Precipitator (ESP). BAT 32 technique (i) is therefore not applicable at the Humber Refinery as a means to improve the collection of dust from calcining green coke. The restriction identified in the Applicability Statement to BAT 32 as applied to graphite and anode coke (as set out above) applies.

Using Note (2) from *Table 8* above, a limit of 150 mg/Nm^3 therefore becomes the relevant associated emission level for the calcining of green coke process at the Humber Refinery. Calciner stacks ST601 and ST5602 are already subject to daily average dust limits of 150 mg/Nm^3 in permit EPR/UP3230LR, which assures that compliance with the BAT-AEL is achieved on a monthly average basis. ST602 has a daily average dust limit of 230 mg/Nm^3, however the stack complies with an emissions limit of 150 mg/Nm^3 on a monthly average basis. Trends of dust emissions from ST601 and ST5602 are provided within the quarterly reports submitted to the Environment Agency as required by EPR/UP3230LR.</td><td></td></tr>
<tr><td>33</td><td>**In order to reduce water consumption and emissions to water from the desalting process, BAT is to use one or a combination of the techniques given below.**

<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Recycling water and optimisation of the desalting process</td><td>An ensemble of good desalting practices aiming at increasing the efficiency of the desalter and reducing wash water usage e.g. using low shear mixing devices,</td><td>Generally applicable</td></tr>
</table></td><td>CC</td><td>Techniques (i), (ii) and (iii) are used.</td><td>1.3.1
2.3.1</td></tr>
</table>

<table>
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<tr><td></td><td><table>
<tr><td></td><td>low water pressure. It includes the management of key parameters for washing (e.g. good mixing) and separation (e.g. pH, density, viscosity, electric field potential for coalescence) steps</td><td></td></tr>
<tr><td>ii. Multistage desalter</td><td>Multistage desalters operate with water addition and dehydration, repeated through two stages or more for achieving a better efficiency in the separation and therefore less corrosion in further processes</td><td>Applicable for new units</td></tr>
<tr><td>iii. Additional separation step</td><td>An additional enhanced oil/water and solid/water separation designed for reducing the charge of oil to the waste water treatment plant and recycling it to the process. This includes, e.g. settling drum, the use of optimum interface level controllers</td><td>Generally applicable</td></tr>
</table></td><td></td><td></td><td></td></tr>
<tr><td>34</td><td>BAT 34. In order to prevent or reduce NO_X emissions to air from the combustion units, BAT is to use one or a combination of the techniques given below.
I. Primary or process-related techniques, such as:</td><td>CC</td><td>Techniques (I)(i)(a) and (I)(ii)(b) are used on refinery combustion plant. Additionally technique (I)(ii)(d) is used on the CHP. Technique (I)(ii)(e) is installed on some refinery fired heaters.</td><td>2.3.1</td></tr>
</table>

<table>
<tr><th>BAT Conclusion Number</th><th>Summary of BAT Conclusion requirement</th><th>Status NA/ CC / FC / NC</th><th>Assessment of the installation capability and any alternative techniques proposed by the operator to demonstrate compliance with the BAT Conclusion requirement</th><th>Relevant permit condition(s)</th></tr>
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<tr><td></td><td>
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td colspan="3">i. Selection or treatment of fuel</td></tr>
<tr><td>(a) Use of gas to replace liquid fuel</td><td>Gas generally contains less nitrogen than liquid and its combustion leads to a lower level of NO_X emissions.
See section 1.20.3, Annex 1.</td><td>The applicability may be limited by the constraints associated with the availability of low sulphur gas fuels, which may be impacted by the energy policy of the Member State</td></tr>
<tr><td>(b) Use of low nitrogen refinery fuel oil (RFO) e.g. by RFO selection or by hydrotreatment of RFO</td><td>Refinery fuel oil selection favours low nitrogen liquid fuels among the possible sources to be used at the unit.
Hydrotreatment aims at reducing the sulphur, nitrogen and metal contents of the fuel.
See section 1.20.3, Annex 1.</td><td>Applicability is limited by the availability of low nitrogen liquid fuels, hydrogen production and hydrogen sulphide (H_2S) treatment capacity (e.g. amine and Claus units)</td></tr>
<tr><td colspan="3">ii. Combustion modifications</td></tr>
<tr><td>(a) Staged combustion:
• air staging</td><td>See section 1.20.2, Annex 1.</td><td>Fuel staging for mixed or liquid firing may</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
</table>

BAT Conclusion Number	Summary of BAT Conclusion requirement			Status NA/ CC / FC / NC	Assessment of the installation capability and any alternative techniques proposed by the operator to demonstrate compliance with the BAT Conclusion requirement	Relevant permit condition(s)
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	• fuel staging		require a specific burner design			
	(b) Optimisation of combustion	See section 1.20.2, Annex 1.	Generally applicable			
	(c) Flue-gas recirculation	See section 1.20.2, Annex 1.	Applicable through the use of specific burners with internal recirculation of the flue-gas. The applicability may be restricted to retrofitting external flue-gas recirculation to units with a forced/induced draught mode of operation			
	(d) Diluent injection	See section 1.20.2, Annex 1.	Applicable for gas turbines where appropriate inert diluents are available			
	(e) Use of low-NO_X burners (LNB)	See section 1.20.2, Annex 1.	Generally applicable for new units taking into account, the fuel-specific limitation (e.g. for heavy oil). For existing units, applicability may be restricted by the complexity caused by site-specific conditions			

<table>
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<table>
<tr><td></td><td></td><td>e.g. furnaces design, surrounding devices.
In very specific cases, substantial modifications may be required.
The applicability may be restricted for furnaces in the delayed coking process, due to possible coke generation in the furnaces.
In gas turbines, the applicability is restricted to low hydrogen content fuels (generally < 10 %)</td></tr>
</table>
II. Secondary or end-of-pipe techniques, such as:
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Selective catalytic reduction (SCR)</td><td>See section 1.20.2, Annex 1.</td><td>Generally applicable for new units.
For existing units, the applicability may be constrained due to the requirements for significant space and optimal reactant injection</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
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	ii. Selective non-catalytic reduction (SNCR)	See section 1.20.2, Annex 1.	Generally applicable for new units. For existing units, the applicability may be constrained by the requirement for the temperature window and the residence time to be reached by reactant injection			
	iii. Low temperature oxidation	See section 1.20.2, Annex 1.	The applicability may be limited by the need for additional scrubbing capacity and by the fact that ozone generation and the associated risk management need to be properly addressed. The applicability may be limited by the need for additional waste water treatment and related cross-media effects (e.g. nitrate emissions) and by an insufficient supply of liquid oxygen (for ozone generation). For existing units, the applicability of the technique may be			

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		limited by space availability
iv. SNO_X combined technique	See section 1.20.4, Annex 1.	Applicable only for high flue-gas (e.g. > 800 000 Nm3/h) flow and when combined NO_X and SO_X abatement is needed

BAT- associated emission levels: See Table 9, Table 10 and Table 11

Table 9 BAT-associated emission levels for NO_X emissions to air from a gas turbine

Parameter	**Type of equipment**	**BAT-AEL (1) (monthly average) mg/Nm^3 at 15% O_2**
NOx, expressed as NO_2	Gas turbine (including combined cycle gas turbine – CCGT) and integrated gasification combined cycle turbine (IGCC))	40 - 120 (existing gas turbine)
		20 - 50 (new turbine) (2)

(1) BAT-AEL refers to combined emissions from the gas turbine and the supplementary firing recovery boiler, where present

(2) For fuel with high H_2 content (i.e. above 10%), the upper end of the range is 75 mg/Nm^3

<table>
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<tr><td></td><td>
Table 10 BAT- associated emission levels for NOX emissions to air from a gas-fired combustion unit, with the exception of gas turbines
<table>
<tr><th>Parameter:</th><th>Type of combustion</th><th>BAT-AEL (monthly average) mg/Nm^3</th></tr>
<tr><td>NOx, expressed as NO_2</td><td>Gas firing</td><td>30 - 150 for existing unit (1)</td></tr>
<tr><td></td><td></td><td>30 - 100 for new unit</td></tr>
<tr><td colspan="3">(1) For an existing unit using high air pre-heat (i.e. > 200 C) or with H2 content in the fuel gas higher that 50% the upper end of the BAT-AEL range is 200 mg/Nm^3</td></tr>
</table>
Table 11 BAT –associated emission levels for NO_X emissions to air from a multi-fuel fired combustion unit with the exception of gas turbines
<table>
<tr><th>Parameter:</th><th>Type of combustion</th><th>BAT-AEL (monthly average) mg/Nm^3</th></tr>
<tr><td>NO_X expressed as NO_2</td><td>Multi-fuel fired combustion unit</td><td>30 -3—for existing unit (1) (2)</td></tr>
<tr><td colspan="3">(1) For existing units < 100 MW firing fuel oil with a nitrogen content higher that 0.5% (w/w) or with liquid firing > 50% or using air preheating values up to 450 mg/Nm^3 may occur
(2) The lower end of the range can be achieved by using the SCR technique</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
</table>

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<tr><td></td><td>The associated monitoring is in BAT 4</td><td></td><td></td><td></td></tr>
<tr><td>35</td><td>**In order to prevent or reduce dust and metal emissions to air from the combustion units, BAT is to use one or a combination of the techniques given below.**
I. Primary or process-related techniques, such as:
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td colspan="3">Selection or treatment of fuel</td></tr>
<tr><td>(a) Use of gas to replace liquid fuel</td><td>Gas instead of liquid combustion leads to lower level of dust emissions
See section 1.20.3, Annex 1.</td><td>The applicability may be limited by the constraints associated with the availability of low sulphur fuels such as natural gas which may be impacted by the energy policy of the Member State</td></tr>
<tr><td>(b) Use of low sulphur refinery fuel oil (RFO) e.g. by RFO selection or by hydro-treatment of RFO</td><td>Refinery fuel oil selection favours low sulphur liquid fuels among the possible sources to be used at the unit.
Hydrotreatment aims at reducing the sulphur, nitrogen and</td><td>The applicability may be limited by the availability of low sulphur liquid fuels, hydrogen production and the hydrogen sulphide (H_2S) treatment capacity</td></tr>
</table>
</td><td>NA</td><td>BAT AELs only apply to multi fuel firing.</td><td>2.3.1</td></tr>
</table>

<table>
<tr><th>BAT Conclusion Number</th><th>Summary of BAT Conclusion requirement</th><th>Status NA/ CC / FC / NC</th><th>Assessment of the installation capability and any alternative techniques proposed by the operator to demonstrate compliance with the BAT Conclusion requirement</th><th>Relevant permit condition(s)</th></tr>
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<table>
<tr><td></td><td>metal contents of the fuel
See section 1.20.3, Annex 1.</td><td>(e.g. amine and Claus units)</td></tr>
<tr><td colspan="3">Combustion modifications</td></tr>
<tr><td>(a) Optimisation of combustion</td><td>See section 1.20.2, Annex 1.</td><td>Generally applicable to all types of combustion</td></tr>
<tr><td>(b) Atomisation of liquid fuel</td><td>Use of high pressure to reduce the droplet size of liquid fuel. Recent optimal burner designs generally include steam atomisation</td><td>Generally applicable to liquid fuel firing</td></tr>
</table>
<p>II Secondary or end-of-pipe techniques, such as:</p>
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Electrostatic precipitator (ESP)</td><td>See section 1.20.1, Annex 1.</td><td>For existing units, the applicability may be limited by space availability</td></tr>
<tr><td>ii. Third stage blowback filter</td><td>See section 1.20.1, Annex 1.</td><td>Generally applicable</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
</table>

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iii.	Wet scrubbing	See section 1.20.1, Annex 1.	The applicability may be limited in arid areas and in the case where by-products from treatment (including e.g. waste water with a high level of salt) cannot be reused or appropriately disposed of. For existing units, the applicability of the technique may be limited by space availability
iv.	Centrifugal washers	See section 1.20.1, Annex 1.	Generally applicable

Table 12 BAT – associated emission levels of dust emissions to air from a multi-fuel fired combustion unit with the exception of gas turbines

Parameter	**Type of combustion**	**BAT-AEL (monthly average) mg/Nm^3**
Dust	Multi-fuel firing	5 – 50 for existing unit (1) (2)
		5 – 25 for new unit < 50 MW

<table>
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<tr><td></td><td>(1) The lower end of the range is achievable for units with the use of end-of-pipe techniques
(2) The upper end of the range refers to the use of a high percentage of oil burning and where only primary techniques are applicable

The associated monitoring is in BAT 4</td><td></td><td></td><td></td></tr>
<tr><td>36</td><td>In order to prevent or reduce SO_x emissions to air from the combustion units, BAT is to use one or a combination of the techniques given below.

I. Primary or process-related techniques
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Use of gas to replace liquid fuel</td><td>See section 1.20.3, Annex 1.</td><td>The applicability may be limited by the constraints associated with the availability of low sulphur fuels such as natural gas, which may be impacted by the energy policy of the Member State</td></tr>
<tr><td>ii. Treatment of refinery fuel gas (RFG)</td><td>Residual H2S concentration in RFG depends on the treatment process parameter, e.g. the</td><td>For low calorific gas containing carbonyl sulphide (COS) e.g. from coking units, a converter may be</td></tr>
</table></td><td></td><td>Techniques (I)(i) and (I)(ii) are used.</td><td>2.3.1</td></tr>
</table>

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<table>
<tr><td></td><td>amine-scrubbing pressure.
See Section 1.20.3, Annex 1.</td><td>required prior to H_2S removal</td></tr>
<tr><td>iii. Use of low sulphur refinery fuel oil (RFO) e.g. by RFO selection or by hydrotreatment of RFO</td><td>Refinery fuel oil selection favours low sulphur liquid fuels among the possible sources to be used at the unit.
Hydrotreatment aims at reducing the sulphur, nitrogen and metal contents of the fuel.
See Section 1.20.3, Annex 1.</td><td>The applicability is limited by the availability of low sulphur liquid fuels, hydrogen production and the hydrogen sulphide (H_2S) treatment capacity (e.g. amine and Claus units</td></tr>
</table>
<p>II. Secondary or end-of-pipe techniques</p>
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Non-regenerative scrubbing</td><td>Wet scrubbing or seawater scrubbing.
See Section 1.20.3, Annex 1.</td><td>The applicability may be limited in arid areas and in the case where the by-products from treatment (including e.g. waste water with high level of salts) cannot be reused or</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
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<table>
<tr><td></td><td></td><td>appropriately disposed of.
For existing units, the applicability of the technique may be limited by space availability</td></tr>
</table>
<p>Table 13 BAT – associated emission levels for SO_2 emissions to air from combustion unit firing refinery fuel gas (RFG), with the exception of gas turbines</p>
<table>
<tr><th>Parameter</th><th>BAT-AEL (monthly average) mg/Nm^3</th></tr>
<tr><td>SO2</td><td>5 – 35 (^{1})</td></tr>
<tr><td colspan="2">(1) In the specific configuration of RFG treatment with a low scrubber operative pressure and with refinery fuel gas with an H/C molar ratio above 5, the upper end of the BAT-AEL range can be as high as 45 mg/Nm3</td></tr>
</table>
<p>The associated monitoring is in BAT 4</p>
<p>Table 14 BAT- associated emission levels for SO_2 emissions to air from multi-fuel fired combustion units, with the exception of gas turbines and stationary engines</p>
<table>
<tr><th>Parameter</th><th>BAT-AEL (monthly average) mg/Nm^3</th></tr>
<tr><td>SO_2</td><td>35 - 600</td></tr>
</table>
<p>The associated monitoring is in BAT 4</p>
</td><td></td><td></td><td></td></tr>
</table>

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37	**In order to reduce carbon monoxide (CO) emissions to air from the combustion units, BAT is to use a combustion operation control.** Description: See section 1.20.5, Annex 1. **Table 15 BAT – associated emission levels for carbon monoxide emissions to air from combustion unit** **Parameter** — **BAT- AEL (monthly average) mg/Nm^3** Carbon monoxide expressed as CO — $\leq$ 100 Associated monitoring is in BAT 4.	CC	Refinery combustion plant meets AEL through combustion control of heaters.	2.3.1
38	**In order to reduce emissions to air from the etherification process, BAT is to ensure the appropriate treatment of process off-gases by routing them to the refinery fuel gas system.**	NA		2.3.1
39	**In order to prevent upset of the biotreatment, BAT is to use a storage tank and an appropriate unit production plan management to control the toxic components dissolved content (e.g. methanol, formic acid, ethers) of the waste water stream prior to final treatment.**	NA		2.3.1
40	**In order to reduce emissions to air of chlorinated compounds, BAT is to optimise the use of chlorinated organic compounds used to maintain catalyst activity when such a process is in place or to use non-chlorinated catalytic systems.**	NA		2.3.1

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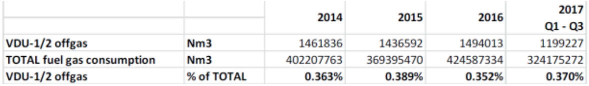
41	**In order to reduce sulphur dioxide emissions to air from the natural gas plant, BAT is to apply BAT 54.**	NA		2.3.1
42	**In order to reduce nitrogen oxides (NO_X) emissions to air from the natural gas plant, BAT is to apply BAT 34**	NA		2.3.1
43	**In order to prevent emissions of mercury when present in raw natural gas, BAT is to remove the mercury and recover the mercury-containing sludge for waste disposal.**	NA		2.3.1

44	**In order to prevent or reduce waste water flow generation from the distillation process, BAT is to use liquid ring vacuum pumps or surface condensers.** **Applicability**. May not be applicable in some retrofit cases. For new units, vacuum pumps, either in or not in combination with the steam ejectors, may be needed to achieve a high volume (10 mm Hg). Also, a spare should be available in case the vacuum pump fails.	CC	Hybrid configuration of steam ejectors and liquid ring pumps were part of original design and construction of No.3 vacuum unit, therefore No.3 vacuum unit meets the requirements of BAT. No.1 and No.2 vacuum unit operate with steam ejectors only and were not designed for operation using liquid ring pumps. Applicability restriction for retrofit applies to No.1 and No.2 vacuum unit. A hybrid configuration of steam ejectors and liquid ring vacuum pumps is used for vacuum generation on the Humber Refinery's newest Vacuum Distillation Unit (VDU-3); this unit therefore meets the requirements of BAT 44. VDU-1 and VDU-2, however, operate in series using steam ejectors only for vacuum generation. These units were not designed for operation using liquid ring vacuum pumps. The steam consumed by these vacuum unit steam ejector systems is collected as condensate and re-used directly as sour wash water in the No.2 Crude Unit (CTU-2) desalting process in accordance with the additional information provided in relation to BAT 45 (Action 13) sent on 3rd July 2017. As such, it has a beneficial use as recycled water rather than being sent directly to waste water treatment/discharge. That use meets the objective of BAT 44 because it reduces waste water flow generation from the distillation process. Furthermore, the additional sour water flow generated by using only steam ejectors on VDU-1/2 has been estimated to be only approx. 10 USgpm (US gallons per minute) or 2.25 m^3/hr. This compares to total Refinery water consumption in excess of 3,500 USgpm (1). The potential water saving opportunity in adopting liquid ring pumps in combination with steam ejectors on VDU-1/2 (should such a retrofit be technically feasible) is therefore very small. The restriction identified in BAT 44 Applicability Statement (as set out above) applies.	2.3.1

45	**In order to prevent or reduce water pollution from the distillation process, BAT is to route sour water to the stripping unit.**	CC	At the Humber Refinery, sour waters are collected and stripped of H_2S and ammonia in the Sour Water Stripping unit. A portion of the resultant stripped sour water is then used as wash water in No.1 and No.2 Crude Unit desalters, where much of the phenol is re-absorbed back into the crude oil. An exception to the above, however, exists for the crude distillation process. Here unstripped accumulated water from No.1 and No.2 Crude unit overhead system, and collected condensate from the Vacuum units' steam ejector system, is re-used directly (in combination with stripped sour water) as wash water in No.2 Crude Unit's desalting process. This alternative routing is possible due to the low H2S content of this collected water and preferable due to the relatively high salt content (i.e. not suitable as SWS tower feed). The Humber Refinery's re-use of water from the crude distillation process is described in the Humber Refinery IPPC Application Document, Crudes Area – Report No.2, and is consistent with Section 4.9.4 of the BAT Reference Document for the Refining of Mineral Oil and Gas (the REF BREF) that says: The following process water streams can be suitable for use as desalter wash water: • The accumulated water in the crude distillation overhead drum; • The (unstripped) steam condensates from the vacuum distiller overhead; • Stripped sour water. The alternative use of crude distillation process water as described above therefore provides an equivalent outcome to the narrative BAT 45 requirement, and is supported by the REF BREF.	2.3.1
46	In order to prevent or reduce emissions to air from distillation units, BAT is to ensure the appropriate treatment of process off-gases, especially incondensable off-gases, by acid gas removal prior to further use. **Applicability**. Generally applicable for crude and vacuum distillation units. May not be applicable for standalone lubricant and bitumen	CC	The Humber Refinery has two crude oil distillation units: CTU-1 and CTU-2, and three vacuum distillation units: VDU-1, VDU-2 and VDU-3. The incondensable process off-gases from these units are all recovered and used as fuel gas, but the gases from VDU-1 and VDU-2 -- burned	2.3.1

<table>
<tr><td></td><td>refineries, with emissions of less than 1 t/d of sulphur compounds. In specific refinery configurations, applicability may be restricted, due to the need for e.g. large piping, compressors or additional amine treating capacity.</td><td></td><td>locally in heater H4101 as a supplementary fuel gas stream -- are not treated for acid gas removal prior to combustion.
These off-gases are, however, a poor candidate for a retrofit to route them to the Refinery’s fuel gas amine treatment facility (to be recovered as RFG) because:
1) VDU-1/2 off-gases are inherently available at low pressure as they come directly from the vacuum distillation process. This means that significant additional piping and compressors to route these gases to the amine treating system, and modifications to the amine treating system itself, would be required. The restriction identified in BAT 46 Applicability Statement (as set out above) therefore applies to VDU-1/2 off-gases.
2) VDU-1/2 off-gases are available in low volume, comprising < 0.5% of the total refinery fuel gas consumption on site:
<table><tr><th></th><th></th><th>2014</th><th>2015</th><th>2016</th><th>2017
Q1 - Q3</th></tr><tr><td>VDU-1/2 offgas</td><td>Nm3</td><td>1461836</td><td>1436592</td><td>1494013</td><td>1199227</td></tr><tr><td>TOTAL fuel gas consumption</td><td>Nm3</td><td>402207763</td><td>369395470</td><td>424587334</td><td>324175272</td></tr><tr><td>VDU-1/2 offgas</td><td>% of TOTAL</td><td>0.363%</td><td>0.389%</td><td>0.352%</td><td>0.370%</td></tr></table>
All fuel gas streams are treated for acid gas removal prior to combustion, apart from VDU-1/2 off-gases. These untreated fuel gas streams contribute approx. 80 tonnes per annum of SO2 emissions to air:
<table><tr><th></th><th></th><th>2014</th><th>2015</th><th>2016</th><th>2017
Q1 - Q3</th></tr><tr><td>VDU-1/2 offgas SO_2</td><td>Tonnes</td><td>75.18</td><td>73.88</td><td>76.83</td><td>61.67</td></tr></table>
In summary, the low volume and low available pressure of VDU-1/2 off-gases means that it is still appropriate to burn these gases directly in VDU-1 charge heater H4101.</td><td></td></tr>
<tr><td>47</td><td>In order to reduce emissions to air from the products treatment process, BAT is to ensure the appropriate disposal of off-gases, especially odorous spent air from sweetening units, by routing them to destruction, e.g. by incineration.</td><td>CC</td><td>The Humber Refinery has two sweetening units that produce odorous spent air (“foul air”). The odours from the LPG Rundown Merox Treatment Unit foul air are destroyed by incineration in the Sulphur Recovery Unit</td><td>2.3.1</td></tr>
</table>

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	Applicability. Generally applicable to products treatment processes where the gas streams can be safely processed to the destruction units. May not be applicable to sweetening units, due to safety reasons.		(I4501 or H4405) or by use as combustion air in a No.2 Catalytic Reforming Unit heater (H6301). Foul air from the Propylene Recovery Merox Treatment Unit is routed to the main FCC air blower discharge and combusted in the FCC Regenerator. The above has been previously described in the Humber Refinery IPPC Application Document: 1) Aromatics Area – Report No.4(c) – LPG Rundown/Merox Treatment; 2) FCC Area – Report No.5(b) – Propylene Recovery Unit (PRU).	
48	**In order to reduce waste and waste water generation when a products treatment process using caustic is in place, BAT is to use cascading caustic solution and a global management of spent caustic, including recycling after appropriate treatment, e.g. by stripping.**	CC	Spent caustic is used for pH control in the Sour Water Stripper and the Effluent Treatment Plant.	2.3.1

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49	**In order to reduce VOC emissions to air from the storage of volatile liquid hydrocarbon compounds, BAT is to use floating roof storage tanks equipped with high efficiency seals or a fixed roof tank connected to a vapour recovery system.** **Description**. High efficiency seals are specific devices for limiting losses of vapour e.g. improved primary seals, additional multiple (secondary or tertiary) seals (according to quantity emitted). **Applicability**. The applicability of high efficiency seals may be restricted for retrofitting tertiary seals in existing tanks.	CC	In order to reduce fugitive VOC emissions to air, floating roof liquid hydrocarbon storage tanks at the Humber Refinery are fitted with both primary and secondary seals (external floating roof tanks) or with an internal floating roof. These devices are in the process of being replaced and upgraded to industry leading, high efficiency products. All external floating roof (EFR) and internal floating roof (IFR) tanks will have these installed whenever a tank is taken out of service and made available by the Refinery's 20-year major tank maintenance programme. This is a rolling programme, so some tanks will already have these new devices fitted and some will not. All EFR and IFR tanks taken out of service since 2013 within the major tank maintenance programme have been upgraded. Upgrades are planned into each tank's scope of works. An engineering review confirms that the products remain current and meet the relevant American Petroleum Institute (API) codes and P66 standards.	2.3.1

<table>
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<tr><td>50</td><td>In order to reduce VOC emissions to air from the storage of volatile liquid hydrocarbon compounds, BAT is to use one or a combination of the techniques given below.
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>i. Manual crude oil tank cleaning</td><td>Oil tank cleaning is performed by workers entering the tank and removing sludge manually</td><td>Generally applicable</td></tr>
<tr><td>ii. Use of a closed-loop system</td><td>For internal inspections, tanks are periodically emptied, cleaned and rendered gas-free. This cleaning includes dissolving the tank bottom. Closed-loop systems that can be combined with end-of-pipe mobile abatement techniques prevent or reduce VOC emissions</td><td>The applicability may be limited by e.g. the type of residues, tank roof construction or tank materials</td></tr>
</table></td><td>CC</td><td>Techniques (i) and (ii) are used.</td><td>2.3.1</td></tr>
<tr><td>51</td><td>In order to prevent or reduce emissions to soil and groundwater from the storage of liquid hydrocarbon compounds, BAT is to use one or a combination of the techniques given below.
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
</table></td><td>CC</td><td>Technique (i) is used. Techniques (ii) and (iii) are applied following inspection and risk assessment of existing tanks. Technique (iv) is used, refinery is subject to Containment Policy inspection and COMAH regulations.</td><td>1.1
2.3.1
3.2.3</td></tr>
</table>

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i. Maintenance programme including corrosion monitoring, prevention and control	A management system including leak detection and operational controls to prevent overfilling, inventory control and risk-based inspection procedures on tanks at intervals to prove their integrity, and maintenance to improve tank containment. It also includes a system response to spill consequences to act before spills can reach the groundwater. To be especially reinforced during maintenance periods	Generally applicable
ii. Double bottomed tanks	A second impervious bottom that provides a measure of protection against releases from the first material	Generally applicable for new tanks and after an overhaul of existing tanks (1)
iii. Impervious membrane liners	A continuous leak barrier under the	Generally applicable for new tanks and

<table>
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<tr><td></td><td><table>
<tr><td></td><td>entire bottom surface of the tank</td><td>after an overhaul of existing tanks (1)</td></tr>
<tr><td>iv. Sufficient tank farm bund containment</td><td>A tank farm bund is designed to contain large spills potentially caused by a shell rupture or overfilling (for both environmental and safety reasons). Size and associated building rules are generally defined by local regulations</td><td>Generally applicable</td></tr>
<tr><td colspan="3">(1) Techniques ii and iii may be generally applicable where tanks are dedicated to products that require heat for liquid handling (e.g. bitumen) and where no leak is likely because of solidification</td></tr>
</table></td><td></td><td></td><td></td></tr>
<tr><td>52</td><td>In order to prevent or reduce VOC emissions to air from loading and unloading operations of volatile liquid hydrocarbon compounds, BAT is to use one or a combination of the techniques given below to achieve a recovery rate of at least 95 %.<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>Vapour recovery by:
i. Condensation
ii. Absorption
iii. Adsorption
iv. Membrane separation
v. Hybrid systems</td><td>See section 1.20.6, Annex 1.</td><td>Generally applicable to loading/unloading operations where annual throughput is > 5 000 m^3/yr. Not applicable to loading/unloading</td></tr>
</table></td><td>FC</td><td>Vapour recovery unit (VRU) is in place utilising techniques (ii) and (iii).

The VRU utilises the carbon bed adsorption with gasoline absorption process -- i.e. a combination of technique (ii) and technique (iii) above -- and is fully described in the Humber Refinery IPPC Application Document (Calcining Area – Report No. 7 – Rail Loading). Consequently we comply with the BAT's requirement re use of techniques.

The VRU is designed to meet the current emission limit of 35g/Nm^3 non-methane VOCs (NMVOCs) to air</td><td>2.3.1</td></tr>
</table>

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<table>
<tr><td></td><td></td><td>operations for sea-going vessels with an annual throughput < 1 million m^3/yr (1)</td></tr>
<tr><td colspan="3">(1) A vapour destruction unit (e.g. by incineration) may be substituted for a vapour recovery unit, if vapour recovery is unsafe or technically impossible because of the volume of return vapour</td></tr>
</table>
Table 16 BAT- associated emission levels for non-methane VOC and benzene emissions to air from loading and unloading operations of volatile liquid hydrocarbon compounds
<table>
<tr><th>Parameter</th><th>BAT-AEL (hourly average) (1)</th></tr>
<tr><td>NMVOC</td><td>0.15 - 10g/Nm^3 (2) (3)</td></tr>
<tr><td>Benzene (3)</td><td><1 mg/Nm^3</td></tr>
<tr><td colspan="2">(1) Hourly values in continuous operation expressed and measured according to Directive 94/63/EA
(2) Lower value achievable with two-stage hybrid systems. Upper value achievable with single-stage adsorption or membrane system
(3) Benzene monitoring may not be necessary where emissions of NMVOC are at the lower end of the range.</td></tr>
</table>
</td><td></td><td>through the vent stack, and is capable of reliably achieving an emission limit of 10g/Nm^3 of NMVOCs. This has been independently confirmed by a third-party industry expert that provides engineering support and test services to vapour recovery units.

Due to the nature and location of ship loading operations, it is not possible to continuously monitor NMVOC emissions, therefore an independent 6 monthly stack emission test shall be used to demonstrate that the new stack limit of 10 g/Nm^3 NMVOCs is achieved. That test should be undertaken when loading operations are ongoing and should last for a period of greater than 1 hour.

Benzene compliance monitoring will not be required if the NMVOC emissions are significantly less than 10g/Nm^3</td><td></td></tr>
<tr><td>53</td><td>In order to reduce emissions to water from visbreaking and other thermal processes, BAT is to ensure the appropriate treatment of waste water streams by applying the techniques of BAT 11.</td><td>CC</td><td>See BAT 11.
Techniques (i), (ii), (iii) and (iv) are used.</td><td>2.3.1</td></tr>
<tr><td>54</td><td>In order to reduce sulphur emissions to air from off-gases containing hydrogen sulphides (H_2S), BAT is to use all of the techniques given below.
<table>
<tr><th>Technique</th><th>Description</th><th>Applicability</th></tr>
</table>
</td><td>CC</td><td>Techniques (i), (ii) and (iii) are used. Trends of SO_2 emissions from the SRUs are provided in the quarterly reports submitted to the EA as required by UP3230LR, see Form Air 6. Detailed performance data, including efficiency and availability, are provided in the quarterly</td><td>2.3.1</td></tr>
</table>

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<table>
<tr><td>i. Acid gas removal e.g. by amine treating</td><td>See section 1.20.3, Annex 1.</td><td>Generally applicable</td></tr>
<tr><td>ii. Sulphur recovery unit (SRU), e.g. by Claus process</td><td>See section 1.20.3, Annex 1.</td><td>Generally applicable</td></tr>
<tr><td>iii. Tail gas treatment unit (TGTU)</td><td>See section 1.20.3, Annex 1.</td><td>For retrofitting existing SRU, the applicability may be limited by the SRU size and configuration of the units and the type of sulphur recovery process already in place</td></tr>
<tr><td colspan="3">(1) My not be applicable for stand-alone lubricant or bitumen refineries with a release of sulphur compounds of less than 1 t/d</td></tr>
</table>
Table 17 BAT-associated environmental performance levels for a waste gas sulphur (H_2S) recovery system
<table>
<tr><th></th><th>BAT-associated environmental performance level (monthly average)</th></tr>
<tr><td>Acid gas removal</td><td>Achieve hydrogen sulphides (H_2S) removal in the treated RFG in order to meet gas firing BAT-AEL for BAT 36</td></tr>
<tr><td>Sulphur recovery efficiency (1)</td><td>New unit: 99.5 – > 99.9 %
Existing unit: ≥ 98.5 %</td></tr>
<tr><td colspan="2">(1) Sulphur recovery efficiency is calculated over the whole treatment chain (including SRU and TGTU) as the fraction of sulphur in the feed that is recovered in the sulphur stream routed to the collection pots. When the applied technique does not include a recovery of sulphur (e.g. seawater scrubber) it refers to the</td></tr>
</table>
</td><td></td><td>reports submitted to the EA as required by UP3230LR, see Form Air 5. Technique (iii), Beavon Sulphur Removal, was commissioned in Q4 2015. The design guarantee was 99.5% sulphur recovery, which operational data indicates is being achieved from data gathered so far.</td><td></td></tr>
</table>

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<tr><td></td><td><table><tr><td>sulphur removal efficiency, as the % of sulphur removed by the whole treatment chain</td></tr></table>The associated monitoring is described in BAT 4.</td><td></td><td></td><td></td></tr>
<tr><td>55</td><td>In order to prevent emissions to air from flares, BAT is to use flaring only for safety reasons or for non-routine operational conditions (e.g. start-ups, shutdown).</td><td>CC</td><td>Flaring used as per requirements of BAT 55.</td><td>2.3.1</td></tr>
<tr><td>56</td><td>In order to reduce emissions to air from flares when flaring is unavoidable, BAT is to use the techniques given below.<table><tr><th>Technique</th><th>Description</th><th>Applicability</th></tr><tr><td>i. Correct plant design</td><td>See section 1.20.7, Annex 1.</td><td>Applicable to new units.
Flare gas recovery system may be retrofitted in existing units</td></tr><tr><td>ii. Plant management</td><td>See section 1.20.7, Annex 1.</td><td>Generally applicable</td></tr><tr><td>iii. Correct flaring devices design</td><td>See section 1.20.7, Annex 1.</td><td>Applicable to new units</td></tr><tr><td>iv. Monitoring and reporting</td><td>See section 1.20.7, Annex 1.</td><td>Generally applicable</td></tr></table></td><td>CC</td><td>Techniques (i), (ii), (iii) and (iv) are used.

The Humber Refinery has two separate dedicated flare systems (No.1 and No.3 Flare) and techniques (i), (ii), (iii) and (iv) – as detailed in Section 1.20.7 of the Commission Implementing Decision establishing BAT Conclusions – are all used.

It is not practical, to eliminate at source all venting to flare from the Closed Blowdown system and some flaring of incondensable coke drum vapours is unavoidable [BAT 29 (iv) refers]. These unrecovered gases are routed to the low pressure flare (No.3) which has a flare gas recovery system . This dual compressor system is used during steady state operation to recover gases continuously sent to flare during routine operation; occasional higher level relief loads are not recovered.

The Humber Refinery's other Flare (No.1), which has no fuel gas recovery system, is a high pressure system</td><td>2.3.1</td></tr>
</table>

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			to which excess refinery fuel gas would be routed. In normal operation the Refinery operates in fuel gas balance (production = consumption) and does so for the vast majority of the time. In such circumstances, flaring on No.1 Flare is limited to a small amount of pilot gas and essential purge gases and there is no 'routine' flaring. Only when the fuel gas system goes into occasional surplus (e.g. due to a refinery heater trip) does the flare gas flow increase significantly. This mode of operation makes No.1 Flare unsuitable for flare gas recovery; the compressors would have to be significantly oversized to recover these occasional loads but would sit idle for most of the time as the flare load would otherwise be below their minimum stable operating load. In addition the Humber Refinery routinely makes fuel gas sales to the adjacent Immingham Combined Heat and Power facility (ICHP). It is usually possible, with the agreement of ICHP, to quickly increase these fuel gas exports in the short-term in order to manage prevailing fuel gas imbalances. This significantly reduces the time during which the No.1 Flare gas recovery system would need to operate and the amount of flare gas available to be recovered.	
57	**In order to achieve an overall reduction of NO_X emissions to air from combustion units and fluid catalytic cracking (FCC) units, BAT is to use an integrated emission management technique as an alternative to applying BAT 24 and BAT 34.**	CC	The NOx Integrated Emissions Management Technique can be applied to any refinery source of NOX for which a BREF derived performance standard can be determined. For FCC and combustion plants, the performance standard is the applicable BATAEL	2.3.1

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	Description: The technique consists of managing NOX emissions from several or all combustion units and FCC units on a refinery site in an integrated manner, by implementing and operating the most appropriate combination of BAT across the different units concerned and monitoring the effectiveness thereof, in such a way that the resulting total emissions are equal to or lower than the emissions that would be achieved through a unit-by-unit application of the BAT-AELs referred to in BAT 24 and BAT 34. This technique is especially suitable to oil refining sites: • with a recognised site complexity, multiplicity of combustion and process units interlinked in terms of their feedstock and energy supply; • with frequent process adjustments required in function of the quality of the crude received; • with a technical necessity to use a part of process residues as internal fuels, causing frequent adjustments of the fuel mix according to process requirements. **BAT-associated emission levels: See Table 18.** In addition, for each new combustion unit or new FCC unit included in the integrated emission management system, the BAT-AELs set out under BAT 24 and BAT 34 remain applicable. **Table 18 BAT associated emission levels for NOX emissions to air when applying BAT 58** The BAT-AEL for NO_X emissions from the units concerned by BAT 57, expressed in mg/Nm3 as a monthly average value, is equal to or less than the weighted average of the NO_X concentrations (expressed in mg/Nm3 as a monthly average) that would be achieved by applying in		specified in BAT 24 & 34 respectively. For the calciner units, BAT30 does not include a BATAEL therefore for release point A9 (calciner 3) a BATAEL equivalent performance standard of 550 mg/m^3 has been derived from the performance data provided in Chapter 4 of the BREF. We are satisfied that the technique is not applicable to release point A11 (calciner numbers 1 and 2). The value of 550 mg/m^3 used for inclusion in the Integrated Emissions Management Technique Protocol was derived based on achieving a 30% reduction (equivalent to demonstrated performance of SNCR) of unabated emissions from the calciner unit. Average unabated emissions were 786 mg/m^3. Table 4.33 of the BREF gives the operating range of an unabated calciner as 450 – 875 mg/m^3, so this is consistent with that range. To be consistent with the IED provisions for the application of confidence intervals to data obtained using CEMS, the operator will assess their operational performance using raw emissions data and then apply a 20% confidence interval when reviewing compliance against the monthly mean IEMT emission limit value. The operator has submitted an Integrated Emissions Management Technique Protocol document (Dated 09/10/18), (IEMT) which sets out how they will comply with a bubble emission limit value, set according to the principles of BAT57	

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	practice at each of those units techniques that would enable the units concerned to meet the following: (a) for catalytic cracking process (regenerator) units: the BAT-AEL range set out in Table 4 (BAT 24); (b) for combustion units burning refinery fuels alone or simultaneously with other fuels: the BAT-AEL ranges set out in Tables 9, 10 and 11 (BAT 34). This BAT-AEL is expressed by the following formula: $\frac{\Sigma\ [(\text{flue gas flow rate of the unit concerned}) \text{ x } (NO_X \text{ concentration that would be achieved for that unit})]}{\Sigma(\text{flue gas flow rate of all units concerned})}$ Notes 1. The applicable reference conditions for oxygen are those specified in Table 1. 2. The weighing of the emission levels of the individual units is done on the basis of the flue-gas flow rate of the unit concerned, expressed as a monthly average value (Nm^3/hour), which is representative for the normal operation of that unit within the refinery installation (applying the reference conditions under Note 1). 3. In case of substantial and structural fuel changes which are affecting the applicable BAT-AEL for a unit or other substantial and structural changes in the nature or functioning of the units concerned, or in case of their replacement or extension or the addition of combustion units or FCC units, the BAT-AEL defined in Table 18 needs to be adjusted accordingly.		This sets out: • The units to be included in the IEMT; • The Representative flue gas flow rate for each unit; • The applicable NOx BAT AEL for each unit; • The calculated fixed IEMT limit; • The emissions and flow monitoring techniques for each unit;and • An explanation of how monitoring and flow data will be treated to demonstrate compliance with the IEMT emission limit value. Also included in the protocol is a demonstration, based on historic data that the operator is capable of being consistently compliant with their IEMT emission limit value. We have reviewed the Operator's IEMT protocol dated 09/10/2018 and their demonstration that they can comply with their IEMT emission limit value. We are satisfied that this delivers the requirements of BAT57 and therefore compliance with BAT 24, 34 and 30. Any revision to the Operator's protocol (such as to include or remove units from the IEMT) must be submitted to the Environment Agency and approved in writing.	

BAT Conclusion Number	Summary of BAT Conclusion requirement	Status NA/ CC / FC / NC	Assessment of the installation capability and any alternative techniques proposed by the operator to demonstrate compliance with the BAT Conclusion requirement	Relevant permit condition(s)
		NA = Not applicable **CC = Currently Compliant** **PC = Partially Complaint** **FC = Complaint in the future (within 4 years of publication of BAT conclusions)** **NC = Not complaint**		
	Monitoring associated with BAT 57 BAT for monitoring emissions of NOX under an integrated emission management technique is as in BAT 4, complemented with the following: • a monitoring plan including a description of the processes monitored, a list of the emission sources and source streams (products, waste gases) monitored for each process and a description of the methodology (calculations, measurements) used and the underlying assumptions and associated level of confidence; • continuous monitoring of the flue-gas flow rates of the units concerned, either through direct measurement or by an equivalent method; • a data management system for collecting, processing and reporting all monitoring data needed to determine the emissions from the sources covered by the integrated emission management technique.			
58	**In order to achieve an overall reduction of SO_2 emissions to air from combustion units, fluid catalytic cracking (FCC) units and waste gas sulphur recovery units, BAT is to use an integrated emission management technique as an alternative to applying BAT 26, BAT 36 and BAT 54.** **Description:** The technique consists of managing SO_2 emissions from several or all combustion units, FCC units and waste gas sulphur recovery units on a refinery site in an integrated manner, by implementing and operating the most appropriate combination of BAT across the different units concerned and monitoring the effectiveness	CC	The SO_2 Integrated Emissions Management Technique can be applied to any refinery source of SO_2 for which a BREF derived performance standard can be determined. For FCC units & combustion plants, the performance standard is the applicable BATAEL specified in BAT 26 & 36 respectively. For sulphur recovery units, (SRU) the BATAEPL of 98.5% sulphur recovery in BAT54 has been used to determine an equivalent SO_2 BATAEL of 7850 mg/m^3. For the calciner units, BAT30 does not include a BATAEL for SO_2 therefore a BATAEL equivalent	2.3.1

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	thereof, in such a way that the resulting total emissions are equal to or lower than the emissions that would be achieved through a unit-by-unit application of the BAT-AELs referred to in BAT 26 and BAT 36 as well as the BAT-AEPL set out under BAT 54. This technique is especially suitable to oil refining sites: • with a recognised site complexity, multiplicity of combustion and process units interlinked in terms of their feedstock and energy supply; • with frequent process adjustments required in function of the quality of the crude received; • with a technical necessity to use a part of process residues as internal fuels, causing frequent adjustments of the fuel mix according to process requirements. **BAT associated emission level**: See Table 19. In addition, for each new combustion unit, new FCC unit or new waste gas sulphur recovery unit included in the integrated emission management system, the BAT-AELs set out under BAT 26 and BAT 36 and the BAT- AEPL set out under BAT 54 remain applicable. **Table 19 BAT associated emission level for SO$_2$ when applying BAT 58** The BAT-AEL for SO$_2$ emissions from the units concerned by BAT 58, expressed in mg/Nm3 as a monthly average value, is equal to or less than the weighted average of the SO$_2$ concentrations (expressed in mg/Nm^3 as a monthly average) that would be achieved by applying in practice at each of those units techniques that would enable the units concerned to meet the following:		performance standard of 700 mg/m^3 per stack has been derived from the performance data provided in Chapter 4 of the BREF. Section 4.7.8.2 of the BREF addresses SO$_2$ emissions from calcining and identifies wet gas scrubbing as BAT. It indicates that when fitted to a catalytic cracker, emissions of 25–300 mg/m^3 can be achieved, however the paragraph on ‘example plants’ says “No examples of the use of these techniques and their associated emissions have been reported to the Technical Working Group (TWG).”; so it cannot be confirmed whether the same level of performance could be achieved on calciner flue gases. The current emission limits for SO$_2$ for the P66 calciners are 1700 mg/m^3 and 2800 mg/m^3 as an hourly average. Tables 4.33 and 4.34 of the BREF do provide data on the emissions performance of unabated European calciners. The best recorded performance for SO$_2$ is 300 -700 mg/m^3, therefore this is proposed as the equivalent BATAEL range. To be consistent with the IED provisions for the application of confidence intervals to data obtained using CEMS, the operator will assess their operational performance using raw emissions data and then apply a 20% confidence interval when reviewing compliance against the monthly mean IEMT emission limit value.	

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		NA = Not applicable **CC = Currently Compliant** **PC = Partially Complaint** **FC = Complaint in the future (within 4 years of publication of BAT conclusions)** **NC = Not complaint**		
	(a) for catalytic cracking process (regenerator) units: the BAT-AEL ranges set out in Table 6 (BAT 26); (b) for combustion units burning refinery fuels alone or simultaneously with other fuels: the BAT-AEL ranges set out in Table 13 and in Table 14 (BAT 36); and (c) for waste gas sulphur recovery units: the BAT-AEPL ranges set out in Table 17 (BAT 54). This BAT-AEL is expressed by the following formula: $\frac{\Sigma [(\text{flue gas flow rate of the unit concerned}) \text{ x } (\text{SO2 concentration that would be achieved for that unit})]}{\Sigma(\text{flue gas flow rate of all units concerned})}$ Notes: 1. The applicable reference conditions for oxygen are those specified in Table 1. 2. The weighing of the emission levels of the individual units is done on the basis of the flue-gas flow rate of the unit concerned, expressed as the monthly average value (Nm^3/hour), which is representative for the normal operation of that unit within the refinery installation (applying the reference conditions under Note 1). 3. In case of substantial and structural fuel changes which are affecting the applicable BAT-AEL for a unit or other substantial and structural changes in the nature or functioning of the units concerned, or in case of their replacement, extension or the addition of combustion, FCC, or waste gas sulphur recovery units, the BAT-AEL defined in Table 19 needs to be adjusted accordingly.		The operator has submitted an Integrated Emissions Management Technique Protocol (IEMT) document (Dated 09/10/18), which sets out how they will comply with a bubble emission limit value, set according to the principals of BAT57 This sets out: • The units to be included in the IEMT; • The Representative flue gas flow rate for each unit • The applicable SO_2 BAT AEL for each unit; • The calculated fixed IEMT limit. • The emissions and flow monitoring techniques for each unit, and • An explanation of how monitoring and flow data will be treated to demonstrate compliance with the IEMT emission limit value, Also included in the protocol is a demonstration, based on historic data that the operator is capable of being consistently compliant with their IEMT emission limit value. We have reviewed the Operator's IEMT protocol dated 09/10/2018 and their demonstration that they can comply with their IEMT emission limit value. We are satisfied that this delivers the requirements of BAT58 and therefore compliance with BAT 26, 36 and 31. Any revision to the Operator's protocol (such as to include or remove units from the IEMT) must be submitted to the Environment Agency and approved in writing.	

BAT Conclusion Number	Summary of BAT Conclusion requirement	Status NA/ CC / FC / NC	Assessment of the installation capability and any alternative techniques proposed by the operator to demonstrate compliance with the BAT Conclusion requirement	Relevant permit condition(s)
		NA = Not applicable **CC = Currently Compliant** **PC = Partially Complaint** **FC = Complaint in the future (within 4 years of publication of BAT conclusions)** **NC = Not complaint**		
	Monitoring associated with BAT 58 BAT for monitoring emissions of SO_2 under an integrated emission management approach is as in BAT 4, complemented with the following: • a monitoring plan including a description of the processes monitored, a list of the emission sources and source streams (products, waste gases) monitored for each process and a description of the methodology (calculations, measurements) used and the underlying assumptions and associated level of confidence; • continuous monitoring of the flue-gas flow rates of the units concerned, either through direct measurement or by an equivalent method; • a data management system for collecting, processing and reporting all monitoring data needed to determine the emissions from the sources covered by the integrated emission management technique			

6 Review and assessment of derogation requests made by the operator in relation to BAT Conclusions which include an associated emission level (AEL) value

The IED enables a competent authority to allow derogations from BAT AELs stated in BAT Conclusions under specific circumstances as detailed under Article 15(4):

By way of derogation from paragraph 3, and without prejudice to Article 18, the competent authority may, in specific cases, set less strict emission limit values. Such a derogation may apply only where an assessment shows that the achievement of emission levels associated with the best available techniques as described in BAT conclusions would lead to disproportionately higher costs compared to the environmental benefits due to:

> *(a) the geographical location or the local environmental conditions of the installation concerned; or*
>
> *(b) the technical characteristics of the installation concerned.*

As part of their Regulation 60 Notice response, the operator has not requested a derogation from compliance with the AEL values included in the BAT Conclusions.

6.1 Overview of the site and installation

The Humber refinery is located at South Killingholme in North Lincolnshire and is operated by Phillips 66 Limited. The refinery processes crude oil for the production of fuels and petroleum coke.

The main environmental releases from the site are sulphur dioxide, oxides of nitrogen, dust and volatile organic compounds.

7 Emissions to Water

The consolidated permit incorporates the current discharges to controlled waters identified as W2a and W2b.

Our review of the emission limits considered the BAT conclusions and also whether the current limits will maintain Water Objectives in the receiving water to ensure the Water Quality Objectives under Water Framework Directive will be met through improvements identified in the Operator's Water Improvement plan.

The relevant waste water BAT-AEL from the BAT Conclusions is BAT 12.

We have set ELVs and monitoring in accordance with Table 3 referenced in BATs 10 and 12.

In addition to the review of compliance against the relevant BAT Conclusions for emissions to water, this Permit review also provides an opportunity to consider whether the discharge to surface water will maintain Water Quality Objectives in the receiving watercourse to ensure the water quality objectives under Water Framework Directive will be met.

The Operator does not currently have sufficient information for this assessment to be made. Improvement Conditions 28 and 29 have been added to Table S1.3 Improvement Programme Requirements to address this. Details of the Improvement Conditions are included in Annex 2 below.

8 Additional IED Chapter II requirements:

No additional IED Chapter II requirements were necessary.

9 Review and assessment of changes that are not part of the BAT Conclusions derived permit review.

Removal of emission point

Emission point A30 has been removed from the permit as the vent is no longer in use.

ANNEX 1

This document should be read in conjunction with the response to the Regulation 60 Notice, additional information and permit/notice.

Aspect considered	Justification / Detail
Confidential information	A claim for commercial or industrial confidentiality has not been made.
Identifying confidential information	We have not identified information provided as part of the Regulation 60 response that we consider to be confidential. The decision was taken in accordance with our guidance on commercial confidentiality.
Scope of consultation	The consultation requirements were reviewed and did not need to be implemented. The decision was taken in accordance with the Environmental Permitting Regulations and our public participation statement.
Control of the facility	We are satisfied that the operator is the person who will have control over the operation of the facility after the issue of the consolidation. The decision was taken in accordance with our guidance on legal operator for environmental permits.
Applicable directives	All applicable European directives have been considered in the determination of the application.
Extent of the site of the facility	The Installation is within the relevant distance criteria of a site of heritage, landscape or nature conservation, and/or protected species or habitat. A full assessment of the application and its potential to affect the site(s)/species/habitat has not been carried out as part of the permitting process. We consider that the review will not affect the features of the site/species/habitat.
Site condition report	The operator has previously provided a description of the condition of the site. We consider this description is satisfactory. The decision was taken in accordance with our guidance on site condition reports and baseline reporting under IED–guidance and templates (H5).

Aspect considered	Justification / Detail
Biodiversity, Heritage, Landscape and Nature Conservation	The Installation is within the relevant distance criteria of a site of heritage, landscape or nature conservation, and/or protected species or habitat. A full assessment of the application and its potential to affect the site(s)/species/habitat has not been carried out as part of the permitting process. We consider that the review will not affect the features of the site/species/habitat.
Operating techniques	We have reviewed the techniques, where relevant to the BAT Conclusions, used by the operator and compared these with the relevant guidance notes. The permit conditions ensure compliance with relevant BREFs and BAT Conclusions, and ELVs deliver compliance with BAT-AELs.
Updating permit conditions during consolidation.	We have updated previous permit conditions to those in the new generic permit template as part of permit consolidation. The new conditions have the same meaning as those in the previous permit(s).
Use of conditions other than those from the template	Based on the information in the application, we consider that we need to impose conditions other than those in our permit template, which was developed in consultation with industry having regard to the relevant legislation. The following conditions have been added: 2.3.7 which requires the operator to record periods when sufficient capacity is not available in the acid gas removal systems, to treat the sour gases produced. 2.3.8 which requires the operator to reduce emissions of SO_2 by treating off gas streams or ensuring equivalence is achieved through the application of an Integrated Emissions Management Technique (IEMT), to implement BAT Conclusion 54. 3.3.6 requires the operator to report details of flaring events over a specific threshold to provide additional information in relation to flaring events and implement BAT conclusions 55 and 56. 3.7.1 requires the operator to undertake monitoring and calculations to implement an IEMT for emissions of NO_X. To implement BAT conclusion 57. 3.7.2 requires the operator to undertake monitoring and calculations to implement an IEMT for emissions of SO_2. To implement BAT conclusion 58.

Aspect considered	Justification / Detail
	4.3.8 requires the operator to notify acid gas flaring events that meet specific criteria to implement BAT conclusions 55 and 56 by providing additional information in relation to acid gas flaring events consistently across the oil refining sector. 4.3.9 requires the operator to notify the Environment Agency and agree any changes to the IEMT.
Raw materials	We have not specified limits and controls on the use of raw materials and fuels.
Improvement conditions	Based on the information on the application, we consider that we need to impose improvement conditions. We have imposed improvement conditions to ensure that: • The Operator submits a VOC monitoring plan to the Environment Agency for written approval (to ensure compliance with BAT conclusion 6). • The Operator shall undertake an assessment of measures to reduce point source and fugitive emissions of VOCs from the loading and unloading of liquid hydrocarbons at road and rail terminals. • The Operator submits a surface water risk assessment report that investigates and reviews the emissions of effluent to the receiving water body (to assess the impact under the WFD).
Incorporating the application	We have specified that the applicant must operate the permit in accordance with descriptions in the application, including all additional information received as part of the determination process. These descriptions are specified in the Operating Techniques table in the permit.
Emission limits	We have decided that emission limits should be set for the parameters listed in the permit. These are described at the relevant BAT Conclusions in Section 5 of this document. It is considered that the ELVs/equivalent parameters or technical measures described above will ensure that significant pollution of the environment is prevented and a high level of protection for the environment secured.

Aspect considered	Justification / Detail
Monitoring	We have decided that monitoring should be carried out for the parameters listed in the permit, using the methods detailed and to the frequencies specified. These are described at the relevant BAT Conclusions in Section 5 of this document. Table S3.4 Process monitoring requirements was amended to include the requirement to monitor mercury in RFG on a six monthly basis. Based on the information in the application we are satisfied that the operator's techniques, personnel and equipment have either MCERTS certification or MCERTS accreditation as appropriate, unless otherwise agreed in writing with us.
Reporting	We have specified reporting in the permit. These are described at the relevant BAT Conclusions in Section 5 of this document.
Management system	There is no known reason to consider that the operator will not have the management system to enable it to comply with the permit conditions. The decision was taken in accordance with the guidance on operator competence and how to develop a management system for environmental permits.
Section 108 Deregulation Act 2015 – Growth duty	We have considered our duty to have regard to the desirability of promoting economic growth set out in section 108(1) of the Deregulation Act 2015 and the guidance issued under section 110 of that Act in deciding whether to grant this permit. Paragraph 1.3 of the guidance says: "The primary role of regulators, in delivering regulation, is to achieve the regulatory outcomes for which they are responsible. For a number of regulators, these regulatory outcomes include an explicit reference to development or growth. The growth duty establishes economic growth as a factor that all specified regulators should have regard to, alongside the delivery of the protections set out in the relevant legislation." We have addressed the legislative requirements and environmental standards to be set for this operation in the body of the decision document above. The guidance is clear at paragraph 1.5 that the growth duty does not legitimise non-compliance and its purpose is not to achieve or pursue economic growth at the expense of necessary protections.

Aspect considered	Justification / Detail
	We consider the requirements and standards we have set in this permit are reasonable and necessary to avoid a risk of an unacceptable level of pollution. This also promotes growth amongst legitimate operators because the standards applied to the operator are consistent across businesses in this sector and have been set to achieve the required legislative standards.

Annex 1: BAT conclusions for the Refining of Mineral Oil and Gas.

BAT conclusions for the Refining of Mineral Oil and Gas - Glossary

1.20 Description of techniques for the prevention and control of emissions to air.

1.20.1 Dust

Technique	**Description**
Electrostatic precipitator (ESP)	Electrostatic precipitators operate such that particles are charged and separated under the influence of an electrical field. Electrostatic precipitators are capable of operating under a wide range of conditions. Abatement efficiency may depend on the number of fields, residence time (size), catalyst properties and upstream particles removal devices. At FCC units, 3-field ESPs and 4-field ESPs are commonly used. ESPs may be used on a dry mode or with ammonia injection to improve the particle collection. For the calcining of green coke, the ESP capture efficiency may be reduced due to the difficulty for coke particles to be electrically charged
Multistage cyclone separators	Cyclonic collection device or system installed following the two stages of cyclones. Generally known as a third stage separator, common configuration consists of a single vessel containing many conventional cyclones or improved swirl-tube technology. For FCC, performance mainly depends on the particle concentration and size distribution of the catalyst fines downstream of the regenerator internal cyclones
Centrifugal washers	Centrifugal washers combine the cyclone principle and an intensive contact with water e.g. venturi washer
Third stage blowback filter	Reverse flow (blowback) ceramic or sintered metal filters where, after retention at the surface as a cake, the solids are dislodged by initiating a reverse flow. The dislodged solids are then purged from the filter system

.20.2. Nitrogen oxides (NO_X)

Technique	**Description**
Combustion modifications	
Staged combustion	– Air staging — involves substoichiometric firing in a first step and the subsequent addition of the remaining air or oxygen into the furnace to complete combustion – Fuel staging — a low impulse primary flame is developed in the port neck; a secondary flame covers the root of the primary flame reducing its core temperature
Flue-gas recirculation	Reinjection of waste gas from the furnace into the flame to reduce the oxygen content and therefore the temperature of the flame. Special burners using the internal recirculation of combustion gases to cool the root of the flames and reduce the oxygen content in the hottest part of the flames

Use of low-NO_X burners (LNB)	The technique (including ultra-low-NO_X burners) is based on the principles of reducing peak flame temperatures, delaying but completing the combustion and increasing the heat transfer (increased emissivity of the flame). It may be associated with a modified design of the furnace combustion chamber. The design of ultra-low-NOX burners (ULNB) includes combustion staging (air/fuel) and flue-gas recirculation. Dry low-NO_X burners (DLNB) are used for gas turbines
Optimisation of combustion	Based on permanent monitoring of appropriate combustion parameters (e.g. O_2, CO content, fuel to air (or oxygen) ratio, unburnt components), the technique uses control technology for achieving the best combustion conditions
Diluent injection	Inert diluents, e.g. flue-gas, steam, water, nitrogen added to combustion equipment reduce the flame temperature and consequently the concentration of NO_X in the flue-gases
Selective catalytic reduction (SCR)	The technique is based on the reduction of NO_X to nitrogen in a catalytic bed by reaction with ammonia (in general aqueous solution) at an optimum operating temperature of around 300-450 °C. One or two layers of catalyst may be applied. A higher NO_X reduction is achieved with the use of higher amounts of catalyst (two layers)
Selective non-catalytic reduction (SNCR)	The technique is based on the reduction of NOX to nitrogen by reaction with ammonia or urea at a high temperature. The operating temperature window must be maintained between 900 °C and 1 050 °C for optimal reaction
Low temperature NO_X oxidation	The low temperature oxidation process injects ozone into a flue-gas stream at optimal temperatures below 150 °C, to oxidise insoluble NO and NO_2 to highly soluble N_2O_5. The N_2O_5 is removed in a wet scrubber by forming dilute nitric acid waste water that can be used in plant processes or neutralised for release and may need additional nitrogen removal

1.20.3. Sulphur oxides (SO_X)

Technique	Description
Treatment of refinery fuel gas (RFG)	Some refinery fuel gases may be sulphur-free at source (e.g. from catalytic reforming and isomerisation processes) but most other processes produce sulphur-containing gases (e.g. off-gases from the visbreaker, hydrotreater or catalytic cracking units). These gas streams require an appropriate treatment for gas desulphurisation (e.g. by acid gas removal — see below — to remove H_2S) before being released to the refinery fuel gas system
Refinery fuel oil (RFO)	desulphurisation by hydrotreatment In addition to selection of low-sulphur crude, fuel desulphurisation is achieved by the hydrotreatment process (see below) where hydrogenation reactions take place and lead to a reduction in sulphur content

Use of gas to replace liquid fuel	Decrease the use of liquid refinery fuel (generally heavy fuel oil containing sulphur, nitrogen, metals, etc.) by replacing it with on-site Liquefied Petroleum Gas (LPG) or refinery fuel gas (RFG) or by externally supplied gaseous fuel (e.g. natural gas) with a low level of sulphur and other undesirable substances. At the individual combustion unit level, under multi-fuel firing, a minimum level of liquid firing is necessary to ensure flame stability
Use of SO_X reducing catalysts additives	Use of a substance (e.g. metallic oxides catalyst) that transfers the sulphur associated with coke from the regenerator back to the reactor. It operates most efficiently in full combustion mode rather than in deep partial-combustion mode. NB: SO_X reducing catalysts additives might have a detrimental effect on dust emissions by increasing catalyst losses due to attrition, and on NO_X emissions by participating in CO promotion, together with the oxidation of SO_2 to SO_3
Hydrotreatment	Based on hydrogenation reactions, hydrotreatment aims mainly at producing low-sulphur fuels (e.g. 10 ppm gasoline and diesel) and optimising the process configuration (heavy residue conversion and middle distillate production). It reduces the sulphur, nitrogen and metal content of the feed. As hydrogen is required, sufficient production capacity is needed. As the technique transfer sulphur from the feed to hydrogen sulphide (H_2S) in the process gas, treatment capacity (e.g. amine and Claus units) is also a possible bottleneck
Acid gas removal e.g. by amine treating	Separation of acid gas (mainly hydrogen sulphide) from the fuel gases by dissolving it in a chemical solvent (absorption). The commonly used solvents are amines. This is generally the first step treatment needed before elemental sulphur can be recovered in the SRU
Sulphur recovery unit (SRU)	Specific unit that generally consists of a Claus process for sulphur removal of hydrogen sulphide (H_2S)-rich gas streams from amine treating units and sour water strippers. SRU is generally followed by a tail gas treatment unit (TGTU) for remaining H_2S removal
Tail gas treatment unit (TGTU)	A family of techniques, additional to the SRU in order to enhance the removal of sulphur compounds. They can be divided into four categories according to the principles applied: – direct oxidation to sulphur – continuation of the Claus reaction (sub-dewpoint conditions) – oxidation to SO_2 and recovering sulphur from SO_2 – reduction to H_2S and recovery of sulphur from this H_2S (e.g. amine process)
Wet scrubbing	In the wet scrubbing process, gaseous compounds are dissolved in a suitable liquid (water or alkaline solution). Simultaneous removal of solid and gaseous compounds

	may be achieved. Downstream of the wet scrubber, the flue-gases are saturated with water and a separation of the droplets is required before discharging the flue-gases. The resulting liquid has to be treated by a waste water process and the insoluble matter is collected by sedimentation or filtration According to the type of scrubbing solution, it can be: – a non-regenerative technique (e.g. sodium or magnesium-based) – a regenerative technique (e.g. amine or soda solution) According to the contact method, the various techniques may require e.g.: – Venturi using the energy from inlet gas by spraying it with the liquid – packed towers, plate towers, spray chambers. Where scrubbers are mainly intended for SO_X removal, a suitable design is needed to also efficiently remove dust. The typical indicative SO_X removal efficiency is in the range 85-98 %.
Non-regenerative scrubbing	Sodium or magnesium-based solution is used as alkaline reagent to absorb SO_X generally as sulphates. Techniques are based on e.g.: — wet limestone — aqueous ammonia — seawater (see infra)
Seawater scrubbing	A specific type of non-regenerative scrubbing using the alkalinity of the seawater as solvent. Generally requires an upstream abatement of dust
Regenerative scrubbing	Use of specific SO_X absorbing reagent (e.g. absorbing solution) that generally enables the recovery of sulphur as a by-product during a regenerating cycle where the reagent is reused

1.20.4. Combined techniques (SOx, NOx and dust)

Technique	Description
Wet scrubbing	See Section 1.20.3
SNO_X combined technique	Combined technique to remove SOX, NOX and dust where a first dust removal stage (ESP) takes place followed by some specific catalytic processes. The sulphur compounds are recovered as commercial-grade concentrated sulphuric acid, while NO_X is reduced to N_2. Overall SO_X removal is in the range: 94-96,6 %. Overall NO_X removal is in the range: 87-90 %

1.20.5. Carbon monoxide (CO) Technique

Technique	Description
Combustion operation control	The increase in CO emissions due to the application of combustion modifications (primary techniques) for the reduction of NO_X emissions can be limited by a careful control of the operational parameters

Catalysts with carbon monoxide (CO) oxidation promoters	Use of a substance which selectively promotes the oxidation of CO into CO_2 (combustion
Carbon monoxide (CO) boiler	Specific post-combustion device where CO present in the flue-gas is consumed downstream of the catalyst regenerator to recover the energy It is usually used only with partial-combustion FCC units

1.20.6. Volatile organic compounds (VOC)

Technique	**Description**
Vapour recovery	Volatile organic compounds emissions from loading and unloading operations of most volatile products, especially crude oil and lighter products, can be abated by various techniques e.g.: – Absorption: the vapour molecules dissolve in a suitable absorption liquid (e.g. glycols or mineral oil fractions such as kerosene or reformate). The loaded scrubbing solution is desorbed by reheating in a further step. The desorbed gases must either be condensed, further processed, and incinerated or re-absorbed in an appropriate stream (e.g. of the product being recovered) – Adsorption: the vapour molecules are retained by activate sites on the surface of adsorbent solid materials, e.g. activated carbon (AC) or zeolite. The adsorbent is periodically regenerated. The resulting desorbate is then absorbed in a circulating stream of the product being recovered in a downstream wash column. Residual gas from wash column is sent to further treatment – Membrane **gas separation**: the vapour molecules are processed through selective membranes to separate the vapour/air mixture into a hydrocarbon- enriched phase (permeate), which is subsequently condensed or absorbed, and a hydrocarbon-depleted phase (retentate). – Two**-stage refrigeration/condensation**: by cooling of the vapour/gas mixture the vapour molecules condense and are separated as a liquid. As the humidity leads to the icing-up of the heat exchanger, a two-stage condensation process providing for alternate operation is required. – Hybrid **systems**: combinations of available techniques *NB* Absorption and adsorption processes cannot notably reduce methane emissions
Vapour destruction	Destruction of VOCs can be achieved through e.g. **thermal oxidation** (incineration) or **catalytic oxidation** when

	recovery is not easily feasible. Safety requirements (e.g. flame arrestors) are needed to prevent explosion. **Thermal oxidation** occurs typically in single chamber, refractory-lined oxidisers equipped with gas burner and a stack. If gasoline is present, heat exchanger efficiency is limited and preheat temperatures are maintained below 180 °C to reduce ignition risk. Operating temperatures range from 760 °C to 870 °C and residence times are typically 1 second. When a specific incinerator is not available for this purpose, an existing furnace may be used to provide the required temperature and residence times. **Catalytic oxidation** requires a catalyst to accelerate the rate of oxidation by adsorbing the oxygen and the VOCs on its surface The catalyst enables the oxidation reaction to occur at lower temperature than required by thermal oxidation: typically ranging from 320 °C to 540 °C. A first preheating step (electrically or with gas) takes place to reach a temperature necessary to initiate the VOCs catalytic oxidation. An oxidation step occurs when the air is passed through a bed of solid catalysts
LDAR (leak detection and repair) programme	An LDAR (leak detection and repair) programme is a structured approach to reduce fugitive VOC emissions by detection and subsequent repair or replacement of leaking components. Currently, sniffing (described by EN 15446) and optical gas imaging methods are available for the identification of the leaks. **Sniffing method**: The first step is the detection using hand-held VOC analysers measuring the concentration adjacent to the equipment (e.g. by using flame ionisation or photo-ionisation). The second step consists of bagging the component to carry out a direct measurement at the source of emission. This second step is sometimes replaced by mathematical correlation curves derived from statistical results obtained from a large number of previous measurements made on similar components. **Optical gas imaging methods**: Optical imaging uses small lightweight hand- held cameras which enable the visualisation of gas leaks in real time, so that they appear as 'smoke' on a video recorder together with the normal image of the component concerned to easily and rapidly locate significant VOC leaks. Active systems produce an image with a back-scattered infrared laser light reflected on the component and its surroundings. Passive systems are based on the natural infrared radiation of the equipment and its surroundings
VOC diffuse emissions monitoring	Full screening and quantification of site emissions can be undertaken with an appropriate combination of complementary methods, e.g. Solar occultation flux (SOF) or differential absorption lidar (DIAL) campaigns. These results

	can be used for trend evaluation in time, cross checking and updating/validation of the ongoing LDAR programme. **Solar occultation flux (SOF)**: The technique is based on the recording and spectrometric Fourier Transform analysis of a broadband infrared or ultraviolet/ visible sunlight spectrum along a given geographical itinerary, crossing the wind direction and cutting through VOC plumes. **Differential absorption LIDAR (DIAL)**: DIAL is a laser-based technique using differential adsorption LIDAR (light detection and ranging) which is the optical analogue of sonic radio wave-based RADAR. The technique relies on the back-scattering of laser beam pulses by atmospheric aerosols, and the analysis of spectral properties of the returned light collected with a telescope
High-integrity equipment	High-integrity equipment includes e.g.: – valves with double packing seals – magnetically driven pumps/compressors/agitators – pumps/compressors/agitators fitted with mechanical seals instead of packing – high-integrity gaskets (such as spiral wound, ring joints) for critical applications

1.20.7. Other techniques

Techniques to prevent or reduce emissions from flaring	**Correct plant design**: includes sufficient flare gas recovery system capacity, the use of high-integrity relief valves and other measures to use flaring only as a safety system for other than normal operations (start-up, shutdown, emergency). **Plant management**: includes organisational and control measures to reduce flaring events by balancing RFG system, using advanced process control, etc. **Flaring devices design**: includes height, pressure, assistance by steam, air or gas, type of flare tips, etc. It aims at enabling smokeless and reliable operations and ensuring an efficient combustion of excess gases when flaring from non- routine operations. **Monitoring and reporting**: Continuous monitoring (measurements of gas flow and estimations of other parameters) of gas sent to flaring and associated parameters of combustion (e.g. flow gas mixture and heat content, ratio of assistance, velocity, purge gas flow rate, pollutant emissions). Reporting of flaring events makes it possible to use flaring ratio as a requirement included in the EMS and to prevent future events. Visual remote monitoring of the flare can also be carried out by using colour TV monitors during flare events
Choice of the catalyst promoter to	During the regeneration of the reformer catalyst, organic chloride is generally needed for effective reforming catalyst performance (to re-establish the proper chloride balance in the catalyst and to assure the correct dispersion of the

avoid dioxins formation	metals). The choice of the appropriate chlorinated compound will have an influence on the possibility of emissions of dioxins and furans
Solvent recovery for base oil production processes	The **solvent recovery** unit consists of a distillation step where the solvents are recovered from the oil stream and a stripping step (with steam or an inert gas) in a fractionator. The solvents used may be a mixture (DiMe) of 1,2-dichloroethane (DCE) and dichloromethane (DCM). In wax-processing units, solvent recovery (e.g. for DCE) is carried out using two systems: one for the deoiled wax and another one for the soft wax. Both consist of heat-integrated flashdrums and a vacuum stripper. Streams from the dewaxed oil and waxes product are stripped for removal of traces of solvents

1.21. Description of techniques for the prevention and control of emissions to water

1.21.1. Waste water pretreatment

Pretreatment of sour water streams before reuse or treatment	Send generated sour water (e.g. from distillation, cracking, coking units) to appropriate pretreatment (e.g. stripper unit)
Pretreatment of other waste water streams prior to treatment	To maintain treatment performance, appropriate pretreatment may be required

1.21.2. Waste water treatment

Removal of insoluble substances by recovering oil	These techniques generally include: – API Separators (APIs) – Corrugated Plate Interceptors (CPIs) – Parallel Plate Interceptors (PPIs) – Tilted Plate Interceptors (TPIs) – Buffer and/or equalisation tanks
Removal of insoluble substances by recovering suspended solid and dispersed oil	These techniques generally include: – Dissolved Gas Flotation (DGF) – Induced Gas Flotation (IGF) – Sand Filtration
Removal of soluble substances including biological treatment and clarification	Biological treatment techniques may include: – Fixed bed systems – Suspended bed systems. One of the most commonly used suspended bed system in refineries WWTP is the activated sludge process. Fixed bed systems may include a biofilter or trickling filter
Additional treatment step	A specific waste water treatment intended to complement the previous treatment steps e.g. for further reducing nitrogen or carbon compounds. Generally used where specific local requirements for water preservation exist.

Annex 2: Improvement Conditions

Based in the information in the Operators Regulation 60 Notice responses and our own records of the capability and performance of the installation at this site, we consider that we need to set improvement conditions so that the outcome of the techniques detailed in the BAT Conclusions are achieved by the installation. These additional improvement conditions are set out below - justifications for them are provided at the relevant section of the decision document.

Table S1.3 Improvement programme requirements

Reference	Requirement	Date
IC25	The Operator shall submit a diffuse VOC monitoring plan to the Environment Agency for written approval. This shall include but not be limited to: • The nature of the material handled; • The sources of emissions; • Justification of the monitoring techniques selected • How the monitoring data will be recorded and reviewed The plan shall take into account the appropriate techniques for VOC monitoring specified in BAT conclusion 6 for the Refining of Mineral Oil and Gas. The Operator shall implement the approved plan and produce and submit an annual report on the results of the monitoring undertaken under the plan.	01/11/19
IC26	The Operator shall develop and implement a monitoring programme for measuring point source emissions of non-methane volatile organic compounds and benzene from the loading and unloading of liquid hydrocarbons as specified in BAT conclusion 52 for the Refining of Mineral Oil and Gas. The monitoring programme and associated methodologies shall be agreed in writing with the Agency having regard to the Agency M2 and M16 Guidance Notes. Routine benzene monitoring is not required where it can be demonstrated that benzene emissions are consistently less than 1mg/m^3 from a point source.	01/05/19
IC27	The Operator shall undertake an assessment of measures to reduce point source and fugitive emissions of VOCs from the loading and unloading of liquid hydrocarbons at road and rail terminals. The assessment shall, as a minimum consider: • Whether the existing recovery rate of VOC's is at least 95% (for sites that have a recovery system in place) • What combination of abatement technology can be used to achieve a VOC recovery rate of at least 95% • If vapour recovery is not practicable, for safety or technical reasons, an explanation of those reasons shall be provided and alternative VOC control measures such as a vapour destruction unit considered. The assessment will take into account the techniques identified in BAT conclusion 52 for the Refining of Mineral Oil and Gas. A written report of the assessment shall be submitted to the Agency, along with a timetable for implementing improvements. The Operator shall implement the improvements identified to the timetable agreed with the Agency.	01/05/20
IC28	The operator shall submit a written monitoring plan to the Environment Agency for approval that includes: (a) proposals to undertake representative monitoring of hazardous pollutants (as set out in the Environment	01/07/19

Table S1.3 Improvement programme requirements		
Reference	**Requirement**	**Date**
	Agency's Surface Water Pollution Risk Assessment guidance) in the discharge to surface water from points W2a/W2b including the parameters to be monitored, frequencies of monitoring and methods to be used. The operator shall carry out the monitoring in accordance with the Environment Agency's written approval.	
IC29	The operator shall submit a written report to the Environment Agency for approval that includes: the results of an assessment of the impact of the emissions to surface water from the site in accordance with the Environment Agency's Surface Water Pollution Risk Assessment Guidance available on our website. The report shall: (a) be based on the parameters monitored in IC28 above; and Include proposals for appropriate measures to mitigate the impact of any emissions where the assessment determines they are liable to cause pollution, including timescales for implementation of individual measures.	01/11/20