RDCG (Rotterdam Capacity Growth) – DEFINITION PHASE
NESTE

ENVIRONMENTAL JOB SPECIFICATION FOR DESIGN

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1. GENERAL

1.1. Introduction

Neste has a target to increase its renewable diesel production capacity in Rotterdam with a new NEXBTL2 Unit; ; in particular the units in RDCG scope of work are:

- Units in MNA Area:
    - Process Units:
        - Heat Treatment Unit (HTU) Unit 11;
        - Pretreatment Unit Unit 12;
        - NExBTL Unit 21;
        - Hot oil Unit 57;
    - Auxiliary Units, Utilities and Offsites:
        - Tank Farm (MNA) Unit 42;
        - Utilities (MNA) Unit 53;
        - Waste Water Treatment (MNA) Unit *62*;
        - Flare System Unit 67;
        - Fire Water Unit 86;
    - Other Units:
        - Technical Buildings (MNA) Unit 76;
        - Interconnecting (MNA) Unit 81;
        - Interconnecting (Corridor) Unit 82,
- Units in Existing Refinery:
    - Auxiliary Units, Utilities and Offsites:
        - Existing Tank Farm (Refinery) Unit 40;
        - New Tank Farm (Refinery + Blake) Unit 41;
        - Jetty Loading Expansion Unit 45;
        - Jetty Loading Expansion Unit 46;
        - Utilities (Refinery) Unit 52;
        - WWT (Refinery) Unit 60;
    - Other Units:
        - Civil/Industrial Buildings Unit 70;
        - Technical Buildings (Refinery) Unit 75;
        - Interconnecting (Refinery + Blake) Unit 80.

1.2. Scope of Present Document and General Environmental Philosophy

Present document establishes the environment protection design criteria to be adopted as part of the design activities related to the entire lifecycle of Project. Environmental protection measures to be adopted during Construction and Commissioning Phases of project are not included in present document since detailed in dedicated document.

Project design shall aim to:

- Safeguard the environment, and where possible improve the environmental condition;

- Eliminate the use of environmental hazardous material from the design wherever practicable, and select lower toxicity chemicals over higher toxicity chemicals;
- Minimize energy demand and maximize energy efficiency;
- Avoid waste generation and minimize both the quantities of waste generated and the hazards of the waste;
- Reduce air emissions by process design and through energy optimization;
- Avoid venting of gases and minimize diffuse gas losses.
- Design process systems to minimize flaring *and to avoid flaring during regular process and/or maintenance*.

In particular, the design shall reduce the quantities and volumes of air /aqueous emissions to environment, solid waste and noise emission in order to meet the local requirements as resulting from legislation and permit application.

The Project will pursue the above targets applying the relevant sector/ EU BATC to the facilities part of project.

1.3. Updating of Present Document

Present document is updated during Project Definition and Execution phases to include input from Local Permitting activities which can provide additional design measures concerning Environment Protection to be included into Project development; during Permitting activities also the compliance of the design to techniques mentioned in the BREF and not included in the BACT has to be done.
In addition as part of Six Step Procedure activities (Ref [4]) Environmental Compliance analysis is performed (Ref. [5]); the Environmental Compliance analysis will be updated during following Project phases.

1.4. Applicable EU Legislation and Standards

EU Directives:

- Directive 2008/50/EC and of the council of 21 May 2008 on ambient air quality and cleaner air for Europe
- Directive 2010/75/EU of the European parliament on industrial emissions (integrated pollution prevention and control)
- Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy
- Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants

Applicable BREF:

- Best Available Techniques (BAT) Reference Document for the Refining of Mineral Oil and Gas - Industrial Emissions Directive 2010/75/EU Integrated Pollution Prevention and control (2015)
- Integrated Pollution Prevention and Control Reference Document on Best Available Techniques on Emissions from Storage (*2006*)
- Reference Document on Best Available Techniques for Energy Efficiency (2009)
- Integrated Pollution Prevention and Control (IPPC) Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (2001)
- Best Available Techniques (BAT) Reference Document for Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector - Industrial Emissions Directive 2010/75/EU Integrated Pollution Prevention and Control (201*9 Draft 1*)
- *Best Available Techniques (BAT) Reference Document for Monitoring of Emissions to Air and Water from IED - Industrial Emissions Directive 2010/75/EU Integrated Pollution Prevention and Control (2018)*
- *Best Available Techniques (BAT) Reference Document for Economics and Cross-media Effects - Industrial Emissions Directive 2010/75/EU Integrated Pollution Prevention and Control (2006)*

Applicable BATC:

- Best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the refining of mineral oil and gas, 2014
- Best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for common waste water and waste gas treatment/ management systems in the chemical sector, 2016
- *Best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for the production of large volume organic chemicals, 2017*

Applicable Local Regulations:

There are several legislations and guidelines concerning the environment protection; they are available only in Dutch, the relevant requirements are included in the Ref. [5] or in other study/permit application documents which will be prepared by Neste in following Project Definition or Execution stages.

1.5. References

Present document should be read in conjunction with:

Ref [1]	Basis of Design (082755C-000-CN-0007-0001 rev A)
Ref [2]	Plant Noise Control Specification (*082755C-000-JSD-6000-0001)*
Ref [3]	HSE Design Criteria (082755C-000-JSD-1900-0003) with attached Neste HSE Design Guidelines (Draft version 1)
Ref [4]	Six Step Procedure in Plant Investment Projects (Standard) NMS ID: 20169829 version 6
Ref [5]	ENVIRONMENTAL COMPLIANCE ANALYSIS REPORT Neste Rotterdam Expansion site Maasvlakte New Area - RDCG: Rotterdam Capacity Growth RDCG01-REPHHS36A-001 revision 1
Ref [6]	*RDCG01-RE-PHHS24A-001 Starting point for Environmental Permit (Definition Phase)*

1.6. Acronyms and Abbreviations

BAT	Best Available Techniques
BATC	Best Available Techniques Conclusions
BREF	Best Available Techniques (BAT) Reference document
EC	European Commission
EU	European Union
GHG	Green House Gas
HSE	Health Safety Environment
HTU	Heat Treatment Unit
MNA	Maasvlakte New Area
NRB	Nederlandse Richtlijn Bodembescherming
PM	Particulate Matter
PTU	Pre Treatment Unit
SCR	Selective Catalytic Reduction
SNCR	Selective Non-Catalytic Reduction
SVHC	Substances of Very High Concern (in Dutch ZZS)
VOC	Volatile Organic Compound
US EPA	United States Environment Protection Agency
ZZS	Zeer Zorgwekkende Stoffen

2. AIR POLLUTION

2.1. Air Quality Standards

The set of applicable EU ambient air quality limits (2008/50/EC) is shown in following table. These figures apply at plant fence.

Pollutant	Averaging period	Limit Value
Limit values for the protection of human health		
Sulphur Dioxide	One hour	350 µg/m3, not to be exceeded more than 24 times a calendar year
	One day	125 µg/m3, not to be exceeded more than 24 times a calendar year
Nitrogen Dioxide	One hour	200 µg/m3, not to be exceeded more than 18 times a calendar year
	Calendar year	40 µg/m3
Carbon monoxide	Maximum daily eight hour mean	10 mg/m3
PM10 (1)	One day	50 µg/m3, not to be exceeded more than 35 times a calendar year
	Calendar year	40 µg/m3
Critical levels for the protection of vegetation		
Sulphur Dioxide	Calendar year and winter (1 October to 31 March)	20 µg/m3
Oxides of nitrogen	Calendar year	30 µg/m3 NOx

(1) Particulate matter with an aerodynamic diameter smaller than 10 µm

During environmental permitting application package performed by NESTE with support of local consultant, the compliance with air quality limits are evaluated including local requirements for nitrogen deposition with reference to Nature act law (wet Natuurbescherming d.d. 16-12-2005).

2.2. Air Emission Limits (Point Emission Sources)

2.2.1. General

Emission limits for discharges to atmosphere are specified in Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control).

The limits for discharges from the above regulation and applicable to process heaters project are summarized below.

Pollutant	**Limit Value**
Sulphur Dioxide	35 mg/Nm3
Nitrogen Oxides	100 mg/Nm3
Carbon monoxide	100 mg/Nm3
Dust	5 mg/Nm3

During the procurement stage of the Project, fired heaters Vendors shall be asked to guarantee that air emissions will not exceed the limits shown in table above. However, for heaters/boilers NOx emission the project agreed to adopt a more stringent emission limit of 70 mg/Nm3 (dry flue gas, 3% O2) in accordance with EU BAT Conclusions (BAT 34) for Refinery, which specify NOx to be in the range 30-100 mg/Nm3.
The limit of 70 mg/Nm3 NOx emission from Hot Oil heater is also stated in Ref.[5].
During feasibility stage of the project possibility to approach more stringent emission limit by use of dedicated technology (DeNOx system by SCR) is investigated. The NOx limit currently adopted on project for Hot Oil heater is 70 mg/Nm3 (MOM-TR-NR-00022). The limit for NOx depends also from outcomes on nitrogen deposition evaluation performed during environmental permit application (refer to paragraph 2.1) by Neste; the target limit to be adopted by project may be revised later during Project development.

2.2.2. Stack height requirements

Stack height for process heaters is preliminarily calculated during feasibility stage of the project based on draught requirements and minimum height for pollutant dispersion.

2.2.3. Monitoring

For process heaters on-line stack emission analyser is required in cases total rated thermal input of combustion is 50 MW or higher. Hence it is not applied to Hot Oil heater as also stated in Ref. [5].

At current definition phase of the Project, it is confirmed that Hot Oil Heater rated thermal input of combustion is lower than 50MW. As already stated in Ref. [5] and considering that no SCR is required, according to BATC no continuous emission monitoring system (CEMS) is foreseen.

2.2.4. Applicable BATC

The BAT Conclusions considered in this document from the above references will be those related to design purpose of the facilities only: i.e. all BATC related to technology not part of project (e.g. continuous catalytic reformer) are not listed in this document and all BATC related to management of the facilities are not listed in this document as not related to design (e.g. BATC related to environmental management system).

The following BATC from Refinery sector are applicable to the project in terms of design (for more details refer to Attachment 1):

- BAT 4 for monitoring emissions to air.
- BAT 5 for monitoring parameters linked to pollutant emissions (e.g. O_2 in flue gas).
- BAT 8 for limiting NH_3 emissions when using SCR/SNCR.
- BAT 34 for preventing or reducing NOx emissions from combustion plants.
- BAT 35 for preventing or reducing dust and metal emissions from combustion plants.
- BAT 36 for preventing or reducing SO_2 emissions from combustion plants.
- BAT 40 for reducing emissions to air of chlorinated compounds.
- BAT 46 for reducing air emissions from distillation units by proper off-gas treatment.
- BAT 55 for preventing emission to air from flares.
- BAT 56 for reducing emission to air from flares.

The following design BATC from waste water and waste gas treatment/ management applies to project (for more details refer to Attachment 2):

- BAT 17 for preventing emission to air from flares.
- BAT 18 for reducing emission to air from flares.

The following design BATC for large volume organic chemicals applies to process units (for more details refer to Attachment 3):

- BAT 4 for reducing NOx emissions from process furnace/heaters.
- BAT 5 for reducing dust emissions from process furnace/heaters.
- BAT 6 for reducing SO2 emissions from process furnace/heaters.
- BAT 7 for reducing NH3 emissions when using SCR/SNCR
- BAT 9 for reducing load of pollutants sent to the final waste gas treatment and to increase energy efficiency.
- BAT 10 for reducing channelled emissions of organic compounds to air.
- BAT 11 for reducing channelled dust emissions to air.
- BAT 13 for reducing emission to air of NOx, CO and SO2 from a thermal oxidizer.
- BAT 15 for increasing resource efficiency when using catalysts.
- BAT 18 for preventing or reducing emissions from equipment malfunctions.

2.3. *Air* Emissions

2.3.1. Fixed Emissions points

One major emission source is the PTU. The off gases coming out from the PTU, e.g. off-gas from heat treatment and vacuum system might contain hazardous chemicals or at least cause smell/odour nuisance for personnel and neighbours.
PTU emission must be minimized with applicable technology; in particular the releases from the PTU and HTU, which are major emission sources, will be minimized by routing the off-gases to the hot oil heater for incineration.

2.3.2. Fugitive emissions

Fugitive emissions refer to diffuse non-point emissions of volatile organic compounds (VOCs) and greenhouse gases (GHGs) from piping components and equipment including valves, flanges, connectors, pumps and compressor seals, relief valves, sampling connections, process drains and open-ended lines.

Fugitive emissions can also occur from storage tanks, loading operations and waste water handling facilities. In waste water handling facilities emissions may also include biological substances, e.g. a micro-organisms, virus or toxins.
The storage of feedstock also generates VOC emissions. The feedstock and intermediate storage tanks have nitrogen blanketing that reduces the off-gas emissions from the storage tanks. Nitrogen blanketing has also a positive effect on the quality of the feedstocks by preventing the degradation of the feedstock.

According to EU Directive 2010/75/EU on industrial emissions definition: *‘volatile organic compound’ means any organic compounds as well as the fraction of creosote, having at 293,15 K a vapor pressure of 0,01 kPa or more, or having a corresponding volatility under the particular conditions of use.*

VOC Service

For present document the minimization of VOC emission is an objective; it shall be targeted following indication from BATC, BREFs and receiving input from local regulation and relevant permitting application. In order to focalize on most important topics and source of emissions it is suggested to adopt the VOC service definition given by US EPA considering VOC service applied *or* equipment handling a fluid that is at least 10%weight VOC.

In Local legislation/guideline (refer to paragraph 1.4) there are 'obligation to minimize' VOC emission (that is applicable for fixed emission point and also for diffuse emissions); such minimization with detail on design measures to be adopted are included in the Ref. [5] and/or in other study/permit application documents which will be prepared by Neste in following Project Definition or Execution stages.

2.3.3. Substance of Very High Concern

The Dutch government has issued a list of (potential) Substances of Very High Concern (SVHC, in Dutch ZZS). Information can be found on following link:
https://rvszoeksysteem.rivm.nl/ZZSlijst/TotaleLijst
SVHC's are substances which are particularly very harmful for humans or the environment. A verification must be done according to Ref. [5], during Project development, on the presence of SVHC's in both product streams and emission streams. If these substances are present, the source must be addressed, or the (diffusive) emission needs to minimize to absolute minimum.

During definition phase the following substances have been defined by Neste as substances of very high concern, according to Ref [6]:

Material	***CAS Number***	***Application***
Benzene	*71-43-2*	*Raw Material and product*
Furan	*110-00-9*	*Raw Material and product*
Naphthalene	*91-20-3*	*Antistatic additive and antioxidant*
Bifenyl	*92-52-4*	*Thermal Oil component*
Glutaraldeyde	*111-30-8*	*Biocide component for Cooling water*

2.3.4. Applicable BATC

The BAT Conclusions considered in this document from the above references will be those related to design purpose of the facilities only: i.e. all BATC related to technology not part of project (e.g. continuous catalytic reformer) are not listed in this document and all BATC related to management of the facilities are not listed in this document as not related to design (e.g. BATC related to environmental management system).

The following BATC from Refinery sector are applicable to the project in terms of design for VOC emissions reduction (for more details refer to Attachment 1):

- BAT 18 for preventing or reducing diffuse VOC emissions.
- BAT 49 for reducing VOC emissions from the storage of volatile liquid hydrocarbon compounds (applicable to Renewable Naphtha storage tanks only since RJF, diesel, feedstock and intermediate storages do not fall in volatile liquid hydrocarbon definition according to BATC document which specifies the following: “Petroleum derivatives with a Reid vapour pressure (RVP) of more than 4 kPa, such as naphtha and aromatics”).
- BAT 52 for preventing or reducing VOC emissions from the loading and unloading operations of volatile liquid hydrocarbon compounds.

The following design BATC from waste water and waste gas treatment/ management applies to project (for more details refer to Attachment 2):

- BAT 15 for facilitating the recovery of compounds and the reduction of emission to air enclosing the emission sources.
- BAT 19 for preventing or reducing diffuse VOC emissions to air.
- BAT 21 for preventing or reducing odour emissions from waste water collection and treatment and from sludge treatment.

2.4. Air Contamination Mitigation Measures Outcomes from Project Studies

According to Six Step Procedure (Ref [4]) dedicated studies and analyses are performed during Project lifecycle concerning the environment protection.
Results from development of dedicated studies as part of environmental permitting application have to be considered and included as required.
Present paragraph is updated during project development to list the air contamination main mitigation measures adopted.

3. WATER EFFLUENT DISCHARGE

Water handled in the Project can be divided in different categories depending on water nature and destination:

- Clean water (rainwater uncontaminated),
- [redacted]
- [redacted] *(Oily water, e.g. fire water, potentially contaminated drainages, process effluent).*

The Clean Water handling system collects water from buildings roof, road, laydown and gravelled areas; such water is considered clean and it can be discharged to the sea. Clean Water is collected in the clean water sewer and discharged directly to the sea.

The [redacted] handling system receives sanitary waste water form building toilets and collects the water in the Sanitary Septic Tank.
Sanitary water is then pumped, to the nearby Maasvlakte Rotterdam Municipal sewage in conjunction with Waste Water Treatment [redacted] coming from other Plant to be built in the same MNA land and part of different Project.

The [redacted] *(oily water)* handling system receive water, which may be polluted by hydrocarbons or fats/vegetable oils, such as rainwater contaminated (potentially), fire water, water drainages from process equipment.

The contaminated water coming from Unit 11 and Unit 12 will be treated into a dedicated deoiling equipment, 62-PK-01 NEXPRE CPI Package. This is mainly due to the process water composition that consists of vegetable oils, fatty acids and animal fats.

The remaining contaminated water streams (rain and/or fire water from potentially contaminated paved areas / wash water of paved areas in process or buildings / water drainages from process equipment) are collected in the oily water sewer and then stored into basins/pond. Stored water will be analysed and if it is in accordance with discharge limit to the sea, water is sent to the clean *rain*water sewer.

In case of contamination, the water is routed to the *NEXPRE Buffer Tank 62FB-01 together with the effluent coming from CPI Package and then sent to* Waste Water Treatment *Unit 60/61 together with the other waste water stream.*

Effluent properties at battery limits, routed to Unit 60/61 Waste water treatment are summarized in doc. n° 082755-062-CN-0009-0001 Waste Water handling Process description.

3.1. Applicable BATC

The BAT Conclusions considered in this document from the above references will be those related to design purpose of the facilities only: i.e. all BATC related to technology not part of project (e.g. continuous catalytic reformer) are not listed in this document and all BATC related to management of the facilities are not listed in this document as not related to design (e.g. BATC related to environmental management system).

The following design BATC from waste water and waste gas treatment/ management applies to project (for more details refer to Attachment 2):

- BAT 7 for reducing the usage of water and the generation of waste water.
- BAT 8 for preventing the contamination of uncontaminated water and to reduce emissions to water (segregation of streams).
- BAT 9 for preventing uncontrolled emissions to water (usage of buffer tanks).
- BAT 10 for reducing emissions to water using integrated treatment strategy.
- BAT 11 for reducing emissions to water with pre-treatment techniques.
- BAT 12 for reducing emissions to water with final treatment techniques and associated BAT target emission levels.

The following design Refinery BATC applies for water treatment reduction (for more details refer to Attachment 1):

- BAT 11 for reducing water consumption.
- BAT 12 for reducing emission load of pollutants in waste water.
- BAT 13 for having treatment steps.
- BAT 44 for preventing or reducing waste water flow generation from the distillation process (liquid ring vacuum pump or surface condenser).
- BAT 45 for preventing or reducing waste water flow generation from the distillation process (sour water to stripping).

3.2. Water Contamination Mitigation Measures Outcomes from Project Studies

According to Six Step Procedure (Ref [4]) dedicated studies and analyses are performed during Project lifecycle concerning the environment protection.
Results from development of dedicated studies as part of environmental permitting application have to be considered and included as required.
Present paragraph is updated during project development to list the water receiving body water contamination main mitigation measures adopted.

4. WASTE MANAGEMENT

4.1. General requirements

Solid and liquid waste produced during the operation/construction of the facility shall be collected, classified, stored and disposed to proper destination (e.g. waste treatment facilities, licensed landfills or incineration facilities depending on type) according to current practice in NESTE Rotterdam existing plant.

An on-site temporary storage before disposal outside *will* be defined *as part of the definition phase activities*. Temporary storage should be in a safe area and provided with adequate containment facilities for liquids to prevent spreading of wastes accidentally leaked from containers. The hazardous waste must be properly managed to prevent environmental pollution and exposure to workers.

Waste management during operation will be defined by Neste during detailed phase of the Project.

4.2. Applicable BATC

The BAT Conclusions considered in this document from the above references will be those related to design purpose of the facilities only: i.e. all BATC related to technology not part of project (e.g. continuous catalytic reformer) are not listed in this document and all BATC related to management of the facilities are not listed in this document as not related to design (e.g. BATC related to environmental management system).

The following design Refinery BATC applies for waste generation (for more details refer to Attachment 1):

- BAT 15 for reducing amount of waste.
- BAT 16 for reducing generation of spent catalyst waste.

The following design BATC from waste water and waste gas treatment/ management applies to project (for more details refer to Attachment 2):

- BAT 14 for reducing volume of waste water sludge.

The following design BATC for large volume organic chemicals applies to process units at MNA (for more details refer to Attachment 3):

- BAT 17 for preventing or reducing amount of waste.

5. SPILL CONTAINMENT AND UNDERGROUND POLLUTION PREVENTION

The following measures shall be part of the design of the facilities in order to prevent the spreading of liquid spills on plant facilities, collect the spilled materials, minimize hazard and possible impacts to environment.
For additional details regarding spill containment refer to Neste HSE Design guideline (Ref [3]) paragraphs 14.4, 27 and 28.4.
For details associated to air emissions refer to chapter 2.

5.1. Oil and Chemical Spill Containment

5.1.1. General requirements

The principle stated in “Nederlandse Richtlijn Bodembescherming (NRB)” (it can be found on www.bodemplus.nl/onderwerpen/wet-regelgeving/nrb/) is that It is mandatory to apply a combination of technical and operational measures to guarantee a ' negligible risk of soil contamination'. During environmental permit application the check for compliance with NRB is performed.

Rain, fire or washing water on contaminated area will be recovered and treated according to pollutants content.

All areas subject to accidental or incidental surface contamination from leaks or spills of oils or chemicals will be constructed of a sufficiently impervious material to contain any spills, and either sloped or curbed to prevent run-on to or run-off from adjacent areas. The involved areas would include any oil or chemical storage tanks, and such equipment items as: compressors and compressor lube consoles; electrical transformers; electrical generators, chemical injection packages, and pump base plates.

Fluid resistant paved surfaces shall be laid where appropriate (e.g. for refuelling areas and processing units) to prevent potential hydrocarbon groundwater contamination. *Fluid tight paved areas can be considered for specific cases and process fluids.*

All drainage from the process and utility/offsite curbed areas will be directed to the potentially oil contaminated sewer system. All drainage from the storage bunds will have two possible destinations (provided with valve normally closed) in order be directed to the potentially oil contaminated sewer system or, after operator check, to the clean water collection system.

For a secondary containment facility exposed to the weather, it should be provided with a system to discharge rainwater collected in the facility. The discharge system should be designed and operated to allow only rainwater to be discharged. If the rainwater is contaminated, it has to be treated before discharge into a watercourse.

5.1.2. Applicable BATC

The BAT Conclusions considered in this document from the above references will be those related to design purpose of the facilities only: i.e. all BATC related to technology not part of project (e.g. continuous catalytic reformer) are not listed in this document and all BATC related to management of the facilities are not listed in this document as not related to design (e.g. BATC related to environmental management system).

According to Refinery BAT 51, to reduce emissions to soil and groundwater, storage tanks shall be provided with double bottom and/or impervious membrane liners.

5.2. Soil Contamination Mitigation Measures Outcomes from Project Studies

According to Six Step Procedure (Ref [4]) dedicated studies and analyses are performed during Project lifecycle concerning the environment protection.
Results from development of dedicated studies as part of environmental permitting application have to be considered and included as required.
Present paragraph is updated during project development to list the soil contamination main mitigation measures adopted.

6. ENVIRONMENTAL NOISE LIMITS

6.1. General requirements

RDCG Basis of Design as per Ref [1] *reports* the maximum permitted noise levels at the boundary of Refinery and at the boundary of MNA *according to regulations.*

However Neste informed that general noise limits *as per Ref [1]* are not applicable in Rotterdam. Neste has a permit which states maximum noise levels at reference points on site, these will be changed as a result of the new Revision of permit as part of project development.

Based on Neste input, the maximum average noise (plot space) level is 69 dB(A)/ha, which is the level that is allowed by the authority (DCMR).
Environmental noise limits are described *in details* in Plant Noise Control Specification (Ref [2]).

As part of the activities for setting the acoustic model for noise verification, the following workflow shall be considered:

1. *Collection of preliminary noise figures for each equipment/sources;*
2. *Development of preliminary noise study on the basis of collected noise data*
3. *During Project development, noise data for each source shall be updated considering both design changes and/or relevant Vendor information*
4. *Final Noise study shall be developed.*

6.2. Applicable BATC

The BAT Conclusions considered in this document from the above references will be those related to design purpose of the facilities only: i.e. all BATC related to technology not part of project (e.g. continuous catalytic reformer) are not listed in this document and all BATC related to management of the facilities are not listed in this document as not related to design (e.g. BATC related to environmental management system).

The following design BATC from waste water and waste gas treatment/ management applies to project (for more details refer to Attachment 2):

- BAT 23 for preventing or reducing noise emissions.

RDCG (Rotterdam Capacity Growth) – DEFINITION PHASE
NESTE

ATTACHMENT 1

BEST AVAILABLE TECHNIQUES (BAT) CONCLUSIONS FOR THE REFINING OF MINERAL OIL AND GAS

(45 sheets)

DECISIONS

COMMISSION IMPLEMENTING DECISION

of 9 October 2014

establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the refining of mineral oil and gas

(notified under document C(2014) 7155)

(Text with EEA relevance)

(2014/738/EU)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (1), and in particular Article 13(5) thereof,

Whereas:

(1) Article 13(1) of Directive 2010/75/EU requires the Commission to organise an exchange of information on industrial emissions between it and Member States, the industries concerned and non-governmental organisations promoting environmental protection in order to facilitate the drawing up of best available techniques (BAT) reference documents as defined in Article 3(11) of that Directive.

(2) In accordance with Article 13(2) of Directive 2010/75/EU, the exchange of information is to address the performance of installations and techniques in terms of emissions, expressed as short- and long-term averages, where appropriate, and the associated reference conditions, consumption and nature of raw materials, water consumption, use of energy and generation of waste and the techniques used, associated monitoring, cross-media effects, economic and technical viability and developments therein and best available techniques and emerging techniques identified after considering the issues mentioned in points (a) and (b) of Article 13(2) of that Directive.

(3) 'BAT conclusions' as defined in Article 3(12) of Directive 2010/75/EU are the key element of BAT reference documents and lay down the conclusions on best available techniques, their description, information to assess their applicability, the emission levels associated with the best available techniques, associated monitoring, associated consumption levels and, where appropriate, relevant site remediation measures.

(4) In accordance with Article 14(3) of Directive 2010/75/EU, BAT conclusions are to be the reference for setting permit conditions for installations covered by Chapter II of that Directive.

(5) Article 15(3) of Directive 2010/75/EU requires the competent authority to set emission limit values that ensure that, under normal operating conditions, emissions do not exceed the emission levels associated with the best available techniques as laid down in the decisions on BAT conclusions referred to in Article 13(5) of Directive 2010/75/EU.

(6) Article 15(4) of Directive 2010/75/EU provides for derogations from the requirement laid down in Article 15(3) only where the costs associated with the achievement of the emission levels associated with the BAT disproportionately outweigh the environmental benefits due to the geographical location, the local environmental conditions or the technical characteristics of the installation concerned.

(7) Article 16(1) of Directive 2010/75/EU provides that the monitoring requirements in the permit referred to in point (c) of Article 14(1) of the Directive are to be based on the conclusions on monitoring as described in the BAT conclusions.

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(1) OJ L 334, 17.12.2010, p. 17.

(8) In accordance with Article 21(3) of Directive 2010/75/EU, within 4 years of publication of decisions on BAT conclusions, the competent authority is to reconsider and, if necessary, update all the permit conditions and ensure that the installation complies with those permit conditions.

(9) The Commission established a forum composed of representatives of Member States, the industries concerned and non-governmental organisations promoting environmental protection by Decision of 16 May 2011 establishing a forum for the exchange of information pursuant to Article 13 of Directive 2010/75/EU on industrial emissions (1).

(10) In accordance with Article 13(4) of Directive 2010/75/EU, the Commission obtained the opinion of the forum, established by Decision of 16 May 2011, on the proposed content of the BAT reference document for the refining of mineral oil and gas on 20 September 2013 and made it publicly available.

(11) The measures provided for in this Decision are in accordance with the opinion of the Committee established by Article 75(1) of Directive 2010/75/EU,

HAS ADOPTED THIS DECISION:

Article 1

The BAT conclusions for the refining of mineral oil and gas, as set out in the Annex, are adopted.

Article 2

This Decision is addressed to the Member States.

Done at Brussels, 9 October 2014.

For the Commission
Janez POTOČNIK
Member of the Commission

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(1) OJ C 146, 17.5.2011, p. 3.

ANNEX

BAT CONCLUSIONS FOR THE REFINING OF MINERAL OIL AND GAS

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SCOPE

These BAT conclusions cover certain industrial activities specified in Section 1.2 of Annex I to Directive 2010/75/EU, namely '1.2. Refining of mineral oil and gas'.

In particular, these BAT conclusions cover the following processes and activities:

Activity	Subactivities or processes included in activity
Alkylation	All alkylation processes: hydrofluoric acid (HF), sulphuric acid (H_2SO_4) and solid-acid
Base oil production	Deasphalting, aromatic extraction, wax processing and lubricant oil hydrofinishing
Bitumen production	All techniques from storage to final product additives
Catalytic cracking	All types of catalytic cracking units such as fluid catalytic cracking
Catalytic reforming	Continuous, cyclic and semi-regenerative catalytic reforming
Coking	Delayed and fluid coking processes. Coke calcination
Cooling	Cooling techniques applied in refineries
Desalting	Desalting of crude oil
Combustion units for energy production	Combustion units burning refinery fuels, excluding units using only conventional or commercial fuels

Activity	Subactivities or processes included in activity
Etherification	Production of chemicals (e.g. alcohols and ethers such as MTBE, ETBE and TAME) used as motor fuels additives
Gas separation	Separation of light fractions of the crude oil e.g. refinery fuel gas (RFG), liquefied petroleum gas (LPG)
Hydrogen consuming processes	Hydrocracking, hydrorefining, hydrotreatments, hydroconversion, hydroprocessing and hydrogenation processes
Hydrogen production	Partial oxidation, steam reforming, gas heated reforming and hydrogen purification
Isomerisation	Isomerisation of hydrocarbon compounds C_4, C_5 and C_6
Natural gas plants	Natural gas (NG) processing including liquefaction of NG
Polymerisation	Polymerisation, dimerisation and condensation
Primary distillation	Atmospheric and vacuum distillation
Product treatments	Sweetening and final product treatments
Storage and handling of refinery materials	Storage, blending, loading and unloading of refinery materials
Visbreaking and other thermal conversions	Thermal treatments such as visbreaking or thermal gas oil process
Waste gas treatment	Techniques to reduce or abate emissions to air
Waste water treatment	Techniques to treat waste water prior to release
Waste management	Techniques to prevent or reduce the generation of waste

These BAT conclusions do not address the following activities or processes:

— the exploration and production of crude oil and natural gas;

— the transportation of crude oil and natural gas;

— the marketing and distribution of products.

Other reference documents which may be relevant for the activities covered by these BAT conclusions are the following:

Reference document	Subject
Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW)	Waste water management and treatment techniques
Industrial Cooling Systems (ICS)	Cooling processes
Economics and Cross-media Effects (ECM)	Economics and cross-media effects of techniques

Reference document	Subject
Emissions from Storage (EFS)	Storage, blending, loading and unloading of refinery materials
Energy Efficiency (ENE)	Energy efficiency and integrated refinery management
Large Combustion Plants (LCP)	Combustion of conventional and commercial fuels
Large Volume Inorganic Chemicals — Ammonia, Acids and Fertilisers Industries (LVIC-AAF)	Steam reforming and hydrogen purification
Large Volume Organic Chemical Industry (LVOC)	Etherification process (MTBE, ETBE and TAME production)
Waste Incineration (WI)	Waste incineration
Waste Treatment (WT)	Waste treatment
General Principles of Monitoring (MON)	Monitoring of emissions to air and water

GENERAL CONSIDERATIONS

The techniques listed and described in these BAT conclusions are neither prescriptive nor exhaustive. Other techniques may be used that ensure at least an equivalent level of environmental protection.

Unless otherwise stated, these BAT conclusions are generally applicable.

Averaging periods and reference conditions for emissions to air

Unless stated otherwise, emission levels associated with the best available techniques (BAT-AELs) for emissions to air given in these BAT conclusions refer to concentrations, expressed as mass of emitted substance per volume of waste gas under the following standard conditions: dry gas, temperature of 273,15 K, pressure of 101,3 kPa.

For continuous measurements	BAT-AELs refer to monthly average values, which are the averages of all valid hourly average values measured over a period of one month
For periodic measurements	BAT-AELs refer to the average value of three spot samples of at least 30 minutes each

For combustion units, catalytic cracking processes, and waste gas sulphur recovery units, reference conditions for oxygen are shown in Table 1.

Table 1

Reference conditions for BAT-AELs concerning emissions to air

Activities	Unit	Oxygen reference conditions
Combustion unit using liquid or gaseous fuels with the exception of gas turbines and engines	mg/Nm^3	3 % oxygen by volume
Combustion unit using solid fuels	mg/Nm^3	6 % oxygen by volume

Activities	Unit	Oxygen reference conditions
Gas turbines (including combined cycle gas turbines — CCGT) and engines	mg/Nm^3	15 % oxygen by volume
Catalytic cracking process (regenerator)	mg/Nm^3	3 % oxygen by volume
Waste gas sulphur recovery unit (1)	mg/Nm^3	3 % oxygen by volume

(1) In case of applying BAT 58.

Conversion of emissions concentration to reference oxygen level

The formula for calculating the emissions concentration at a reference oxygen level (see Table 1) is shown below.

$$E_R = \frac{21 - O_R}{21 - O_M} \times E_M$$

Where:

E_R (mg/Nm^3): emissions concentration referred to the reference oxygen level O_R

O_R (vol %): reference oxygen level

E_M (mg/Nm^3): emissions concentration referred to the measured oxygen level O_M

O_M (vol %): measured oxygen level.

Averaging periods and reference conditions for emissions to water

Unless stated otherwise, emission levels associated with the best available techniques (BAT-AELs) for emissions to water given in these BAT conclusions refer to values of concentration (mass of emitted substances per volume of water) expressed in mg/l.

Unless stated otherwise, the averaging periods associated with the BAT-AELs are defined as follows:

Daily average	Average over a sampling period of 24 hours taken as a flow-proportional composite sample or, provided that sufficient flow stability is demonstrated, from a time-proportional sample
Yearly/Monthly average	Average of all daily averages obtained within a year/month, weighted according to the daily flows

DEFINITIONS

For the purpose of these BAT conclusions, the following definitions apply:

Term used	Definition
Unit	A segment/subpart of the installation in which a specific processing operation is conducted
New unit	A unit first permitted on the site of the installation following the publication of these BAT conclusions or a complete replacement of a unit on the existing foundations of the installation following the publication of these BAT conclusions
Existing unit	A unit which is not a new unit

Term used	Definition
Process off-gas	The collected gas generated by a process which must be treated e.g. in an acid gas removal unit and a sulphur recovery unit (SRU)
Flue-gas	The exhaust gas exiting a unit after an oxidation step, generally combustion (e.g. regenerator, Claus unit)
Tail gas	Common name of the exhaust gas from an SRU (generally Claus process)
VOC	Volatile organic compounds as defined in Article 3(45) of Directive 2010/75/EU
NMVOC	VOC excluding methane
Diffuse VOC emissions	Non-channelled VOC emissions that are not released via specific emission points such as stacks. They can result from 'area' sources (e.g. tanks) or 'point' sources (e.g. pipe flanges)
NO_X expressed as NO_2	The sum of nitrogen oxide (NO) and nitrogen dioxide (NO_2) expressed as NO_2
SO_X expressed as SO_2	The sum of sulphur dioxide (SO_2) and sulphur trioxide (SO_3) expressed as SO_2
H_2S	Hydrogen sulphide. Carbonyl sulphide and mercaptan are not included
Hydrogen chloride expressed as HCl	All gaseous chlorides expressed as HCl
Hydrogen fluoride expressed as HF	All gaseous fluorides expressed as HF
FCC unit	Fluid catalytic cracking: a conversion process for upgrading heavy hydrocarbons, using heat and a catalyst to break larger hydrocarbon molecules into lighter molecules
SRU	Sulphur recovery unit. See definition in Section 1.20.3
Refinery fuel	Solid, liquid or gaseous combustible material from the distillation and conversion steps of the refining of crude oil. Examples are refinery fuel gas (RFG), syngas and refinery oils, pet coke
RFG	Refinery fuel gas: off-gases from distillation or conversion units used as a fuel
Combustion unit	Unit burning refinery fuels alone or with other fuels for the production of energy at the refinery site, such as boilers (except CO boilers), furnaces, and gas turbines.
Continuous measurement	Measurement using an 'automated measuring system' (AMS) or a 'continuous emission monitoring system' (CEMS) permanently installed on site
Periodic measurement	Determination of a measurand at specified time intervals using manual or automated reference methods
Indirect monitoring of emissions to air	Estimation of the emissions concentration in the flue-gas of a pollutant obtained through an appropriate combination of measurements of surrogate parameters (such as O_2 content, sulphur or nitrogen content in the feed/fuel), calculations and periodic stack measurements. The use of emission ratios based on S content in the fuel is one example of indirect monitoring. Another example of indirect monitoring is the use of PEMS

Term used	Definition
Predictive Emissions monitoring system (PEMS)	System to determine the emissions concentration of a pollutant based on its relationship with a number of characteristic continuously monitored process parameters (e.g. fuel-gas consumption, air/fuel ratio) and fuel or feed quality data (e.g. the sulphur content) of an emission source
Volatile liquid hydrocarbon compounds	Petroleum derivatives with a Reid vapour pressure (RVP) of more than 4 kPa, such as naphtha and aromatics
Recovery rate	Percentage of NMVOC recovered from the streams conveyed into a vapour recovery unit (VRU)

1.1. General BAT conclusions for the refining of mineral oil and gas

The process-specific BAT conclusions included in Sections 1.2 to 1.19 apply in addition to the general BAT conclusions mentioned in this section.

1.1.1. *Environmental management systems*

BAT 1. In order to improve the overall environmental performance of 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 for 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 the procedures paying particular attention to:

  (a) structure and responsibility

  (b) training, awareness and competence

  (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;

(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;

(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.

1.1.2. *Energy efficiency*

BAT 2. In order to use energy efficiently, BAT is to use an appropriate combination of the techniques given below.

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 — use of waste heat in district heating
(ii) Process control and maintenance techniques	
a. 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
b. Management and reduction of steam consumption	Systematic mapping of drain valve systems in order to reduce steam consumption and optimise its use
c. Use of energy benchmark	Participation in ranking and benchmarking activities in order to achieve continuous improvement by learning from best practice
(iii) Energy-efficient production techniques	
a. Use of combined heat and power	System designed for the co-production (or the cogeneration) of heat (e.g. steam) and electric power from the same fuel
b. Integrated gasification combined cycle (IGCC)	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

1.1.3. *Solid materials storage and handling*

BAT 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.

1.1.4. *Monitoring of emissions to air and key process parameters*

BAT 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.

Description	Unit	Minimum frequency	Monitoring technique
(i) SO_X, NO_X, and dust emissions	Catalytic cracking	Continuous (1) (2)	Direct measurement
	Combustion units ≥ 100 MW (3) and calcining units	Continuous (1) (2)	Direct measurement (4)
	Combustion units of 50 to 100 MW (3)	Continuous (1) (2)	Direct measurement or indirect monitoring
	Combustion units < 50 MW (3)	Once a year and after significant fuel changes (5)	Direct measurement or indirect monitoring
	Sulphur recovery units (SRU)	Continuous for SO_2 only	Direct measurement or indirect monitoring (6)
(ii) NH_3 emissions	All units equipped with SCR or SNCR	Continuous	Direct measurement
(iii) CO emissions	Catalytic cracking and combustion units ≥ 100 MW (3)	Continuous	Direct measurement
	Other combustion units	Once every 6 months (5)	Direct measurement
(iv) Metals emissions: Nickel (Ni), Antimony (Sb) (7), Vanadium (V)	Catalytic cracking	Once every 6 months and after significant changes to the unit (5)	Direct measurement or analysis based on metals content in the catalyst fines and in the fuel
	Combustion units (8)		

Description	Unit	Minimum frequency	Monitoring technique
(v) Polychlorinated dibenzodioxins/furans (PCDD/F) emissions	Catalytic reformer	Once a year or once a regeneration, whichever is longer	Direct measurement

(1) Continuous measurement of SO_2 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.

(6) SO_2 emissions measurements from SRU may be replaced by a 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 fuels.

BAT 5. 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.

Description	Minimum frequency
Monitoring of parameters linked to pollutant emissions, e.g. O_2 content in flue-gas, N and S content in fuel or feed (1)	Continuous for O_2 content. For N and S content, periodic at a frequency based on significant fuel/feed changes

(1) N and S monitoring in fuel or feed may not be necessary when continuous emission measurements of NO_X and SO_2 are carried out at the stack.

BAT 6. 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.

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.

1.1.5. *Operation of waste gas treatment systems*

BAT 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.

Description

Special procedures can be defined for other than normal operating conditions, in particular:

(i) during start-up and shutdown operations;

(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.

BAT 8. 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.

BAT-associated emission levels: See Table 2.

Table 2

BAT-associated emission levels for ammonia (NH_3) emissions to air for a combustion or process unit where SCR or SNCR techniques are used

Parameter	BAT-AEL z(monthly average) mg/Nm^3
Ammonia expressed as NH_3	< 5 – 15 (1) (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.

BAT 9. 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.

It is not BAT to directly incinerate the untreated sour water stripping gases.

1.1.6. *Monitoring of emissions to water*

BAT 10. BAT is to monitor emissions to water by using the monitoring techniques with at least the frequency given in Table 3) 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.

1.1.7. *Emissions to water*

BAT 11. In order to reduce water consumption and the volume of contaminated water, BAT is to use all of the techniques given below.

Technique	Description	Applicability
(i) Water stream integration	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	Generally applicable for new units. For existing units, applicability may require a complete rebuilding of the unit or the installation

Technique	Description	Applicability
(ii) Water and drainage system for segregation of contaminated water streams	Design of an industrial site to optimise water management, where each stream is treated as appropriate, by e.g. routing generated sour water (from distillation, cracking, coking units, etc.) to appropriate pretreatment, such as a stripping unit	Generally applicable for new units. For existing units, applicability may require a complete rebuilding of the unit or the installation
(iii) Segregation of non-contaminated water streams (e.g. once-through cooling, rain water)	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	Generally applicable for new units. For existing units, applicability may require a complete rebuilding of the unit or the installation
(iv) Prevention of spillages and leaks	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.	Generally applicable

BAT 12. 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.

Technique	Description	Applicability
(i) Removal of insoluble substances by recovering oil	See Section 1.21.2	Generally applicable
(ii) Removal of insoluble substances by recovering suspended solids and dispersed oil	See Section 1.21.2	Generally applicable
(iii) Removal of soluble substances including biological treatment and clarification	See Section 1.21.2	Generally applicable

BAT-associated emission levels: See Table 3.

BAT 13. 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.

Table 3

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

Parameter	Unit	BAT-AEL (yearly average)	Monitoring (2) frequency and analytical method (standard)
Hydrocarbon oil index (HOI)	mg/l	0,1-2,5	Daily EN 9377- 2 (3)
Total suspended solids (TSS)	mg/l	5-25	Daily
Chemical oxygen demand (COD) (4)	mg/l	30-125	Daily

Parameter	Unit	BAT-AEL (yearly average)	Monitoring (²) frequency and analytical method (standard)
BOD_5	mg/l	No BAT-AEL	Weekly
Total nitrogen (⁵), expressed as N	mg/l	1-25 (⁶)	Daily
Lead, expressed as Pb	mg/l	0,005-0,030	Quarterly
Cadmium, expressed as Cd	mg/l	0,002-0,008	Quarterly
Nickel, expressed as Ni	mg/l	0,005-0,100	Quarterly
Mercury, expressed as Hg	mg/l	0,0001-0,001	Quarterly
Vanadium	mg/l	No BAT-AEL	Quarterly
Phenol Index	mg/l	No BAT-AEL	Monthly EN 14402
Benzene, toluene, ethyl benzene, xylene (BTEX)	mg/l	Benzene: 0,001-0,050 No BAT-AEL for T, E, X	Monthly

(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 a 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 total Kjeldahl nitrogen (TKN), nitrates and nitrites.
(⁶) When nitrification/denitrification is used, levels below 15 mg/l can be achieved.

1.1.8. *Waste generation and management*

BAT 14. 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.

BAT 15. 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.

Technique	Description	Applicability
(i) Sludge pretreatment	Prior to final treatment (e.g. in a fluidised bed incinerator), the sludges are dewatered and/or de-oiled (by e.g. centrifugal decanters or steam dryers) to reduce their volume and to recover oil from slop equipment	Generally applicable
(ii) Reuse of sludge in process units	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	Applicability is restricted to sludges that can fulfil the requirements to be processed in units with appropriate treatment

BAT 16. In order to reduce the generation of spent solid catalyst waste, BAT is to use one or a combination of the techniques given below.

Technique	Description
(i) Spent solid catalyst management	Scheduled and safe handling of the materials used as catalyst (e.g. by contractors) in order to recover or reuse them in off-site facilities. These operations depend on the type of catalyst and process
(ii) Removal of catalyst from slurry decant oil	Decanted oil sludge from process units (e.g. FCC unit) can contain significant concentrations of catalyst fines. These fines need to be separated prior to the reuse of decant oil as a feedstock

1.1.9. *Noise*

BAT 17. 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.

1.1.10. *BAT conclusions for integrated refinery management*

BAT 18. In order to prevent or reduce diffuse VOC emissions, BAT is to apply the techniques given below.

Technique	Description	Applicability
[redacted] related to plant design	(i) limiting the number of potential emission sources (ii) maximising inherent process containment features (iii) selecting high integrity equipment (iv) facilitating monitoring and maintenance activities by ensuring access to potentially leaking components	Applicability may be limited for existing units
II. Techniques related to plant installation and commissioning	(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	Applicability may be limited for existing units
III. Techniques related to plant operation	Use of a risk-based leak detection and repair (LDAR) programme in order to identify leaking components, and to repair these leaks. See Section 1.20.6	Generally applicable

1.2. BAT conclusions for the alkylation process

1.2.1. *Hydrofluoric acid alkylation process*

BAT 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.

Applicability:

The technique is generally applicable. Safety requirements, due to the hazardous nature of hydrofluoric acid, are to be considered

BAT 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. a settlement basin	Generally applicable

1.2.2. *Sulphuric acid alkylation process*

BAT 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.

1.3. BAT conclusions for base oil production processes

BAT 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.

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	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

Technique	Description	Applicability
(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
(iv) Catalytic processes based on hydrogenation	Processes based on conversion of undesired compounds via catalytic hydrogenation similar to hydrotreatment. See Section 1.20.3 (Hydrotreatment)	Generally applicable to new units

1.4. BAT conclusions for the bitumen production process

BAT 23. 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.

Technique	Description	Applicability
(i) Thermal oxidation of gaseous overhead over 800 °C	See Section 1.20.6	Generally applicable for the bitumen blowing unit
(ii) Wet scrubbing of gaseous overhead	See Section 1.20.3	Generally applicable for the bitumen blowing unit

1.5. BAT conclusions for the fluid catalytic cracking process

BAT 24. 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.

2E or process-related techniques, such as:

Technique	Description	Applicability
Process optimisation and use of promoters or additives		
(i) Process optimisation	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	Generally applicable
(ii) Low-NO_X CO oxidation promoters	Use of a substance that selectively promotes the combustion of CO only and prevents the oxidation of the nitrogen that contains intermediates to NO_X: e.g. non-platinum promoters	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 benefit

Technique	Description	Applicability
(iii) Specific additives for NO_X reduction	Use of specific catalytic additives for enhancing the reduction of NO by CO	Applicable only in full combustion mode in an appropriate design and with achievable oxygen excess. The applicability of copper-based NO_X reduction additives may be limited by the gas compressor capacity

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

Technique	Description	Applicability
(i) Selective catalytic reduction (SCR)	See Section 1.20.2	To avoid potential fouling downstream, additional filtering might be required upstream of the SCR. For existing units, the applicability may be limited by space availability
(ii) Selective non-catalytic reduction (SNCR)	See Section 1.20.2	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
(iii) Low temperature oxidation	See Section 1.20.2	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

BAT-associated emission levels: See Table 4.

Table 4

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

Parameter	Type of unit/combustion mode	BAT-AEL (monthly average) mg/Nm³
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)

(¹) When antimony (Sb) injection is used for metal passivation, NO_X levels up to 700 mg/Nm³ may occur. The lower end of the range can be achieved by using the SCR technique.

The associated monitoring is in BAT 4.

BAT 25. 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.

[redacted] or process-related techniques, such as:

Technique	Description	Applicability
(i) Use of an attrition-resistant catalyst	Selection of catalyst substance that is able to resist abrasion and fragmentation in order to reduce dust emissions	Generally applicable provided the activity and selectivity of the catalyst are sufficient
(ii) Use of low sulphur feedstock (e.g. by feedstock selection or by hydrotreatment of feed)	Feedstock selection favours low sulphur feedstocks among the possible sources to be processed at the unit. Hydrotreatment aims at reducing the sulphur, nitrogen and metal contents of the feed. See Section 1.20.3	Requires sufficient availability of low sulphur feedstocks, hydrogen production and hydrogen sulphide (H_2S) treatment capacity (e.g. amine and Claus units)

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

Technique	Description	Applicability
(i) Electrostatic precipitator (ESP)	See Section 1.20.1	For existing units, the applicability may be limited by space availability
(ii) Multistage cyclone separators	See Section 1.20.1	Generally applicable
(iii) Third stage blowback filter	See Section 1.20.1	Applicability may be restricted
(iv) Wet scrubbing	See Section 1.20.3	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

BAT-associated emission levels: See Table 5.

Table 5

BAT-associated emission levels for dust emissions to air from the regenerator in the catalytic cracking process

Parameter	Type of unit	BAT-AEL (monthly average) (1) mg/Nm^3
Dust	New unit	10-25
	Existing unit	10-50 (2)

(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.

The associated monitoring is in BAT 4.

BAT 26. 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.

2E or process-related techniques, such as:

Technique	Description	Applicability
(i) Use of SO_X reducing catalyst additives	Use of a substance that transfers the sulphur associated with coke from the regenerator back to the reactor. See description in 1.20.3	Applicability may be restricted by regenerator conditions design. Requires appropriate hydrogen sulphide abatement capacity (e.g. SRU)
(ii) Use of low sulphur feedstock (e.g. by feedstock selection or by hydrotreatment of the feed)	Feedstock selection favours low sulphur feedstocks among the possible sources to be processed at the unit. Hydrotreatment aims at reducing the sulphur, nitrogen and metal contents of the feed. See description in 1.20.3	Requires sufficient availability of low sulphur feedstocks, hydrogen production and hydrogen sulphide (H_2S) treatment capacity (e.g. amine and Claus units)

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

Techniques	Description	Applicability
(i) Non-regenerative scrubbing	Wet scrubbing or seawater scrubbing. See Section 1.20.3	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
(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. See Section 1.20.3	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

BAT-associated emission levels: See Table 6.

Table 6

BAT-associated emission levels for SO_2 emissions to air from the regenerator in the catalytic cracking process

Parameter	Type of units/mode	BAT-AEL (monthly average) mg/Nm³
SO_2	New units	≤ 300
	Existing units/full combustion	< 100-800 (¹)
	Existing units/partial combustion	100-1 200 (¹)

(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/Nm³.

The associated monitoring is in BAT 4.

BAT 27. 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.

Technique	Description	Applicability
(i) Combustion operation control	See Section 1.20.5	Generally applicable
(ii) Catalysts with carbon monoxide (CO) oxidation promoters	See Section 1.20.5	Generally applicable only for full combustion mode
(iii) Carbon monoxide (CO) boiler	See Section 1.20.5	Generally applicable only for partial combustion mode

BAT-associated emission levels: See Table 7.

Table 7

BAT-associated emission levels for carbon monoxide emissions to air from the regenerator in the catalytic cracking process for partial combustion mode

Parameter	Combustion mode	BAT-AEL (monthly average) mg/Nm³
Carbon monoxide, expressed as CO	Partial combustion mode	≤ 100 (¹)

(¹) May not be achievable when not operating the CO boiler at full load.

The associated monitoring is in BAT 4.

1.6. BAT conclusions for the catalytic reforming process

BAT 28. 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.

Technique	Description	Applicability
(i) Choice of the catalyst promoter	Use of catalyst promoter in order to minimise polychlorinated dibenzo-dioxins/furans (PCDD/F) formation during regeneration. See Section 1.20.7	Generally applicable

(ii) Treatment of the regeneration flue-gas

Technique	Description	Applicability
a. Regeneration gas recycling loop with adsorption bed	Waste gas from the regeneration step is treated to remove chlorinated compounds (e.g. dioxins)	Generally applicable to new units. For existing units the applicability may depend on the current regeneration unit design
b. Wet scrubbing	See Section 1.20.3	Not applicable to semi-regenerative reformers
c. Electrostatic precipitator (ESP)	See Section 1.20.1	Not applicable to semi-regenerative reformers

1.7. BAT conclusions for the coking processes

BAT 29. 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:

Primary or process-related techniques, such as:

Technique	Description	Applicability
(i) Collection and recycling of coke fines	Systematic collection and recycling of coke fines generated during the whole coking process (drilling, handling, crushing, cooling, etc.)	Generally applicable
(ii) Handling and storage of coke according to BAT 3	See BAT 3	Generally applicable
(iii) Use of a closed blowdown system	Arrestment system for pressure relief from the coke drums	Generally applicable
(iv) Recovery of gas (including the venting prior to the drum being opened to atmosphere) as a component of refinery fuel gas (RFG)	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 H_2S) is needed prior to treating the gas from the coking unit	For existing units, the applicability of the techniques may be limited by space availability

BAT 30. 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.

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.

BAT 31. 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.

Technique	Description	Applicability
(i) Non-regenerative scrubbing	Wet scrubbing or seawater scrubbing. See Section 1.20.3	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
(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. See Section 1.20.3	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

BAT 32. 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.

Technique	Description	Applicability
(i) Electrostatic precipitator (ESP)	See Section 1.20.1	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
(ii) Multistage cyclone separators	See Section 1.20.1	Generally applicable

BAT-associated emission levels: See Table 8

Table 8

BAT-associated emission levels for dust emissions to air from a unit for the calcining of green coke

Parameter	BAT-AEL (monthly average) mg/Nm^3
Dust	10-50 (1) (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.

The associated monitoring is in BAT 4.

1.8. BAT conclusions for the desalting process

BAT 33. 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.

Technique	Description	Applicability
(i) Recycling water and optimisation of the desalting process	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, 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	Generally applicable
(ii) Multistage desalter	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	Applicable for new units
(iii) Additional separation step	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	Generally applicable

1.9. BAT conclusions for the combustion units

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.

[redacted] or process-related techniques, such as:

Technique	Description	Applicability
(i) Selection or treatment of fuel		
(a) Use of gas to replace liquid fuel	Gas generally contains less nitrogen than liquid and its combustion leads to a lower level of NO_X emissions. See Section 1.20.3	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
(b) Use of low nitrogen refinery fuel oil (RFO) e.g. by RFO selection or by hydrotreatment of RFO	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	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)

Technique	Description	Applicability
(ii) Combustion modifications		
(a) Staged combustion: — air staging — fuel staging	See Section 1.20.2	Fuel staging for mixed or liquid firing may require a specific burner design
(b) Optimisation of combustion	See Section 1.20.2	Generally applicable
(c) Flue-gas recirculation	See Section 1.20.2	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	Generally applicable for gas turbines where appropriate inert diluents are available
(e) Use of low-NO_X burners (LNB)	See Section 1.20.2	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 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 %)

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

Technique	Description	Applicability
(i) Selective catalytic reduction (SCR)	See Section 1.20.2	Generally applicable for new units. For existing units, the applicability may be constrained due to the requirements for significant space and optimal reactant injection
(ii) Selective non-catalytic reduction (SNCR)	See Section 1.20.2	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

Technique	Description	Applicability
(iii) Low temperature oxidation	See Section 1.20.2	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 limited by space availability
(iv) SNO_X combined technique	See Section 1.20.4	Applicable only for high flue-gas (e.g. > 800 000 Nm^3/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
NO_X expressed as NO_2	Gas turbine (including combined cycle gas turbine — CCGT) and integrated gasification combined cycle turbine (IGCC))	40-120 (existing 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.

The associated monitoring is in BAT 4.

Table 10

BAT-associated emission levels for NO_X emissions to air from a gas-fired combustion unit, with the exception of gas turbines

Parameter	Type of combustion	BAT-AEL (monthly average) mg/Nm^3
NO_X expressed as NO_2	Gas firing	30-150 for existing unit (1)
		30-100 for new unit

(1) For an existing unit using high air pre-heat (i.e. > 200 °C) or with H_2 content in the fuel gas higher than 50 %, the upper end of the BAT-AEL range is 200 mg/Nm^3.

The associated monitoring is in BAT 4.

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

Parameter	Type of combustion	BAT-AEL (monthly average) mg/Nm³
NO_X expressed as NO_2	Multi-fuel fired combustion unit	30-300 for existing unit (¹) (²)

(¹) For existing units < 100 MW firing fuel oil with a nitrogen content higher than 0,5 % (w/w) or with liquid firing > 50 % or using air preheating, values up to 450 mg/Nm³ may occur.

(²) The lower end of the range can be achieved by using the SCR technique.

The associated monitoring is in BAT 4.

BAT 35. 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.

[redacted] or process-related techniques, such as:

Technique	Description	Applicability
(i) Selection or treatment of fuel		
(a) Use of gas to replace liquid fuel	Gas instead of liquid combustion leads to lower level of dust emissions See Section 1.20.3	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
(b) Use of low sulphur refinery fuel oil (RFO) e.g. by RFO selection or by hydrotreatment of RFO	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	The applicability may be 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)
(ii) Combustion modifications		
(a) Optimisation of combustion	See Section 1.20.2	Generally applicable to all types of combustion
(b) Atomisation of liquid fuel	Use of high pressure to reduce the droplet size of liquid fuel. Recent optimal burner designs generally include steam atomisation	Generally applicable to liquid fuel firing

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

Technique	Description	Applicability
(i) Electrostatic precipitator (ESP)	See Section 1.20.1	For existing units, the applicability may be limited by space availability
(ii) Third stage blowback filter	See Section 1.20.1	Generally applicable
(iii) Wet scrubbing	See Section 1.20.3	The applicability may be limited in arid areas and in the case where the 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	Generally applicable

BAT-associated emission levels: See Table 12.

Table 12

BAT-associated emission levels for 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

(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.

BAT 36. 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.

[redacted] or process-related techniques based on a selection or a treatment of the fuel, such as:

Technique	Description	Applicability
(i) Use of gas to replace liquid fuel	See Section 1.20.3	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

Technique	Description	Applicability
(ii) Treatment of refinery fuel gas (RFG)	Residual H_2S concentration in RFG depends on the treatment process parameter, e.g. the amine-scrubbing pressure. See Section 1.20.3	For low calorific gas containing carbonyl sulphide (COS) e.g. from coking units, a converter may be required prior to H_2S removal
(iii) Use of low sulphur refinery fuel oil (RFO) e. g. by RFO selection or by hydrotreatment of RFO	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	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)

II. Secondary or end-of-pipe techniques:

Technique	Description	Applicability
(i) Non-regenerative scrubbing	Wet scrubbing or seawater scrubbing. See Section 1.20.3	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 of the technique may be limited by space availability
(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. See Section 1.20.3	The applicability is limited to the case where regenerated by-products can be sold. Retrofitting to existing units may be limited by the existing sulphur recovery capacity. For existing units, the applicability of the technique may be limited by space availability
(iii) SNO_X combined technique	See Section 1.20.4	Applicable only for high flue-gas (e.g. > 800 000 Nm^3/h) flow and when combined NO_X and SO_X abatement is required

BAT-associated emission levels: See Table 13 and Table 14.

Table 13

BAT-associated emission levels for SO_2 emissions to air from a combustion unit firing refinery fuel gas (RFG), with the exception of gas turbines

Parameter	BAT-AEL (monthly average) mg/Nm^3
SO_2	5-35 (¹)

(¹) In the specific configuration of RFG treatment with a low scrubber operative pressure and with a 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/Nm^3.

The associated monitoring is in BAT 4.

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 gas engines

This BAT-AEL refers to the weighted average emissions from existing multi-fuel fired combustion units within the refinery, with the exception of gas turbines and stationary gas engines.

Parameter	BAT-AEL (monthly average) mg/Nm^3
SO_2	35-600

The associated monitoring is in BAT 4.

BAT 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.

BAT-associated emission levels: See Table 15.

Table 15

BAT-associated emission levels for carbon monoxide emissions to air from a combustion unit

Parameter	BAT-AEL (monthly average) mg/Nm^3
Carbon monoxide, expressed as CO	≤ 100

The associated monitoring is in BAT 4.

1.10. BAT conclusions for the etherification process

BAT 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.

BAT 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.

1.11. BAT conclusions for the isomerisation process

BAT 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.

1.12. BAT conclusions for the natural gas refinery

BAT 41. In order to reduce sulphur dioxide emissions to air from the natural gas plant, BAT is to apply BAT 54.

BAT 42. In order to reduce nitrogen oxides (NO_X) emissions to air from the natural gas plant, BAT is to apply BAT 34

BAT 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.

1.13. BAT conclusions for the distillation process

BAT 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 steam ejectors, may be needed to achieve a high vacuum (10 mm Hg). Also, a spare should be available in case the vacuum pump fails.

BAT 45. In order to prevent or reduce water pollution from the distillation process, BAT is to route sour water to the stripping unit.

BAT 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 stand-alone lubricant and bitumen 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.

1.14. BAT conclusions for the products treatment process

BAT 47. 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.

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.

BAT 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.

1.15. BAT conclusions for storage and handling processes

BAT 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.

BAT 50. 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.

Technique	Description	Applicability
(i) Manual crude oil tank cleaning	Oil tank cleaning is performed by workers entering the tank and removing sludge manually	Generally applicable
(ii) Use of a closed-loop system	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	The applicability may be limited by e.g. the type of residues, tank roof construction or tank materials

BAT 51. 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.

Technique	Description	Applicability
(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 overhaul of existing tanks (1)
(iii) Impervious membrane liners	A continuous leak barrier under the entire bottom surface of the tank	Generally applicable for new tanks and after an overhaul of existing tanks (1)

Technique	Description	Applicability
(iv) Sufficient tank farm bund containment	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	Generally applicable

(1) Techniques ii and iii may not 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.

BAT 52. 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 %.

Technique	Description	Applicability (1)
Vapour recovery by: (i) Condensation (ii) Absorption (iii) Adsorption (iv) Membrane separation (v) Hybrid systems	See Section 1.20.6	Generally applicable to loading/unloading operations where annual throughput is > 5 000 m^3/yr. Not applicable to loading/unloading operations for sea-going vessels with an annual throughput < 1 million m^3/yr

(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.

BAT-associated emission levels: See Table 16.

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

Parameter	BAT-AEL (hourly average) (1)
NMVOC	0,15-10 g/Nm^3 (2) (3)
Benzene (3)	< 1 mg/Nm^3

(1) Hourly values in continuous operation expressed and measured according to European Parliament and Council Directive 94/63/EC (OJ L 365, 31.12.1994, p. 24).
(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.

1.16. BAT conclusions for visbreaking and other thermal processes

BAT 53. 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.

1.17. BAT conclusions for waste gas sulphur treatment

BAT 54. 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.

Technique	Description	Applicability (1)
(i) Acid gas removal e.g. by amine treating	See Section 1.20.3	Generally applicable
(ii) Sulphur recovery unit (SRU), e.g. by Claus process	See Section 1.20.3	Generally applicable
(iii) Tail gas treatment unit (TGTU)	See Section 1.20.3	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

(1) May not be applicable for stand-alone lubricant or bitumen refineries with a release of sulphur compounds of less than 1 t/d

BAT-associated environmental performance levels (BAT-AEPL): See Table 17.

Table 17

BAT-associated environmental performance levels for a waste gas sulphur (H_2S) recovery system

	BAT-associated environmental performance level (monthly average)
Acid gas removal	Achieve hydrogen sulphides (H_2S) removal in the treated RFG in order to meet gas firing BAT-AEL for BAT 36
Sulphur recovery efficiency (1)	New unit: 99,5 – > 99,9 %
	Existing unit: ≥ 98,5 %

(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 pits.
When the applied technique does not include a recovery of sulphur (e.g. seawater scrubber), it refers to the sulphur removal efficiency, as the % of sulphur removed by the whole treatment chain.

The associated monitoring is described in BAT 4.

1.18. BAT conclusions for flares

BAT 55. 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).

BAT 56. In order to reduce emissions to air from flares when flaring is unavoidable, BAT is to use the techniques given below.

Technique	Description	Applicability
(i) Correct plant design	See Section 1.20.7	Applicable to new units. Flare gas recovery system may be retrofitted in existing units
(ii) Plant management	See Section 1.20.7	Generally applicable
(iii) Correct flaring devices design	See Section 1.20.7	Applicable to new units
(iv) Monitoring and reporting	See Section 1.20.7	Generally applicable

1.19. BAT conclusions for integrated emission management

BAT 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.

Description

The technique consists of managing NO_X 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 NO_x emissions to air when applying BAT 57

The BAT-AEL for NO_x emissions from the units concerned by BAT 57, expressed in mg/Nm^3 as a monthly average value, is equal to or less than the weighted average of the NO_x 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:

(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:

$$\frac{\Sigma\left[(\text{flue gas flow rate of the unit concerned}) \times (\text{NO}_X \text{ concentration that would be achieved for that unit})\right]}{\Sigma(\text{flue gas flow rate of all units concerned})}$$

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.

Monitoring associated with BAT 57

BAT for monitoring emissions of NO_x 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.

BAT 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 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 levels for SO_2 emissions to air when applying BAT 58

The BAT-AEL for SO_2 emissions from the units concerned by BAT 58, expressed in mg/Nm^3 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:

(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:

$$\frac{\Sigma\left[(\text{flue gas flow rate of the unit concerned}) \times (SO_2\ \text{concentration that would be achieved for that unit})\right]}{\Sigma(\text{flue gas flow rate of all units concerned})}$$

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.

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.

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.

Technique	Description
	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

1.20.2. *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-NO_X 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

Technique	Description
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 NO_X 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

Technique	Description
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)

Technique	Description
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 (SO_x, NO_x and dust)*

Technique	Description
Wet scrubbing	See Section 1.20.3
SNO_X combined technique	Combined technique to remove SO_X, NO_X 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	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)*

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 handheld 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 avoid dioxins formation	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 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.

RDCG (Rotterdam Capacity Growth) – DEFINITION PHASE
NESTE

ATTACHMENT 2

BEST AVAILABLE TECHNIQUES (BAT) CONCLUSIONS FOR COMMON WASTE WATER AND WASTE GAS TREATMENT/ MANAGEMENT SYSTEMS IN THE CHEMICAL SECTOR

(20 sheets)

DECISIONS

COMMISSION IMPLEMENTING DECISION (EU) 2016/902

of 30 May 2016

establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for common waste water and waste gas treatment/management systems in the chemical sector

(notified under document C(2016) 3127)

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (1), and in particular Article 13(5) thereof,

Whereas:

(1) Best available techniques (BAT) conclusions are the reference for setting permit conditions for installations covered by Chapter II of Directive 2010/75/EU. The competent authorities should set emission limit values which ensure that, under normal operating conditions, emissions do not exceed the emission levels associated with the best available techniques as laid down in the BAT conclusions.

(2) The forum composed of representatives of Member States, the industries concerned and non-governmental organisations promoting environmental protection, established by Commission Decision of 16 May 2011 (2), provided the Commission with its opinion on the proposed content of the BAT reference document on 24 September 2014. That opinion is publicly available.

(3) The BAT conclusions set out in the Annex to this Decision are the key element of that BAT reference document.

(4) The measures provided for in this Decision are in accordance with the opinion of the Committee established by Article 75(1) of Directive 2010/75/EU,

HAS ADOPTED THIS DECISION:

Article 1

The best available techniques (BAT) conclusions for common waste water and waste gas treatment/management systems in the chemical sector, as set out in the Annex, are adopted.

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(1) OJ L 334, 17.12.2010, p. 17.

(2) OJ C 146, 17.5.2011, p. 3.

Article 2

This Decision is addressed to the Member States.

Done at Brussels, 30 May 2016.

For the Commission

Karmenu VELLA

Member of the Commission

ANNEX

BEST AVAILABLE TECHNIQUES (BAT) CONCLUSIONS FOR COMMON WASTE WATER/WASTE GAS TREATMENT/MANAGEMENT SYSTEMS IN THE CHEMICAL SECTOR

SCOPE

These BAT conclusions concern the activities specified in Sections 4 and 6.11 of Annex I to Directive 2010/75/EU, namely:

- Section 4: Chemical industry;
- Section 6.11: Independently operated treatment of waste water not covered by Council Directive 91/271/EEC and discharged by an installation undertaking activities covered under Section 4 of Annex I to Directive 2010/75/EU.

These BAT conclusions also cover the combined treatment of waste water from different origins if the main pollutant load originates from the activities covered under Section 4 of Annex I to Directive 2010/75/EU.

In particular, these BAT conclusions cover the following issues:

- environmental management systems;
- water saving;
- waste water management, collection and treatment;
- waste management;
- treatment of waste water sludge with the exception of incineration;
- waste gas management, collection and treatment;
- flaring;
- diffuse emissions of volatile organic compounds (VOC) to air;
- odour emissions;
- noise emissions.

Other BAT conclusions and reference documents which could be relevant for the activities covered by these BAT conclusions are the following:

- Production of Chlor-alkali (CAK);
- Manufacture of Large Volume Inorganic Chemicals — Ammonia, Acids and Fertilisers (LVIC-AAF);
- Manufacture of Large Volume Inorganic Chemicals — Solids and Others Industry (LVIC-S);
- Production of Speciality Inorganic Chemicals (SIC);
- Large Volume Organic Chemical Industry (LVOC);
- Manufacture of Organic Fine Chemicals (OFC);
- Production of Polymers (POL);
- Emissions from Storage (EFS);
- Energy Efficiency (ENE);
- Monitoring of Emissions to Air and Water from IED installations (ROM);
- Industrial Cooling Systems (ICS);

— Large Combustion Plants (LCP);

— Waste Incineration (WI);

— Waste Treatments Industries (WT);

— Economics and Cross-media Effects (ECM).

GENERAL CONSIDERATIONS

Best Available Techniques

The techniques listed and described in these BAT conclusions are neither prescriptive nor exhaustive. Other techniques may be used that ensure at least an equivalent level of environmental protection.

Unless otherwise stated, the BAT conclusions are generally applicable.

Emission levels associated with BAT

Emission levels associated with the best available techniques (BAT-AELs) for emissions to water given in these BAT conclusions refer to values of concentrations (mass of emitted substances per volume of water), expressed in µg/l or mg/l.

Unless otherwise stated, the BAT-AELs refer to flow-weighted yearly averages of 24-hour flow-proportional composite samples, taken with the minimum frequency set for the relevant parameter and under normal operating conditions. Time-proportional sampling can be used provided that sufficient flow stability is demonstrated.

The flow-weighted yearly average concentration of the parameter (c_w) is calculated using the following equation:

$$c_w = \sum_{i=1}^{n} c_i q_i / \sum_{i=1}^{n} q_i$$

Where

n = number of measurements;

c_i = average concentration of the parameter during ith measurement;

q_i = average flow rate during ith measurement.

Abatement efficiencies

In the case of total organic carbon (TOC), chemical oxygen demand (COD), total nitrogen (TN) and total inorganic nitrogen (N_{inorg}), the calculation of the average abatement efficiency referred to in these BAT conclusions (see Table 1 and Table 2) is based on loads and includes both pretreatment (BAT 10 c) and final treatment (BAT 10 d) of waste water.

DEFINITIONS

For the purposes of these BAT conclusions, the following definitions apply:

Term used	Definition
New plant	A plant first permitted at the site of the installation following the publication of these BAT conclusions or a complete replacement of a plant following the publication of these BAT conclusions.
Existing plant	A plant that is not a new plant.

Term used	Definition
Biochemical oxygen demand (BOD_5)	Amount of oxygen needed for the biochemical oxidation of the organic matter to carbon dioxide in 5 days. BOD is an indicator for the mass concentration of biodegradable organic compounds.
Chemical oxygen demand (COD)	Amount of oxygen needed for the total oxidation of the organic matter to carbon dioxide. COD is an indicator for the mass concentration of organic compounds.
Total organic carbon (TOC)	Total organic carbon, expressed as C, includes all organic compounds.
Total suspended solids (TSS)	Mass concentration of all suspended solids, measured via filtration through glass fibre filters and gravimetry.
Total nitrogen (TN)	Total nitrogen, expressed as N, includes free ammonia and ammonium (NH_4-N), nitrites (NO_2-N), nitrates (NO_3-N) and organic nitrogen compounds.
Total inorganic nitrogen (N_{inorg})	Total inorganic nitrogen, expressed as N, includes free ammonia and ammonium (NH_4-N), nitrites (NO_2-N) and nitrates (NO_3-N).
Total phosphorus (TP)	Total phosphorus, expressed as P, includes all inorganic and organic phosphorus compounds, dissolved or bound to particles.
Adsorbable organically bound halogens (AOX)	Adsorbable organically bound halogens, expressed as Cl, include adsorbable organically bound chlorine, bromine and iodine.
Chromium (Cr)	Chromium, expressed as Cr, includes all inorganic and organic chromium compounds, dissolved or bound to particles.
Copper (Cu)	Copper, expressed as Cu, includes all inorganic and organic copper compounds, dissolved or bound to particles.
Nickel (Ni)	Nickel, expressed as Ni, includes all inorganic and organic nickel compounds, dissolved or bound to particles.
Zinc (Zn)	Zinc, expressed as Zn, includes all inorganic and organic zinc compounds, dissolved or bound to particles.
VOC	Volatile organic compounds as defined in Article 3(45) of Directive 2010/75/EU.
Diffuse VOC emissions	Non-channelled VOC emissions which can result from 'area' sources (e.g. tanks) or 'point' sources (e.g. pipe flanges).
Fugitive VOC emissions	Diffuse VOC emissions from 'point' sources.
Flaring	High-temperature oxidation to burn combustible compounds of waste gases from industrial operations with an open flame. Flaring is primarily used for burning off flammable gas for safety reasons or during non-routine operational conditions.

1. **Environmental management systems**

BAT 1. In order to improve the overall environmental performance, 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) 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 paying particular attention to:

  (a) structure and responsibility;

  (b) recruitment, training, awareness and competence;

  (c) communication;

  (d) employee involvement;

  (e) documentation;

  (f) effective 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 Report on Monitoring of emissions to Air and Water from IED installations — ROM);

  (b) corrective and preventive action;

  (c) maintenance of records;

  (d) independent (where practicable) internal or 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;

(vii) following the development of cleaner technologies;

(viii) consideration for the environmental impacts from the eventual decommissioning of the plant at the design stage of a new plant, and throughout its operating life;

(ix) application of sectoral benchmarking on a regular basis;

(x) waste management plan (see BAT 13).

Specifically for chemical sector activities, BAT is to incorporate the following features in the EMS:

(xi) on multi-operator installations/sites, establishment of a convention that sets out the roles, responsibilities and coordination of operating procedures of each plant operator in order to enhance the cooperation between the various operators;

(xii) establishment of inventories of waste water and waste gas streams (see BAT 2).

In some cases, the following features are part of the EMS:

(xiii) odour management plan (see BAT 20);

(xiv) noise management plan (see BAT 22).

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.

BAT 2. In order to facilitate the reduction of emissions to water and air and the reduction of water usage, BAT is to establish and to maintain an inventory of waste water and waste gas streams, as part of the environmental management system (see BAT 1), that incorporates all of the following features:

(i) information about the chemical production processes, including:

  (a) chemical reaction equations, also showing side products;

  (b) simplified process flow sheets that show the origin of the emissions;

  (c) descriptions of process-integrated techniques and waste water/waste gas treatment at source including their performances;

(ii) information, as comprehensive as is reasonably possible, about the characteristics of the waste water streams, such as:

  (a) average values and variability of flow, pH, temperature, and conductivity;

  (b) average concentration and load values of relevant pollutants/parameters and their variability (e.g. COD/TOC, nitrogen species, phosphorus, metals, salts, specific organic compounds);

  (c) data on bioeliminability (e.g. BOD, BOD/COD ratio, Zahn-Wellens test, biological inhibition potential (e.g. nitrification));

(iii) information, as comprehensive as is reasonably possible, about the characteristics of the waste gas streams, such as:

  (a) average values and variability of flow and temperature;

  (b) average concentration and load values of relevant pollutants/parameters and their variability (e.g. VOC, CO, NO_X, SO_X, chlorine, hydrogen chloride);

  (c) flammability, lower and higher explosive limits, reactivity;

  (d) presence of other substances that may affect the waste gas treatment system or plant safety (e.g. oxygen, nitrogen, water vapour, dust).

2. **Monitoring**

BAT 3. For relevant emissions to water as identified by the inventory of waste water streams (see BAT 2), BAT is to monitor key process parameters (including continuous monitoring of waste water flow, pH and temperature) at key locations (e.g. influent to pretreatment and influent to final treatment).

BAT 4. BAT is to monitor emissions to water in accordance with EN standards with at least the minimum frequency given below. 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.

Substance/parameter	Standard(s)	Minimum monitoring frequency (1) (2)
Total organic carbon (TOC) (3)	EN 1484	Daily
Chemical oxygen demand (COD) (3)	No EN standard available	
Total suspended solids (TSS)	EN 872	
Total nitrogen (TN) (4)	EN 12260	
Total inorganic nitrogen (N_{inorg}) (4)	Various EN standards available	
Total phosphorus (TP)	Various EN standards available	

Substance/parameter		Standard(s)	Minimum monitoring frequency (1) (2)
Adsorbable organically bound halogens (AOX)		EN ISO 9562	Monthly
Metals	Cr	Various EN standards available	
	Cu		
	Ni		
	Pb		
	Zn		
	Other metals, if relevant		
Toxicity (5)	Fish eggs (*Danio rerio*)	EN ISO 15088	To be decided based on a risk assessment, after an initial characterisation
	Daphnia (*Daphnia magna Straus*)	EN ISO 6341	
	Luminescent bacteria (*Vibrio fischeri*)	EN ISO 11348-1, EN ISO 11348-2 or EN ISO 11348-3	
	Duckweed (*Lemna minor*)	EN ISO 20079	
	Algae	EN ISO 8692, EN ISO 10253 or EN ISO 10710	

(1) Monitoring frequencies may be adapted if the data series clearly demonstrate a sufficient stability.
(2) The sampling point is located where the emission leaves the installation.
(3) TOC monitoring and COD monitoring are alternatives. TOC monitoring is the preferred option because it does not rely on the use of very toxic compounds.
(4) TN and N_{inorg} monitoring are alternatives.
(5) An appropriate combination of these methods can be used.

BAT 5. BAT is to periodically monitor diffuse VOC emissions to air from relevant sources by using an appropriate combination of the techniques I-III or, where large amounts of VOC are handled, all of the techniques I-III.

I. sniffing methods (e.g. with portable instruments according to EN 15446) associated with correlation curves for key equipment;

II. optical gas imaging methods;

III. calculation of emissions based on emissions factors, periodically validated (e.g. once every two years) by measurements.

Where large amounts of VOCs are handled, the screening and quantification of emissions from the installation 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 to the techniques I to III.

Description

See Section 6.2.

BAT 6. BAT is to periodically monitor odour emissions from relevant sources in accordance with EN standards.

Description

Emissions can be monitored by dynamic olfactometry according to EN 13725. Emission monitoring may be complemented by measurement/estimation of odour exposure or estimation of odour impact.

Applicability

The applicability is restricted to cases where odour nuisance can be expected or has been substantiated.

3. **Emissions to water**

3.1. *Water usage and waste water generation*

BAT 7. In order to reduce the usage of water and the generation of waste water, BAT is to reduce the volume and/or pollutant load of waste water streams, to enhance the reuse of waste water within the production process and to recover and reuse raw materials.

3.2. *Waste water collection and segregation*

BAT 8. In order to prevent the contamination of uncontaminated water and to reduce emissions to water, BAT is to segregate uncontaminated waste water streams from waste water streams that require treatment.

Applicability

The segregation of uncontaminated rainwater may not be applicable in the case of existing waste water collection systems.

BAT 9. In order to prevent uncontrolled emissions to water, BAT is to provide an appropriate buffer storage capacity for waste water incurred during other than normal operating conditions based on a risk assessment (taking into account e.g. the nature of the pollutant, the effects on further treatment, and the receiving environment), and to take appropriate further measures (e.g. control, treat, reuse).

Applicability

The interim storage of contaminated rainwater requires segregation, which may not be applicable in the case of existing waste water collection systems.

3.3. *Waste water treatment*

BAT 10. In order to reduce emissions to water, BAT is to use an integrated waste water management and treatment strategy that includes an appropriate combination of the techniques in the priority order given below.

	Technique	Description
(a)	Process-integrated techniques (1)	Techniques to prevent or reduce the generation of water pollutants.
(b)	Recovery of pollutants at source (1)	Techniques to recover pollutants prior to their discharge to the waste water collection system.

	Technique	Description
(c)	Waste water pretreatment (¹) (²)	Techniques to abate pollutants before the final waste water treatment. Pretreatment can be carried out at the source or in combined streams.
(d)	Final waste water treatment (³)	Final waste water treatment by, for example, preliminary and primary treatment, biological treatment, nitrogen removal, phosphorus removal and/or final solids removal techniques before discharge to a receiving water body.

(¹) These techniques are further described and defined in other BAT conclusions for the chemical industry.
(²) See BAT 11.
(³) See BAT 12.

Description

The integrated waste water management and treatment strategy is based on the inventory of waste water streams (see BAT 2).

BAT-associated emission levels (BAT-AELs): see Section 3.4.

BAT 11. In order to reduce emissions to water, BAT is to pretreat waste water that contains pollutants that cannot be dealt with adequately during final waste water treatment by using appropriate techniques.

Description

Waste water pretreatment is carried out as part of an integrated waste water management and treatment strategy (see BAT 10) and is generally necessary to:

— protect the final waste water treatment plant (e.g. protection of a biological treatment plant against inhibitory or toxic compounds);

— remove compounds that are insufficiently abated during final treatment (e.g. toxic compounds, poorly/non-biodegradable organic compounds, organic compounds that are present in high concentrations, or metals during biological treatment);

— remove compounds that are otherwise stripped to air from the collection system or during final treatment (e.g. volatile halogenated organic compounds, benzene);

— remove compounds that have other negative effects (e.g. corrosion of equipment; unwanted reaction with other substances; contamination of waste water sludge).

In general, pretreatment is carried out as close as possible to the source in order to avoid dilution, in particular for metals. Sometimes, waste water streams with appropriate characteristics can be segregated and collected in order to undergo a dedicated combined pretreatment.

BAT 12. In order to reduce emissions to water, BAT is to use an appropriate combination of final waste water treatment techniques.

Description

Final waste water treatment is carried out as part of an integrated waste water management and treatment strategy (see BAT 10).

Appropriate final waste water treatment techniques, depending on the pollutant, include:

	Technique [1]	Typical pollutants abated	Applicability
Preliminary and primary treatment			
(a)	Equalisation	All pollutants	Generally applicable.
(b)	Neutralisation	Acids, alkalis	
(c)	Physical separation, e.g. screens, sieves, grit separators, grease separators or primary settlement tanks	Suspended solids, oil/grease	
Biological treatment (secondary treatment), e.g.			
(d)	Activated sludge process	Biodegradable organic compounds	Generally applicable.
(e)	Membrane bioreactor		
Nitrogen removal			
(f)	Nitrification/denitrification	Total nitrogen, ammonia	Nitrification may not be applicable in case of high chloride concentrations (i.e. around 10 g/l) and provided that the reduction of the chloride concentration prior to nitrification would not be justified by the environmental benefits. Not applicable when the final treatment does not include a biological treatment.
Phosphorus removal			
(g)	Chemical precipitation	Phosphorus	Generally applicable.
Final solids removal			
(h)	Coagulation and flocculation	Suspended solids	Generally applicable.
(i)	Sedimentation		
(j)	Filtration (e.g. sand filtration, microfiltration, ultrafiltration)		
(k)	Flotation		

[1] The descriptions of the techniques are given in Section 6.1.

3.4. *BAT-associated emission levels for emissions to water*

The BAT-associated emission levels (BAT-AELs), for emissions to water given in Table 1, Table 2 and Table 3 apply to direct emissions to a receiving water body from:

(i) the activities specified in Section 4 of Annex I to Directive 2010/75/EU;

(ii) independently operated waste water treatment plants specified in Section 6.11 of Annex I to Directive 2010/75/EU provided that the main pollutant load originates from activities specified in Section 4 of Annex I to Directive 2010/75/EU;

(iii) the combined treatment of waste water from different origins provided that the main pollutant load originates from activities specified in Section 4 of Annex I to Directive 2010/75/EU.

The BAT-AELs apply at the point where the emission leaves the installation.

Table 1

BAT-AELs for direct emissions of TOC, COD and TSS to a receiving water body

Parameter	BAT-AEL (yearly average)	Conditions
Total organic carbon (TOC) (1) (2)	10-33 mg/l (3) (4) (5) (6)	The BAT-AEL applies if the emission exceeds 3,3 t/yr.
Chemical oxygen demand (COD) (1) (2)	30-100 mg/l (3) (4) (5) (6)	The BAT-AEL applies if the emission exceeds 10 t/yr.
Total suspended solids (TSS)	5,0-35 mg/l (7) (8)	The BAT-AEL applies if the emission exceeds 3,5 t/yr.

(1) No BAT-AEL applies for Biochemical oxygen demand (BOD). As an indication, the yearly average BOD_5 level in the effluent from a biological waste water treatment plant will generally be ≤ 20 mg/l.

(2) Either the BAT-AEL for TOC or the BAT-AEL for COD applies. TOC is the preferred option because its monitoring does not rely on the use of very toxic compounds.

(3) The lower end of the range is typically achieved when few tributary waste water streams contain organic compounds and/or the waste water mostly contains easily biodegradable organic compounds.

(4) The upper end of the range may be up to 100 mg/l for TOC or up to 300 mg/l for COD, both as yearly averages, if both of the following conditions are fulfilled:
- Condition A: Abatement efficiency ≥ 90 % as a yearly average (including both pretreatment and final treatment).
- Condition B: If a biological treatment is used, at least one of the following criteria is met:
  - A low-loaded biological treatment step is used (i.e. ≤ 0,25 kg COD/kg of organic dry matter of sludge). This implies that the BOD_5 level in the effluent is ≤ 20 mg/l.
  - Nitrification is used.

(5) The upper end of the range may not apply if all of the following conditions are fulfilled:
- Condition A: Abatement efficiency ≥ 95 % as a yearly average (including both pretreatment and final treatment).
- Condition B: same as Condition B in footnote (4).
- Condition C: The influent to the final waste water treatment shows the following characteristics: TOC > 2 g/l (or COD > 6 g/l) as a yearly average and a high proportion of refractory organic compounds.

(6) The upper end of the range may not apply when the main pollutant load originates from the production of methylcellulose.

(7) The lower end of the range is typically achieved when using filtration (e.g. sand filtration, microfiltration, ultrafiltration, membrane bioreactor), while the upper end of the range is typically achieved when using sedimentation only.

(8) This BAT-AEL may not apply when the main pollutant load originates from the production of soda ash via the Solvay process or from the production of titanium dioxide.

Table 2

BAT-AELs for direct emissions of nutrients to a receiving water body

Parameter	BAT-AEL (yearly average)	Conditions
Total nitrogen (TN) (1)	5,0-25 mg/l (2) (3)	The BAT-AEL applies if the emission exceeds 2,5 t/yr.
Total inorganic nitrogen (N_{inorg}) (1)	5,0-20 mg/l (2) (3)	The BAT-AEL applies if the emission exceeds 2,0 t/yr.
Total phosphorus (TP)	0,50-3,0 mg/l (4)	The BAT-AEL applies if the emission exceeds 300 kg/yr.

(1) Either the BAT-AEL for total nitrogen or the BAT-AEL for total inorganic nitrogen applies.

(2) The BAT-AELs for TN and N_{inorg} do not apply to installations without biological waste water treatment. The lower end of the range is typically achieved when the influent to the biological waste water treatment plant contains low levels of nitrogen and/or when nitrification/denitrification can be operated under optimum conditions.

(3) The upper end of the range may be higher and up to 40 mg/l for TN or 35 mg/l for N_{inorg}, both as yearly averages, if the abatement efficiency is ≥ 70 % as a yearly average (including both pretreatment and final treatment).

(4) The lower end of the range is typically achieved when phosphorus is added for the proper operation of the biological waste water treatment plant or when phosphorus mainly originates from heating or cooling systems. The upper end of the range is typically achieved when phosphorus-containing compounds are produced by the installation.

Table 3

BAT-AELs for direct emission of AOX and metals to a receiving water body

Parameter	BAT-AEL (yearly average)	Conditions
Adsorbable organically bound halogens (AOX)	0,20-1,0 mg/l (1) (2)	The BAT-AEL applies if the emission exceeds 100 kg/yr.
Chromium (expressed as Cr)	5,0-25 μg/l (3) (4) (5) (6)	The BAT-AEL applies if the emission exceeds 2,5 kg/yr.
Copper (expressed as Cu)	5,0-50 μg/l (3) (4) (5) (7)	The BAT-AEL applies if the emission exceeds 5,0 kg/yr.
Nickel (expressed as Ni)	5,0-50 μg/l (3) (4) (5)	The BAT-AEL applies if the emission exceeds 5,0 kg/yr.
Zinc (expressed as Zn)	20-300 μg/l (3) (4) (5) (8)	The BAT-AEL applies if the emission exceeds 30 kg/yr.

(1) The lower end of the range is typically achieved when few halogenated organic compounds are used or produced by the installation.

(2) This BAT-AEL may not apply when the main pollutant load originates from the production of iodinated X-ray contrast agents due to the high refractory loads. This BAT-AEL may also not apply when the main pollutant load originates from the production of propylene oxide or epichlorohydrin via the chlorohydrin process due to the high loads.

(3) The lower end of the range is typically achieved when few of the corresponding metal (compounds) are used or produced by the installation.

(4) This BAT-AEL may not apply to inorganic effluents when the main pollutant load originates from the production of inorganic heavy metal compounds.

(5) This BAT-AEL may not apply when the main pollutant load originates from the processing of large volumes of solid inorganic raw materials that are contaminated with metals (e.g. soda ash from the Solvay process, titanium dioxide).

(6) This BAT-AEL may not apply when the main pollutant load originates from the production of chromium-organic compounds.

(7) This BAT-AEL may not apply when the main pollutant load originates from the production of copper-organic compounds or the production of vinyl chloride monomer/ethylene dichloride via the oxychlorination process.

(8) This BAT-AEL may not apply when the main pollutant load originates from the production of viscose fibres.

The associated monitoring is in BAT 4.

4. **Waste**

BAT 13. In order to prevent or, where this is not practicable, to reduce the quantity of waste being sent for disposal, BAT is to set up and implement a waste management plan as part of the environmental management system (see BAT 1) that, in order of priority, ensures that waste is prevented, prepared for reuse, recycled or otherwise recovered.

BAT 14. In order to reduce the volume of waste water sludge requiring further treatment or disposal, and to reduce its potential environmental impact, BAT is to use one or a combination of the techniques given below.

	Technique	Description	Applicability
(a)	Conditioning	Chemical conditioning (i.e. adding coagulants and/or flocculants) or thermal conditioning (i.e. heating) to improve the conditions during sludge thickening/dewatering.	Not applicable to inorganic sludges. The necessity for conditioning depends on the sludge properties and on the thickening/dewatering equipment used.
(b)	Thickening/dewatering	Thickening can be carried out by sedimentation, centrifugation, flotation, gravity belts, or rotary drums. Dewatering can be carried out by belt filter presses or plate filter presses.	Generally applicable.
(c)	Stabilisation	Sludge stabilisation includes chemical treatment, thermal treatment, aerobic digestion, or anaerobic digestion.	Not applicable to inorganic sludges. Not applicable for short-term handling before final treatment.
(d)	Drying	Sludge is dried by direct or indirect contact with a heat source.	Not applicable to cases where waste heat is not available or cannot be used.

5. **Emissions to air**

5.1. *Waste gas collection*

BAT 15. In order to facilitate the recovery of compounds and the reduction of emissions to air, BAT is to enclose the emission sources and to treat the emissions, where possible.

Applicability

The applicability may be restricted by concerns on operability (access to equipment), safety (avoiding concentrations close to the lower explosive limit) and health (where operator access is required inside the enclosure).

5.2. *Waste gas treatment*

BAT 16. In order to reduce emissions to air, BAT is to use an integrated waste gas management and treatment strategy that includes process-integrated and waste gas treatment techniques.

Description

The integrated waste gas management and treatment strategy is based on the inventory of waste gas streams (see BAT 2) giving priority to process-integrated techniques.

5.3. *Flaring*

BAT 17. In order to prevent emissions to air from flares, BAT is to use flaring only for safety reasons or non-routine operational conditions (e.g. start-ups, shutdowns) by using one or both of the techniques given below.

	Technique	Description	Applicability
(a)	Correct plant design	This includes the provision of a gas recovery system with sufficient capacity and the use of high-integrity relief valves.	Generally applicable to new plants. Gas recovery systems may be retrofitted in existing plants.
(b)	Plant management	This includes balancing the fuel gas system and using advanced process control.	Generally applicable.

BAT 18. In order to reduce emissions to air from flares when flaring is unavoidable, BAT is to use one or both of the techniques given below.

	Technique	Description	Applicability
(a)	Correct design of flaring devices	Optimisation of height, pressure, assistance by steam, air or gas, type of flare tips (either enclosed or shielded), etc., aimed to enable smokeless and reliable operation and to ensure the efficient combustion of excess gases.	Applicable to new flares. In existing plants, applicability may be restricted due to e.g. maintenance time availability during the turnaround of the plant.
(b)	Monitoring and recording as part of flare management	Continuous monitoring of the gas sent to flaring, measurements of gas flow and estimations of other parameters (e.g. composition, heat content, ratio of assistance, velocity, purge gas flow rate, pollutant emissions (e.g. NO_X, CO, hydrocarbons, noise)). The recording of flaring events usually includes the estimated/measured flare gas composition, the estimated/measured flare gas quantity and the duration of operation. The recording allows for the quantification of emissions and the potential prevention of future flaring events.	Generally applicable.

5.4. *Diffuse VOC emissions*

BAT 19. In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to use a combination of the techniques given below.

	Technique	Applicability
Techniques related to plant design		
(a)	Limit the number of potential emission sources	Applicability may be restricted in the case of existing plants due to operability requirements.
(b)	Maximise process-inherent containment features	
(c)	Select high-integrity equipment (see the description in Section 6.2)	
(d)	Facilitate maintenance activities by ensuring access to potentially leaky equipment	

	Technique	Applicability
Techniques related to plant/equipment construction, assembly and commissioning		
(e)	Ensure well-defined and comprehensive procedures for plant/equipment construction and assembly. This includes using the designed gasket stress for flanged joint assembly (see the description in Section 6.2)	Generally applicable.
(f)	Ensure robust plant/equipment commissioning and handover procedures in line with the design requirements	
Techniques related to plant operation		
(g)	Ensure good maintenance and timely replacement of equipment	Generally applicable.
(h)	Use a risk-based leak detection and repair (LDAR) programme (see the description in Section 6.2)	
(i)	As far as it is reasonable, prevent diffuse VOC emissions, collect them at source, and treat them	

The associated monitoring is in BAT 5.

5.5. *Odour emissions*

BAT 20. In order to prevent or, where that is not practicable, to reduce odour emissions, BAT is to set up, implement and regularly review an odour management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements:

(i) a protocol containing appropriate actions and timelines;

(ii) a protocol for conducting odour monitoring;

(iii) a protocol for response to identified odour incidents;

(iv) an odour prevention and reduction programme designed to identify the source(s); to measure/estimate odour exposure; to characterise the contributions of the sources; and to implement prevention and/or reduction measures.

The associated monitoring is in BAT 6.

Applicability

The applicability is restricted to cases where odour nuisance can be expected or has been substantiated.

BAT 21. In order to prevent or, where that is not practicable, to reduce odour emissions from waste water collection and treatment and from sludge treatment, BAT is to use one or a combination of the techniques given below.

	Technique	Description	Applicability
(a)	Minimise residence times	Minimise the residence time of waste water and sludge in collection and storage systems, in particular under anaerobic conditions.	Applicability may be restricted in the case of existing collection and storage systems.
(b)	Chemical treatment	Use chemicals to destroy or to reduce the formation of odorous compounds (e.g. oxidation or precipitation of hydrogen sulphide).	Generally applicable.
(c)	Optimise aerobic treatment	This can include: (i) controlling the oxygen content; (ii) frequent maintenance of the aeration system; (iii) use of pure oxygen; (iv) removal of scum in tanks.	Generally applicable.
(d)	Enclosure	Cover or enclose facilities for collecting and treating waste water and sludge to collect the odorous waste gas for further treatment.	Generally applicable.
(e)	End-of-pipe treatment	This can include: (i) biological treatment; (ii) thermal oxidation.	Biological treatment is only applicable to compounds that are easily soluble in water and readily bioeliminable.

5.6. *Noise emissions*

BAT 22. In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to set up and implement a noise management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements:

(i) a protocol containing appropriate actions and timelines;

(ii) a protocol for conducting noise monitoring;

(iii) a protocol for response to identified noise incidents;

(iv) a noise prevention and reduction programme designed to identify the source(s), to measure/estimate noise exposure, to characterise the contributions of the sources and to implement prevention and/or reduction measures.

Applicability

The applicability is restricted to cases where noise nuisance can be expected or has been substantiated.

BAT 23. In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques given below.

	Technique	Description	Applicability
(a)	Appropriate location of equipment and buildings	Increasing the distance between the emitter and the receiver and using buildings as noise screens.	For existing plants, the relocation of equipment may be restricted by a lack of space or excessive costs.
(b)	Operational measures	This includes: (i) improved inspection and maintenance of equipment; (ii) closing of doors and windows of enclosed areas, if possible; (iii) equipment operation by experienced staff; (iv) avoidance of noisy activities at night, if possible; (v) provisions for noise control during maintenance activities.	Generally applicable.
(c)	Low-noise equipment	This includes low-noise compressors, pumps and flares.	Applicable only when the equipment is new or replaced.
(d)	Noise-control equipment	This includes: (i) noise-reducers; (ii) equipment insulation; (iii) enclosure of noisy equipment; (iv) soundproofing of buildings.	Applicability may be restricted due to space requirements (for existing plants), health, and safety issues.
(e)	Noise abatement	Inserting obstacles between emitters and receivers (e.g. protection walls, embankments and buildings).	Applicable only to existing plants; since the design of new plants should make this technique unnecessary. For existing plants, the insertion of obstacles may be restricted by a lack of space.

6. **Descriptions of techniques**

6.1. *Waste water treatment*

Technique	Description
Activated sludge process	The biological oxidation of dissolved organic substances with oxygen using the metabolism of microorganisms. In the presence of dissolved oxygen (injected as air or pure oxygen) the organic components are mineralised into carbon dioxide and water or are transformed into other metabolites and biomass (i.e. the activated sludge). The microorganisms are maintained in suspension in the waste water and the whole mixture is mechanically aerated. The activated sludge mixture is sent to a separation facility from which the sludge is recycled to the aeration tank.
Nitrification/denitrification	A two-step process that is typically incorporated into biological waste water treatment plants. The first step is the aerobic nitrification where microorganisms oxidise ammonium (NH_4^+) to the intermediate nitrite (NO_2^-), which is then further oxidised to nitrate (NO_3^-). In the subsequent anoxic denitrification step, microorganisms chemically reduce nitrate to nitrogen gas.

Technique	Description
Chemical precipitation	The conversion of dissolved pollutants into an insoluble compound by adding chemical precipitants. The solid precipitates formed are subsequently separated by sedimentation, air flotation or filtration. If necessary, this may be followed by microfiltration or ultrafiltration. Multivalent metal ions (e.g. calcium, aluminium, iron) are used for phosphorus precipitation.
Coagulation and flocculation	Coagulation and flocculation are used to separate suspended solids from waste water and are often carried out in successive steps. Coagulation is carried out by adding coagulants with charges opposite to those of the suspended solids. Flocculation is carried out by adding polymers, so that collisions of microfloc particles cause them to bond to produce larger flocs.
Equalisation	Balancing of flows and pollutant loads at the inlet of the final waste water treatment by using central tanks. Equalisation may be decentralised or carried out using other management techniques.
Filtration	The separation of solids from waste water by passing them through a porous medium e.g. sand filtration, microfiltration and ultrafiltration.
Flotation	The separation of solid or liquid particles from waste water by attaching them to fine gas bubbles, usually air. The buoyant particles accumulate at the water surface and are collected with skimmers.
Membrane bioreactor	A combination of activated sludge treatment and membrane filtration. Two variants are used: a) an external recirculation loop between the activated sludge tank and the membrane module; and b) immersion of the membrane module into the aerated activated sludge tank, where the effluent is filtered through a hollow fibre membrane, the biomass remaining in the tank (this variant is less energy-consuming and results in more compact plants).
Neutralisation	The adjustment of the pH of waste water to a neutral level (approximately 7) by the addition of chemicals. Sodium hydroxide ($NaOH$) or calcium hydroxide ($Ca(OH)_2$) is generally used to increase the pH; whereas, sulphuric acid (H_2SO_4), hydrochloric acid (HCl) or carbon dioxide (CO_2) is generally used to decrease the pH. The precipitation of some substances may occur during neutralisation.
Sedimentation	The separation of suspended particles and suspended material by gravitational settling.

6.2. *Diffuse VOC emissions*

Technique	Description
High-integrity equipment	High-integrity equipment includes: — 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; — corrosion-resistant equipment.

Technique	Description
Leak detection and repair (LDAR) programme	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 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
Thermal oxidation	The oxidation of combustible gases and odorants in a waste gas stream by heating the mixture of contaminants with air or oxygen to above its auto-ignition point in a combustion chamber and maintaining it at a high temperature long enough to complete its combustion to carbon dioxide and water. Thermal oxidation is also referred to as 'incineration', 'thermal incineration' or 'oxidative combustion'.
Using the designed gasket stress for flanged joint assembly	This includes: (i) obtaining a certified high quality gasket, e.g. according to EN 13555; (ii) calculating the highest possible bolt load, e.g. according to EN 1591-1; (iii) obtaining a qualified flange-assembling equipment; (iv) supervision of the bolt tightening by a qualified fitter.
VOC diffuse emissions monitoring	Sniffing and optical gas imaging methods are described under leak detection and repair programme. Full screening and quantification of emissions from the installation 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 infra-red or ultraviolet/visible sunlight spectra along a given geographical itinerary, crossing the wind direction and cutting through VOC plumes. **Differential absorption LIDAR (DIAL)**: This is a laser-based technique using differential absorption LIDAR (light detection and ranging), which is the optical analogue of 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.

RDCG (Rotterdam Capacity Growth) – DEFINITION PHASE
NESTE

ATTACHMENT 3

BEST AVAILABLE TECHNIQUES (BAT) CONCLUSIONS FOR THE PRODUCTION OF LARGE VOLUME ORGANIC CHEMICALS

(50 sheets)

II

(Non-legislative acts)

DECISIONS

COMMISSION IMPLEMENTING DECISION (EU) 2017/2117

of 21 November 2017

establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for the production of large volume organic chemicals

(notified under document C(2017) 7469)

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (1), and in particular Article 13(5) thereof,

Whereas:

(1) Best available techniques (BAT) conclusions are the reference for setting permit conditions for installations covered by Chapter II of Directive 2010/75/EU and competent authorities should set emission limit values which ensure that, under normal operating conditions, emissions do not exceed the emission levels associated with the best available techniques as laid down in the BAT conclusions.

(2) The forum composed of representatives of Member States, the industries concerned and non-governmental organisations promoting environmental protection, established by Commission Decision of 16 May 2011 (2), provided the Commission on 5 April 2017 with its opinion on the proposed content of the BAT reference document for the production of large volume organic chemicals. That opinion is publicly available.

(3) The BAT conclusions set out in the Annex to this Decision are the key element of that BAT reference document.

(4) The measures provided for in this Decision are in accordance with the opinion of the Committee established by Article 75(1) of Directive 2010/75/EU,

HAS ADOPTED THIS DECISION:

Article 1

The best available techniques (BAT) conclusions for the production of large volume organic chemicals, as set out in the Annex, are adopted.

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(1) OJ L 334, 17.12.2010, p. 17.

(2) Commission Decision of 16 May 2011 establishing a forum for the exchange of information pursuant to Article 13 of the Directive 2010/75/EU on industrial emissions (OJ C 146, 17.5.2011, p. 3).

Article 2

This Decision is addressed to the Member States.

Done at Brussels, 21 November 2017.

For the Commission
Karmenu VELLA
Member of the Commission

ANNEX

BEST AVAILABLE TECHNIQUES (BAT) CONCLUSIONS FOR THE PRODUCTION OF LARGE VOLUME ORGANIC CHEMICALS

SCOPE

These BAT conclusions concern the production of the following organic chemicals, as specified in Section 4.1 of Annex I to Directive 2010/75/EU:

(a) simple hydrocarbons (linear or cyclic, saturated or unsaturated, aliphatic or aromatic);

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

(c) sulphurous hydrocarbons;

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

(e) phosphorus-containing hydrocarbons;

(f) halogenic hydrocarbons;

(g) organometallic compounds;

(k) surface-active agents and surfactants.

These BAT conclusions also cover the production of hydrogen peroxide as specified in Section 4.2(e) of Annex I to Directive 2010/75/EU.

These BAT conclusions cover combustion of fuels in process furnaces/heaters, where this is part of the abovementioned activities.

These BAT conclusions cover production of the aforementioned chemicals in continuous processes where the total production capacity of those chemicals exceeds 20 kt/year.

These BAT conclusions do not address the following:

- combustion of fuels other than in a process furnace/heater or a thermal/catalytic oxidiser; this may be covered by the BAT conclusions for Large Combustion Plants (LCP);
- incineration of waste; this may be covered by the BAT conclusions for Waste Incineration (WI);
- ethanol production taking place on an installation covered by the activity description in Section 6.4(b)(ii) of Annex I to Directive 2010/75/EU or covered as a directly associated activity to such an installation; this may be covered by the BAT conclusions for Food, Drink and Milk Industries (FDM).

Other BAT conclusions which are complementary for the activities covered by these BAT conclusions include:

- Common Waste Water/Waste Gas Treatment/Management Systems in the Chemical Sector (CWW);
- Common Waste Gas Treatment in the Chemical Sector (WGC).

Other BAT conclusions and reference documents which may be of relevance for the activities covered by these BAT conclusions are the following:

- Economics and Cross-media Effects (ECM);
- Emissions from Storage (EFS);
- Energy Efficiency (ENE);
- Industrial Cooling Systems (ICS);

— Large Combustion Plants (LCP);

— Refining of Mineral Oil and Gas (REF);

— Monitoring of Emissions to Air and Water from IED installations (ROM);

— Waste Incineration (WI);

— Waste Treatment (WT).

GENERAL CONSIDERATIONS

Best Available Techniques

The techniques listed and described in these BAT conclusions are neither prescriptive nor exhaustive. Other techniques may be used that ensure at least an equivalent level of environmental protection.

Unless otherwise stated, the BAT conclusions are generally applicable.

Averaging periods and reference conditions for emissions to air

Unless stated otherwise, the emission levels associated with the best available techniques (BAT-AELs) for emissions to air given in these BAT conclusions refer to values of concentration, expressed as mass of emitted substance per volume of waste gas under standard conditions (dry gas at a temperature of 273,15 K, and a pressure of 101,3 kPa), and expressed in the unit mg/Nm^3.

Unless stated otherwise, the averaging periods associated with the BAT-AELs for emissions to air are defined as follows.

Type of measurement	Averaging period	Definition
Continuous	Daily average	Average over a period of 1 day based on valid hourly or half-hourly averages
Periodic	Average over the sampling period	Average of three consecutive measurements of at least 30 minutes each (¹) (²)

(¹) For any parameter where, due to sampling or analytical limitations, 30-minute sampling is inappropriate, a suitable sampling period is employed.

(²) For PCDD/F, a sampling period of 6 to 8 hours is used.

Where BAT-AELs refer to specific emission loads, expressed as load of emitted substance per unit of production output, the average specific emission loads l_s are calculated using Equation 1:

Equation 1: $$l_s = \frac{1}{n}\sum_{i=1}^{n}\frac{c_i q_i}{p_i}$$

where:

n = number of measurement periods;

c_i = average concentration of the substance during ith measurement period;

q_i = average flow rate during ith measurement period;

p_i = production output during ith measurement period.

Reference oxygen level

For process furnaces/heaters, the reference oxygen level of the waste gases (O_R) is 3 vol-%.

Conversion to reference oxygen level

The emission concentration at the reference oxygen level is calculated using Equation 2:

Equation 2: $$E_R = \frac{21 - O_R}{21 - O_M} \times E_M$$

where:

E_R = emission concentration at the reference oxygen level O_R;

O_R = reference oxygen level in vol-%;

E_M = measured emission concentration;

O_M = measured oxygen level in vol-%.

Averaging periods for emissions to water

Unless stated otherwise, the averaging periods associated with the environmental performance levels associated with the best available techniques (BAT-AEPLs) for emissions to water expressed in concentrations are defined as follows.

Averaging period	Definition
Average of values obtained during one month	Flow-weighted average value from 24-hour flow-proportional composite samples obtained during 1 month under normal operating conditions (1)
Average of values obtained during one year	Flow-weighted average value from 24-hour flow-proportional composite samples obtained during 1 year under normal operating conditions (1)

(1) Time-proportional composite samples can be used provided that sufficient flow stability can be demonstrated.

Flow-weighted average concentrations of the parameter (c_w) are calculated using Equation 3:

Equation 3: $$c_w = \sum_{i=1}^{n} c_i q_i / \sum_{i=1}^{n} q_i$$

where:

n = number of measurement periods;

c_i = average concentration of the parameter during i^th^ measurement period;

q_i = average flow rate during i^th^ measurement period.

Where BAT-AEPLs refer to specific emission loads, expressed as load of emitted substance per unit of production output, the average specific emission loads are calculated using Equation 1.

Acronyms and definitions

For the purposes of these BAT conclusions, the following acronyms and definitions apply.

Term used	Definition
BAT-AEPL	Environmental performance level associated with BAT, as described in Commission Implementing Decision 2012/119/EU (1). BAT-AEPLs include emission levels associated with the best available techniques (BAT-AELs) as defined in Article 3(13) of Directive 2010/75/EU
BTX	Collective term for benzene, toluene and ortho-/meta-/para-xylene or mixtures thereof
CO	Carbon monoxide

Term used	Definition
Combustion unit	Any technical apparatus in which fuels are oxidised in order to use the heat thus generated. Combustion units include boilers, engines, turbines and process furnaces/heaters, but do not include waste gas treatment units (e.g. a thermal/catalytic oxidiser used for the abatement of organic compounds)
Continuous measurement	Measurement using an 'automated measuring system' permanently installed on site
Continuous process	A process in which the raw materials are fed continuously into the reactor with the reaction products then fed into connected downstream separation and/or recovery units
Copper	The sum of copper and its compounds, in dissolved or particulate form, expressed as Cu
DNT	Dinitrotoluene
EB	Ethylbenzene
EDC	Ethylene dichloride
EG	Ethylene glycols
EO	Ethylene oxide
Ethanolamines	Collective term for monoethanolamine, diethanolamine and triethanolamine, or mixtures thereof
Ethylene glycols	Collective term for monoethylene glycol, diethylene glycol and triethylene glycol, or mixtures thereof
Existing plant	A plant that is not a new plant
Existing unit	A unit that is not a new unit
Flue-gas	The exhaust gas exiting a combustion unit
I-TEQ	International toxic equivalent – derived by using the international toxic equivalence factors, as defined in Annex VI, part 2 to Directive 2010/75/EU
Lower olefins	Collective term for ethylene, propylene, butylene and butadiene, or mixtures thereof
Major plant upgrade	A major change in the design or technology of a plant with major adjustments or replacements of the process and/or abatement units and associated equipment
MDA	Methylene diphenyl diamine
MDI	Methylene diphenyl diisocyanate
MDI plant	Plant for the production of MDI from MDA via phosgenation
New plant	A plant first permitted on the site of the installation following the publication of these BAT conclusions or a complete replacement of a plant following the publication of these BAT conclusions
New unit	A unit first permitted following the publication of these BAT conclusions or a complete replacement of a unit following the publication of these BAT conclusions

Term used	Definition
NO_X precursors	Nitrogen-containing compounds (e.g. ammonia, nitrous gases and nitrogen-containing organic compounds) in the input to a thermal treatment that lead to NO_X emissions. Elementary nitrogen is not included
PCDD/F	Polychlorinated dibenzo-dioxins and -furans
Periodic measurement	Measurement at specified time intervals using manual or automated methods
Process furnace/heater	Process furnaces or heaters are: — combustion units whose flue-gases are used for the thermal treatment of objects or feed material through direct contact, e.g. in drying processes or chemical reactors; or — combustion units whose radiant and/or conductive heat is transferred to objects or feed material through a solid wall without using an intermediary heat transfer fluid, e.g. furnaces or reactors heating a process stream used in the (petro-)chemical industry such as steam cracker furnaces. It should be noted that, as a consequence of the application of good energy recovery practices, some of the process furnaces/heaters may have an associated steam/electricity generation system. This is considered to be an integral design feature of the process furnace/heater that cannot be considered in isolation.
Process off-gas	The gas leaving a process which is further treated for recovery and/or abatement
NO_X	The sum of nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as NO_2
Residues	Substances or objects generated by the activities covered by the scope of this document, as waste or by-products
RTO	Regenerative thermal oxidiser
SCR	Selective catalytic reduction
SMPO	Styrene monomer and propylene oxide
SNCR	Selective non-catalytic reduction
SRU	Sulphur recovery unit
TDA	Toluene diamine
TDI	Toluene diisocyanate
TDI plant	Plant for the production of TDI from TDA via phosgenation
TOC	Total organic carbon, expressed as C; includes all organic compounds (in water)
Total suspended solids (TSS)	Mass concentration of all suspended solids, measured via filtration through glass fibre filters and gravimetry
TVOC	Total volatile organic carbon; total volatile organic compounds which are measured by a flame ionisation detector (FID) and expressed as total carbon
Unit	A segment/subpart of a plant in which a specific process or operation is carried out (e.g. reactor, scrubber, distillation column). Units can be new units or existing units

Term used	Definition
Valid hourly or half-hourly average	An hourly (or half-hourly) average is considered valid when there is no maintenance or malfunction of the automated measuring system
VCM	Vinyl chloride monomer
VOCs	Volatile organic compounds as defined in Article 3(45) of Directive 2010/75/EU

(1) Commission Implementing Decision 2012/119/EU of 10 February 2012 laying down rules concerning guidance on the collection of data and on the drawing up of BAT reference documents and on their quality assurance referred to in Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions (OJ L 63, 2.3.2012, p. 1).

1. GENERAL BAT CONCLUSIONS

The sector-specific BAT conclusions included in Sections 2 to 11 apply in addition to the general BAT conclusions given in this section.

1.1. **Monitoring of emissions to air**

BAT 1: BAT is to monitor channelled emissions to air from process furnaces/heaters in accordance with EN standards and with at least the minimum frequency given in the table below. 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.

Substance/Parameter	Standard(s) (1)	Total rated thermal input (MW_{th}) (2)	Minimum monitoring frequency (3)	Monitoring associated with
CO	Generic EN standards	≥ 50	Continuous	Table 2.1, Table 10.1
	EN 15058	10 to < 50	Once every 3 months (4)	
Dust (5)	Generic EN standards and EN 13284-2	≥ 50	Continuous	BAT 5
	EN 13284-1	10 to < 50	Once every 3 months (4)	
NH_3 (6)	Generic EN standards	≥ 50	Continuous	BAT 7, Table 2.1
	No EN standard available	10 to < 50	Once every 3 months (4)	
NO_X	Generic EN standards	≥ 50	Continuous	BAT 4, Table 2.1, Table 10.1
	EN 14792	10 to < 50	Once every 3 months (4)	
SO_2 (7)	Generic EN standards	≥ 50	Continuous	BAT 6
	EN 14791	10 to < 50	Once every 3 months (4)	

(1) Generic EN standards for continuous measurements are EN 15267-1, -2, and -3, and EN 14181. EN standards for periodic measurements are given in the table.

(2) Refers to the total rated thermal input of all process furnaces/heaters connected to the stack where emissions occur.

(3) In the case of process furnaces/heaters with a total rated thermal input of less than 100 MW_{th} operated less than 500 hours per year, the monitoring frequency may be reduced to at least once every year.

(4) The minimum monitoring frequency for periodic measurements may be reduced to once every 6 months, if the emission levels are proven to be sufficiently stable.

(5) Monitoring of dust does not apply when combusting exclusively gaseous fuels.

(6) Monitoring of NH_3 only applies when SCR or SNCR is used.

(7) In the case of process furnaces/heaters combusting gaseous fuels and/or oil with a known sulphur content and where no flue-gas desulphurisation is carried out, continuous monitoring can be replaced either by periodic monitoring with a minimum frequency of once every 3 months or by calculation ensuring the provision of data of an equivalent scientific quality.

BAT 2: BAT is to monitor channelled emissions to air other than from process furnaces/heaters in accordance with EN standards and with at least the minimum frequency given in the table below. 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.

Substance/Parameter	Processes/Sources	Standard(s)	Minimum monitoring frequency	Monitoring associated with
Benzene	Waste gas from the cumene oxidation unit in phenol production (1)	No EN standard available	Once every month (2)	BAT 57
	All other processes/sources (3)			BAT 10
Cl_2	TDI/MDI (1)	No EN standard available	Once every month (2)	BAT 66
	EDC/VCM			BAT 76
CO	Thermal oxidiser	EN 15058	Once every month (2)	BAT 13
	Lower olefins (decoking)	No EN standard available (4)	Once every year or once during decoking, if decoking is less frequent	BAT 20
	EDC/VCM (decoking)			BAT 78
Dust	Lower olefins (decoking)	No EN standard available (5)	Once every year or once during decoking, if decoking is less frequent	BAT 20
	EDC/VCM (decoking)			BAT 78
	All other processes/sources (3)	EN 13284-1	Once every month (2)	BAT 11
EDC	EDC/VCM	No EN standard available	Once every month (2)	BAT 76
Ethylene oxide	Ethylene oxide and ethylene glycols	No EN standard available	Once every month (2)	BAT 52
Formaldehyde	Formaldehyde	No EN standard available	Once every month (2)	BAT 45
Gaseous chlorides, expressed as HCl	TDI/MDI (1)	EN 1911	Once every month (2)	BAT 66
	EDC/VCM			BAT 76
	All other processes/sources (3)			BAT 12
NH_3	Use of SCR or SNCR	No EN standard available	Once every month (2)	BAT 7
NO_X	Thermal oxidiser	EN 14792	Once every month (2)	BAT 13
PCDD/F	TDI/MDI (6)	EN 1948-1, -2, and -3	Once every 6 months (2)	BAT 67
PCDD/F	EDC/VCM			BAT 77

Substance/Parameter	Processes/Sources	Standard(s)	Minimum monitoring frequency	Monitoring associated with
SO_2	All processes/sources (3)	EN 14791	Once every month (2)	BAT 12
Tetrachloromethane	TDI/MDI (1)	No EN standard available	Once every month (2)	BAT 66
TVOC	TDI/MDI	EN 12619	Once every month (2)	BAT 66
	EO (desorption of CO_2 from scrubbing medium)		Once every 6 months (2)	BAT 51
	Formaldehyde		Once every month (2)	BAT 45
	Waste gas from the cumene oxidation unit in phenol production	EN 12619	Once every month (2)	BAT 57
	Waste gas from other sources in phenol production when not combined with other waste gas streams		Once every year	
	Waste gas from the oxidation unit in hydrogen peroxide production		Once every month (2)	BAT 86
	EDC/VCM		Once every month (2)	BAT 76
	All other processes/sources (3)		Once every month (2)	BAT 10
VCM	EDC/VCM	No EN standard available	Once every month (2)	BAT 76

(1) The monitoring applies where the pollutant is present in the waste gas based on the inventory of waste gas streams specified by the CWW BAT conclusions.

(2) The minimum monitoring frequency for periodic measurements may be reduced to once every year, if the emission levels are proven to be sufficiently stable.

(3) All (other) processes/sources where the pollutant is present in the waste gas based on the inventory of waste gas streams specified by the CWW BAT conclusions.

(4) EN 15058 and the sampling period need adaptation so that the measured values are representative of the whole decoking cycle.

(5) EN 13284-1 and the sampling period need adaptation so that the measured values are representative of the whole decoking cycle.

(6) The monitoring applies where the chlorine and/or chlorinated compounds are present in the waste gas and thermal treatment is applied

1.2. Emissions to air

1.2.1. *Emissions to air from process furnaces/heaters*

BAT 3: In order to reduce emissions to air of CO and unburnt substances from process furnaces/heaters, BAT is to ensure an optimised combustion.

Optimised combustion is achieved by good design and operation of the equipment which includes optimisation of the temperature and residence time in the combustion zone, efficient mixing of the fuel and combustion air, and combustion control. Combustion control is based on the continuous monitoring and automated control of appropriate combustion parameters (e.g. O_2, CO, fuel to air ratio, and unburnt substances).

BAT 4: In order to reduce NO_X emissions to air from process furnaces/heaters, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Choice of fuel	See Section 12.3. This includes switching from liquid to gaseous fuels, taking into account the overall hydrocarbon balance	The switch from liquid to gaseous fuels may be restricted by the design of the burners in the case of existing plants
b.	Staged combustion	Staged combustion burners achieve lower NO_X emissions by staging the injection of either air or fuel in the near burner region. The division of fuel or air reduces the oxygen concentration in the primary burner combustion zone, thereby lowering the peak flame temperature and reducing thermal NO_X formation	Applicability may be restricted by space availability when upgrading small process furnaces, thus limiting the retrofit of fuel/air staging without reducing capacity For existing EDC crackers, the applicability may be restricted by the design of the process furnace
c.	Flue-gas recirculation (external)	Recirculation of part of the flue-gas to the combustion chamber to replace part of the fresh combustion air, with the effect of reducing the oxygen content and therefore cooling the temperature of the flame	For existing process furnaces/heaters, the applicability may be restricted by their design. Not applicable to existing EDC crackers
d.	Flue-gas recirculation (internal)	Recirculation of part of the flue-gas within the combustion chamber to replace part of the fresh combustion air, with the effect of reducing the oxygen content and therefore reducing the temperature of the flame	For existing process furnaces/heaters, the applicability may be restricted by their design
e.	Low-NO_X burner (LNB) or ultra-low-NO_X burner (ULNB)	See Section 12.3	For existing process furnaces/heaters, the applicability may be restricted by their design
f.	Use of inert diluents	'Inert' diluents, e.g. steam, water, nitrogen, are used (either by being premixed with the fuel prior to its combustion or directly injected into the combustion chamber) to reduce the temperature of the flame. Steam injection may increase CO emissions	Generally applicable
g.	Selective catalytic reduction (SCR)	See Section 12.1	Applicability to existing process furnaces/heaters may be restricted by space availability
h.	Selective non-catalytic reduction (SNCR)	See Section 12.1	Applicability to existing process furnaces/heaters may be restricted by the temperature window (900–1 050 °C) and the residence time needed for the reaction. Not applicable to EDC crackers

BAT-associated emission levels (BAT-AELs): See Table 2.1 and Table 10.1.

BAT 5: In order to prevent or reduce dust emissions to air from process furnaces/heaters, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Choice of fuel	See Section 12.3. This includes switching from liquid to gaseous fuels, taking into account the overall hydrocarbon balance	The switch from liquid to gaseous fuels may be restricted by the design of the burners in the case of existing plants
b.	Atomisation of liquid fuels	Use of high pressure to reduce the droplet size of liquid fuel. Current optimal burner design generally includes steam atomisation	Generally applicable
c.	Fabric, ceramic or metal filter	See Section 12.1	Not applicable when only combusting gaseous fuels

BAT 6: In order to prevent or reduce SO_2 emissions to air from process furnaces/heaters, BAT is to use one or both of the techniques given below.

Technique		Description	Applicability
a.	Choice of fuel	See Section 12.3. This includes switching from liquid to gaseous fuels, taking into account the overall hydrocarbon balance	The switch from liquid to gaseous fuels may be restricted by the design of the burners in the case of existing plants
b.	Caustic scrubbing	See Section 12.1	Applicability may be restricted by space availability

1.2.2. *Emissions to air from the use of SCR or SNCR*

BAT 7: In order to reduce emissions to air of ammonia which is used in selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) for the abatement of NO_X emissions, BAT is to optimise the design and/or operation of SCR or SNCR (e.g. optimised reagent to NO_X ratio, homogeneous reagent distribution and optimum size of the reagent drops).

BAT-associated emission levels (BAT-AELs) for emissions from a lower olefins cracker furnace when SCR or SNCR is used: Table 2.1.

1.2.3. *Emissions to air from other processes/sources*

1.2.3.1. Techniques to reduce emissions from other processes/sources

BAT 8: In order to reduce the load of pollutants sent to the final waste gas treatment, and to increase resource efficiency, BAT is to use an appropriate combination of the techniques given below for process off-gas streams.

Technique		Description	Applicability
a.	Recovery and use of excess or generated hydrogen	Recovery and use of excess hydrogen or hydrogen generated from chemical reactions (e.g. for hydrogenation reactions). Recovery techniques such as pressure swing adsorption or membrane separation may be used to increase the hydrogen content	Applicability may be restricted where the energy demand for recovery is excessive due to the low hydrogen content or when there is no demand for hydrogen

Technique		Description	Applicability
b.	Recovery and use of organic solvents and unreacted organic raw materials	Recovery techniques such as compression, condensation, cryogenic condensation, membrane separation and adsorption may be used. The choice of technique may be influenced by safety considerations, e.g. presence of other substances or contaminants	Applicability may be restricted where the energy demand for recovery is excessive due to the low organic content
c.	Use of spent air	The large volume of spent air from oxidation reactions is treated and used as low-purity nitrogen	Only applicable where there are available uses for low-purity nitrogen which do not compromise process safety
d.	Recovery of HCl by wet scrubbing for subsequent use	Gaseous HCl is absorbed in water using a wet scrubber, which may be followed by purification (e.g. using adsorption) and/or concentration (e.g. using distillation) (see Section 12.1 for the technique descriptions). The recovered HCl is then used (e.g. as acid or to produce chlorine)	Applicability may be restricted in the case of low HCl loads
e.	Recovery of H_2S by regenerative amine scrubbing for subsequent use	Regenerative amine scrubbing is used for recovering H_2S from process off-gas streams and from the acidic off-gases of sour water stripping units. H_2S is then typically converted to elemental sulphur in a sulphur recovery unit in a refinery (Claus process).	Only applicable if a refinery is located nearby
f.	Techniques to reduce solids and/or liquids entrainment	See Section 12.1	Generally applicable

BAT 9: In order to reduce the load of pollutants sent to the final waste gas treatment, and to increase energy efficiency, BAT is to send process off-gas streams with a sufficient calorific value to a combustion unit. BAT 8a and 8b have priority over sending process off-gas streams to a combustion unit.

Applicability:

Sending process off-gas streams to a combustion unit may be restricted due to the presence of contaminants or due to safety considerations.

BAT 10: In order to reduce channelled emissions of organic compounds to air, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Condensation	See Section 12.1. The technique is generally used in combination with further abatement techniques	Generally applicable

Technique		Description	Applicability
b.	Adsorption	See Section 12.1	Generally applicable
c.	Wet scrubbing	See Section 12.1	Only applicable to VOCs that can be absorbed in aqueous solutions
d.	Catalytic oxidiser	See Section 12.1	Applicability may be restricted by the presence of catalyst poisons
e.	Thermal oxidiser	See Section 12.1. Instead of a thermal oxidiser, an incinerator for the combined treatment of liquid waste and waste gas may be used	Generally applicable

BAT 11: In order to reduce channelled dust emissions to air, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Cyclone	See Section 12.1. The technique is used in combination with further abatement techniques	Generally applicable
b.	Electrostatic precipitator	See Section 12.1	For existing units, the applicability may be restricted by space availability or safety considerations
c.	Fabric filter	See Section 12.1	Generally applicable
d.	Two-stage dust filter	See Section 12.1	
e.	Ceramic/metal filter	See Section 12.1	
f.	Wet dust scrubbing	See Section 12.1	

BAT 12: In order to reduce emissions to air of sulphur dioxide and other acid gases (e.g. HCl), BAT is to use wet scrubbing.

Description:

For the description of wet scrubbing, see Section 12.1

1.2.3.2. Techniques to reduce emissions from a thermal oxidiser

BAT 13: In order to reduce emissions to air of NO_X, CO, and SO_2 from a thermal oxidiser, BAT is to use an appropriate combination of the techniques given below.

Technique		Description	Main pollutant targeted	Applicability
a.	Removal of high levels of NO_X precursors from the process off-gas streams	Remove (if possible, for reuse) high levels of NO_X precursors prior to thermal treatment, e.g. by scrubbing, condensation or adsorption	NO_X	Generally applicable

Technique		Description	Main pollutant targeted	Applicability
b.	Choice of support fuel	See Section 12.3	NO_X, SO_2	Generally applicable
c.	Low-NO_X burner (LNB)	See Section 12.1	NO_X	Applicability to existing units may be restricted by design and/or operational constraints
d.	Regenerative thermal oxidiser (RTO)	See Section 12.1	NO_X	Applicability to existing units may be restricted by design and/or operational constraints
e.	Combustion optimisation	Design and operational techniques used to maximise the removal of organic compounds, while minimising emissions to air of CO and NO_X (e.g. by controlling combustion parameters such as temperature and residence time)	CO, NO_X	Generally applicable
f.	Selective catalytic reduction (SCR)	See Section 12.1	NO_X	Applicability to existing units may be restricted by space availability
g.	Selective non-catalytic reduction (SNCR)	See Section 12.1	NO_X	Applicability to existing units may be restricted by the residence time needed for the reaction

1.3. Emissions to water

BAT 14: In order to reduce the waste water volume, the pollutant loads discharged to a suitable final treatment (typically biological treatment), and emissions to water, BAT is to use an integrated waste water management and treatment strategy that includes an appropriate combination of process-integrated techniques, techniques to recover pollutants at source, and pretreatment techniques, based on the information provided by the inventory of waste water streams specified in the CWW BAT conclusions.

1.4. Resource efficiency

BAT 15: In order to increase resource efficiency when using catalysts, BAT is to use a combination of the techniques given below.

Technique		Description
a.	Catalyst selection	Select the catalyst to achieve the optimal balance between the following factors: — catalyst activity;

Technique		Description
		— catalyst selectivity; — catalyst lifetime (e.g. vulnerability to catalyst poisons); — use of less toxic metals.
b.	Catalyst protection	Techniques used upstream of the catalyst to protect it from poisons (e.g. raw material pretreatment)
c.	Process optimisation	Control of reactor conditions (e.g. temperature, pressure) to achieve the optimal balance between conversion efficiency and catalyst lifetime
d.	Monitoring of catalyst performance	Monitoring of the conversion efficiency to detect the onset of catalyst decay using suitable parameters (e.g. the heat of reaction and the CO_2 formation in the case of partial oxidation reactions)

BAT 16: In order to increase resource efficiency, BAT is to recover and reuse organic solvents.

Description:

Organic solvents used in processes (e.g. chemical reactions) or operations (e.g. extraction) are recovered using appropriate techniques (e.g. distillation or liquid phase separation), purified if necessary (e.g. using distillation, adsorption, stripping or filtration) and returned to the process or operation. The amount recovered and reused is process-specific.

1.5. Residues

BAT 17: In order to prevent or, where that is not practicable, to reduce the amount of waste being sent for disposal, BAT is to use an appropriate combination of the techniques given below.

Technique		Description	Applicability
Techniques to prevent or reduce the generation of waste			
a.	Addition of inhibitors to distillation systems	Selection (and optimisation of dosage) of polymerisation inhibitors that prevent or reduce the generation of residues (e.g. gums or tars). The optimisation of dosage may need to take into account that it can lead to higher nitrogen and/or sulphur content in the residues which could interfere with their use as a fuel	Generally applicable
b.	Minimisation of high-boiling residue formation in distillation systems	Techniques that reduce temperatures and residence times (e.g. packing instead of trays to reduce the pressure drop and thus the temperature; vacuum instead of atmospheric pressure to reduce the temperature)	Only applicable to new distillation units or major plant upgrades

Technique		Description	Applicability
Techniques to recover materials for reuse or recycling			
c.	Material recovery (e.g. by distillation, cracking)	Materials (i.e. raw materials, products, and by-products) are recovered from residues by isolation (e.g. distillation) or conversion (e.g. thermal/catalytic cracking, gasification, hydrogenation)	Only applicable where there are available uses for these recovered materials
d.	Catalyst and adsorbent regeneration	Regeneration of catalysts and adsorbents, e.g. using thermal or chemical treatment	Applicability may be restricted where regeneration results in significant cross-media effects.
Techniques to recover energy			
e.	Use of residues as a fuel	Some organic residues, e.g. tar, can be used as fuels in a combustion unit	Applicability may be restricted by the presence of certain substances in the residues, making them unsuitable to use in a combustion unit and requiring disposal

1.6. Other than normal operating conditions

BAT 18: In order to prevent or reduce emissions from equipment malfunctions, BAT is to use all of the techniques given below.

Technique		Description	Applicability
a.	Identification of critical equipment	Equipment critical to the protection of the environment ('critical equipment') is identified on the basis of a risk assessment (e.g. using a Failure Mode and Effects Analysis)	Generally applicable
b.	Asset reliability programme for critical equipment	A structured programme to maximise equipment availability and performance which includes standard operating procedures, preventive maintenance (e.g. against corrosion), monitoring, recording of incidents, and continuous improvements	Generally applicable
c.	Back-up systems for critical equipment	Build and maintain back-up systems, e.g. vent gas systems, abatement units	Not applicable if appropriate equipment availability can be demonstrated using technique b.

BAT 19: In order to prevent or reduce emissions to air and water occurring during other than normal operating conditions, BAT is to implement measures commensurate with the relevance of potential pollutant releases for:

(i) start-up and shutdown operations;

(ii) other circumstances (e.g. regular and extraordinary maintenance work and cleaning operations of the units and/or of the waste gas treatment system) including those that could affect the proper functioning of the installation.

2. BAT CONCLUSIONS FOR LOWER OLEFINS PRODUCTION

The BAT conclusions in this section apply to the production of lower olefins using the steam cracking process, and apply in addition to the general BAT conclusions given in Section 1.

2.1. **Emissions to air**

2.1.1. *BAT-AELs for emissions to air from a lower olefins cracker furnace*

Table 2.1

BAT-AELs for emissions to air of NO_X and NH_3 from a lower olefins cracker furnace

Parameter	BAT-AELs (1) (2) (3) (daily average or average over the sampling period) (mg/Nm³, at 3 vol-% O_2)	
	New furnace	Existing furnace
NO_X	60–100	70–200
NH_3	< 5–15 (4)	

(1) Where the flue gases of two or more furnaces are discharged through a common stack, the BAT-AEL applies to the combined discharge from the stack.
(2) The BAT-AELs do not apply during decoking operations.
(3) No BAT-AEL applies for CO. As an indication, the CO emission level will generally be 10–50 mg/Nm³ expressed as a daily average or an average over the sampling period.
(4) The BAT-AEL only applies when SCR or SNCR are used.

The associated monitoring is in BAT 1.

2.1.2. *Techniques to reduce emissions from decoking*

BAT 20: In order to reduce emissions to air of dust and CO from the decoking of the cracker tubes, BAT is to use an appropriate combination of the techniques to reduce the frequency of decoking given below and one or a combination of the abatement techniques given below.

	Technique	Description	Applicability
Techniques to reduce the frequency of decoking			
a.	Tube materials that retard coke formation	Nickel present at the surface of the tubes catalyses coke formation. Employing materials that have lower nickel levels, or coating the interior tube surface with an inert material, can therefore retard the rate of coke build-up	Only applicable to new units or major plant upgrades
b.	Doping of the raw material feed with sulphur compounds	As nickel sulphides do not catalyse coke formation, doping the feed with sulphur compounds when they are not already present at the desired level can also help retard the build-up of coke, as this will promote the passivation of the tube surface	Generally applicable

Technique		Description	Applicability
c.	Optimisation of thermal decoking	Optimisation of operating conditions, i.e. airflow, temperature and steam content across the decoking cycle, to maximise coke removal	Generally applicable
Abatement techniques			
d.	Wet dust scrubbing	See Section 12.1	Generally applicable
e.	Dry cyclone	See Section 12.1	Generally applicable
f.	Combustion of decoking waste gas in process furnace/heater	The decoking waste gas stream is passed through the process furnace/heater during decoking where the coke particles (and CO) are further combusted	Applicability for existing plants may be restricted by the design of the pipework systems or fire-duty restrictions

2.2. Emissions to water

BAT 21: In order to prevent or reduce the amount of organic compounds and waste water discharged to waste water treatment, BAT is to maximise the recovery of hydrocarbons from the quench water of the primary fractionation stage and reuse the quench water in the dilution steam generation system.

Description:

The technique consists of ensuring an effective separation of organic and aqueous phases. The recovered hydrocarbons are recycled to the cracker or used as raw materials in other chemical processes. Organic recovery can be enhanced, e.g. through the use of steam or gas stripping, or the use of a reboiler. Treated quench water is reused within the dilution steam generation system. A quench water purge stream is discharged to downstream final waste water treatment to prevent the build-up of salts in the system.

BAT 22: In order to reduce the organic load discharged to waste water treatment from the spent caustic scrubber liquor originating from the removal of H_2S from the cracked gases, BAT is to use stripping.

Description:

For the description of stripping see Section 12.2. The stripping of scrubber liquors is carried out using a gaseous stream, which is then combusted (e.g. in the cracker furnace).

BAT 23: In order to prevent or reduce the amount of sulphides discharged to waste water treatment from the spent caustic scrubber liquor originating from the removal of acid gases from the cracked gases, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Use of low-sulphur raw materials in the cracker feed	Use of raw materials that have a low sulphur content or have been desulphurised	Applicability may be restricted by a need for sulphur doping to reduce coke build-up
b.	Maximisation of the use of amine scrubbing for the removal of acid gases	The scrubbing of the cracked gases with a regenerative (amine) solvent to remove acid gases, mainly H_2S, to reduce the load on the downstream caustic scrubber	Not applicable if the lower olefin cracker is located far away from an SRU. Applicability for existing plants may be restricted by the capacity of the SRU

Technique		Description	Applicability
c.	Oxidation	Oxidation of sulphides present in the spent scrubbing liquor to sulphates, e.g. using air at elevated pressure and temperature (i.e. wet air oxidation) or an oxidising agent such as hydrogen peroxide	Generally applicable

3. BAT CONCLUSIONS FOR AROMATICS PRODUCTION

The BAT conclusions in this section apply to the production of benzene, toluene, ortho-, meta- and para-xylene (commonly known as BTX aromatics) and cyclohexane from the pygas by-product of steam crackers and from reformate/naphtha produced in catalytic reformers; and apply in addition to the general BAT conclusions given in Section 1.

3.1. **Emissions to air**

BAT 24: In order to reduce the organic load from process off-gases sent to the final waste gas treatment and to increase resource efficiency, BAT is to recover organic materials by using BAT 8b. or, where that is not practicable, to recover energy from these process off-gases (see also BAT 9).

BAT 25: In order to reduce emissions to air of dust and organic compounds from the regeneration of hydrogenation catalyst, BAT is to send the process off-gas from catalyst regeneration to a suitable treatment system.

Description:

The process off-gas is sent to wet or dry dust abatement devices to remove dust and then to a combustion unit or a thermal oxidiser to remove organic compounds in order to avoid direct emissions to air or flaring. The use of decoking drums alone is not sufficient.

3.2. **Emissions to water**

BAT 26: In order to reduce the amount of organic compounds and waste water discharged from aromatic extraction units to waste water treatment, BAT is either to use dry solvents or to use a closed system for the recovery and reuse of water when wet solvents are used.

BAT 27: In order to reduce the waste water volume and the organic load discharged to waste water treatment, BAT is to use an appropriate combination of the techniques given below.

Technique		Description	Applicability
a.	Water-free vacuum generation	Use mechanical pumping systems in a closed circuit procedure, discharging only a small amount of water as blowdown, or use dry-running pumps. In some cases, waste-water-free vacuum generation can be achieved by use of the product as a barrier liquid in a mechanical vacuum pump, or by use of a gas stream from the production process	Generally applicable

Technique		Description	Applicability
b.	Source segregation of aqueous effluents	Aqueous effluents from aromatics plants are segregated from waste water from other sources in order to facilitate the recovery of raw materials or products	For existing plants, the applicability may be restricted by site-specific drainage systems
c.	Liquid phase separation with recovery of hydrocarbons	Separation of organic and aqueous phases with appropriate design and operation (e.g. sufficient residence time, phase boundary detection and control) to prevent any entrainment of undissolved organic material	Generally applicable
d	Stripping with recovery of hydrocarbons	See Section 12.2. Stripping can be used on individual or combined streams	Applicability may be restricted when the concentration of hydrocarbons is low
e.	Reuse of water	With further treatment of some waste water streams, water from stripping can be used as process water or as boiler feed water, replacing other sources of water	Generally applicable

3.3. Resource efficiency

BAT 28: In order to use resources efficiently, BAT is to maximise the use of co-produced hydrogen, e.g. from dealkylation reactions, as a chemical reagent or fuel by using BAT 8a. or, where that is not practicable, to recover energy from these process vents (see BAT 9).

3.4. Energy efficiency

BAT 29: In order to use energy efficiently when using distillation, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Distillation optimisation	For each distillation column, the number of trays, reflux ratio, feed location and, for extractive distillations, the solvents to feed ratio are optimised	Applicability to existing units may be restricted by design, space availability and/or operational constraints
b.	Recovery of heat from column overhead gaseous stream	Reuse condensation heat from the toluene and the xylene distillation column to supply heat elsewhere in the installation	

Technique		Description	Applicability
c.	Single extractive distillation column	In a conventional extractive distillation system, the separation would require a sequence of two separation steps (i.e. main distillation column with side column or stripper). In a single extractive distillation column, the separation of the solvent is carried out in a smaller distillation column that is incorporated into the column shell of the first column	Only applicable to new plants or major plant upgrades. Applicability may be restricted for smaller capacity units as operability may be constrained by combining a number of operations into one piece of equipment
d.	Distillation column with a dividing wall	In a conventional distillation system, the separation of a three-component mixture into its pure fractions requires a direct sequence of at least two distillation columns (or main columns with side columns). With a dividing wall column, separation can be carried out in just one piece of apparatus	
e.	Thermally coupled distillation	If distillation is carried out in two columns, energy flows in both columns can be coupled. The steam from the top of the first column is fed to a heat exchanger at the base of the second column	Only applicable to new plants or major plant upgrades. Applicability depends on the set-up of the distillation columns and process conditions, e.g. working pressure

3.5. **Residues**

BAT 30: In order to prevent or reduce the amount of spent clay being sent for disposal, BAT is to use one or both of the techniques given below.

Technique		Description	Applicability
a.	Selective hydrogenation of reformate or pygas	Reduce the olefin content of reformate or pygas by hydrogenation. With fully hydrogenated raw materials, clay treaters have longer operating cycles	Only applicable to plants using raw materials with a high olefin content
b.	Clay material selection	Use a clay that lasts as long as possible for its given conditions (i.e. having surface/structural properties that increase the operating cycle length), or use a synthetic material that has the same function as the clay but that can be regenerated	Generally applicable

4. BAT CONCLUSIONS FOR ETHYLBENZENE AND STYRENE MONOMER PRODUCTION

The BAT conclusions in this section apply to the production of ethlybenzene using either the zeolite or $AlCl_3$ catalysed alkylation process; and the production of styrene monomer either by ethylbenzene dehydrogenation or co-production with propylene oxide; and apply in addition to the general BAT conclusions given in Section 1.

4.1. Process selection

BAT 31: In order to prevent or reduce emissions to air of organic compounds and acid gases, the generation of waste water and the amount of waste being sent for disposal from the alkylation of benzene with ethylene, BAT for new plants and major plant upgrades is to use the zeolite catalyst process.

4.2. Emissions to air

BAT 32: In order to reduce the load of HCl sent to the final waste gas treatment from the alkylation unit in the $AlCl_3$-catalysed ethylbenzene production process, BAT is to use caustic scrubbing.

Description:

For the description of caustic scrubbing, see Section 12.1.

Applicability:

Only applicable to existing plants using the $AlCl_3$ catalysed ethylbenzene production process.

BAT 33: In order to reduce the load of dust and HCl sent to the final waste gas treatment from catalyst replacement operations in the $AlCl_3$-catalysed ethylbenzene production process, BAT is to use wet scrubbing and then use the spent scrubbing liquor as wash water in the post-alkylation reactor wash section.

Description:

For the description of wet scrubbing, see Section 12.1.

BAT 34: In order to reduce the organic load sent to the final waste gas treatment from the oxidation unit in the SMPO production process, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Techniques to reduce liquids entrainment	See Section 12.1	Generally applicable
b.	Condensation	See Section 12.1	Generally applicable
c.	Adsorption	See Section 12.1	Generally applicable
d.	Scrubbing	See Section 12.1. Scrubbing is carried out with a suitable solvent (e.g. the cool, recirculated ethylbenzene) to absorb ethylbenzene, which is recycled to the reactor	For existing plants, the use of the recirculated ethylbenzene stream may be restricted by the plant design

BAT 35: In order to reduce emissions of organic compounds to air from the acetophenone hydrogenation unit in the SMPO production process, during other than normal operating conditions (such as start-up events), BAT is to send the process off-gas to a suitable treatment system.

4.3. Emissions to water

BAT 36: In order to reduce waste water generation from ethylbenzene dehydrogenation and to maximise the recovery of organic compounds, BAT is to use an appropriate combination of the techniques given below.

Technique		Description	Applicability
a.	Optimised liquid phase separation	Separation of organic and aqueous phases with appropriate design and operation (e.g. sufficient residence time, phase boundary detection and control) to prevent any entrainment of undissolved organic material	Generally applicable
b.	Steam stripping	See Section 12.2	Generally applicable
c.	Adsorption	See Section 12.2	Generally applicable
d.	Reuse of water	Condensates from the reaction can be used as process water or as boiler feed after steam stripping (see technique b.) and adsorption (see technique c.)	Generally applicable

BAT 37: In order to reduce emissions to water of organic peroxides from the oxidation unit in the SMPO production process and to protect the downstream biological waste water treatment plant, BAT is to pretreat waste water containing organic peroxides using hydrolysis before it is combined with other waste water streams and discharged to the final biological treatment.

Description:

For the description of hydrolysis see Section 12.2.

4.4. Resource efficiency

BAT 38: In order to recover organic compounds from ethylbenzene dehydrogenation prior to the recovery of hydrogen (see BAT 39), BAT is to use one or both of the techniques given below.

Technique		Description	Applicability
a.	Condensation	See Section 12.1	Generally applicable
b.	Scrubbing	See Section 12.1. The absorbent consists of commercial organic solvents (or tar from ethylbenzene plants) (see BAT 42b). VOCs are recovered by stripping of the scrubber liquor	

BAT 39: In order to increase resource efficiency, BAT is to recover the co-produced hydrogen from ethylbenzene dehydrogenation, and to use it either as a chemical reagent or to combust the dehydrogenation off-gas as a fuel (e.g. in the steam superheater).

BAT 40: In order to increase the resource efficiency of the acetophenone hydrogenation unit in the SMPO production process, BAT is to minimise excess hydrogen or to recycle hydrogen by using BAT 8a. If BAT 8a is not applicable, BAT is to recover energy (see BAT 9).

4.5. Residues

BAT 41: In order to reduce the amount of waste being sent for disposal from spent catalyst neutralisation in the $AlCl_3$-catalysed ethylbenzene production process, BAT is to recover residual organic compounds by stripping and then concentrate the aqueous phase to give a usable $AlCl_3$ by-product.

Description:

Steam stripping is first used to remove VOCs, then the spent catalyst solution is concentrated by evaporation to give a usable $AlCl_3$ by-product. The vapour phase is condensed to give a HCl solution that is recycled into the process.

BAT 42: In order to prevent or reduce the amount of waste tar being sent for disposal from the distillation unit of ethylbenzene production, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Material recovery (e.g. by distillation, cracking)	See BAT 17c	Only applicable where there are available uses for these recovered materials
b.	Use of tar as an absorbent for scrubbing	See section 12.1. Use the tar as an absorbent in the scrubbers used in styrene monomer production by ethylbenzene dehydrogenation, instead of commercial organic solvents (see BAT 38b). The extent to which tar can be used depends on the scrubber capacity	Generally applicable
c.	Use of tar as a fuel	See BAT 17e	Generally applicable

BAT 43: In order to reduce the generation of coke (which is both a catalyst poison and a waste) from units producing styrene by ethylbenzene dehydrogenation, BAT is to operate at the lowest possible pressure that is safe and practicable.

BAT 44: In order to reduce the amount of organic residues being sent for disposal from styrene monomer production including its co-production with propylene oxide, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Addition of inhibitors to distillation systems	See BAT 17a	Generally applicable
b.	Minimisation of high-boiling residue formation in distillation systems	See BAT 17b	Only applicable to new distillation units or major plant upgrades
c.	Use of residues as a fuel	See BAT 17e	Generally applicable

5. BAT CONCLUSIONS FOR FORMALDEHYDE PRODUCTION

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 1.

5.1. Emissions to air

BAT 45: In order to reduce emissions of organic compounds to air from formaldehyde production and to use energy efficiently, BAT is to use one of the techniques given below.

Technique		Description	Applicability
a.	Send the waste gas stream to a combustion unit	See BAT 9	Only applicable to the silver process
b.	Catalytic oxidiser with energy recovery	See Section 12.1. Energy is recovered as steam	Only applicable to the metal oxide process. The ability to recover energy may be restricted in small stand-alone plants
c.	Thermal oxidiser with energy recovery	See Section 12.1. Energy is recovered as steam	Only applicable to the silver process

Table 5.1

BAT-AELs for emissions of TVOC and formaldehyde to air from formaldehyde production

Parameter	BAT-AEL (daily average or average over the sampling period) (mg/Nm^3, no correction for oxygen content)
TVOC	< 5–30 (1)
Formaldehyde	2–5

(1) The lower end of the range is achieved when using a thermal oxidiser in the silver process.

The associated monitoring is in BAT 2.

5.2. Emissions to water

BAT 46: In order to prevent or reduce waste water generation (e.g. from cleaning, spills and condensates) and the organic load discharged to further waste water treatment, BAT is to use one or both of the techniques given below.

Technique		Description	Applicability
a.	Reuse of water	Aqueous streams (e.g. from cleaning, spills and condensates) are recirculated into the process mainly to adjust the formaldehyde product concentration. The extent to which water can be reused depends on the desired formaldehyde concentration	Generally applicable
b.	Chemical pretreatment	Conversion of formaldehyde into other substances which are less toxic, e.g. by addition of sodium sulphite or by oxidation	Only applicable to effluents which, due to their formaldehyde content, could have a negative effect on the downstream biological waste water treatment

5.3. Residues

BAT 47: In order to reduce the amount of paraformaldehyde-containing waste being sent for disposal, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Minimisation of paraformaldehyde generation	The formation of paraformaldehyde is minimised by improved heating, insulation and flow circulation	Generally applicable
b.	Material recovery	Paraformaldehyde is recovered by dissolution in hot water where it undergoes hydrolysis and depolymerisation to give a formaldehyde solution, or is reused directly in other processes	Not applicable when the recovered paraformaldehyde cannot be used due to its contamination
c.	Use of residues as a fuel	Paraformaldehyde is recovered and used as a fuel	Only applicable when technique b. cannot be applied

6. BAT CONCLUSIONS FOR ETHYLENE OXIDE AND ETHYLENE GLYCOLS PRODUCTION

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 1.

6.1. Process selection

BAT 48: In order to reduce the consumption of ethylene and emissions to air of organic compounds and CO_2, BAT for new plants and major plant upgrades is to use oxygen instead of air for the direct oxidation of ethylene to ethylene oxide.

6.2. Emissions to air

BAT 49: In order to recover ethylene and energy and to reduce emissions of organic compounds to air from the EO plant, BAT is to use both of the techniques given below.

Technique		Description	Applicability
Techniques to recover organic material for reuse or recycling			
a.	Use of pressure swing adsorption or membrane separation to recover ethylene from the inerts purge	With the pressure swing adsorption technique, the target gas (in this case ethylene) molecules are adsorbed on a solid (e.g. molecular sieve) at high pressure, and subsequently desorbed in more concentrated form at lower pressure for reuse or recycling. For membrane separation, see Section 12.1	Applicability may be restricted when the energy demand is excessive due to a low ethylene mass flow
Energy recovery techniques			
b.	Send the inerts purge stream to a combustion unit	See BAT 9	Generally applicable

BAT 50: In order to reduce the consumption of ethylene and oxygen and to reduce CO_2 emissions to air from the EO unit, BAT is to use a combination of the techniques in BAT 15 and to use inhibitors.

Description:

The addition of small amounts of an organochlorine inhibitor (such as ethylchloride or dichloroethane) to the reactor feed in order to reduce the proportion of ethylene that is fully oxidised to carbon dioxide. Suitable parameters for the monitoring of catalyst performance include the heat of reaction and the CO_2 formation per tonne of ethylene feed.

BAT 51: In order to reduce emissions of organic compounds to air from the desorption of CO_2 from the scrubbing medium used in the EO plant, BAT is to use a combination of the techniques given below.

	Technique	Description	Applicability
Process-integrated techniques			
a.	Staged CO_2 desorption	The technique consists of conducting the depressurisation necessary to liberate the carbon dioxide from the absorption medium in two steps rather than one. This allows an initial hydrocarbon-rich stream to be isolated for potential recirculation, leaving a relatively clean carbon dioxide stream for further treatment.	Only applicable to new plants or major plant upgrades
Abatement techniques			
b.	Catalytic oxidiser	See Section 12.1	Generally applicable
c.	Thermal oxidiser	See Section 12.1	Generally applicable

Table 6.1

BAT-AEL for emissions of organic compounds to air from the desorption of CO_2 from the scrubbing medium used in the EO plant

Parameter	BAT-AEL
TVOC	1-10 g/t of EO produced (¹) (²) (³)

(¹) The BAT-AEL is expressed as an average of values obtained during 1 year.

(²) In the case of significant methane content in the emission, methane monitored according to EN ISO 25140 or EN ISO 25139 is subtracted from the result.

(³) EO produced is defined as the sum of EO produced for sale and as an intermediate.

The associated monitoring is in BAT 2.

BAT 52: In order to reduce EO emissions to air, BAT is to use wet scrubbing for waste gas streams containing EO.

Description:

For the description of wet scrubbing, see Section 12.1. Scrubbing with water to remove EO from waste gas streams before direct release or before further abatement of organic compounds.

BAT 53: In order to prevent or reduce emissions of organic compounds to air from cooling of the EO absorbent in the EO recovery unit, BAT is to use one of the techniques given below.

Technique		Description	Applicability
a.	Indirect cooling	Use indirect cooling systems (with heat exchangers) instead of open cooling systems	Only applicable to new plants or major plant upgrades
b.	Complete EO removal by stripping	Maintain appropriate operating conditions and use online monitoring of the EO stripper operation to ensure that all EO is stripped out; and provide adequate protection systems to avoid EO emissions during other than normal operating conditions	Only applicable when technique a. cannot be applied

6.3. **Emissions to water**

BAT 54: In order to reduce the waste water volume and to reduce the organic load discharged from the product purification to final waste water treatment, BAT is to use one or both of the techniques given below.

Technique		Description	Applicability
a.	Use of the purge from the EO plant in the EG plant	The purge streams from the EO plant are sent to the EG process and not discharged as waste water. The extent to which the purge can be reused in the EG process depends on EG product quality considerations.	Generally applicable
b.	Distillation	Distillation is a technique used to separate compounds with different boiling points by partial evaporation and recondensation. The technique is used in EO and EG plants to concentrate aqueous streams to recover glycols or enable their disposal (e.g. by incineration, instead of their discharge as waste water) and to enable the partial reuse/recycling of water.	Only applicable to new plants or major plant upgrades

6.4. **Residues**

BAT 55: In order to reduce the amount of organic waste being sent for disposal from the EO and EG plant, BAT is to use a combination of the techniques given below.

Technique		Description	Applicability
a.	Hydrolysis reaction optimisation	Optimisation of the water to EO ratio to both achieve lower co-production of heavier glycols and avoid excessive energy demand for the dewatering of glycols. The optimum ratio depends on the target output of di- and triethylene glycols	Generally applicable
b.	Isolation of by-products at EO plants for use	For EO plants, the concentrated organic fraction obtained after the dewatering of the liquid effluent from EO recovery is distilled to give valuable short-chain glycols and a heavier residue	Only applicable to new plants or major plant upgrades
c.	Isolation of by-products at EG plants for use	For EG plants, the longer chain glycols fraction can either be used as such or further fractionated to yield valuable glycols	Generally applicable

7. BAT CONCLUSIONS FOR PHENOL PRODUCTION

The BAT conclusions in this section apply to the production of phenol from cumene, and apply in addition to the general BAT conclusions given in Section 1.

7.1. Emissions to air

BAT 56: In order to recover raw materials and to reduce the organic load sent from the cumene oxidation unit to the final waste gas treatment, BAT is to use a combination of the techniques given below.

Technique		Description	Applicability
Process-integrated techniques			
a.	Techniques to reduce liquids entrainment	See Section 12.1	Generally applicable
Techniques to recover organic material for reuse			
b.	Condensation	See Section 12.1	Generally applicable
c.	Adsorption (regenerative)	See Section 12.1	Generally applicable

BAT 57: In order to reduce emissions of organic compounds to air, BAT is to use technique d given below for waste gas from the cumene oxidation unit. For any other individual or combined waste gas streams, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Send the waste gas stream to a combustion unit	See BAT 9	Only applicable where there are available uses for the waste gas as gaseous fuel
b.	Adsorption	See Section 12.1	Generally applicable
c.	Thermal oxidiser	See Section 12.1	Generally applicable
d.	Regenerative thermal oxidiser (RTO)	See Section 12.1	Generally applicable

Table 7.1

BAT-AELs for emissions of TVOC and benzene to air from the production of phenol

Parameter	Source	BAT-AEL (daily average or average over the sampling period) (mg/Nm^3, no correction for oxygen content)	Conditions
Benzene	Cumene oxidation unit	< 1	The BAT-AEL applies if the emission exceeds 1 g/h
TVOC		5–30	—

The associated monitoring is in BAT 2.

7.2. Emissions to water

BAT 58: In order to reduce emissions to water of organic peroxides from the oxidation unit and, if necessary, to protect the downstream biological waste water treatment plant, BAT is to pretreat waste water containing organic peroxides using hydrolysis before it is combined with other waste water streams and discharged to the final biological treatment.

Description:

For the description of hydrolysis, see Section 12.2. Waste water (mainly from the condensers and the adsorber regeneration, after phase separation) is treated thermally (at temperatures above 100 °C and a high pH) or catalytically to decompose organic peroxides to non-ecotoxic and more readily biodegradable compounds.

Table 7.2

BAT-AEPL for organic peroxides at the outlet of the peroxides decomposition unit

Parameter	BAT-AEPL (average value from at least three spot samples taken at intervals of at least half an hour)	Associated monitoring
Total organic peroxides, expressed as cumene hydroperoxide	< 100 mg/l	No EN standard available. The minimum monitoring frequency is once every day and may be reduced to four times per year if adequate performance of the hydrolysis is demonstrated by controlling the process parameters (e.g. pH, temperature and residence time)

BAT 59: In order to reduce the organic load discharged from the cleavage unit and the distillation unit to further waste water treatment, BAT is to recover phenol and other organic compounds (e.g. acetone) using extraction followed by stripping.

Description:

Recovery of phenol from phenol-containing waste water streams by adjustment of the pH to < 7, followed by extraction with a suitable solvent and stripping of the waste water to remove residual solvent and other low-boiling compounds (e.g. acetone). For the description of the treatment techniques, see Section 12.2.

7.3. Residues

BAT 60: In order to prevent or reduce the amount of tar being sent for disposal from phenol purification, BAT is to use one or both of the techniques given below.

	Technique	Description	Applicability
a.	Material recovery (e.g. by distillation, cracking)	See BAT 17c. Use distillation to recover cumene, α-methylstyrene phenol, etc.	Generally applicable
b.	Use of tar as a fuel	See BAT 17e.	Generally applicable

8. BAT CONCLUSIONS FOR ETHANOLAMINES PRODUCTION

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 1.

8.1. Emissions to air

BAT 61: In order to reduce ammonia emissions to air and to reduce the consumption of ammonia from the aqueous ethanolamines production process, BAT is to use a multistage wet scrubbing system.

Description:

For the description of wet scrubbing, see Section 12.1. Unreacted ammonia is recovered from the off-gas of the ammonia stripper and also from the evaporation unit by wet scrubbing in at least two stages followed by ammonia recycling into the process.

8.2. Emissions to water

BAT 62: In order to prevent or reduce emissions of organic compounds to air and emissions to water of organic substances from the vacuum systems, BAT is to use one or a combination of the techniques given below.

	Technique	Description	Applicability
a.	Water-free vacuum generation	Use of dry-running pumps, e.g. positive displacement pumps	Applicability to existing plants may be restricted by design and/or operational constraints
b.	Use of water ring vacuum pumps with recirculation of the ring water	The water used as the sealant liquid of the pump is recirculated to the pump casing via a closed loop with only small purges, so that waste water generation is minimised	Only applicable when technique a. cannot be applied. Not applicable for triethanolamine distillation

Technique		Description	Applicability
c.	Reuse of aqueous streams from vacuum systems in the process	Return aqueous streams from water ring pumps or steam ejectors to the process for recovery of organic material and reuse of the water. The extent to which water can be reused in the process is restricted by the water demand of the process	Only applicable when technique a. cannot be applied
d.	Condensation of organic compounds (amines) upstream of vacuum systems	See Section 12.1	Generally applicable

8.3. Raw material consumption

BAT 63: In order to use ethylene oxide efficiently, BAT is to use a combination of the techniques given below.

Technique		Description	Applicability
a.	Use of excess ammonia	Maintaining a high level of ammonia in the reaction mixture is an effective way of ensuring that all the ethylene oxide is converted into products	Generally applicable
b.	Optimisation of the water content in the reaction	Water is used to accelerate the main reactions without changing the product distribution and without significant side reactions with ethylene oxide to glycols	Only applicable for the aqueous process
c.	Optimise the process operating conditions	Determine and maintain the optimum operating conditions (e.g. temperature, pressure, residence time) to maximise the conversion of ethylene oxide to the desired mix of mono-, di-, triethanolamines	Generally applicable

9. BAT CONCLUSIONS FOR TOLUENE DIISOCYANATE (TDI) AND METHYLENE DIPHENYL DIISOCYANATE (MDI) PRODUCTION

The BAT conclusions in this section cover the production of:

- dinitrotoluene (DNT) from toluene;
- toluene diamine (TDA) from DNT;
- TDI from TDA;
- methylene diphenyl diamine (MDA) from aniline;
- MDI from MDA;

and apply in addition to the general BAT conclusions given in Section 1.

9.1. Emissions to air

BAT 64: In order to reduce the load of organic compounds, NO_X, NO_X precursors and SO_X sent to the final waste gas treatment (see BAT 66) from DNT, TDA and MDA plants, BAT is to use a combination of the techniques given below.

Technique		Description	Applicability
a.	Condensation	See Section 12.1	Generally applicable
b.	Wet scrubbing	See Section 12.1. In many cases, scrubbing efficiency is enhanced by the chemical reaction of the absorbed pollutant (partial oxidation of NO_X with recovery of nitric acid, removal of acids with caustic solution, removal of amines with acidic solutions, reaction of aniline with formaldehyde in caustic solution)	
c.	Thermal reduction	See Section 12.1	Applicability to existing units may be restricted by space availability
d.	Catalytic reduction	See Section 12.1	

BAT 65: In order to reduce the load of HCl and phosgene sent to the final waste gas treatment and to increase resource efficiency, BAT is to recover HCl and phosgene from the process off-gas streams of TDI and/or MDI plants by using an appropriate combination of the techniques given below.

Technique		Description	Applicability
a.	Absorption of HCl by wet scrubbing	See BAT 8d.	Generally applicable
b.	Absorption of phosgene by scrubbing	See Section 12.1. The excess phosgene is absorbed using an organic solvent and returned to the process	Generally applicable
c.	HCl/phosgene condensation	See Section 12.1	Generally applicable

BAT 66: In order to reduce emissions to air of organic compounds (including chlorinated hydrocarbons), HCl and chlorine, BAT is to treat combined waste gas streams using a thermal oxidiser followed by caustic scrubbing.

Description:

The individual waste gas streams from DNT, TDA, TDI, MDA and MDI plants are combined to one or several waste gas streams for treatment. (See Section 12.1 for the descriptions of thermal oxidiser and scrubbing.) Instead of a thermal oxidiser, an incinerator may be used for the combined treatment of liquid waste and the waste gas. Caustic scrubbing is wet scrubbing with caustic added to improve the HCl and chlorine removal efficiency.

Table 9.1

BAT-AELs for emissions of TVOC, tetrachloromethane, Cl_2, HCl and PCDD/F to air from the TDI/MDI process

Parameter	BAT-AEL (mg/Nm^3, no correction for oxygen content)
TVOC	1–5 (1) (2)
Tetrachloromethane	≤ 0,5 g/t MDI produced (3) ≤ 0,7 g/t TDI produced (3)

Parameter	BAT-AEL (mg/Nm³, no correction for oxygen content)
Cl_2	< 1 (²) (⁴)
HCl	2–10 (²)
PCDD/F	0,025–0,08 ng I-TEQ/Nm³ (²)

(¹) The BAT-AEL only applies to combined waste gas streams with flow rates of > 1 000 Nm³/h.
(²) The BAT-AEL is expressed as a daily average or an average over the sampling period.
(³) The BAT-AEL is expressed as an average of values obtained during 1 year. TDI and/or MDI produced refers to the product without residues, in the sense used to define the capacity of the plant.
(⁴) In the case of NO_X values above 100 mg/Nm³ in the sample, the BAT-AEL may be higher and up to 3 mg/Nm³ due to analytical interferences.

The associated monitoring is in BAT 2.

BAT 67: In order to reduce emissions to air of PCDD/F from a thermal oxidiser (see Section 12.1) treating process off-gas streams containing chlorine and/or chlorinated compounds, BAT is to use technique a, if necessary followed by technique b, given below.

	Technique	Description	Applicability
a.	Rapid quenching	Rapid cooling of exhaust gases to prevent the *de novo* synthesis of PCDD/F	Generally applicable
b.	Activated carbon injection	Removal of PCDD/F by adsorption onto activated carbon that is injected into the exhaust gas, followed by dust abatement	

BAT-associated emission levels (BAT-AELs): See Table 9.1.

9.2. Emissions to water

BAT 68: BAT is to monitor emissions to water with at least the 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.

Substance/Parameter	Plant	Sampling point	Standard(s)	Minimum monitoring frequency	Monitoring associated with
TOC	DNT plant	Outlet of the pretreatment unit	EN 1484	Once every week (¹)	BAT 70
	MDI and/or TDI plant	Outlet of the plant		Once every month	BAT 72
Aniline	MDA plant	Outlet of the final waste water treatment	No EN standard available	Once every month	BAT 14
Chlorinated solvents	MDI and/or TDI plant		Various EN standards available (e.g. EN ISO 15680)		BAT 14

(¹) In the case of discontinuous waste water discharges, the minimum monitoring frequency is once per discharge.

BAT 69: In order to reduce the load of nitrite, nitrate and organic compounds discharged from the DNT plant to waste water treatment, BAT is to recover raw materials, to reduce the waste water volume and to reuse water by using an appropriate combination of the techniques given below.

	Technique	Description	Applicability
a.	Use of highly concentrated nitric acid	Use highly concentrated HNO_3 (e.g. about 99 %) to increase the process efficiency and to reduce the waste water volume and the load of pollutants	Applicability to existing units may be restricted by design and/or operational constraints
b.	Optimised regeneration and recovery of spent acid	Perform the regeneration of the spent acid from the nitration reaction in such a way that water and the organic content are also recovered for reuse, by using an appropriate combination of evaporation/distillation, stripping and condensation	Applicability to existing units may be restricted by design and/or operational constraints
c.	Reuse of process water to wash DNT	Reuse process water from the spent acid recovery unit and the nitration unit to wash DNT	Applicability to existing units may be restricted by design and/or operational constraints
d.	Reuse of water from the first washing step in the process	Nitric and sulphuric acid are extracted from the organic phase using water. The acidified water is returned to the process, for direct reuse or further processing to recover materials	Generally applicable
e.	Multiple use and recirculation of water	Reuse water from washing, rinsing and equipment cleaning e.g. in the counter-current multistep washing of the organic phase	Generally applicable

BAT-associated waste water volume: See Table 9.2.

BAT 70: In order to reduce the load of poorly biodegradable organic compounds discharged from the DNT plant to further waste water treatment, BAT is to pretreat the waste water using one or both of the techniques given below.

	Technique	Description	Applicability
a.	Extraction	See Section 12.2	Generally applicable
b.	Chemical oxidation	See Section 12.2	

Table 9.2

BAT-AEPLs for discharge from the DNT plant at the outlet of the pretreatment unit to further waste water treatment

Parameter	BAT-AEPL (average of values obtained during 1 month)
TOC	< 1 kg/t DNT produced
Specific waste water volume	< 1 m^3/t DNT produced

The associated monitoring for TOC is in BAT 68.

BAT 71: In order to reduce waste water generation and the organic load discharged from the TDA plant to waste water treatment, BAT is to use a combination of techniques a., b. and c. and then to use technique d. as given below.

Technique		Description	Applicability
a.	Evaporation	See Section 12.2	Generally applicable
b.	Stripping	See Section 12.2	
c.	Extraction	See Section 12.2	
d.	Reuse of water	Reuse of water (e.g. from condensates or from scrubbing) in the process or in other processes (e.g. in a DNT plant). The extent to which water can be reused at existing plants may be restricted by technical constraints	Generally applicable

Table 9.3

BAT-AEPL for discharge from the TDA plant to waste water treatment

Parameter	BAT-AEPL (average of values obtained during 1 month)
Specific waste water volume	< 1 m^3/t TDA produced

BAT 72: In order to prevent or reduce the organic load discharged from MDI and/or TDI plants to final waste water treatment, BAT is to recover solvents and reuse water by optimising the design and operation of the plant.

Table 9.4

BAT-AEPL for discharge to waste water treatment from a TDI or MDI plant

Parameter	BAT-AEPL (average of values obtained during 1 year)
TOC	< 0,5 kg/t product (TDI or MDI) (1)

(1) The BAT-AEPL refers to the product without residues, in the sense used to define the capacity of the plant.

The associated monitoring is in BAT 68.

BAT 73: In order to reduce the organic load discharged from a MDA plant to further waste water treatment, BAT is to recover organic material using one or a combination of the techniques given below.

Technique		Description	Applicability
a.	Evaporation	See Section 12.2. Used to facilitate extraction (see technique b)	Generally applicable
b.	Extraction	See Section 12.2. Used to recover/remove MDA	Generally applicable
c.	Steam stripping	See Section 12.2. Used to recover/remove aniline and methanol	For methanol, the applicability depends on the assessment of alternative options as part of the waste water management and treatment strategy
d.	Distillation	See Section 12.2. Used to recover/remove aniline and methanol	

9.3. **Residues**

BAT 74: In order to reduce the amount of organic residues being sent for disposal from the TDI plant, BAT is to use a combination of the techniques given below.

Technique		Description	Applicability
Techniques to prevent or reduce the generation of waste			
a.	Minimisation of high-boiling residue formation in distillation systems	See BAT 17b.	Only applicable to new distillation units or major plant upgrades
Techniques to recover organic material for reuse or recycling			
b.	Increased recovery of TDI by evaporation or further distillation	Residues from distillation are additionally processed to recover the maximum amount of TDI contained therein, e.g. using a thin film evaporator or other short-path distillation units followed by a dryer.	Only applicable to new distillation units or major plant upgrades
c.	Recovery of TDA by chemical reaction	Tars are processed to recover TDA by chemical reaction (e.g. hydrolysis).	Only applicable to new plants or major plant upgrades

10. BAT CONCLUSIONS FOR ETHYLENE DICHLORIDE AND VINYL CHLORIDE MONOMER PRODUCTION

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 1.

10.1. Emissions to air

10.1.1. *BAT-AEL for emissions to air from an EDC cracker furnace*

Table 10.1

BAT-AELs for emissions to air of NO_X from an EDC cracker furnace

Parameter	BAT-AELs (1) (2) (3) (daily average or average over the sampling period) (mg/Nm^3, at 3 vol-% O_2)
NO_x	50–100

(1) Where the flue-gases of two or more furnaces are discharged through a common stack, the BAT-AEL applies to the combined discharge from the stack.

(2) The BAT-AELs do not apply during decoking operations.

(3) No BAT-AEL applies for CO. As an indication, the CO emission level will generally be 5–35 mg/Nm^3 expressed as a daily average or an average over the sampling period.

The associated monitoring is in BAT 1.

10.1.2. *Techniques and BAT-AEL for emissions to air from other sources*

BAT 75: In order to reduce the organic load sent to the final waste gas treatment and to reduce raw material consumption, BAT is to use all of the techniques given below.

	Technique	Description	Applicability
Process-integrated techniques			
a.	Control of feed quality	Control the quality of the feed to minimise the formation of residues (e.g. propane and acetylene content of ethylene; bromine content of chlorine; acetylene content of hydrogen chloride)	Generally applicable
b.	Use of oxygen instead of air for oxychlorination		Only applicable to new oxychlorination plants or major oxychlorination plant upgrades
Techniques to recover organic material			
c.	Condensation using chilled water or refrigerants	Use condensation (see Section 12.1) with chilled water or refrigerants such as ammonia or propylene to recover organic compounds from individual vent gas streams before sending them to final treatment	Generally applicable

BAT 76: In order to reduce emissions to air of organic compounds (including halogenated compounds), HCl and Cl_2, BAT is to treat the combined waste gas streams from EDC and/or VCM production by using a thermal oxidiser followed by two-stage wet scrubbing.

Description:

For the description of thermal oxidiser, wet and caustic scrubbing, see Section 12.1. Thermal oxidation can be carried out in a liquid waste incineration plant. In this case, the oxidation temperature exceeds 1 100 °C with a minimum residence time of 2 seconds, with subsequent rapid cooling of exhaust gases to prevent the *de novo* synthesis of PCDD/F.

Scrubbing is carried out in two stages: Wet scrubbing with water and, typically, recovery of hydrochloric acid, followed by wet scrubbing with caustic.

Table 10.2

BAT-AELs for emissions of TVOC, the sum of EDC and VCM, Cl_2, HCl and PCDD/F to air from the production of EDC/VCM

Parameter	BAT-AEL (daily average or average over the sampling period) (mg/Nm^3, at 11 vol-% O_2)
TVOC	0,5–5
Sum of EDC and VCM	< 1
Cl_2	< 1–4
HCl	2–10
PCDD/F	0,025–0,08 ng I-TEQ/Nm^3

The associated monitoring is in BAT 2.

BAT 77: In order to reduce emissions to air of PCDD/F from a thermal oxidiser (see Section 12.1) treating process off-gas streams containing chlorine and/or chlorinated compounds, BAT is to use technique a, if necessary followed by technique b, given below.

Technique		Description	Applicability
a.	Rapid quenching	Rapid cooling of exhaust gases to prevent the *de novo* synthesis of PCDD/F	Generally applicable
b.	Activated carbon injection	Removal of PCDD/F by adsorption onto activated carbon that is injected into the exhaust gas, followed by dust abatement	

BAT-associated emission levels (BAT-AELs): See Table 10.2.

BAT 78: In order to reduce emissions to air of dust and CO from the decoking of the cracker tubes, BAT is to use one of the techniques to reduce the frequency of decoking given below and one or a combination of the abatement techniques given below.

Technique		Description	Applicability
Techniques to reduce the frequency of decoking			
a.	Optimisation of thermal decoking	Optimisation of operating conditions, i.e. airflow, temperature and steam content across the decoking cycle, to maximise coke removal	Generally applicable

Technique		Description	Applicability
b.	Optimisation of mechanical decoking	Optimise mechanical decoking (e.g. sand jetting) to maximise coke removal as dust	Generally applicable
Abatement techniques			
c.	Wet dust scrubbing	See Section 12.1	Only applicable to thermal decoking
d.	Cyclone	See Section 12.1	Generally applicable
e.	Fabric filter	See Section 12.1	Generally applicable

10.2. Emissions to water

BAT 79: BAT is to monitor emissions to water with at least the 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.

Substance/Parameter	Plant	Sampling point	Standard(s)	Minimum monitoring frequency	Monitoring associated with
EDC	All plants	Outlet of the waste water stripper	EN ISO 10301	Once every day	BAT 80
VCM					
Copper	Oxy-chlorination plant using the fluidised-bed design	Outlet of the pretreatment for solids removal	Various EN standards available, e.g. EN ISO 11885, EN ISO 15586, EN ISO 17294-2	Once every day (1)	BAT 81
PCDD/F			No EN standard available	Once every 3 months	
Total suspended solids (TSS)			EN 872	Once every day (1)	
Copper	Oxy-chlorination plant using the fluidised-bed design	Outlet of the final waste water treatment	Various EN standards available, e.g. EN ISO 11885, EN ISO 15586, EN ISO 17294-2	Once every month	BAT 14 and BAT 81
EDC	All plants		EN ISO 10301	Once every month	BAT 14 and BAT 80
PCDD/F			No EN standard available	Once every 3 months	BAT 14 and BAT 81

(1) The minimum monitoring frequency may be reduced to once every month if adequate performance of the solids and copper removal is controlled by frequent monitoring of other parameters (e.g. by continuous measurement of turbidity).

BAT 80: In order to reduce the load of chlorinated compounds discharged to further waste water treatment and to reduce emissions to air from the waste water collection and treatment system, BAT is to use hydrolysis and stripping as close as possible to the source.

Description:

For the description of hydrolysis and stripping, see Section 12.2. Hydrolysis is carried out at alkaline pH to decompose chloral hydrate from the oxychlorination process. This results in the formation of chloroform which is then removed by stripping, together with EDC and VCM.

BAT-associated environmental performance levels (BAT-AEPLs): See Table 10.3.

BAT-associated emission levels (BAT-AELs) for direct emissions to a receiving water body at the outlet of the final treatment: See Table 10.5.

Table 10.3

BAT-AEPLs for chlorinated hydrocarbons in waste water at the outlet of a waste water stripper

Parameter	BAT-AEPL (average of values obtained during 1 month) (1)
EDC	0,1–0,4 mg/l
VCM	< 0,05 mg/l

(1) The average of values obtained during 1 month is calculated from the averages of values obtained during each day (at least three spot samples taken at intervals of at least half an hour).

The associated monitoring is in BAT 79.

BAT 81: In order to reduce emissions to water of PCDD/F and copper from the oxychlorination process, BAT is to use technique a. or, alternatively, technique b together with an appropriate combination of techniques c., d. and e. given below.

	Technique	Description	Applicability
Process-integrated techniques			
a.	Fixed-bed design for oxychlorination	Oxychlorination reaction design: in the fixed-bed reactor, catalyst particulates entrained in the overhead gaseous stream are reduced	Not applicable to existing plants using the fluidised-bed design
b.	Cyclone or dry catalyst filtration system	A cyclone or a dry catalyst filtration system reduces catalyst losses from the reactor and therefore also their transfer to waste water	Only applicable to plants using the fluidised-bed design
Waste water pretreatment			
c.	Chemical precipitation	See Section 12.2. Chemical precipitation is used to remove dissolved copper	Only applicable to plants using the fluidised-bed design
d.	Coagulation and flocculation	See Section 12.2	Only applicable to plants using the fluidised-bed design
e.	Membrane filtration (micro- or ultrafiltration)	See Section 12.2	Only applicable to plants using the fluidised-bed design

Table 10.4

BAT-AEPLs for emissions to water from EDC production via oxychlorination at the outlet of the pretreatment for solids removal at plants using the fluidised-bed design

Parameter	BAT-AEPL (average of values obtained during 1 year)
Copper	0,4–0,6 mg/l
PCDD/F	< 0,8 ng I-TEQ/l
Total suspended solids (TSS)	10–30 mg/l

The associated monitoring is in BAT 79.

Table 10.5

BAT-AELs for direct emissions of copper, EDC and PCDD/F to a receiving water body from EDC production

Parameter	BAT-AEL (average of values obtained during 1 year)
Copper	0,04–0,2 g/t EDC produced by oxychlorination (1)
EDC	0,01–0,05 g/t EDC purified (2) (3)
PCDD/F	0,1– 0,3 µg I-TEQ/t EDC produced by oxychlorination

(1) The lower end of the range is typically achieved when the fixed-bed design is used.
(2) The average of values obtained during one year is calculated from the averages of values obtained during each day (at least three spot samples taken at intervals of at least half an hour).
(3) Purified EDC is the sum of EDC produced by oxychlorination and/or direct chlorination and of EDC returned from VCM production to purification.

The associated monitoring is in BAT 79.

10.3. Energy efficiency

BAT 82: In order to use energy efficiently, BAT is to use a boiling reactor for the direct chlorination of ethylene.

Description:

The reaction in the boiling reactor system for the direct chlorination of ethylene is typically carried out at a temperature between below 85 °C and 200 °C. In contrast to the low-temperature process, it allows for the effective recovery and reuse of the heat of reaction (e.g. for the distillation of EDC).

Applicability:

Only applicable to new direct chlorination plants.

BAT 83: In order to reduce the energy consumption of EDC cracker furnaces, BAT is to use promoters for the chemical conversion.

Description:

Promoters, such as chlorine or other radical-generating species, are used to enhance the cracking reaction and reduce the reaction temperature and therefore the required heat input. Promoters may be generated by the process itself or added.

10.4. Residues

BAT 84: In order to reduce the amount of coke being sent for disposal from VCM plants, BAT is to use a combination of the techniques given below.

Technique		Description	Applicability
a.	Use of promoters in cracking	See BAT 83	Generally applicable
b.	Rapid quenching of the gaseous stream from EDC cracking	The gaseous stream from EDC cracking is quenched by direct contact with cold EDC in a tower to reduce coke formation. In some cases, the stream is cooled by heat exchange with cold liquid EDC feed prior to quenching	Generally applicable
c.	Pre-evaporation of EDC feed	Coke formation is reduced by evaporating EDC upstream of the reactor to remove high-boiling coke precursors	Only applicable to new plants or major plant upgrades
d.	Flat flame burners	A type of burner in the furnace that reduces hot spots on the walls of the cracker tubes	Only applicable to new furnaces or major plant upgrades

BAT 85: In order to reduce the amount of hazardous waste being sent for disposal and to increase resource efficiency, BAT is to use all of the techniques given below.

Technique		Description	Applicability
a.	Hydrogenation of acetylene	HCl is generated in the EDC cracking reaction and recovered by distillation. Hydrogenation of the acetylene present in this HCl stream is carried out to reduce the generation of unwanted compounds during oxychlorination. Acetylene values below 50 ppmv at the outlet of the hydrogenation unit are advisable	Only applicable to new plants or major plant upgrades
b.	Recovery and reuse of HCl from incineration of liquid waste	HCl is recovered from incinerator off-gas by wet scrubbing with water or diluted HCl (see Section 12.1) and reused (e.g. in the oxychlorination plant)	Generally applicable
c.	Isolation of chlorinated compounds for use	Isolation and, if needed, purification of by-products for use (e.g. monochloroethane and/or 1,1,2-trichloroethane, the latter for the production of 1,1-dichloroethylene)	Only applicable to new distillation units or major plant upgrades. Applicability may be restricted by a lack of available uses for these compounds

11. BAT CONCLUSIONS FOR HYDROGEN PEROXIDE PRODUCTION

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 1.

11.1. Emissions to air

BAT 86: In order to recover solvents and to reduce emissions of organic compounds to air from all units other than the hydrogenation unit, BAT is to use an appropriate combination of the techniques given below. In the case of using air in the oxidation unit, this includes at least technique d. In the case of using pure oxygen in the oxidation unit, this includes at least technique b. using chilled water.

	Technique	Description	Applicability
Process-integrated techniques			
a.	Optimisation of the oxidation process	Process optimisation includes elevated oxidation pressure and reduced oxidation temperature in order to reduce the solvent vapour concentration in the process off-gas	Only applicable to new oxidation units or major plant upgrades
b.	Techniques to reduce solids and/or liquids entrainment	See Section 12.1	Generally applicable
Techniques to recover solvent for reuse			
c.	Condensation	See Section 12.1	Generally applicable
d.	Adsorption (regenerative)	See Section 12.1	Not applicable to process off-gas from oxidation with pure oxygen

Table 11.1

BAT-AELs for emissions of TVOC to air from the oxidation unit

Parameter	BAT-AEL (¹) (daily average or average over the sampling period) (²) (no correction for oxygen content)
TVOC	5–25 mg/Nm³ (³)

(¹) The BAT-AEL does not apply when the emission is below 150 g/h.
(²) When adsorption is used, the sampling period is representative of a complete adsorption cycle.
(³) In the case of significant methane content in the emission, methane monitored according to EN ISO 25140 or EN ISO 25139 is subtracted from the result.

The associated monitoring is in BAT 2.

BAT 87: In order to reduce emissions of organic compounds to air from the hydrogenation unit during start-up operations, BAT is to use condensation and/or adsorption.

Description:

For the description of condensation and adsorption, see Section 12.1.

BAT 88: In order to prevent benzene emissions to air and water, BAT is not to use benzene in the working solution.

11.2. Emissions to water

BAT 89: In order to reduce the waste water volume and the organic load discharged to waste water treatment, BAT is to use both of the techniques given below.

Technique		Description	Applicability
a.	Optimised liquid phase separation	Separation of organic and aqueous phases with appropriate design and operation (e.g. sufficient residence time, phase boundary detection and control) to prevent any entrainment of undissolved organic material	Generally applicable
b.	Reuse of water	Reuse of water, e.g. from cleaning or liquid phase separation. The extent to which water can be reused in the process depends on product quality considerations	Generally applicable

BAT 90: In order to prevent or reduce emissions to water of poorly bioeliminable organic compounds, BAT is to use one of the techniques given below.

Technique		Description
a.	Adsorption	See Section 12.2. Adsorption is carried out prior to sending waste water streams to the final biological treatment
b.	Waste water incineration	See Section 12.2

Applicability:

Only applicable to waste water streams carrying the main organic load from the hydrogen peroxide plant and when the reduction of the TOC load from the hydrogen peroxide plant by means of biological treatment is lower than 90 %.

12. DESCRIPTIONS OF TECHNIQUES

12.1. Process off-gas and waste gas treatment techniques

Technique	Description
Adsorption	A technique for removing compounds from a process off-gas or waste gas stream by retention on a solid surface (typically activated carbon). Adsorption may be regenerative or non-regenerative (see below).
Adsorption (non-regenerative)	In non-regenerative adsorption, the spent adsorbent is not regenerated but disposed of.
Adsorption (regenerative)	Adsorption where the adsorbate is subsequently desorbed, e.g. with steam (often on site) for reuse or disposal and the adsorbent is reused. For continuous operation, typically more than two adsorbers are operated in parallel, one of them in desorption mode.

Technique	Description
Catalytic oxidiser	Abatement equipment which oxidises combustible compounds in a process off-gas or waste gas stream with air or oxygen in a catalyst bed. The catalyst enables oxidation at lower temperatures and in smaller equipment compared to a thermal oxidiser.
Catalytic reduction	NO_x is reduced in the presence of a catalyst and a reducing gas. In contrast to SCR, no ammonia and/or urea are added.
Caustic scrubbing	The removal of acidic pollutants from a gas stream by scrubbing using an alkaline solution.
Ceramic/metal filter	Ceramic filter material. In circumstances where acidic compounds such as HCl, NO_X, SO_X and dioxins are to be removed, the filter material is fitted with catalysts and the injection of reagents may be necessary. In metal filters, surface filtration is carried out by sintered porous metal filter elements.
Condensation	A technique for removing the vapours of organic and inorganic compounds from a process off-gas or waste gas stream by reducing its temperature below its dew point so that the vapours liquefy. Depending on the operating temperature range required, there are different methods of condensation, e.g. cooling water, chilled water (temperature typically around 5 °C) or refrigerants such as ammonia or propene.
Cyclone (dry or wet)	Equipment for removal of dust from a process off-gas or waste gas stream based on imparting centrifugal forces, usually within a conical chamber.
Electrostatic precipitator (dry or wet)	A particulate control device that uses electrical forces to move particles entrained within a process off-gas or waste gas stream onto collector plates. The entrained particles are given an electrical charge when they pass through a corona where gaseous ions flow. Electrodes in the centre of the flow lane are maintained at a high voltage and generate the electrical field that forces the particles to the collector walls.
Fabric filter	Porous woven or felted fabric through which gases flow to remove particles by use of a sieve or other mechanisms. Fabric filters can be in the form of sheets, cartridges or bags with a number of the individual fabric filter units housed together in a group.
Membrane separation	Waste gas is compressed and passed through a membrane which relies on the selective permeability of organic vapours. The enriched permeate can be recovered by methods such as condensation or adsorption, or can be abated, e.g. by catalytic oxidation. The process is most appropriate for higher vapour concentrations. Additional treatment is, in most cases, needed to achieve concentration levels low enough to discharge.
Mist filter	Commonly mesh pad filters (e.g. mist eliminators, demisters) which usually consist of woven or knitted metallic or synthetic monofilament material in either a random or specific configuration. A mist filter is operated as deep-bed filtration, which takes place over the entire depth of the filter. Solid dust particles remain in the filter until it is saturated and requires cleaning by flushing. When the mist filter is used to collect droplets and/or aerosols, they clean the filter as they drain out as a liquid. It works by mechanical impingement and is velocity-dependent. Baffle angle separators are also commonly used as mist filters.

Technique	Description
Regenerative thermal oxidiser (RTO)	Specific type of thermal oxidiser (see below) where the incoming waste gas stream is heated by a ceramic-packed bed by passing through it before entering the combustion chamber. The purified hot gases exit this chamber by passing through one (or more) ceramic-packed bed(s) (cooled by an incoming waste gas stream in an earlier combustion cycle). This reheated packed bed then begins a new combustion cycle by preheating a new incoming waste gas stream. The typical combustion temperature is 800–1 000 °C.
Scrubbing	Scrubbing or absorption is the removal of pollutants from a gas stream by contact with a liquid solvent, often water (see 'Wet scrubbing'). It may involve a chemical reaction (see 'Caustic scrubbing'). In some cases, the compounds may be recovered from the solvent.
Selective catalytic reduction (SCR)	The reduction of NO_X to nitrogen in a catalytic bed by reaction with ammonia (usually supplied as an aqueous solution) at an optimum operating temperature of around 300–450 ° 2E [illegible] or more layers of catalyst may be applied.
Selective non-catalytic reduction (SNCR)	The reduction of NO_X 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.
Techniques to reduce solids and/or liquids entrainment	Techniques that reduce the carry-over of droplets or particles in gaseous streams (e.g. from chemical processes, condensers, distillation columns) by mechanical devices such as settling chambers, mist filters, cyclones and knock-out drums.
Thermal oxidiser	Abatement equipment which oxidises the combustible compounds in a process off-gas or waste gas stream by heating it with air or oxygen to above its auto-ignition point in a combustion chamber and maintaining it at a high temperature long enough to complete its combustion to carbon dioxide and water.
Thermal reduction	NO_X is reduced at elevated temperatures in the presence of a reducing gas in an additional combustion chamber, where an oxidation process takes place but under low oxygen conditions/deficit of oxygen. In contrast to SNCR, no ammonia and/or urea are added.
Two-stage dust filter	A device for filtering on a metal gauze. A filter cake builds up in the first filtration stage and the actual filtration takes place in the second stage. Depending on the pressure drop across the filter, the system switches between the two stages. A mechanism to remove the filtered dust is integrated into the system.
Wet scrubbing	See 'Scrubbing' above. Scrubbing where the solvent used is water or an aqueous solution, e.g. caustic scrubbing for abating HCl. See also 'Wet dust scrubbing'.
Wet dust scrubbing	See 'Wet scrubbing' above. Wet dust scrubbing entails separating the dust by intensively mixing the incoming gas with water, mostly combined with the removal of the coarse particles by the use of centrifugal force. In order to achieve this, the gas is released inside tangentially. The removed solid dust is collected at the bottom of the dust scrubber.

12.2. Waste water treatment techniques

All of the techniques listed below can also be used to purify water streams in order to enable reuse/recycling of water. Most of them are also used to recover organic compounds from process water streams.

Technique	Description
Adsorption	Separation method in which compounds (i.e. pollutants) in a fluid (i.e. waste water) are retained on a solid surface (typically activated carbon).
Chemical oxidation	Organic compounds are oxidised with ozone or hydrogen peroxide, optionally supported by catalysts or UV radiation, to convert them into less harmful and more easily biodegradable compounds
Coagulation and flocculation	Coagulation and flocculation are used to separate suspended solids from waste water and are often carried out in successive steps. Coagulation is carried out by adding coagulants with charges opposite to those of the suspended solids. Flocculation is carried out by adding polymers, so that collisions of microfloc particles cause them to bond to produce larger flocs.
Distillation	Distillation is a technique to separate compounds with different boiling points by partial evaporation and recondensation. Waste water distillation is the removal of low-boiling contaminants from waste water by transferring them into the vapour phase. Distillation is carried out in columns, equipped with plates or packing material, and a downstream condenser.
Extraction	Dissolved pollutants are transferred from the waste water phase to an organic solvent, e.g. in counter-current columns or mixer-settler systems. After phase separation, the solvent is purified, e.g. by distillation, and returned to the extraction. The extract containing the pollutants is disposed of or returned to the process. Losses of solvent to the waste water are controlled downstream by appropriate further treatment (e.g. stripping).
Evaporation	The use of distillation (see above) to concentrate aqueous solutions of high-boiling substances for further use, processing or disposal (e.g. waste water incineration) by transferring water to the vapour phase. Typically carried out in multistage units with increasing vacuum, to reduce the energy demand. The water vapours are condensed, to be reused or discharged as waste water.
Filtration	The separation of solids from a waste water carrier by passing it through a porous medium. It includes different types of techniques, e.g. sand filtration, microfiltration and ultrafiltration.
Flotation	A process in which solid or liquid particles are separated from the waste water phase by attaching to fine gas bubbles, usually air. The buoyant particles accumulate at the water surface and are collected with skimmers.
Hydrolysis	A chemical reaction in which organic or inorganic compounds react with water, typically in order to convert non-biodegradable to biodegradable or toxic to non-toxic compounds. To enable or enhance the reaction, hydrolysis is carried out at an elevated temperature and possibly pressure (thermolysis) or with the addition of strong alkalis or acids or using a catalyst.

Technique	Description
Precipitation	The conversion of dissolved pollutants (e.g. metal ions) into insoluble compounds by reaction with added precipitants. The solid precipitates formed are subsequently separated by sedimentation, flotation or filtration.
Sedimentation	Separation of suspended particles and suspended material by gravitational settling.
Stripping	Volatile compounds are removed from the aqueous phase by a gaseous phase (e.g. steam, nitrogen or air) that is passed through the liquid, and are subsequently recovered (e.g. by condensation) for further use or disposal. The removal efficiency may be enhanced by increasing the temperature or reducing the pressure.
Waste water incineration	The oxidation of organic and inorganic pollutants with air and simultaneous evaporation of water at normal pressure and temperatures between 730 °C and 1 200 °2E [redacted] water incineration is typically self-sustaining at COD levels of more than 50 g/l. In the case of low organic loads, a support/auxiliary fuel is needed.

12.3. Techniques to reduce emissions to air from combustion

Technique	Description
Choice of (support) fuel	The use of fuel (including support/auxiliary fuel) with a low content of potential pollution-generating compounds (e.g. lower sulphur, ash, nitrogen, mercury, fluorine or chlorine content in the fuel).
Low-NO_X burner (LNB) and ultra-low-NO_X burner (ULNB)	The technique 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-NO_X burners (ULNB) includes (air/)fuel staging and exhaust/flue-gas recirculation.