RISK & HAZARD MANAGEMENT

# 007 - Technical Standards

## Saffil Ltd (also known as Unifrax/Alkegen)
## Line 4 Permit Variation

| Version | Issue | Date | Comments | Author | Reviewer |
|---|---|---|---|---|---|
| 1 | - | 19/01/21 | Working draft with client. | J. Carroll<br>R. Nibbs | C. Nicholls |
| 2 | 1 | 01/07/22 | Issue as part of permit application. | J. Carroll<br>R. Nibbs | C. Nicholls<br>R. Ritchie<br>R. Nibbs |

# Contents

# 1 Introduction

This document is submitted as part of Form C3 of the environmental permit variation.

Please note that this document refers to the site as Unifrax Widnes and to the owning company as Unifrax. Unifrax was the name of the American company that owns Widnes site. A further complexity is added because due to a recent merger, Unifrax has changed its name to Alkegen. So, it is possible in correspondence or discussions that the site may be referred to as Alkegen.

The legal entity that owns the site at Widnes is however called Saffil Ltd and remains so despite the name changes to Unifrax and Alkegen – and it is in this name that the EPR application is made on the accompanying forms.

The document is structured as follows:

- Section 2: Review of applicable BREF/BAT Conclusions
- Section 3: Overarching summary of BAT conclusions and how they are to be imposed onsite
- Section 4: More detailed BAT assessment of air emissions
- Section 5: More detailed BAT assessment of aqueous emissions
- Section 6: Appendix containing the reference material that has been consulted.

Due to the nature of the site which will be explored in Section 2, it was decided that up front summary tables of the BAT conclusions for each component emitted by the processes onsite was the best way to present the final proposed limits, abatement techniques and monitoring frequencies to be adopted by the site, with the detailed assessment of technologies following this summary.

# 2 Review of applicable BREF/BAT Conclusions

A review of all the BREF Documents and BAT Conclusions has been carried out, and as per previous permit applications and variations, there does not appear to be a directly applicable primary BREF for the activity carried out onsite. This is because the inorganic chemicals version of the Large Volume Organic Chemicals (LVOC) BREF is yet to be published. This means that there is no direct reference for which abatement technologies, general BAT conclusions and emission limit values (ELVs) for the particular activity can be extracted, and as a result a review of several indirectly applicable BREFs has been carried out.

Whilst there is no directly applicable BREF, Sector Guidance Note 4.03 is applicable to the activity and was consulted at the previous permit variation, and largely used to derive ELVs for emissions from the activity. Both this and a combination of the other BREFs have been consulted.

The table below provides a list of all the BREF/BAT Conclusions as specified at https://eippcb.jrc.ec.europa.eu/reference and indicates whether they are or are not applicable or where some aspects have been deemed to be indirectly applicable.

**Table 1 BREF/BAT Conclusions**

| Code | BREF/BAT Conclusions | Applicability to the site/variation |
|---|---|---|
| LVIC | Large Volume Inorganic Chemicals | Relevant but not yet published. |
| CWW | Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector | Activity undertaken not specifically listed within the scope, but waste water and waste gas are treated as part of the process therefore conclusions given consideration. |
| ECM | Economics and cross-media effects | General BAT approach adopted within site operations. |
| EFS | Emissions from storage | General BAT approach adopted within site operations. Specific aspects covered within other BREFs/BAT Conclusions. |
| ENE | Energy Efficiency | General BAT approach adopted within site operations. Specific aspects covered within other BREFs/BAT Conclusions. |
| ICS | Industrial Cooling Systems | General BAT approach adopted with cooling system onsite. |
| LVIC-S | Large Volume Inorganic Chemicals – Solids and Others Industry | Not strictly relevant - relates to the bulk manufacture of some of the raw materials involved in the processes onsite but not the use of them in a process. Technologies covered within other BREFs. |
| LVOC | Production of Large Volume Organic Chemicals | Activity undertaken not listed within scope; site does not produce LVOCs. However, in the absence of a directly relevant primary BREF, the generic BAT conclusions provided within this document are given consideration as they cover substances and technologies applicable to the site. |

| Code | BREF/BAT Conclusions | Applicability to the site/variation |
|---|---|---|
| ROM | Monitoring of emissions to air and water | General BAT approach adopted within site operations. Specific aspects covered within other BREFs/BAT Conclusions. |
| SIC | Production of speciality Inorganic Chemicals | Activity undertaken not specifically listed within the scope. Technologies covered within other BREFs |
| WI | Waste Incineration | Activity undertaken not listed within scope; site does not incinerate waste. However, in the absence of a directly relevant primary BREF, the generic BAT conclusions provided within this document are given consideration as they cover substances and technologies applicable to the site. |
| WGCS | Common Waste Gas Management and Treatment Systems in the Chemical Sector | Not yet published |
| FDM | Food, drink and milk industries | Not relevant – different industry |
| FMP | Ferrous metals processing industry | Not relevant – different industry |
| GLS | Manufacture of glass | Not relevant – different industry |
| CAK | Production of Chlor-alkali | Not relevant – different industry |
| CER | Ceramic Manufacturing Industry | Not relevant – different industry |
| CLM | Production of Cement, Lime and Magnesium Oxide | Not relevant – different industry |
| IRPP | Intensive rearing of poultry or pigs | Not relevant – different industry |
| IS | Iron and steel production | Not relevant – different industry |
| LCP | Large Combustion Plants | Not relevant – below threshold of LCP |
| LVIC-AAF | Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers | Not relevant – different industry |
| NFM | Non-ferrous metals industries | Not relevant – different industry |
| OFC | Manufacture of organic fine chemicals | Not relevant – different industry |
| POL | Production of polymers | Not relevant – different industry |
| PP | Production of pulp, paper and board | Not relevant – different industry |
| REF | Refining of mineral oil and gas | Not relevant – different industry |
| SA | Slaughterhouses and animals by-products industries | Not relevant – different industry |
| SF | Smitheries and foundries industry | Not relevant – different industry |
| STM | Surface treatment of metals and plastics | Not relevant – different industry |
| STS | Surface Treatment Using Organic Solvents including Wood and Wood Products Preservation with Chemicals | Not relevant – different industry |
| TAN | Tanning of Hides and Skins | Not relevant – different industry |
| TXT | Textiles Industry | Not relevant – different industry |
| WBP | Wood based panels production | Not relevant – different industry |

| Code | BREF/BAT Conclusions | Applicability to the site/variation |
|---|---|---|
| WT | Waste Treatment | Not relevant – different industry |

Based on the table above, as well as the Sector Guidance notes consulted in the previous variation, SGN 4.01 The Production of Organic Chemicals and SGN 4.03 The Production of Inorganic Chemicals, the following BREFs/BAT Conclusions are deemed indirectly relevant to the activities carried out onsite and have been consulted for guidance on technologies and emission limits:

- Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector
- Production of Large Volume Organic Chemicals
- Waste Incineration

Short extracts of these relevant BREFs are provided in the Appendix to show they have been consulted.

# 3 BAT Conclusions Summary

The following tables provide a list of all the components emitted by the processes onsite, a comparison of the different emission limits, abatement technologies and monitoring frequencies which have been extracted from the numerous potentially relevant BAT Conclusions, with details of the proposed limits, abatement techniques and monitoring frequencies to be adopted by the site. Superscript numbers in the tables refer to the notes below the tables.

## 3.1 Gaseous

**Table 2 Main process stacks**

| Component | BAT-AEL | Reference | Average Readings 2016-2021 inc unless stated | | Proposed ELVs | Recommended abatement | Reference | Proposed abatement | Recommended monitoring frequency | Reference | Proposed monitoring frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A3 | A5 | | | | | | | |
| Class A VOC | 20 mg/m$^3$ | SGN 4.03 for Inorganic Chemicals | 6.5 mg/m$^3$ | 9.6 mg/m$^3$ | A3, A5 and A11 – 20 mg/m$^3$ - meets SGN limit | Wet scrubber and thermal oxidiser | LVOC BAT Conclusions (BAT 10) | Dual wet scrubber and regenerative thermal oxidiser | Monthly | LVOC BAT Conclusions (BAT 2) | Quarterly as per current permit requirements [1] |
| Class B VOC | 75 mg/m$^3$ | | 3.1 mg/m$^3$ | 9.43 mg/m$^3$ | A3, A5 and A11 – 75 mg/m$^3$ - meets SGN limit | Wet scrubber and thermal oxidiser | | Dual wet scrubber and regenerative thermal oxidiser | Continuous | WI BAT Conclusions (BAT 4) | Quarterly as per current permit requirements [1, 3] |
| Dioxin | 0.1 ng/m$^3$ | LVOC BREF | 0.20 ng/m$^3$ (2007-2021 inc) | 0.088 ng/m$^3$ (2007-2021 inc) | A3 – 0.3 ng/m$^3$<br>A5 – 0.3 ng/m$^3$<br>A11 – 0.3 ng/m$^3$ | Thermal oxidiser with rapid quenching and potentially carbon injection | LVOC BAT Conclusions (BAT 67) | Dual wet scrubber and regenerative thermal oxidiser | 6 monthly | LVOC BAT Conclusions (BAT 4) | Annual as per current permit requirements [2] |
| | < 0.01 - 0.04 ng/m$^3$ (new plant)<br>< 0.01 – 0.06 ng/m$^3$ (existing plant) | WI BAT Conclusions | | | | Optimisation of the process<br>Control of the waste feed<br>Online and offline boiler cleaning<br>Rapid flue-gas cooling followed by: Dry sorbent injection<br>Fixed or moving bed adsorption<br>SCR<br>Catalytic filter bags<br>Carbon sorbent in a wet scrubber | WI BAT Conclusions (BAT 30) | Dual wet scrubber and regenerative thermal oxidiser | 6 monthly | LVOC BAT Conclusions (BAT 2) | |
| Hydrogen Chloride | < 2 – 6 mg/m$^3$ (new plant)<br>< 2 – 8 mg/m$^3$ (existing plant) | WI BAT Conclusions | 0.71 mg/m$^3$ | 2.2 mg/m$^3$ | A3, A5 and A11 – 10 mg/m$^3$ - meets SGN limit | Wet scrubber | LVOC BAT Conclusions (BAT 12)<br>WI BAT Conclusions (BAT 27) | Dual wet scrubber | Monthly | LVOC BAT Conclusions (BAT 2) | Quarterly as per current permit requirements [1, 3] |
| | 10 mg/m$^3$ | SGN 4.03 for Inorganic Chemicals | | | | | | | Continuous | WI BAT Conclusions (BAT 4) | |
| | 30 mg/m$^3$ | LVOC BREF | | | | | | | | | |
| Ethylene Oxide | 2 mg/m$^3$ | SGN 4.01 for Organic Chemicals | 0.77 mg/m$^3$ | 0.51 mg/m$^3$ | 5 mg/m$^3$ | As per VOCs above | | | | | |
| Vinyl chloride | 1 - 5 mg/m$^3$ | SGN 4.01 for Organic Chemicals | 0.80 mg/m$^3$ | 0.87 mg/m$^3$ | 5 mg/m$^3$ | | | | | | |

**Table 3 Particulate stacks**

| Component | BAT-AEL | Reference | Average Readings 2016-2021 inc unless stated | | | Proposed ELVs | Recommended abatement | Reference | Proposed abatement | Recommended monitoring frequency | Reference | Proposed monitoring frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A2 | A4 | A6 | | | | | | | |
| Particulates | < 2 – 5 mg/m$^3$ | WI BAT Conclusions | 1.05 mg/m$^3$ | 0.91 mg/m$^3$ | 1.07 mg/m$^3$ | A2, A4, A6 and A12a/b - 5 mg/m$^3$ | Bag filter | WI BAT Conclusions (BAT 15) | Bag filter | Continuous | WI BAT Conclusions (BAT 4) | Quarterly as per current permit requirements [2] |
| | 5 – 20 mg/m$^3$ | SGN 4.03 for Inorganic Chemicals | | | | | | | | | | |
| | 30 mg/m$^3$ | LVOC BREF | | | | | Bag filter | LVOC BAT Conclusions (BAT 11) | | Monthly | LVOC BAT Conclusions (BAT 2) | |

**Table 4 Boilers**

| Component | BAT-AEL | Reference | Average Readings 2016-2021 inc unless stated | | Proposed ELVs | Recommended abatement | Reference | Proposed abatement | Recommended monitoring frequency | Reference | Proposed monitoring frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A7 | A9 | | | | | | | |
| NOx | 200 mg/m$^3$ (new plant – fuel)<br>100 mg/m$^3$ (new plant – gas)<br>200 mg/m$^3$ (existing – fuel - 5 – 50 MW)<br>200 mg/m$^3$ (existing – fuel - 1 - 5 MW)<br>200 mg/m$^3$ (existing – gas - 5 – 50 MW)<br>250 mg/m$^3$ (existing – gas - 1 - 5 MW) | Medium Combustion Plant Directive | 119 mg/m$^3$ | 93 mg/m$^3$ | A7 – 140 mg/m$^3$<br>A9 – 100 mg/m$^3$<br>A13 – 100 mg/m$^3$ - meets MCPD for new plant | Choice of fuel, staged combustion, flue-gas recirculation, low NOx burner, use of inert diluents, SCR or SNCR. | LVOC BAT Conclusions (BAT 4) | Choice of fuel (primarily natural gas) and low NOx burners. Use of economisers and condensate recovery. | - | - | Annual as per current permit requirements |

Notes:

1. Monitoring of speciated VOC components and hydrogen chloride was carried out monthly for many years under previous IPC/IPPC permits, notably BT1614IW (August 2005) and earlier IPC permits. The Line 3 EPR permit variation process XP3533CB (May 2012) recognised that a large database of results demonstrated good compliance with ELV and monitoring frequency was changed in agreement with the EA to quarterly within the EPR permit.
2. Similar reasoning was used to agree with the EA the retention of dioxin monitoring frequency as annual and particulates monitoring at quarterly within the Line 3 EPR permit. (May 2012).
3. The use of continuous monitoring for hydrogen chloride emissions has also been reviewed with the EA in the past. It was concluded that the additional costs of continuous hydrogen chloride monitoring were not justified given that water scrubbing was considered BAT and there was a large amount of historical data demonstrating compliance with benchmark ELVs. While continuous monitoring of VOCs has not been formally considered, it is likely that the same conclusion would be reached on cost vs benefit.

## 3.2 Aqueous

### 3.2.1 To water

**Table 5 Emissions to water**

| Component | BAT-AEL | Reference | Average Readings 2016-2021 inc unless stated | | | Proposed ELV | Recommended abatement | Reference | Proposed abatement | Recommended monitoring frequency | Reference | Proposed monitoring frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | W1 | W2 | W3 | | | | | | | |
| Suspended solids | 5 – 35 mg/l if emission exceeds 3.5 te/year | CWWWGT BAT Conclusions | 152 mg/l | 4.02 mg/l | 96 mg/l | 300 mg/l for W1 and W3 and 20 mg/l for W2 as per current permit allowance – emission does not exceed 3.5 te/year. | Preliminary and primary treatment<br>• Equalisation<br>• Neutralisation<br>• Physical separation eg. Screens, sieves etc<br>Biological treatment (secondary treatment)<br>• Activated sludge process<br>• Membrane bioreactor<br>Nitrogen removal<br>• Nitrification/denitrification<br>Phosphorus removal<br>• Chemical precipitation<br>Final solids removal<br>• Coagulation and flocculation<br>• Sedimentation<br>• Filtration (sand filtration, microfiltration etc)<br>• Flotation<br>Physico-chemical treatment<br>• Adsorption on activated carbon<br>• Precipitation<br>• Oxidation<br>• Ion exchange<br>• Reverse osmosis | CWWWGT BAT Conclusions (BAT 12)<br>WI BAT Conclusions (BAT 34)<br>*Physico-chemical treatment is WI only. | No treatment – minor flow, stormwater run off from site. Potential for accidental release mitigated by site equipment and procedures. | Daily | CWWWGT BAT Conclusions (BAT 4)<br>WI BAT Conclusions (BAT 6) | Monthly as per current EPR permit requirements $^{1,2,3}$ |
| | 10 – 30 mg/l | WI BAT Conclusions | | | | | | | | | | |
| COD | 30 – 100 mg/l if emission exceeds 10 te/year | CWWWGT BAT Conclusions | 61 mg/l | 27 mg/l | 57 mg/l | 250 mg/l for W1 and W3 and 100 mg/l as per current permit allowance – emission does not exceed 10 te/year | | | | Daily | CWWWGT BAT Conclusions (BAT 4) | Monthly as per current EPR permit requirements $^{1,2,3}$ |
| pH | - | - | 7 | 8 | 8 | 6 -10 as per current permit | | | | Continuous | CWWWGT BAT Conclusions (BAT 3) | Monthly as per EPR current permit requirements W2 continuous |
| Mercury | 0.001 - 0.01 mg/l | CWWWGT BAT Conclusions and WI BAT Conclusions | 0.00039 mg/l | - | 0.0017 mg/l | 0.005 mg/l as per current permit. Minimal concentrations, could be removed from permit altogether. | | | | Monthly | CWWWGT BAT Conclusions (BAT 4) | Monthly as per EPR current permit requirements |
| Cadmium | 0.005 – 0.03 mg/l | CWWWGT BAT Conclusions and WI BAT Conclusions | 0.00032 mg/l | - | 0.00048 mg/l | 0.01 mg/l as per current permit Minimal concentrations, could be removed from permit altogether. | | | | Monthly | CWWWGT BAT Conclusions (BAT 4) | Monthly as per EPR current permit requirements |
| Dry weather flow | - | - | 1.5 m$^3$/hr | 0.51 m$^3$/hr | 1.5 m$^3$/hr | 15 m$^3$/hr as per current permit – not measured and could be removed from permit | | | | Continuous | CWWWGT BAT Conclusions (BAT 3) | Not measured – remove from permit |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | - | - | 23 deg. C | - | 23 deg. C | 45 deg. C as per current permit | | | | Continuous | CWWWGT BAT Conclusions (BAT 3) | Monthly as per current EPR permit requirements |

Notes:

1. W2 is a very small flow from a cooling tower purge and other than low levels of water treatment chemicals can be considered a ‘clean’ stream. This combined with levels of suspended solids and COD below benchmark means that more frequent monitoring is not required.
2. W1/W3 are relatively very small flows, discharging (after mixing with other run off) into a very large estuarine receiving water. Benchmark levels are achieved for all components except suspended solids. Control of suspended solids is difficult due to the nature of these flows being primarily storm water run off. Environmental impact has been modelled and is insignificant. Increased monitoring frequency of suspended solids is therefore not required.
3. Addition of Line 4 will make minimal difference to flow or composition of W1 and W3 because they are primarily used for storm water drainage from the site. Monitoring frequency has proved appropriate over more then twenty years so increase in frequency not required.

## 3.2.2 To sewer

**Table 6 Emissions to sewer**

| Component | BAT-AEL | Reference | Average Readings 2016-2021 inc unless stated | | Proposed ELV to sewer (EPR) | Proposed ELV to sewer (UU) | Recommended abatement | Reference | Proposed abatement | Recommended monitoring frequency | Reference | Proposed monitoring frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | S2 | S3 | S2, S3 and S5 | S2, S3 and S5 | | | | | | |
| Suspended solids | 5 – 35 mg/l if emission exceeds 3.5 te/year | CWWWGT BAT Conclusions | 226 mg/l | 206 mg/l | - | 400 mg/l | Preliminary and primary treatment<br>• Equalisation<br>• Neutralisation<br>• Physical separation eg. Screens, sieves etc<br>Biological treatment (secondary treatment)<br>• Activated sludge process<br>• Membrane bioreactor<br>Nitrogen removal<br>• Nitrification/denitrification<br>Phosphorus removal<br>• Chemical precipitation<br>Final solids removal<br>• Coagulation and flocculation<br>• Sedimentation<br>• Filtration (sand filtration, microfiltration etc)<br>• Flotation<br>Physico-chemical treatment<br>• Adsorption on activated carbon<br>• Precipitation<br>• Oxidation<br>• Ion exchange | CWWWGT BAT Conclusions (BAT 12)<br>WI BAT Conclusions (BAT 34)<br>*Physico-chemical treatment is WI only. | Neutralisation in dual vessels using caustic soda and then treatment by UU at the local treatment works | Daily | CWWWGT BAT Conclusions (BAT 4)<br>WI BAT Conclusions (BAT 6) | Monthly as per UU consent requirements $^{1,2,3}$ |
| | 10 – 30 mg/l | WI BAT Conclusions | | | | | | | | | | |
| COD | 30 – 100 mg/l if emission exceeds 10 te/year | CWWWGT BAT Conclusions | 411 mg/l | 405 mg/l | - | 250 kg/day (under review) | | | | Daily | CWWWGT BAT Conclusions (BAT 4) | Monthly as per UU consent requirements $^{1,2,3}$ |
| pH | - | - | 8 | 8 | 6-10 | 6-10 | | | | Continuous | CWWWGT BAT Conclusions (BAT 3) | Continuous by instrument and analysis quarterly as per current EPR permit |
| Mercury | 0.001 - 0.01 mg/l | CWWWGT BAT Conclusions and WI BAT Conclusions | 0.0001 mg/l | 0.00004 mg/l | 0.005 mg/l (possible removal of limit) | 0.005 mg/l | | | | Monthly | CWWWGT BAT Conclusions (BAT 4)<br>WI BAT Conclusions (BAT 6) | Monthly as per UU consent requirements |
| Cadmium | 0.005 – 0.03 mg/l | CWWWGT BAT Conclusions and WI BAT Conclusions | 0.001 mg/l | 0.001 mg/l | - | 0.05 mg/l | | | | Monthly | CWWWGT BAT Conclusions (BAT 4) | Monthly as per UU consent requirements |

| Component | BAT-AEL | Reference | Average Readings 2016-2021 inc unless stated | | Proposed ELV to sewer (EPR) | Proposed ELV to sewer (UU) | Recommended abatement | Reference | Proposed abatement | Recommended monitoring frequency | Reference | Proposed monitoring frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | S2 | S3 | S2, S3 and S5 | S2, S3 and S5 | | | | | | |
| | | | | | | | - Reverse osmosis | | | | WI BAT Conclusions (BAT 6) | |
| Flow | - | - | - | - | - | 100 $m^3$/day (under review) | | | | Continuous | CWWWGT BAT Conclusions (BAT 3) | Continuous - metered for charging basis |
| Temperature | - | - | - | - | - | 43.3°C | | | | Continuous | CWWWGT BAT Conclusions (BAT 3) | Not monitored as currently. |
| 1, 2 Dichloroethane | - | - | 0.01 mg/l (6.21 ug/l) | 0.02 mg/l (15.04 ug/l) | 0.04 mg/l | 0.04 mg/l | | | | - | - | Monthly as per current EPR requirements – reported quarterly |
| Chromium | 5 – 25 ug/l if emission exceeds 2.5 kg/year | CWWWGT BAT Conclusions | 0.35 mg/l (348 ug/l) | 0.30 mg/l (302 ug/l) | - | 10 mg/l (individually or as sum of Be, Cr, Cu, Pb, Ni, Se, Ag, Sn, V, Zn) | | | | Monthly | CWWWGT BAT Conclusions (BAT 4)<br>WI BAT Conclusions (BAT 6) | Monthly as per UU consent requirements |
| | 0.01 – 0.1 mg/l | WI BAT Conclusions | | | | | | | | | | |
| Copper | 5 – 50 ug/l if emission exceeds 5 kg/year | CWWWGT BAT Conclusions | 0.04 mg/l (43 ug/l) | 0.04 mg/l (36 ug/l) | - | As above | | | | Monthly | CWWWGT BAT Conclusions (BAT 4)<br>WI BAT Conclusions (BAT 6) | Monthly as per UU consent requirements |
| | 0.03 – 0.15 mg/l | WI BAT Conclusions | | | | | | | | | | |
| Nickel | 5 – 50 ug/l if emission exceeds 5 kg/year | CWWWGT BAT Conclusions | 0.69 mg/l (694 ug/l) | 0.64 mg/l (636 ug/l) | - | As above | | | | Monthly | CWWWGT BAT Conclusions (BAT 4)<br>WI BAT Conclusions (BAT 6) | Monthly as per UU consent requirements |
| | 0.03 – 0.15 mg/l | WI BAT Conclusions | | | | | | | | | | |
| Zinc | 20 – 300 ug/l if emission exceeds 30 kg/year | CWWWGT BAT Conclusions | 0.14 mg/l (136 ug/l) | 0.04 mg/l (41 ug/l) | - | As above | | | | Monthly | CWWWGT BAT Conclusions (BAT 4)<br>WI BAT Conclusions (BAT 6) | Monthly as per UU consent requirements |
| | 0.01 – 0.5 mg/l | WI BAT Conclusions | | | | | | | | | | |
| Lead | 0.02 – 0.06 mg/l | WI BAT Conclusions | 0.02 mg/l | 0.02 mg/l | - | As above | | | | Monthly | WI BAT Conclusions (BAT 6) | Monthly as per UU consent requirements |
| Dioxins | 0.01 – 0.05 ngl-TEC/l | WI BAT Conclusions | - | - | - | - | | | | Monthly | WI BAT Conclusions (BAT 6) | Not monitored as currently. |
| Chloroform | - | - | 28 ug/l | 70 ug/l | - | 35 ug/l current limit is under review with | | | | - | - | Monthly as per UU consent requirements |

| Component | BAT-AEL | Reference | Average Readings 2016-2021 inc unless stated | | Proposed ELV to sewer (EPR) | Proposed ELV to sewer (UU) | Recommended abatement | Reference | Proposed abatement | Recommended monitoring frequency | Reference | Proposed monitoring frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | S2 | S3 | S2, S3 and S5 | S2, S3 and S5 | | | | | | |
| | | | | | | United Utilities | | | | | | |

Notes:

1. A project was completed in 2001 to connect Line 1 to sewer, previously process effluent discharge had been direct to controlled waters. At this time other action was also taken, by reconfiguring and removing or stopping drains and the installation of containment areas, in order to eliminate fugitive process emissions to controlled waters. Lines 2 and 3 were also connected to sewer when they were built in 2004 and 2013 respectively.
2. Emissions to sewer have been effectively regulated since that time under consents with the sewerage provider (United Utilities). Compliance with consent limits has been good with sampling and analysis of effluent undertaken by United Utilities. Frequency of monitoring is considered appropriate given the level of compliance, relatively small flows and relatively low impact of the effluent on the receiving treatment works.
3. Deviation of recommended monitoring frequency vs guidance is principally on COD and suspended solids. These are areas of minor concern, given the relatively very low effluent flows and impact. United Utilities have suggested removing the COD limit from the consent because it is of minor concern and difficult to measure.

# 4 Review of technologies/techniques

## 4.1 Gaseous emissions

The following table is a simplified recreation of a table from the CWW BREF report, illustrating how different BAT techniques are relevant for different pollutants.

**Table 7 Waste gas treatment techniques and the relevant pollutant**

| Technique | Dry Matter | Wet Matter | Inorganic Particulates | Organic Particulates | Inorganic gas/vapour | Organic gas /vapours | Odour |
|---|---|---|---|---|---|---|---|
| **Recovery and abatement for VOCs and inorganic compounds** | | | | | | | |
| Membrane separation | | | | | | X | |
| Condensation | | | | | | X | |
| Cryocondensation | | | | | | X | |
| Adsorption | | | | | X | X | X |
| Wet gas scrubber (water) | | | | | X | X | X |
| Wet gas scrubber (alkaline) | | | | | X | X | X |
| Wet gas scrubber (alkaline oxidative) | | | | | | | X |
| Wet gas scrubber (acidic) | | | | | X | X | X |
| **Abatement for VOCs and inorganic compounds** | | | | | | | |
| Biofiltration | | | | | X | X | X |
| Bioscrubbing | | | | | X | X | X |
| Biotrickling | | | | | X | X | X |
| Moving-bed trickling filter | | | | | X | X | X |
| Thermal Oxidation | | | | X | | X | X |
| Catalytic oxidation | | | | | | X | X |
| Ionisation | | | | | | X | X |
| Photo/UV Oxidation | | | | | | X | X |
| **Recovery and abatement for particulates** | | | | | | | |
| Settling chamber/ gravitational separator | X | X | X | X | | | |
| Cyclone | X | X | X | X | | | |
| Electrostatic precipitator | X | X | X | X | | | |
| Wet dust scrubber | X | X | X | X | | | |
| Fabric filter | X | | X | X | | | |
| Ceramic and metal filter | X | | X | X | | | |
| Catalytic filtration | X | X | X | X | | X | |
| Two-stage dust filter | X | | X | X | | | |
| Absolute (HEPA) filter | X | | X | X | | | |
| High-efficiency air filter | | X | | | | | |
| Mist filter | | X | | | | | |
| **Recovery and abatement for inorganic compounds** | | | | | | | |
| Dry alkali injection | | | | | X | | |
| Semi-dry alkali injection | | | | | X | | |
| Wet lime injection | | | | | X | | |
| SNCR | | | | | X | | |
| SCR | | | | | X | | |
| NSCR | | | | | X | | |
| Wet gas scrubber for NOx | | | | | X | | |
| **Flaring** | | | | | | | |
| Flaring | | | | | | X | X |

Based on this table from the BREF, the relevant techniques for each pollutant type can be identified. For the emissions from Line 4 the predominant pollutant types are inorganic and organic gas/vapours (in particular hydrogen chloride, VOCs and dioxins) and particulates. Emissions of NOx from the boilers onsite are also considered within a separate section. Hence, the BAT techniques applicable to the treatment of these substances will be considered further. The techniques applicable to other pollutant types are ruled out at this stage.

A review of the techniques in Section 3 against each pollutant of concern has been carried out and is provided within this section. As the process for Line 4 is predominantly the same as for Lines 2 and 3, where a review of technologies has been carried out in the past, this has been utilised here but reviewed to check it is still relevant.

### 4.1.1 Hydrogen Chloride Emission Control Techniques

Both the LVOC BAT Conclusions (BAT 12) and Waste Incineration BAT Conclusions (BAT 27) state that for Hydrogen Chloride emissions, BAT is to use a wet scrubber. The following table shows different wet scrubber technologies considered previously for Line 2 and 3 and why certain techniques were dismissed. The considerations made then are still valid and hold true for the new production line. The scrubber utilised for Lines 2 and 3 (2 circulated packed beds in series) has performed well in ensuring HCl in gas passing through is reduced to below the current benchmark concentration (10 mg/m$^3$) and is therefore selected again for use in Line 4.

**Table 8 Scrubber Technologies**

| Technique | Description | Advantages | Disadvantages | Feasible Technology? |
|---|---|---|---|---|
| Plate scrubber | Plate disperses gas into bubbles creating surface area for mass transfer by absorption | Good for gases which have higher particulates and when fluctuations in flow can exist | Plugging and channelling of scrubber liquor is possible<br>High pressure drop.<br>Taller column for same removal efficiency | No - diameter of scrubber vessel ~3m. Materials of construction GRP. Support and fabrication of plates at this diameter could be a problem. |
| Packed scrubber | Packed bed provides surface area for mass transfer by absorption | Good for high gas removal efficiency and more effective with particle free gas. Easy construction with chemical resistant materials | Not very effective for VOC and dioxin abatement on its own | Yes - suitable for size of column and materials of construction. |
| Spray Tower | Liquid atomised through nozzles to enable mass transfer | Inexpensive and good removal rates for HCl.<br>Low energy requirements | Nozzles can be prone to clogging<br>Poor approach between circulating acid & | No - for a large column redistribution of liquor and effective contact |

| Technique | Description | Advantages | Disadvantages | Feasible Technology? |
|---|---|---|---|---|
| | | | low HCl concentration in vent gas.<br>Possible gas bypassing | with gas stream can be a problem. |
| Wet Mop Scrubber / Rotaclones | Absorbent injected into impeller casing to atomise for mass transfer | Relatively cheap and efficient | Build up of dust deposits and abrasion of particles on impeller | No - moving parts in a corrosive environment is not advisable. |

### 4.1.2 VOC Emission Control Techniques

The following table shows technologies that have been considered for the control of VOC emissions onsite and why certain techniques were dismissed.

| Technique | Description | Advantages | Disadvantages | Feasible Technology? |
|---|---|---|---|---|
| Membrane separation | Membrane separation of gases takes into account the selective permeability of organic vapours when permeating through a membrane. Organic vapours have a considerably higher permeation rate than oxygen, nitrogen, hydrogen or carbon dioxide (10 to 100 times higher. The waste gas stream is compressed and passed over the membrane. The enriched permeate can be recovered by methods such as condensation or adsorption, or it 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. | The reuse of raw material is possible<br>The operation in itself is simple; little maintenance is required<br>No waste generated by the process | Subsequent work-up and/or treatment step is necessary<br>Explosion risk<br>Only suitable for large – fixed – upstream vapour volumes because of potential safety issues with inlet compressor | No - Membrane separation works with high-concentration, low-flow gas streams, and is not considered applicable for the process lines. |
| Condensation | Elimination of solvent vapours from a waste gas steam by reducing its temperature below its dew point | Compact and robust technology<br>Good process handling<br>Downstream treatment facilities are relieved of high loads and can therefore, be operated more economically | The amount of cooling water required can be an issue<br>Efficiency considerably dependent on gas flow rate and composition<br>Subsequent work-up and/or treatment step necessary | No - condensation works with high-concentration, low-flow gas streams, and is not considered applicable for the process lines. |

| Technique | Description | Advantages | Disadvantages | Feasible Technology? |
|---|---|---|---|---|
| Cryogenic Condensation | Forcing VOCs to condense at high pressure or low temperature | VOCs can be recovered and reused. Cheap and simple technique which is suitable for high concentrations | Temperature reduction required is expensive<br>No need for N2 on site<br>Cocktail of VOCs needs further treatment. | No - expensive. |
| Adsorption | Removal of VOCs by adhering surface of solid material (e.g. carbon bed) | Typically used as a polishing stage after condensers or scrubbers. | Poor results for aldehydes. Adsorbers don't operate above 55 °C. Hot spots can be created within the carbon bed.<br>High C consumption.<br>C effluent to be disposed of. | No - preferential adsorption of water vapour can occur after quenching. The capital and operating costs for carbon injection technology, the potential for increased particulate emissions and the installation issues within a tight footprint made this option unsuitable. |
| Wet gas scrubber (absorption) | Removal of VOC gas by mass transfer into scrubbing liquor | Requires low temperatures for good absorption. | Wet scrubbing alone is not effective for VOCs. | Yes --Can be used in conjunction with thermal oxidation and quenching. |
| Bio-oxidation | Biofiltration, where the gas stream is passed through a moist substrate (peat, heather, etc) which supports the micro-organisms;<br>Bioscrubbing, where the gas stream is passed through a trickling filter or column.<br>Destruction of VOCs by aerobic micro-organisms on a substrate | Fast biodegradation for aldehydes | High investment costs. High risk technology.<br>Inhibited by acid gases and toxic gases.<br>Depends on absorption of VOCs into water, which is poor | No - Not suitable for this mixture of gases |
| Thermal Oxidation | Complete thermal breakdown of VOCs | Self supporting –just a small amount of support fuel. Possible destruction of | High temperatures required for destruction, therefore high energy costs | Yes – use of regenerative thermal oxidation has proved successful on existing lines |

| Technique | Description | Advantages | Disadvantages | Feasible Technology? |
|---|---|---|---|---|
| | | dioxins | Filter required to prevent fouling. | |
| Catalytic Oxidation | See table below | | | |
| Plasma destruction, RF/microwaves. | Use of RF/microwaves or high voltage plasma to destroy VOCs | Clean. | High capital & energy cost.<br>Complex equipment.<br>Immature technology | No. High technical risk & high cost. |
| Ionisation | The air or the incoming gas flow is led through a reaction chamber where it is submitted to a very strong electrical field (20–30 kV) generated by electrodes, causing ions, free electrons, radicals and other highly reactive particles to be formed. The highly reactive compounds cause the decomposition and (partial) oxidation of the pollutants present in the incoming gas. The most active particles in this process are the N, O and OH radicals. They are formed of nitrogen (N2), oxygen (O2) and water (H2O). | Low energy consumption compared to thermal oxidisers (for gas streams with low-energy levels)<br>Very compact<br>May be turned on and off at will (almost no start-up time)<br>Relatively simple operation<br>Not sensitive to variations in the gas stream<br>The ionisation process takes place at a low temperature<br>When operating in bypass, not sensitive to dust | Electricity consumption<br>Test installation is preferred for the proper evaluation of situation-specific effects and possible removal efficiency<br>Only suitable for VOC removal when the system is applied directly to the gas stream<br>Risk of electromagnetic radiation. This risk is limited when the casing is made of metals | No. High technical risk & high cost. |
| Photo/UV Oxidation | The incoming waste gas stream is led through a reaction chamber and radiated with UV waves (100–280 nm). This radiation causes the decomposition of the undesired compounds. | Compact and modular system<br>Close to no start-up time<br>Operation at low temperature<br>Low energy consumption<br>Noise-free | Not suitable for high concentrations of pollutants | No. High technical risk & high cost. |

| Technique | Description | Advantages | Disadvantages | Feasible Technology? |
|---|---|---|---|---|
| | This decomposition takes place in two ways:<br>- direct photolysis: compounds such as VOCs, NH3, H2S and amines are directly broken down by the radiation;<br>- oxidation by reactive oxygen radicals: the presence of highly reactive oxygen radicals oxidises compounds that are not broken down by direct photolysis and reaction products from the photolysis. | | | |

Thermal oxidation technology was selected on the basis of satisfying the following criteria:

- Proven operation on Lines 2 and 3
- Previous EA acceptance that this technology is BAT for VOC/Dioxin emissions treatment on the fibre production lines at Widnes
- Effective VOC destruction efficiency to required emission limit values
- High reliability
- Tolerance of corrosive and dusty gas stream (pre filter (ceramic candle filter) to be used in conjunction with the technology)

This technology is selected to be utilised in conjunction with a wet scrubber and quench system.

A number of different thermal oxidisation techniques were considered and are provided in the table below.

| Techniques | Advantages | Disadvantages | Feasible Technology |
|---|---|---|---|
| Direct Fired Thermal Oxidation | Well established, robust technology<br>Two second residence time will ensure destruction of VOCs and dioxins.  Can | Significant quantities of natural gas required to ensure high temperatures – this will increase NOx levels emitted. | Yes.  Can be used with downstream quenching to prevent dioxins reforming due to de novo mechanism. |

| Techniques | Advantages | Disadvantages | Feasible Technology |
|---|---|---|---|
| | achieve <0.1ng I-TEQ/Nm$^3$of dioxins. | Quench of gas required before scrubbing<br>Large swings in VOC content of feed may lead to unit tripping.<br>Will require a filter on the inlet to prevent particulate build up in regenerators | Heat regenerators/recuperators can be used to improve thermal efficiency. |
| Flameless Thermal Oxidation | No support fuel required<br>Process gas stream at low enough temperature for scrubbers<br>Low NOx levels<br>Large ceramic bed ensures robust enough for swings in VOC | Ceramic bed is prone to fouling with particulates<br>Valves controlling flow direction through unit could be prone to blockage or leakage<br>Controlled amount of oxygen required. | Yes |
| Catalytic Thermal Oxidation | Small amount of support fuel required<br>Compact unit | Catalyst poisoning and fouling reduces life to approx 3 years<br>No guarantee on dioxin destruction – higher risk technology | No. Components in the vent stream are potential catalyst poisons. |

Abatement of Class A VOCs at the site has been a subject of investigation with the EA over several years. Direct fired Thermal Oxidation has been used on Lines 2 and 3 to treat the low volume high concentration streams from the decomposition ovens and the low temperature furnace. Pre-filtration directed through a quench system followed by regenerative thermal oxidisation is utilised for Lines 2 and 3 and is believed to be the best technique to also utilise for Line 4.

The LVOC BAT Conclusions (BAT 10) states that for channelled emissions of organic compounds to air, BAT is one of or a combination of techniques including a wet scrubber and thermal oxidiser. Both these technologies are currently in place and operating effectively on Lines 2 and 3 to abate VOCs. It is therefore believed, and has previously been agreed with the Environment Agency that the best available techniques are selected.

### 4.1.3 Dioxin Emission Control Techniques

Aliphatic compounds arising from the thermal degradation of siloxanes in the Decomposition Oven and LT Furnace are believed to be converted to simple ring molecules which later evolve into complex aromatic precursors.  Dioxins are then formed from these intermediate aromatic compounds together with chlorine formed by the decomposition of aluminium chlorohydrate.  Particulate bound carbon is suggested as the primary reagent in the de novo synthesis pathway.  De Novo synthesis involves heterogeneous reactions on dust (containing transition metal catalyst) in the presence of oxygen, hydrogen and chlorine.  De novo synthesis takes place in the temperature range 200 to 500 deg. C.

Because dioxin formation cannot be totally prevented a number of techniques have been invented to reduce dioxin emissions.  The table below shows the technologies considered for Lines 2 and 3 and why certain techniques were dismissed.  The table below shows why thermal oxidation was selected as the preferred technology.

| Technique | Description | Advantage | Disadvantage | Feasible Technology? |
|---|---|---|---|---|
| Wet scrubbers | Removal of dioxins gas by mass transfer into scrubbing liquor. | None for dioxin removal. | Analysis has shown that the dioxins are not effectively removed in the wet scrubber alone. | No - for dioxin removal, but effective for HCl and already installed on Lines 2 and 3. |
| Bag Filters | Achieve particulate release of 10 mg/m$^3$ | Used in combination with an activated carbon system to capture dioxin, up to 99% removal of dioxins. | Needs to be used in combination with a scrubber. After the wet scrubbing stage the gas is saturated. The operation of bag-filters in this situation can be problematic. Still have to dispose of contaminated dust. | No - The operation of bag-filters in this situation can be problematic. Still have to dispose of contaminated dust. |
| Activated carbon injections | Dioxins are removed from flue gas by adsorption onto carbon | Up to 99% removal of dioxins. | Installation after scrubber and bag filter. High operational costs as bed must be replaced regularly. Spent carbon requires incineration. Hot spots can be created within the carbon bed. | No - preferential adsorption of water vapour can occur after quenching. Current wet scrubber (PP) is a better alternative. |
| Selective Catalytic Oxidation or Reduction | Catalysts on a SCO or SCR unit breakdown the dioxins. | Can remove 62 to 96% dioxins. Catalysts breakdown dioxins.<br>Can also destroy $N_2O$ | Install downstream of scrubber and bag filter. Dust can reduce activity of catalyst. Reheating of flue gas after filter maybe required | No - components in the vent stream are potential catalyst poisons. |

| Technique | Description | Advantage | Disadvantage | Feasible Technology? |
|---|---|---|---|---|
| Ammonia or urea injection (SNCR) | Converts NO and $NO_2$ into nitrogen and water | Inhibits the formation of dioxins in cooler areas of circuit | Could lead to production of $N_2O$ and ammonia.<br>Large quantity of $NH_3$ or urea must be added to neutralise HCl.<br>$NH_3$ or urea in liquid effluent. | No - The dioxins are formed in the oven and associated ductwork. Injection of urea into the process oven steam system is not practical. |
| Plasma, RF/microwaves | Use of RF/microwaves or high voltage plasma to destroy VOCs | Clean | High capital & energy cost.<br>Complex equipment.<br>Immature technology | No. Technical risk & high cost. |
| Thermal Oxidation | Complete thermal breakdown of VOCs and dioxins | Compatible with VOC destruction | Rapid quenching required to drop flue gas from 450 to 200 °C | Yes |

Within the LVOC BAT Conclusions, BAT 67 states that in order to reduce emissions to air of dioxins from a thermal oxidiser, BAT is to use rapid quenching followed by activated carbon injection as necessary. Rapid quenching is carried out in the wet scrubber. The use of activated carbon injections was explored and ruled out as explained in the table above.

Within the Waste Incineration BAT Conclusions, BAT 30 states that in order to reduce emissions to air of dioxins from the incineration of waste, BAT is to use the following techniques:

- Optimisation of the process
- Control of the waste feed
- Online and offline boiler cleaning
- Rapid flue-gas cooling

These techniques could then be followed by one or a combination of the following techniques:

- Dry sorbent injection
- Fixed or moving bed adsorption
- SCR
- Catalytic filter bags
- Carbon sorbent in a wet scrubber

Further evaluation of the thermal oxidation route for Lines 2 and 3 was carried out with vendors of the technology. This has included visits to reference plants to see the technology in operation. Vendors are confident that better than 99% destruction of dioxins is possible using this technology and that temperature control can be achieved to prevent reformation.

The process design basis for the treatment of the VOC/Dioxin streams was reviewed with the conclusion that an estimated 85% of VOC/Dioxins are contained in a limited number of concentrated streams from the decomposition oven and low temperature furnace. A small proportion (15%) passes out through the extract hoods where heavy dilution with large volumes of extracted air takes place before passing to the scrubbing section.

The agreed approach to the treatment of dioxin, agreed at previous permit variations, is as follows:

- Treat the relatively concentrated, hot vent streams from the hoods and body of the steaming oven by regenerative thermal oxidation.
- Other vent streams contain relatively small quantities of dioxin and are highly diluted with volumes of extracted air. Treat these relatively dilute streams by wet scrubbing. Thermal oxidation of these dilute streams is not justified because of the additional capital costs for larger abatement units. Operating costs and environmental impact are significant - associated with burning a significant quantity of natural gas to heat the dilute streams to required temperatures.

Operation of Lines 1, 2 and 3 has confirmed that satisfactory dioxin emissions performance can be achieved. Modelling shows that previous emissions rates cause no significant harm due to potential dosage rates. This permit proposes that Line 1 be removed from service and Line 4 brought into service. Typical Line 1 performance (mean 0.23 ng/m$^3$, 15 samples) will be replaced by Line 4 which can be expected to have similar performance to Line 3 (mean 0.07 ng/m$^3$, 9 samples). Overall, the impact of dioxin emissions can be predicted to be lower with Lines 2,3 and 4 in operation when compared to the previous operation of Lines 1,2 and 3.

For Line 4 it is therefore proposed that the philosophy with regard to the capture of dioxin and furans should remain the same. It is appropriate to review emission limit values for Lines 2,3 and 4 based on historical performance.

### 4.1.4 Dust Emissions Control Techniques

For all lines, the dust extraction system comprises a large bag filter system exhausting at height via a stack. Both the LVOC BAT Conclusions (BAT 11) and Waste Incineration BAT Conclusions (BAT 5) state that for dust emissions, BAT is to one of or a combination of techniques including a bag filter. The systems in place are effective for limiting concentrations emitted to below levels accepted within the environmental permit, (5 mg/m$^3$) for Lines 2 and 3. This technique is therefore to be implemented for Line 4.

### 4.1.5 Boilers Emissions Control Techniques

The diesel used in the boiler will be low sulphur content; although it is anticipated for a very large proportion of the time the dual fuel boiler will be run on gas. The diesel boiler will only be run as an emergency back up should there be issues with the natural gas supply.

The total combined maximum thermal input of the boilers (including the additional one proposed to support Line 4) is <10 MW, so Large Combustion Plant Directive does not apply.

Within the LVOC BAT Conclusions, BAT 4 states that to reduce NOx emissions to air, BAT is to use one or a combination of the following techniques: choice of fuel, staged combustion, flue-gas recirculation, low NOx burner, use of inert diluents, SCR or SNCR. Emissions from the boilers are minimised as follows:

- NOx emissions are minimised by using natural gas as a main fuel burnt in low NOx burners
- SOx emissions are minimised by choice of low sulphur fuels
- $CO_2$ emissions are minimised by energy efficiency measures such as installation of flue gas economisers, modulating burners with inverter driven combustion air fans, automated blowdown systems and blowdown heat recovery.
- The current site condensate recovery system will be extended to cover the boiler to be installed to serve Line 4.

## 4.2 Aqueous emissions

For aqueous emissions to sewer and to water, the following techniques are implemented in line with the Best Available Techniques and agreements in place with the EA and United Utilities for the current emission points to water and sewer.

### 4.2.1 Trade effluent

Process effluent arisings, predominantly from spent scrubber liquor (dilute aqueous sodium chloride), are discharged under Trade Effluent agreement into United Utilities sewerage system.

The effluent passes by sewer via the Ditton pumping station to the United Utilities treatment works at Widnes. Here it passes through screens and grit removal, settlement and biological treatment before discharge to the River Mersey near Pickerings Pasture.

### 4.2.2 Surface water discharge

There are 3 surface water discharges from the site to the River Mersey, these being:

- W1/W3 – surface water drainage from the west and east of the site respectively. W3 drains the building in which Line 4 will be located. Humidifier overflows (treated water), rainwater and some steam trap and HVAC condensate is drained to these systems. Tank bunds are also pumped out after pH check into these drainage systems.
- W2 – Cooling tower blowdown – which leaves the site through W3.

These streams join together with other surface water drainage from the wider area adjacent to the site before discharge to controlled waters.

### 4.2.3 Neutralisation system

Effluent from all the lines has similar but separate treatment. Neutralisation with sodium hydroxide is used on both effluents. The system on line 3 and proposed for line 4 is a repeat of that used on Line 2 but with improvements designed into the neutralisation tanks and control system to improve pH control. These include larger neutralisation tanks to increase residence time, in line mixing of effluent and caustic soda on ratio control prior to neutralisation and effluent feeds dip piped to the neutralisation tanks.

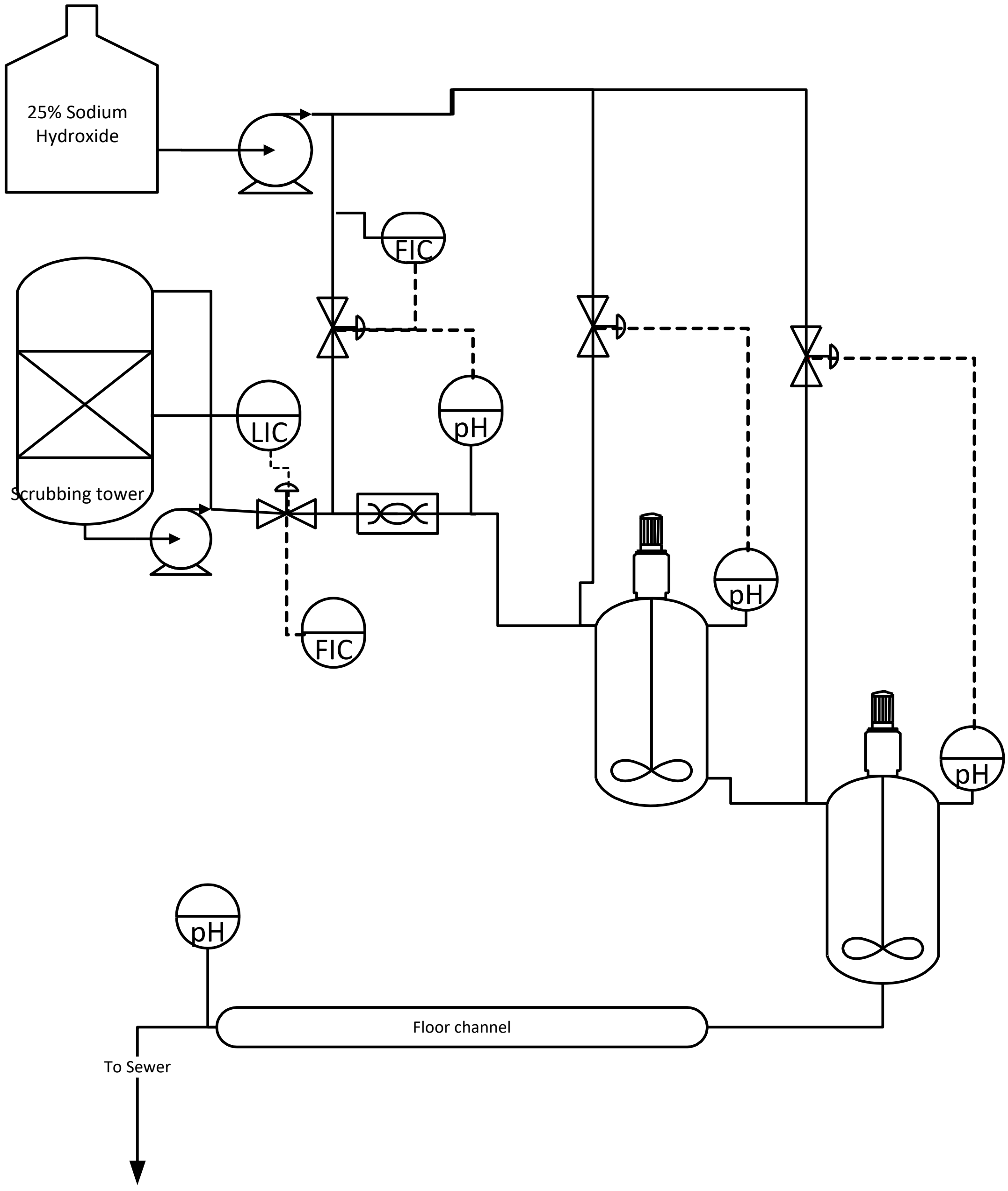


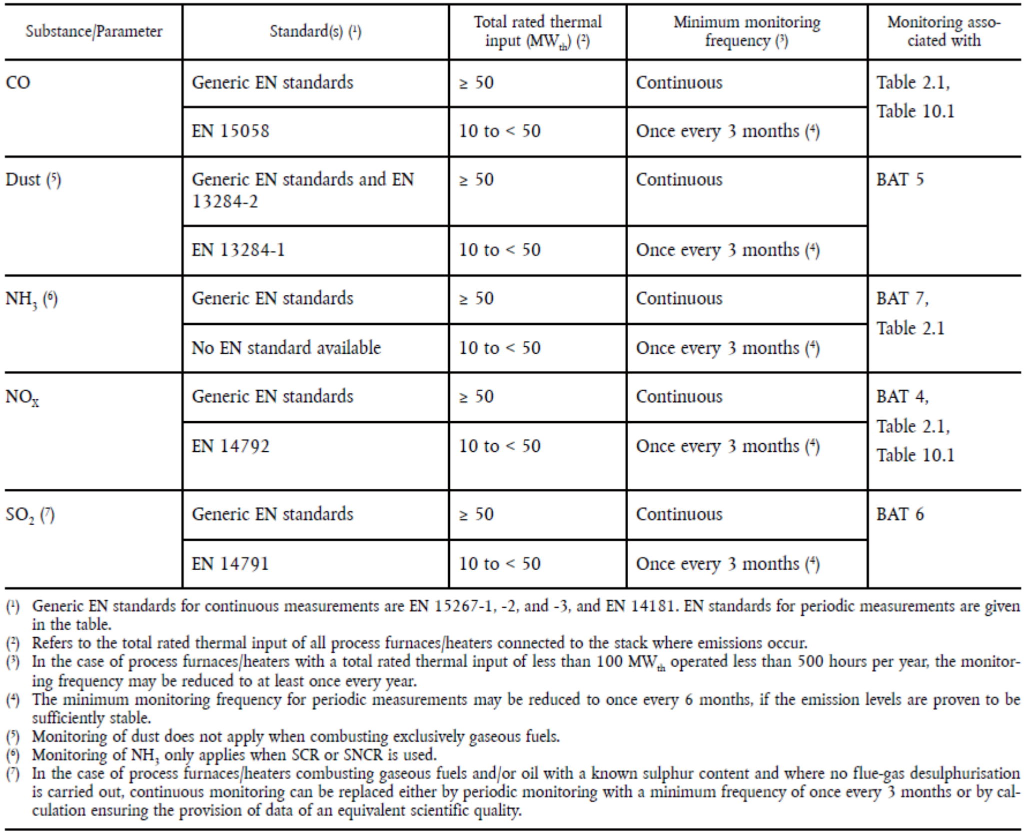
Figure 1 Effluent Neutralisation System (Lines 2,3 and 4)

# 5 Appendix

## 5.1 Potentially Relevant BAT Conclusions

## 5.1.1 LVOC BAT Conclusions

| BAT No. | BAT Criterion |
|---|---|
| **Monitoring of emissions to air** | |
| 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,<br>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,<br>Table 2.1 |
| | No EN standard available | 10 to < 50 | Once every 3 months (4) | |
| $NO_X$ | Generic EN standards | ≥ 50 | Continuous | BAT 4,<br>Table 2.1,<br>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.

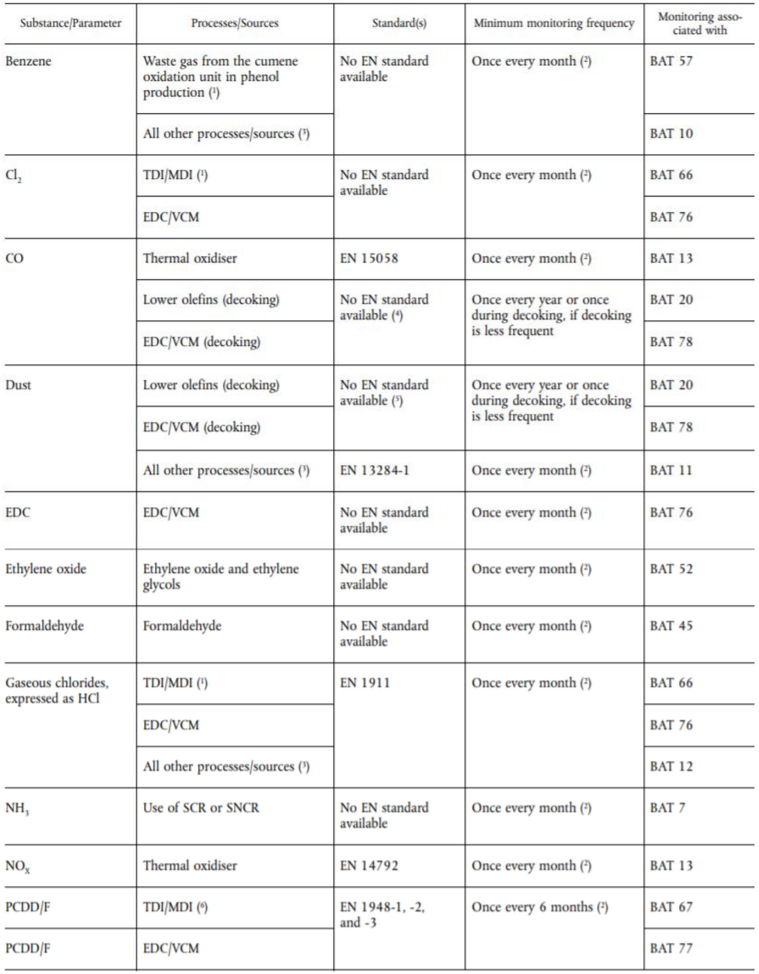
(5) Monitoring of dust does not apply when combusting exclusively gaseous fuels.

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

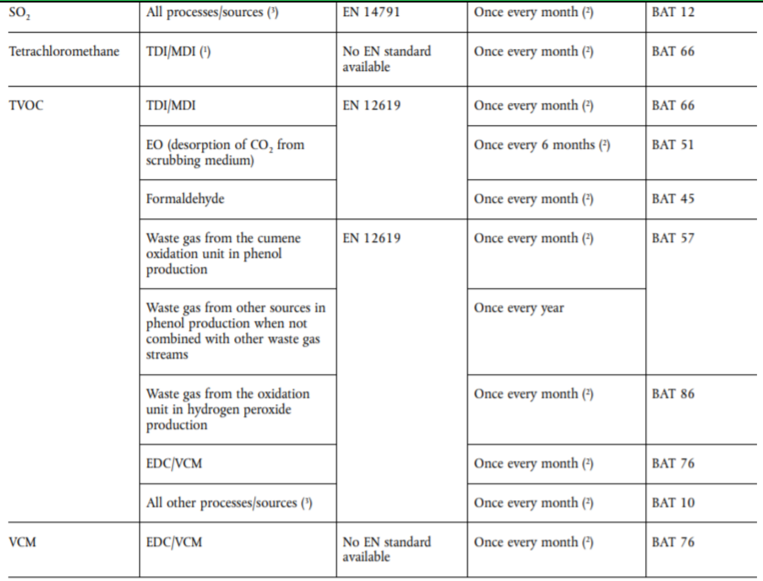
(7) In the case of process furnaces/heaters combusting gaseous fuels and/or oil with a known sulphur content and where no flue-gas desulphurisation is carried out, continuous monitoring can be replaced either by periodic monitoring with a minimum frequency of once every 3 months or by calculation ensuring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

| | |
|---|---|
| 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 |

| BAT No. | BAT Criterion |
|---|---|
| | international standards that ensure the provision of data of an equivalent scientific quality. |



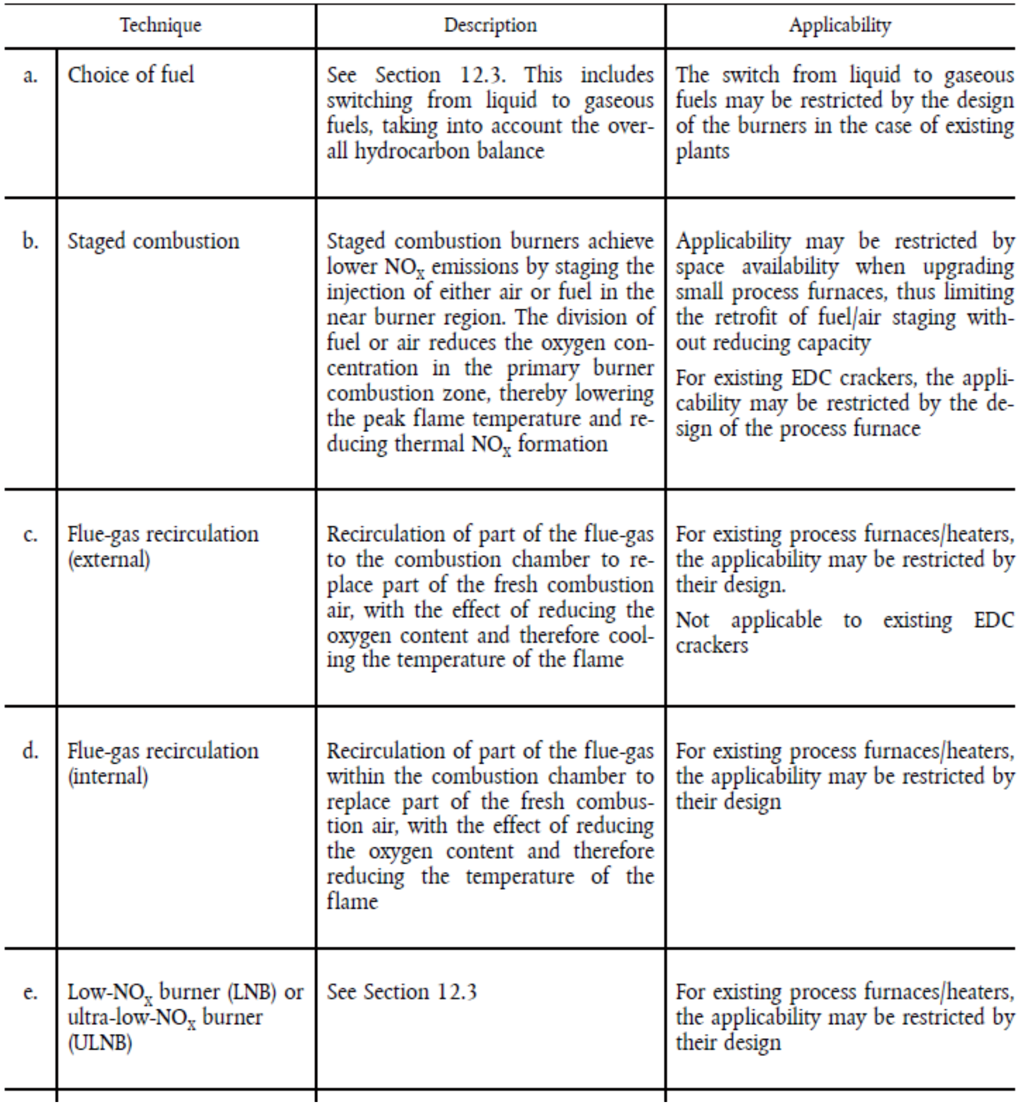
| Substance/Parameter | Processes/Sources | Standard(s) | Minimum monitoring frequency | Monitoring associated with |
|---|---|---|---|---|
| Benzene | Waste gas from the cumene oxidation unit in phenol production (1) | No EN standard available | Once every month (2) | BAT 57 |
| | All other processes/sources (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 |

| BAT No. | BAT Criterion |
|---|---|
|  |  |

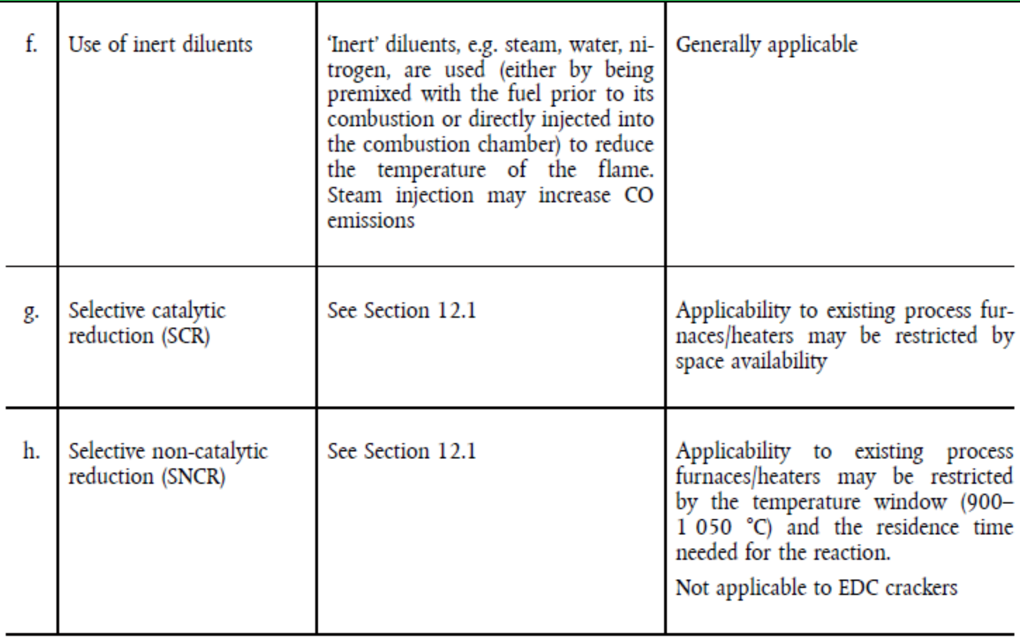
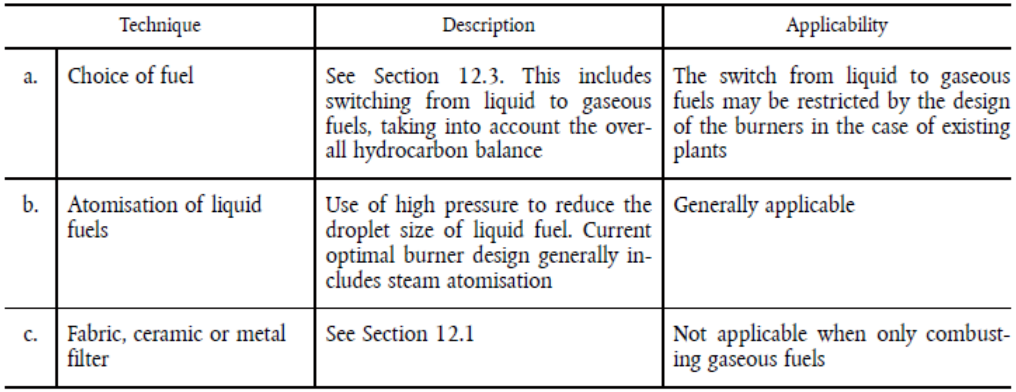
|  |  |  |  |  |
|---|---|---|---|---|
| $SO_2$ | All processes/sources (3) | EN 14791 | Once every month (2) | BAT 12 |
| Tetrachloromethane | TDI/MDI (1) | No EN standard available | Once every month (2) | BAT 66 |
| TVOC | TDI/MDI | EN 12619 | Once every month (2) | BAT 66 |
|  | EO (desorption of $CO_2$ 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 |

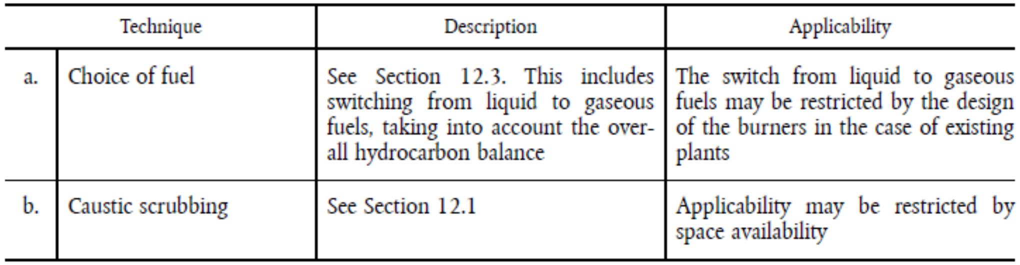
|  |  |
|---|---|
| 3 | In order to reduce emissions to air of CO and unburnt substances from process furnaces/heaters, BAT is to ensure an optimised combustion. Optimised combustion is achieved by good design and operation of the equipment which includes optimisation of the temperature and residence 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 |
| 4 | In order to reduce NOX emissions to air from process furnaces/heaters, BAT is to use one or a combination of the techniques given below. |

| BAT No. | BAT Criterion |
|---|---|



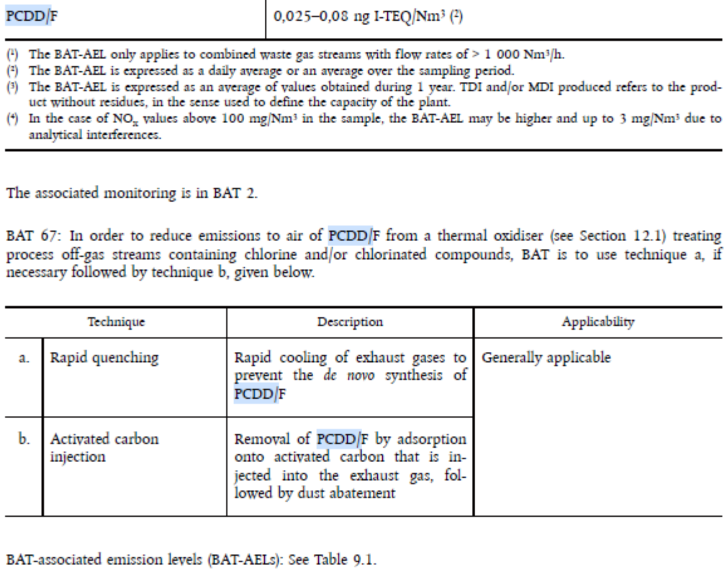
| Technique | | Description | Applicability |
|---|---|---|---|
| a. | Choice of fuel | See Section 12.3. This includes switching from liquid to gaseous fuels, taking into account the overall hydrocarbon balance | The switch from liquid to gaseous fuels may be restricted by the design of the burners 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<br>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.<br>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 |

<table>
<tr><th>BAT No.</th><th>BAT Criterion</th></tr>
<tr><td></td><td>

<table>
<tr><td>f.</td><td>Use of inert diluents</td><td>'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</td><td>Generally applicable</td></tr>
<tr><td>g.</td><td>Selective catalytic reduction (SCR)</td><td>See Section 12.1</td><td>Applicability to existing process furnaces/heaters may be restricted by space availability</td></tr>
<tr><td>h.</td><td>Selective non-catalytic reduction (SNCR)</td><td>See Section 12.1</td><td>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.<br>Not applicable to EDC crackers</td></tr>
</table>
</td></tr>
<tr><td>5</td><td>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.

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

<table>
<tr><th>BAT No.</th><th>BAT Criterion</th></tr>
<tr><td>6</td><td>In order to prevent or reduce SO2 emissions to air from process furnaces/heaters, BAT is to use one or both of the techniques given below.<br><br>
<table>
<tr><th colspan="2">Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>a.</td><td>Choice of fuel</td><td>See Section 12.3. This includes switching from liquid to gaseous fuels, taking into account the overall hydrocarbon balance</td><td>The switch from liquid to gaseous fuels may be restricted by the design of the burners in the case of existing plants</td></tr>
<tr><td>b.</td><td>Caustic scrubbing</td><td>See Section 12.1</td><td>Applicability may be restricted by space availability</td></tr>
</table>
</td></tr>
<tr><td colspan="2"><b>Emissions to air from the use of SCR or SNCR – N/A</b></td></tr>
<tr><td colspan="2"><b>Emissions to air from other processes/sources</b></td></tr>
<tr><td>8</td><td>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:<br>a) Recovery and use of excess or generated hydrogen<br>b) Recovery and use of organic solvents and unreacted organic raw materials<br>c) Use of spent air<br>d) Recovery of HCl by wet scrubbing for subsequent use<br>e) Recovery of $H_2S$ by regenerative amine scrubbing for subsequent use<br>f) Techniques to reduce solids and/or liquid entrainment</td></tr>
<tr><td>9</td><td>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</td></tr>
<tr><td>10</td><td>In order to reduce channelled emissions of organic compounds to air, BAT is to use one or a combination of the techniques given below:<br>a) Condensation<br>b) Adsorption<br>c) Wet scrubbing<br>d) Catalytic oxidiser<br>e) Thermal oxidiser</td></tr>
<tr><td>11</td><td>In order to reduce channelled dust emissions to air, BAT is to use one or a combination of the techniques given below:</td></tr>
</table>

| BAT No. | BAT Criterion |
|---|---|
| | a) Cyclone<br>b) Electrostatic precipitator<br>c) Fabric filter<br>d) Two-stage dust filter<br>e) Ceramic/metal filter<br>f) Wet dust scrubbing |
| 12 | In order to reduce emissions to air of sulphur dioxide and other acid gases (e.g. HCl), BAT is to use wet scrubbing. |
| 13 | In order to reduce emissions to air of NOX, CO, and SO2 from a thermal oxidiser, BAT is to use an appropriate combination of the techniques given below.<br>a) Removal of high levels of NOx precursors from the process off-gas stream<br>b) Choice of support fuel<br>c) Low-NOx burner (LNB)<br>d) Regenerative thermal oxidiser (RTO)<br>e) Combustion optimisation<br>f) Selective catalytic reduction (SCR)<br>g) Selective non-catalytic reduction (SNCR) |
| **Emissions to water** | |
| 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. |
| **Resource efficiency** | |
| 15 | In order to increase resource efficiency when using catalysts, BAT is to use a combination of the techniques given below:<br>a) Catalyst selection<br>b) Catalyst protection<br>c) Process optimisation<br>d) Monitoring of catalyst performance |
| 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. |
| **Residues** | |

| BAT No. | BAT Criterion |
|---|---|
| 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:<br>a) Addition of inhibitors to distillation systems<br>b) Minimisation of high-boiling residue formation in distillation systems<br>c) Material recovery<br>d) Catalyst and adsorbent regeneration<br>e) Use of residues as fuel |
| **Other than normal operating conditions** | |
| 18 | In order to prevent or reduce emissions from equipment malfunctions, BAT is to use all of the techniques given below:<br>a) Identification of critical equipment<br>b) Asset reliability programme for critical equipment<br>a) Back-up system for critical equipment |
| 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:<br>(i) start-up and shutdown operations;<br>a) 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. |
| **Lower Olefins Production – N/A** | |
| **Aromatics Production – N/A** | |
| **BAT Conclusions for Ethylbenzene and Styrene Monomer Production – N/A** | |
| **BAT Conclusions for Formaldehyde Production – N/A** | |
| **BAT Conclusions for Ethylene Oxide and Ethylene Glycols Production – N/A** | |
| **BAT Conclusions for Phenol Production – N/A** | |
| **BAT Conclusions for Ethanolamines Production – N/A** | |
| **BAT Conclusions for Toluene Disocyanate (TDI) and Methylene Diphenyl Disocynate (MDI) Production– N/A but mentions dioxins.** | |

<table>
<tr><th>BAT No.</th><th>BAT Criterion</th></tr>
<tr><td>67</td><td>


<table>
<tr><td>PCDD/F</td><td>0,025–0,08 ng I-TEQ/Nm³ (²)</td></tr>
</table>

(¹) The BAT-AEL only applies to combined waste gas streams with flow rates of > 1 000 Nm³/h.<br>
(²) The BAT-AEL is expressed as a daily average or an average over the sampling period.<br>
(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.<br>
(⁴) In the case of NO<sub>X</sub> 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.

<table>
<tr><th colspan="2">Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>a.</td><td>Rapid quenching</td><td>Rapid cooling of exhaust gases to prevent the <i>de novo</i> synthesis of PCDD/F</td><td>Generally applicable</td></tr>
<tr><td>b.</td><td>Activated carbon injection</td><td>Removal of PCDD/F by adsorption onto activated carbon that is injected into the exhaust gas, followed by dust abatement</td><td></td></tr>
</table>

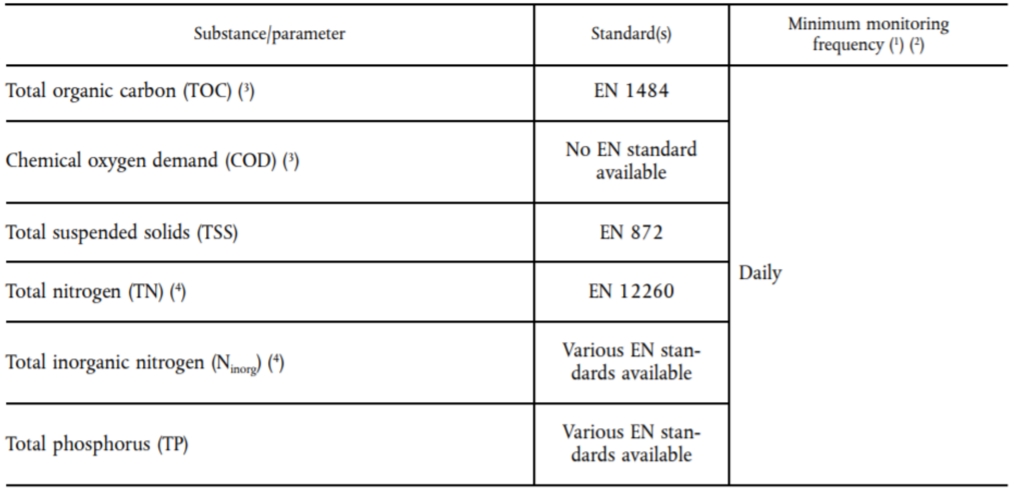
BAT-associated emission levels (BAT-AELs): See Table 9.1.

b)
</td></tr>
<tr><td colspan="2"><b>BAT Conclusions for Ethylene Dichloride and Vinyl Chloride Monomer Production – N/A</b></td></tr>
<tr><td colspan="2"><b>BAT Conclusions for Hydrogen Peroxide Production – N/A</b></td></tr>
</table>

## 5.1.2 CWWWGT BAT Conclusions (air/general)

| BAT No. | BAT Criterion |
|---|---|
| **Environmental Management Systems** | |
| 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:<br>(i) commitment of the management, including senior management;<br>(ii) an environmental policy that includes the continuous improvement of the installation by the management;<br>(iii) planning and establishing the necessary procedures, objectives and targets, in conjunction with financial planning and investment;<br>(iv) implementation of procedures paying particular attention to:<br>(a) structure and responsibility;<br>(b) recruitment, training, awareness and competence;<br>(c) communication;<br>(d) employee involvement;<br>(e) documentation;<br>(f) effective process control;<br>(g) maintenance programmes;<br>(h) emergency preparedness and response;<br>(i) safeguarding compliance with environmental legislation;<br>(v) checking performance and taking corrective action, paying particular attention to:<br>(a) monitoring and measurement (see also the Reference Report on Monitoring of emissions to Air and Water from IED installations — ROM);<br>(b) corrective and preventive action;<br>(c) maintenance of records;<br>(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;<br>(vi) review of the EMS and its continuing suitability, adequacy and effectiveness by senior management;<br>(vii) following the development of cleaner technologies;<br>(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;<br>(ix) application of sectoral benchmarking on a regular basis;<br>(x) waste management plan (see BAT 13). |

| BAT No. | BAT Criterion |
|---|---|
| | Specifically for chemical sector activities, BAT is to incorporate the following features in the EMS:<br>(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;<br>(xii) establishment of inventories of waste water and waste gas streams (see BAT 2). |
| 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:<br>(i) information about the chemical production processes, including:<br>(a) chemical reaction equations, also showing side products;<br>(b) simplified process flow sheets that show the origin of the emissions;<br>(c) descriptions of process-integrated techniques and waste water/waste gas treatment at source including their performances;<br>(ii) information, as comprehensive as is reasonably possible, about the characteristics of the waste water streams, such as:<br>(a) average values and variability of flow, pH, temperature, and conductivity;<br>(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);<br>(c) data on bioeliminability (e.g. BOD, BOD/COD ratio, Zahn-Wellens test, biological inhibition potential (e.g. nitrification));<br>(iii) information, as comprehensive as is reasonably possible, about the characteristics of the waste gas streams, such as:<br>(a) average values and variability of flow and temperature;<br>(b) average concentration and load values of relevant pollutants/parameters and their variability (e.g. VOC, CO, NOX, SOX, chlorine, hydrogen chloride);<br>(c) flammability, lower and higher explosive limits, reactivity;<br>(d) presence of other substances that may affect the waste gas treatment system or plant safety (e.g. oxygen, nitrogen, water vapour, dust). |
| **Monitoring** | |
| 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). |
| 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. |

| BAT No. | BAT Criterion |
|---|---|
| |  |

| 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 | |

| BAT No. | BAT Criterion |
|---|---|

| | | | |
|---|---|---|---|
| Adsorbable organically bound halogens (AOX) | | EN ISO 9562 | |
| Metals | Cr | Various EN standards available | Monthly |
| | 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,<br>EN ISO 11348-2 or<br>EN ISO 11348-3 | |
| | Duckweed (*Lemna minor*) | EN ISO 20079 | |
| | Algae | EN ISO 8692,<br>EN ISO 10253 or<br>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 No. | BAT Criterion |
|---|---|
| 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.<br>I. sniffing methods (e.g. with portable instruments according to EN 15446) associated with correlation curves for key equipment;<br>II. optical gas imaging methods;<br>III. calculation of emissions based on emissions factors, periodically validated (e.g. once every two years) by measurements. |
| 6 | BAT is to periodically monitor odour emissions from relevant sources in accordance with EN standards. |
| **Emissions to water** | |
| 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. |
| 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. |
| 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). |
| 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.<br>a) Process-integrated techniques<br>b) Recovery of pollutants at source<br>c) Waste water pre-treatment<br>d) Final waste water treatment |
| 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. |
| 12 | In order to reduce emissions to water, BAT is to use an appropriate combination of final waste water treatment techniques.<br>- Preliminary and primary treatment<br>a) Equalisation<br>b) Neutralisation<br>c) Physical separation eg. Screens, sieves etc<br>- Biological treatment (secondary treatment)<br>d) Activated sludge process<br>e) Membrane bioreactor |

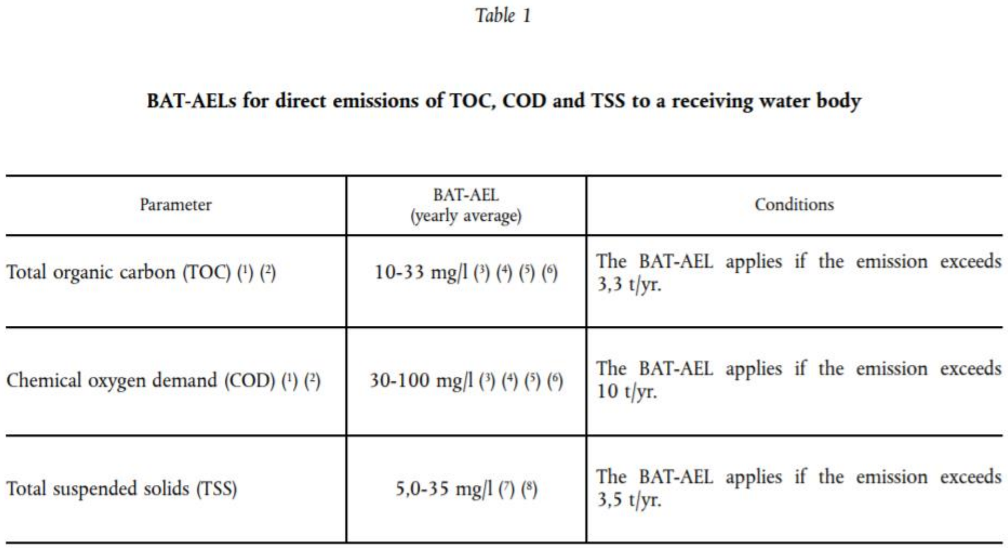
| BAT No. | BAT Criterion |
|---|---|
| | - Nitrogen removal<br>f) Nitrification/denitrification<br>- Phosphorus removal<br>g) Chemical precipitation<br>- Final solids removal<br>h) Coagulation and flocculation<br>i) Sedimentation<br>j) Filtration (sand filtration, microfiltration etc)<br>k) Flotation<br>Final waste water treatment is carried out as part of an integrated waste water management and treatment strategy (see BAT 10).<br><br>The BAT-associated emission levels (BAT-AELs), for emissions to water apply to indirect emissions to a receiving water body. The BAT-AELs apply at the point where the emission leaves the installation.<br> |

*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. |

| BAT No. | BAT Criterion |
|---|---|

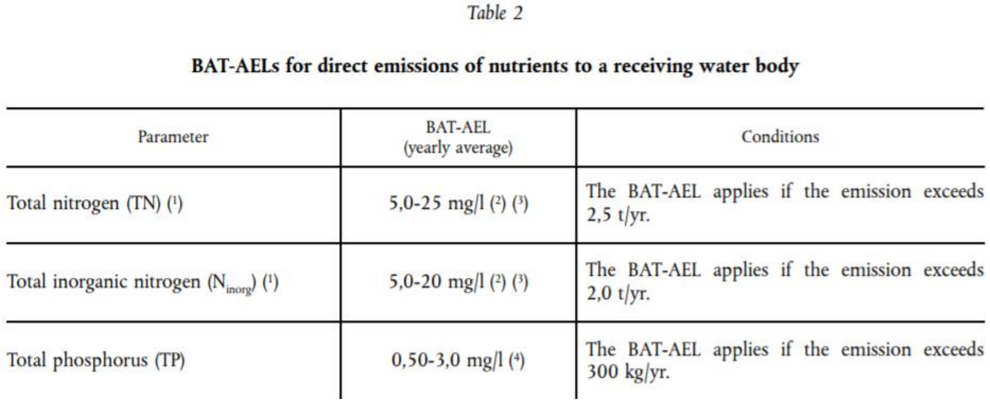


*Table 2*

**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. |

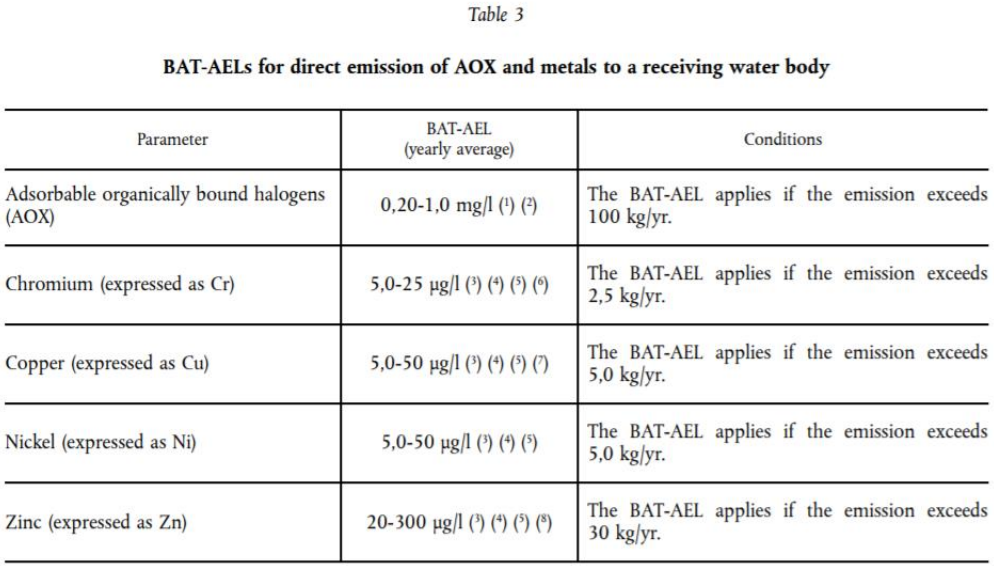


*Table 3*

**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. |

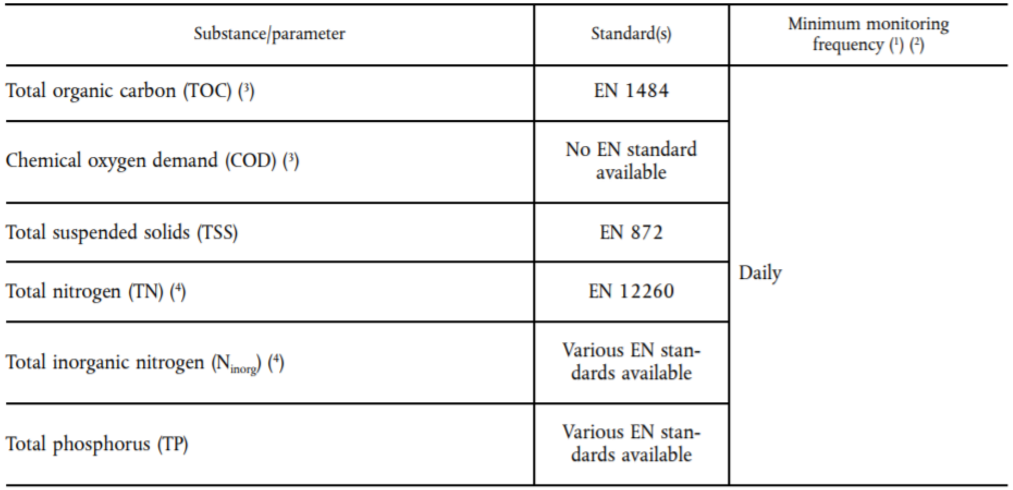
| | |
|---|---|
| **Waste** | |
| 13 | In order to prevent or, where this is not practicable, to reduce the quantity of waste being sent for disposal, BAT is to set up and implement a waste management plan as part of the environmental management system (see BAT 1) that, in order of priority, ensures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

| BAT No. | BAT Criterion |
|---|---|
| 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.<br>a) Conditioning<br>b) Thickening/dewatering<br>c) Stabilisation<br>d) Drying |
| **Emissions to air** | |
| 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 |
| 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. |
| 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.<br>a) Correct plant design<br>b) Plant management |
| 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.<br>b) Correct design of flaring devices<br>c) Monitoring and recording as part of flare management |
| 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.<br>- Techniques related to plant design<br>c) Limit the number of potential emission sources<br>d) Maximise process-inherent containment features<br>e) Select high-integrity equipment (see the description in Section 6.2)<br>f) Facilitate maintenance activities by ensuring access to potentially leaky equipment<br>- Techniques related to plant/equipment construction, assembly, and commissioning<br>g) 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)<br>h) Ensure robust plant/equipment commissioning and handover procedures in line with the design requirements<br>- Techniques related to plant operation<br>i) Ensure good maintenance and timely replacement of equipment<br>j) Use a risk-based leak detection and repair (LDAR) programme (see the description in Section 6.2) |

| BAT No. | BAT Criterion |
|---|---|
| | k) As far as it is reasonable, prevent diffuse VOC emissions, collect them at source, and treat them |
| 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:<br>(i) a protocol containing appropriate actions and timelines;<br>(ii) a protocol for conducting odour monitoring;<br>(iii) a protocol for response to identified odour incidents;<br>(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.<br>The associated monitoring is in BAT 6. |
| 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.<br>(a) Minimise residence times<br>(b) Chemical treatment<br>(c) Optimise aerobic treatment<br>(d) Enclosure<br>(e) End-of-pipe treatment |
| 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:<br>(i) a protocol containing appropriate actions and timelines;<br>(ii) a protocol for conducting noise monitoring;<br>(iii) a protocol for response to identified noise incidents;<br>(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. |
| 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.<br>a) Appropriate location of equipment and buildings<br>b) Operational measures<br>c) Low-noise equipment<br>d) Noise-control equipment<br>e) Noise abatement |

## 5.1.3 CWWWGT BAT Conclusions (water)

| BAT No. | BAT Criterion |
|---|---|
| 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:<br>(i) information about the chemical production processes, including:<br>(d) chemical reaction equations, also showing side products;<br>(e) simplified process flow sheets that show the origin of the emissions;<br>(f) descriptions of process-integrated techniques and waste water/waste gas treatment at source including their performances;<br>(ii) information, as comprehensive as is reasonably possible, about the characteristics of the waste water streams, such as:<br>(d) average values and variability of flow, pH, temperature, and conductivity;<br>(e) average concentration and load values of relevant pollutants/parameters and their variability (e.g. COD/TOC, nitrogen species, phosphorus, metals, salts, specific organic compounds);<br>(f) data on bioeliminability (e.g. BOD, BOD/COD ratio, Zahn-Wellens test, biological inhibition potential (e.g. nitrification));<br>(iii) information, as comprehensive as is reasonably possible, about the characteristics of the waste gas streams, such as:<br>(d) average values and variability of flow and temperature;<br>(e) average concentration and load values of relevant pollutants/parameters and their variability (e.g. VOC, CO, NOX, SOX, chlorine, hydrogen chloride);<br>(f) flammability, lower and higher explosive limits, reactivity;<br>(d) presence of other substances that may affect the waste gas treatment system or plant safety (e.g. oxygen, nitrogen, water vapour, dust). |
| **Monitoring** | |
| 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). |
| 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. |

| BAT No. | BAT Criterion |
|---|---|
|  |  |

| 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 |  |

| BAT No. | BAT Criterion |
|---|---|

| | | | |
|---|---|---|---|
| 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,<br>EN ISO 11348-2 or<br>EN ISO 11348-3 | |
| | Duckweed (*Lemna minor*) | EN ISO 20079 | |
| | Algae | EN ISO 8692,<br>EN ISO 10253 or<br>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 No. | BAT Criterion |
|---|---|
| **Emissions to water** | |
| 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. |
| 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. |
| 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). |
| 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.<br>e) Process-integrated techniques<br>f) Recovery of pollutants at source<br>g) Waste water pre-treatment<br>h) Final waste water treatment |
| 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. |
| 12 | In order to reduce emissions to water, BAT is to use an appropriate combination of final waste water treatment techniques.<br>- Preliminary and primary treatment<br>l) Equalisation<br>m) Neutralisation<br>n) Physical separation eg. Screens, sieves etc<br>- Biological treatment (secondary treatment)<br>o) Activated sludge process<br>p) Membrane bioreactor<br>- Nitrogen removal<br>q) Nitrification/denitrification<br>- Phosphorus removal<br>r) Chemical precipitation<br>- Final solids removal<br>s) Coagulation and flocculation |

| BAT No. | BAT Criterion |
|---|---|
|  | t) Sedimentation<br>u) Filtration (sand filtration, microfiltration etc)<br>v) Flotation<br>Final waste water treatment is carried out as part of an integrated waste water management and treatment strategy (see BAT 10).<br><br>The BAT-associated emission levels (BAT-AELs), for emissions to water apply to indirect emissions to a receiving water body. The BAT-AELs apply at the point where the emission leaves the installation. |

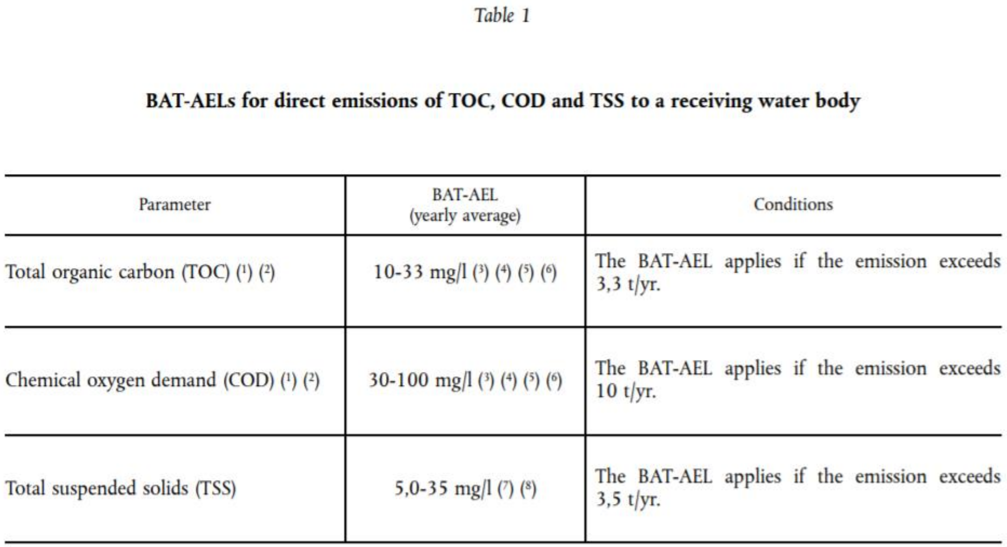


*Table 1*

**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. |

| BAT No. | BAT Criterion |
|---|---|

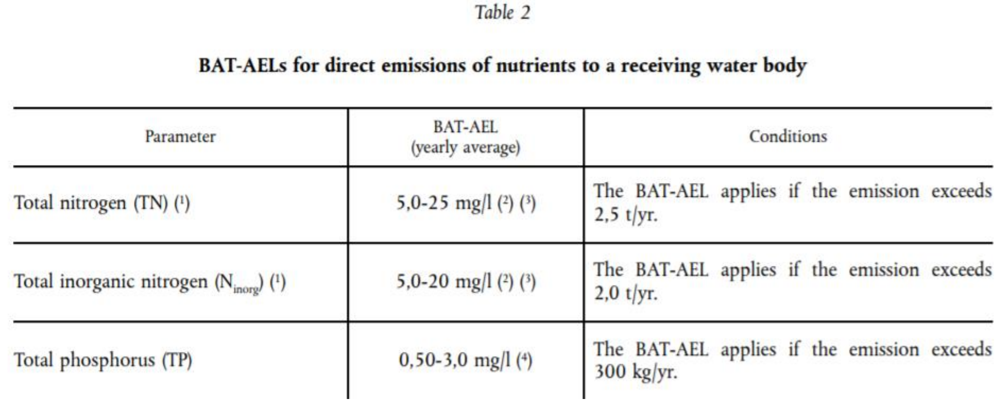


*Table 2*

**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. |

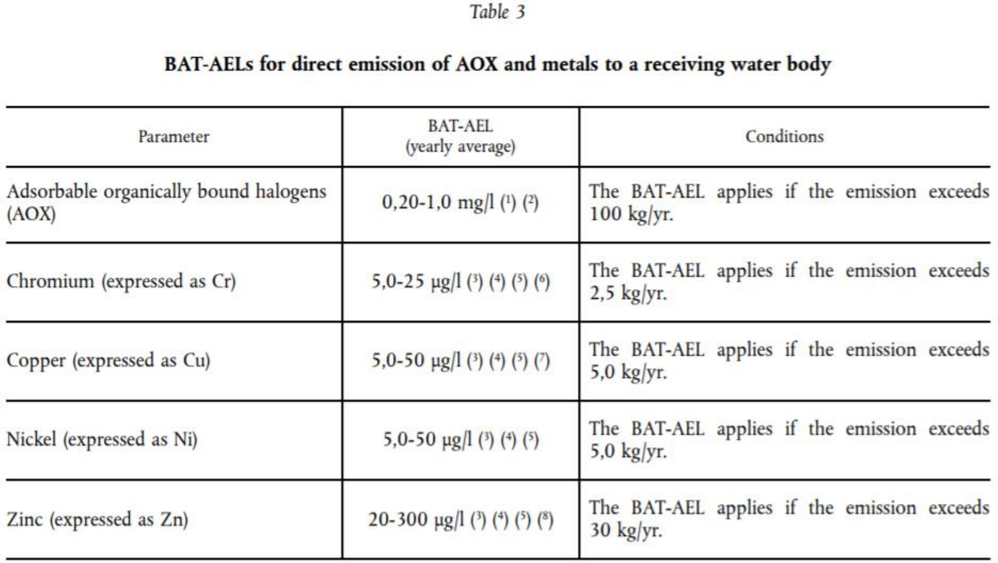
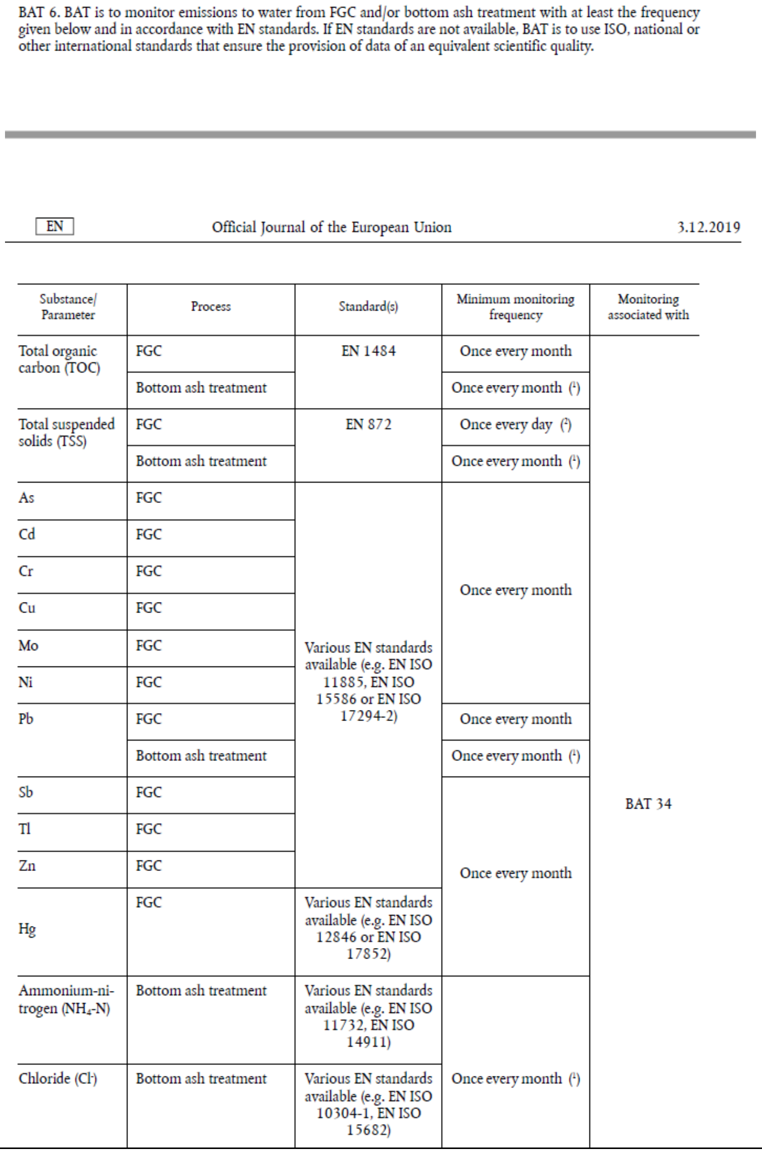


*Table 3*

**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. |

## 5.1.4 Waste Incineration BAT Conclusions

| BAT No. | BAT Criterion |
|---|---|
| 6 |  |

BAT 6. BAT is to monitor emissions to water from FGC and/or bottom ash treatment 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.

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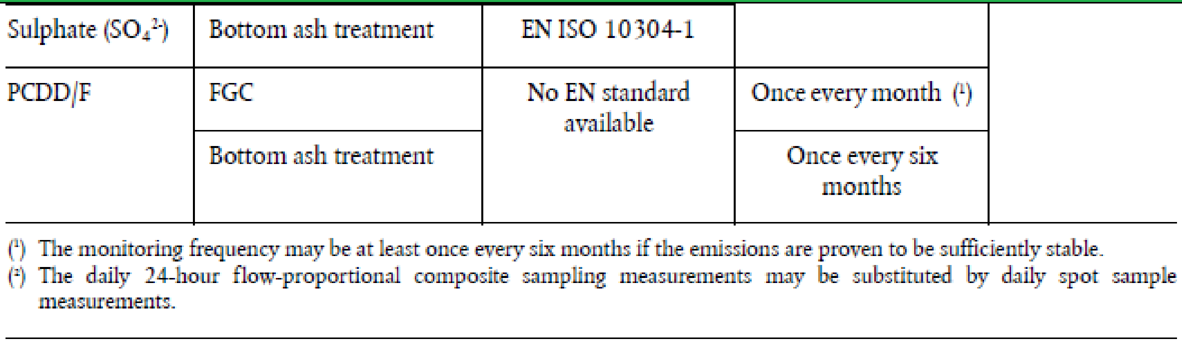
| Substance/ Parameter | Process | Standard(s) | Minimum monitoring frequency | Monitoring associated with |
|---|---|---|---|---|
| Total organic carbon (TOC) | FGC | EN 1484 | Once every month | BAT 34 |
| | Bottom ash treatment | | Once every month (1) | |
| Total suspended solids (TSS) | FGC | EN 872 | Once every day (2) | |
| | Bottom ash treatment | | Once every month (1) | |
| As | FGC | Various EN standards available (e.g. EN ISO 11885, EN ISO 15586 or EN ISO 17294-2) | Once every month | |
| Cd | FGC | | | |
| Cr | FGC | | | |
| Cu | FGC | | | |
| Mo | FGC | | | |
| Ni | FGC | | | |
| Pb | FGC | | Once every month | |
| | Bottom ash treatment | | Once every month (1) | |
| Sb | FGC | | Once every month | |
| Tl | FGC | | | |
| Zn | FGC | | | |
| Hg | FGC | Various EN standards available (e.g. EN ISO 12846 or EN ISO 17852) | | |
| Ammonium-nitrogen ($NH_4$-N) | Bottom ash treatment | Various EN standards available (e.g. EN ISO 11732, EN ISO 14911) | Once every month (1) | |
| Chloride ($Cl^-$) | Bottom ash treatment | Various EN standards available (e.g. EN ISO 10304-1, EN ISO 15682) | | |

| BAT No. | BAT Criterion |
|---|---|

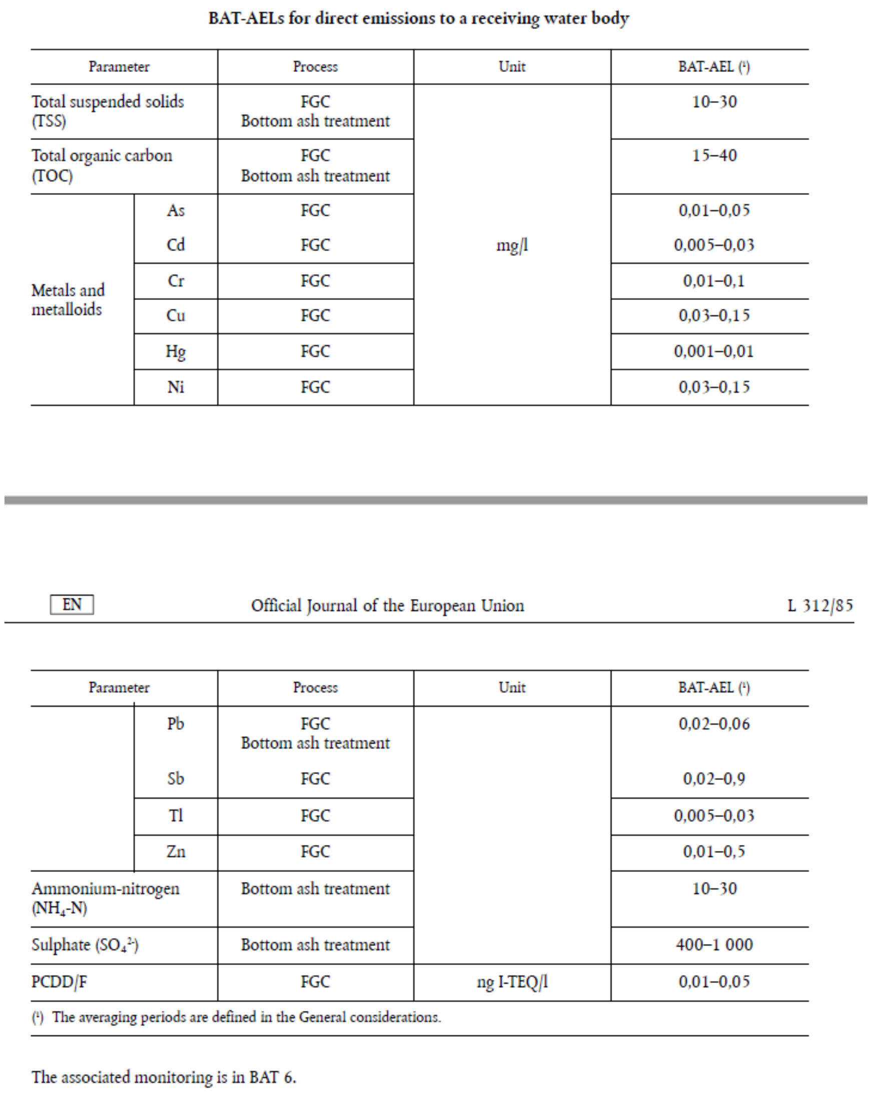


| | | | |
|---|---|---|---|
| Sulphate ($SO_4^{2-}$) | Bottom ash treatment | EN ISO 10304-1 | |
| PCDD/F | FGC | No EN standard available | Once every month (1) |
| | Bottom ash treatment | | Once every six months |

(1) The monitoring frequency may be at least once every six months if the emissions are proven to be sufficiently stable.

(2) The daily 24-hour flow-proportional composite sampling measurements may be substituted by daily spot sample measurements.

| BAT No. | BAT Criterion |
|---|---|

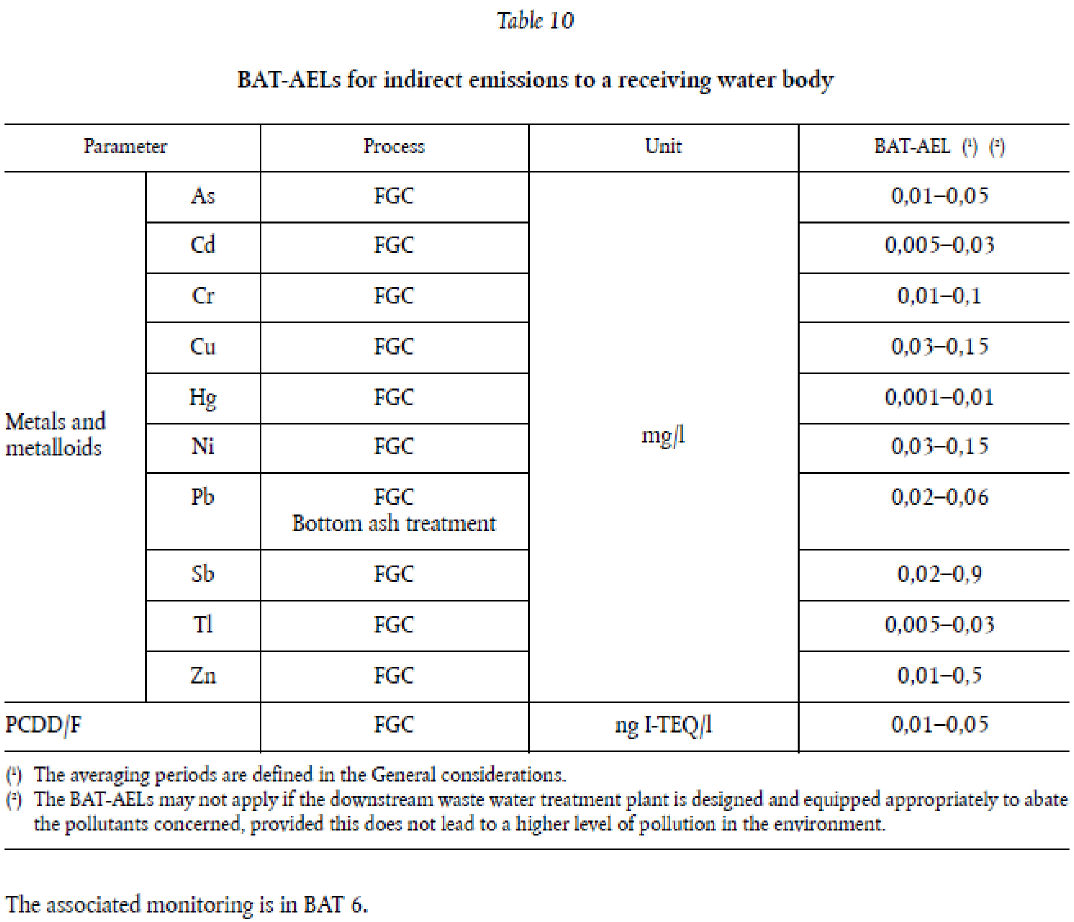


**BAT-AELs for direct emissions to a receiving water body**

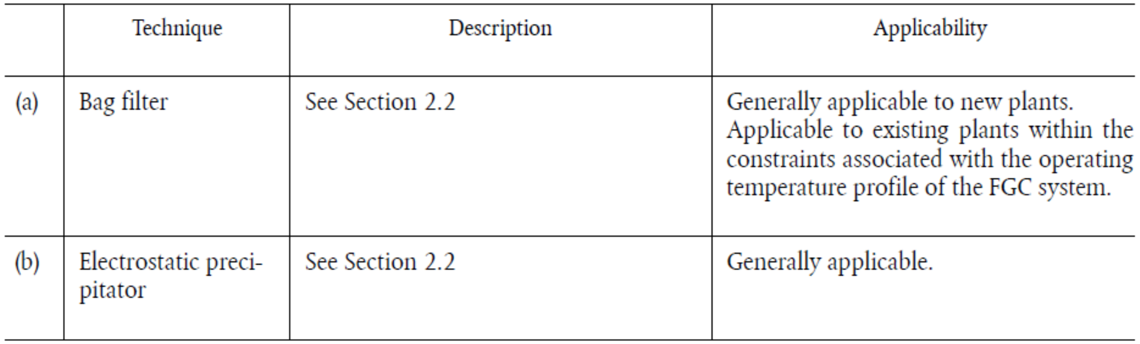
| Parameter | | Process | Unit | BAT-AEL (1) |
|---|---|---|---|---|
| Total suspended solids (TSS) | | FGC<br>Bottom ash treatment | mg/l | 10–30 |
| Total organic carbon (TOC) | | FGC<br>Bottom ash treatment | | 15–40 |
| Metals and metalloids | As | FGC | | 0,01–0,05 |
| | Cd | FGC | | 0,005–0,03 |
| | Cr | FGC | | 0,01–0,1 |
| | Cu | FGC | | 0,03–0,15 |
| | Hg | FGC | | 0,001–0,01 |
| | Ni | FGC | | 0,03–0,15 |
| | Pb | FGC<br>Bottom ash treatment | | 0,02–0,06 |
| | Sb | FGC | | 0,02–0,9 |
| | Tl | FGC | | 0,005–0,03 |
| | Zn | FGC | | 0,01–0,5 |
| Ammonium-nitrogen ($NH_4$-N) | | Bottom ash treatment | | 10–30 |
| Sulphate ($SO_4^{2-}$) | | Bottom ash treatment | | 400–1 000 |
| PCDD/F | | FGC | ng I-TEQ/l | 0,01–0,05 |

(1) The averaging periods are defined in the General considerations.

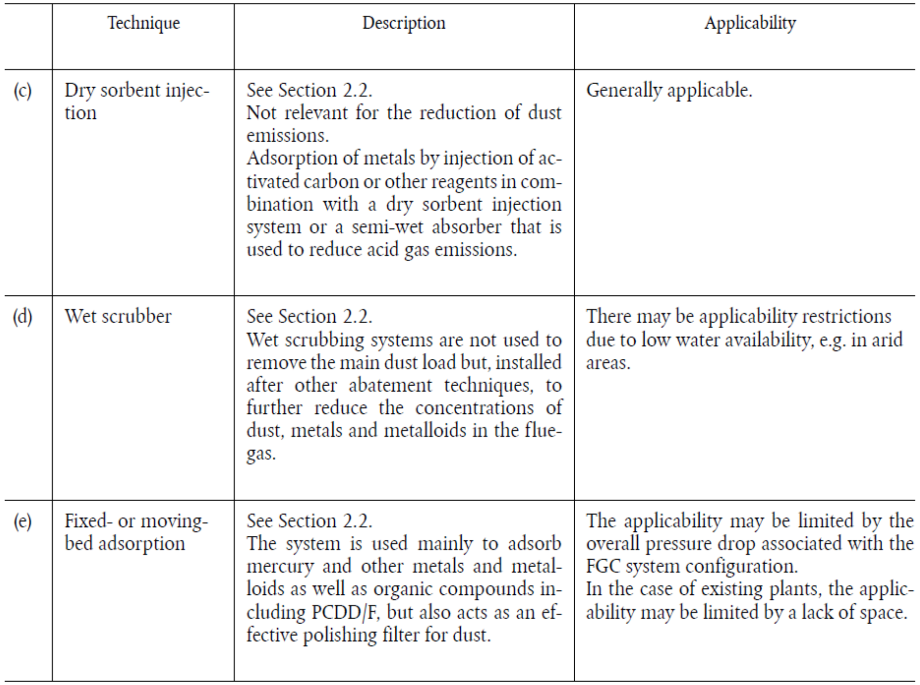
The associated monitoring is in BAT 6.

<table>
<tr><th>BAT No.</th><th>BAT Criterion</th></tr>
<tr><td></td><td>

<p><em>Table 10</em></p>
<p><strong>BAT-AELs for indirect emissions to a receiving water body</strong></p>
<table>
<tr><th colspan="2">Parameter</th><th>Process</th><th>Unit</th><th>BAT-AEL (1) (2)</th></tr>
<tr><td>Metals and metalloids</td><td>As</td><td>FGC</td><td>mg/l</td><td>0,01–0,05</td></tr>
<tr><td></td><td>Cd</td><td>FGC</td><td></td><td>0,005–0,03</td></tr>
<tr><td></td><td>Cr</td><td>FGC</td><td></td><td>0,01–0,1</td></tr>
<tr><td></td><td>Cu</td><td>FGC</td><td></td><td>0,03–0,15</td></tr>
<tr><td></td><td>Hg</td><td>FGC</td><td></td><td>0,001–0,01</td></tr>
<tr><td></td><td>Ni</td><td>FGC</td><td></td><td>0,03–0,15</td></tr>
<tr><td></td><td>Pb</td><td>FGC<br>Bottom ash treatment</td><td></td><td>0,02–0,06</td></tr>
<tr><td></td><td>Sb</td><td>FGC</td><td></td><td>0,02–0,9</td></tr>
<tr><td></td><td>Tl</td><td>FGC</td><td></td><td>0,005–0,03</td></tr>
<tr><td></td><td>Zn</td><td>FGC</td><td></td><td>0,01–0,5</td></tr>
<tr><td colspan="2">PCDD/F</td><td>FGC</td><td>ng I-TEQ/l</td><td>0,01–0,05</td></tr>
</table>
<p>(1) The averaging periods are defined in the General considerations.<br>
(2) The BAT-AELs may not apply if the downstream waste water treatment plant is designed and equipped appropriately to abate the pollutants concerned, provided this does not lead to a higher level of pollution in the environment.</p>
<p>The associated monitoring is in BAT 6.</p>
</td></tr>
<tr><td>25</td><td>In order to reduce channelled emissions to air of dust, metals and metalloids from the incineration of waste, BAT is to use one or a combination of the techniques given below.</td></tr>
</table>

| BAT No. | BAT Criterion |
|---|---|

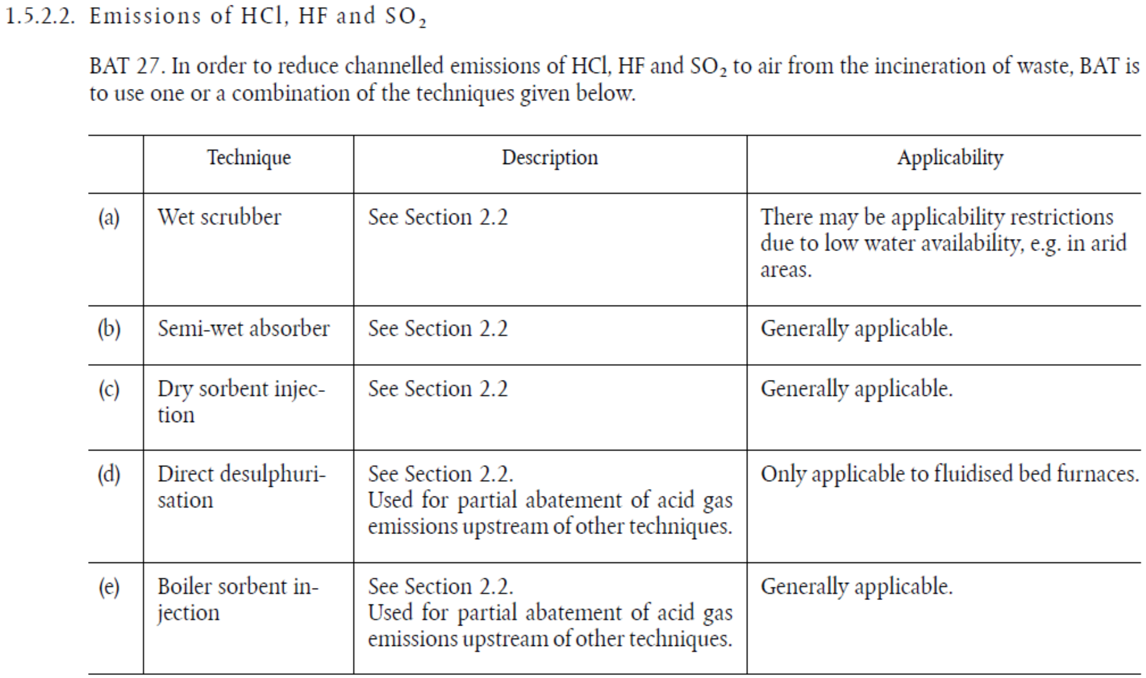


| | Technique | Description | Applicability |
|---|---|---|---|
| (a) | Bag filter | See Section 2.2 | Generally applicable to new plants.<br>Applicable to existing plants within the constraints associated with the operating temperature profile of the FGC system. |
| (b) | Electrostatic precipitator | See Section 2.2 | Generally applicable. |



| | Technique | Description | Applicability |
|---|---|---|---|
| (c) | Dry sorbent injection | See Section 2.2.<br>Not relevant for the reduction of dust emissions.<br>Adsorption of metals by injection of activated carbon or other reagents in combination with a dry sorbent injection system or a semi-wet absorber that is used to reduce acid gas emissions. | Generally applicable. |
| (d) | Wet scrubber | See Section 2.2.<br>Wet scrubbing systems are not used to remove the main dust load but, installed after other abatement techniques, to further reduce the concentrations of dust, metals and metalloids in the flue-gas. | There may be applicability restrictions due to low water availability, e.g. in arid areas. |
| (e) | Fixed- or moving-bed adsorption | See Section 2.2.<br>The system is used mainly to adsorb mercury and other metals and metalloids as well as organic compounds including PCDD/F, but also acts as an effective polishing filter for dust. | The applicability may be limited by the overall pressure drop associated with the FGC system configuration.<br>In the case of existing plants, the applicability may be limited by a lack of space. |

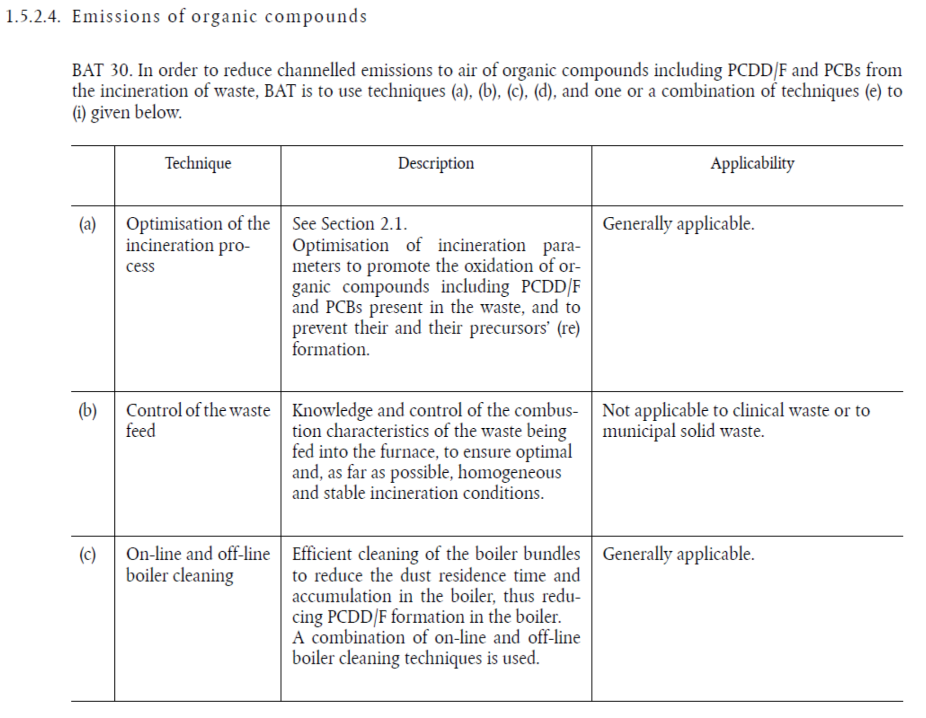
| BAT No. | BAT Criterion |
|---|---|
| 27 | |



### 1.5.2.2. Emissions of HCl, HF and $SO_2$

BAT 27. In order to reduce channelled emissions of HCl, HF and $SO_2$ to air from the incineration of waste, BAT is to use one or a combination of the techniques given below.

| | Technique | Description | Applicability |
|---|---|---|---|
| (a) | Wet scrubber | See Section 2.2 | There may be applicability restrictions due to low water availability, e.g. in arid areas. |
| (b) | Semi-wet absorber | See Section 2.2 | Generally applicable. |
| (c) | Dry sorbent injection | See Section 2.2 | Generally applicable. |
| (d) | Direct desulphurisation | See Section 2.2.<br>Used for partial abatement of acid gas emissions upstream of other techniques. | Only applicable to fluidised bed furnaces. |
| (e) | Boiler sorbent injection | See Section 2.2.<br>Used for partial abatement of acid gas emissions upstream of other techniques. | Generally applicable. |

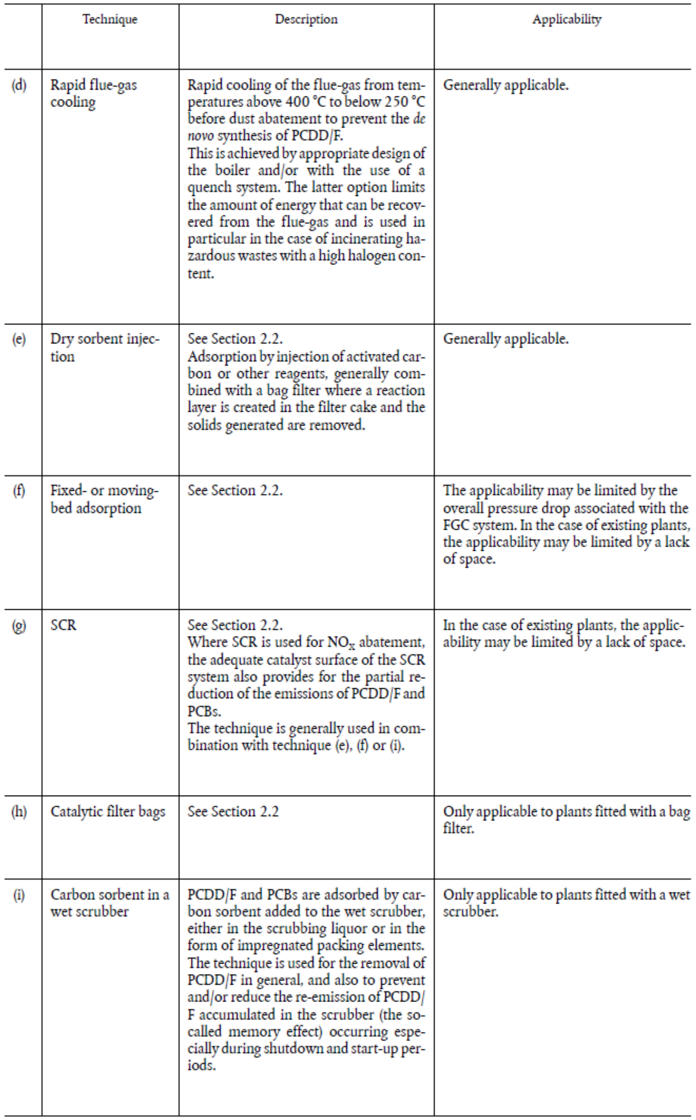
| BAT No. | BAT Criterion |
|---|---|
| 30 |  |

1.5.2.4. Emissions of organic compounds

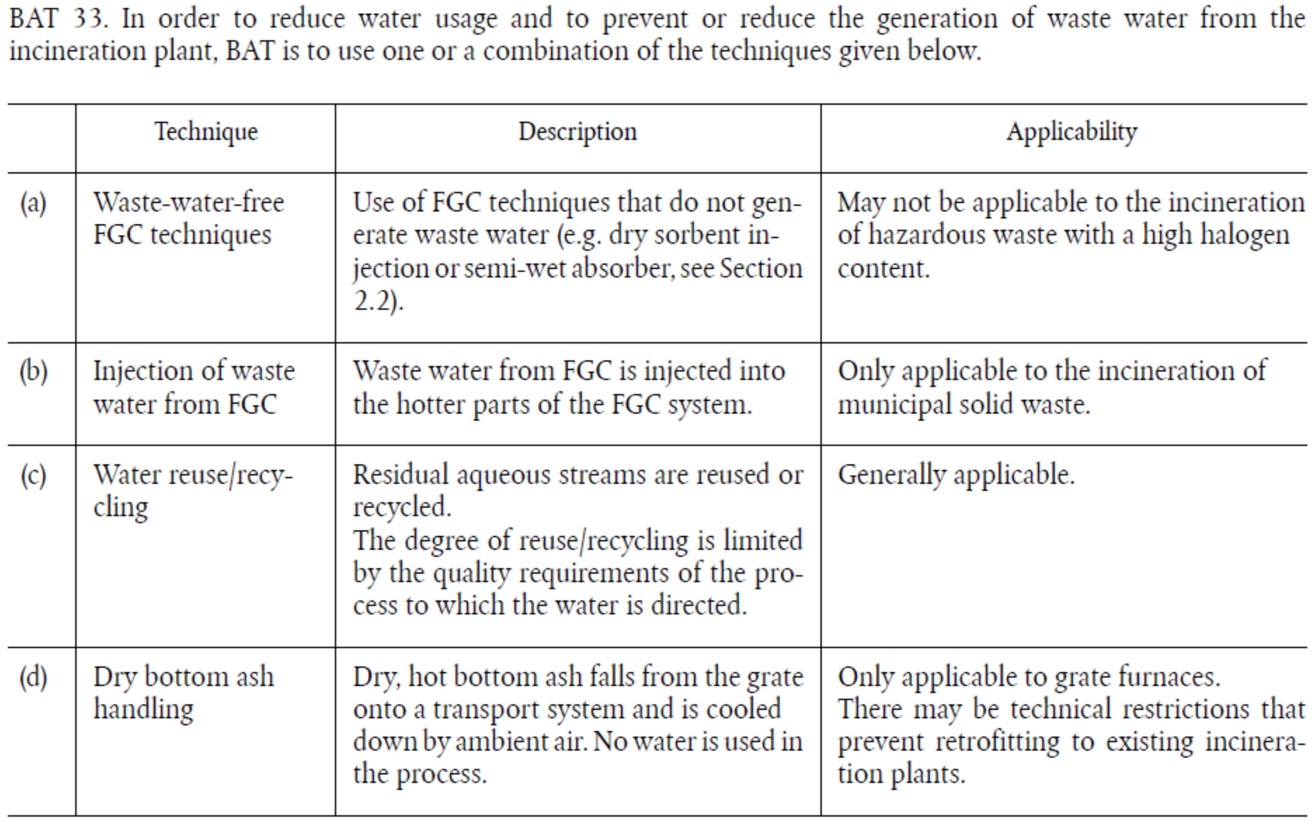
BAT 30. In order to reduce channelled emissions to air of organic compounds including PCDD/F and PCBs from the incineration of waste, BAT is to use techniques (a), (b), (c), (d), and one or a combination of techniques (e) to (i) given below.

| | Technique | Description | Applicability |
|---|---|---|---|
| (a) | Optimisation of the incineration process | See Section 2.1.<br>Optimisation of incineration parameters to promote the oxidation of organic compounds including PCDD/F and PCBs present in the waste, and to prevent their and their precursors' (re) formation. | Generally applicable. |
| (b) | Control of the waste feed | Knowledge and control of the combustion characteristics of the waste being fed into the furnace, to ensure optimal and, as far as possible, homogeneous and stable incineration conditions. | Not applicable to clinical waste or to municipal solid waste. |
| (c) | On-line and off-line boiler cleaning | Efficient cleaning of the boiler bundles to reduce the dust residence time and accumulation in the boiler, thus reducing PCDD/F formation in the boiler.<br>A combination of on-line and off-line boiler cleaning techniques is used. | Generally applicable. |

| BAT No. | BAT Criterion |
|---|---|

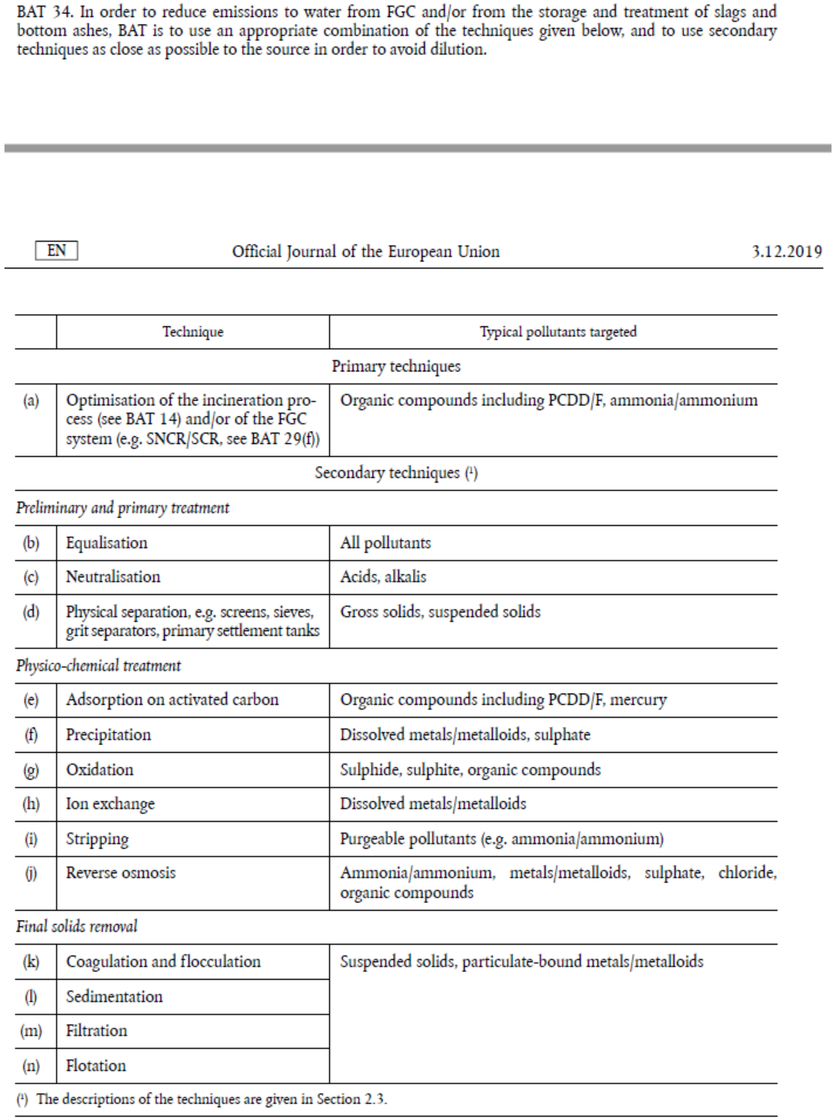


| | Technique | Description | Applicability |
|---|---|---|---|
| (d) | Rapid flue-gas cooling | Rapid cooling of the flue-gas from temperatures above 400 °C to below 250 °C before dust abatement to prevent the *de novo* synthesis of PCDD/F.<br>This is achieved by appropriate design of the boiler and/or with the use of a quench system. The latter option limits the amount of energy that can be recovered from the flue-gas and is used in particular in the case of incinerating hazardous wastes with a high halogen content. | Generally applicable. |
| (e) | Dry sorbent injection | See Section 2.2.<br>Adsorption by injection of activated carbon or other reagents, generally combined with a bag filter where a reaction layer is created in the filter cake and the solids generated are removed. | Generally applicable. |
| (f) | Fixed- or moving-bed adsorption | See Section 2.2. | The applicability may be limited by the overall pressure drop associated with the FGC system. In the case of existing plants, the applicability may be limited by a lack of space. |
| (g) | SCR | See Section 2.2.<br>Where SCR is used for $NO_X$ abatement, the adequate catalyst surface of the SCR system also provides for the partial reduction of the emissions of PCDD/F and PCBs.<br>The technique is generally used in combination with technique (e), (f) or (i). | In the case of existing plants, the applicability may be limited by a lack of space. |
| (h) | Catalytic filter bags | See Section 2.2 | Only applicable to plants fitted with a bag filter. |
| (i) | Carbon sorbent in a wet scrubber | PCDD/F and PCBs are adsorbed by carbon sorbent added to the wet scrubber, either in the scrubbing liquor or in the form of impregnated packing elements.<br>The technique is used for the removal of PCDD/F in general, and also to prevent and/or reduce the re-emission of PCDD/F accumulated in the scrubber (the so-called memory effect) occurring especially during shutdown and start-up periods. | Only applicable to plants fitted with a wet scrubber. |

| BAT No. | BAT Criterion |
|---|---|
| 32 | In order to prevent the contamination of uncontaminated water, to reduce emissions to water, and to increase resource efficiency, BAT is to segregate waste water streams and to treat them separately, depending on their characteristics. |
| 33 |  |

BAT 33. In order to reduce water usage and to prevent or reduce the generation of waste water from the incineration plant, BAT is to use one or a combination of the techniques given below.

| | Technique | Description | Applicability |
|---|---|---|---|
| (a) | Waste-water-free FGC techniques | Use of FGC techniques that do not generate waste water (e.g. dry sorbent injection or semi-wet absorber, see Section 2.2). | May not be applicable to the incineration of hazardous waste with a high halogen content. |
| (b) | Injection of waste water from FGC | Waste water from FGC is injected into the hotter parts of the FGC system. | Only applicable to the incineration of municipal solid waste. |
| (c) | Water reuse/recycling | Residual aqueous streams are reused or recycled.<br>The degree of reuse/recycling is limited by the quality requirements of the process to which the water is directed. | Generally applicable. |
| (d) | Dry bottom ash handling | Dry, hot bottom ash falls from the grate onto a transport system and is cooled down by ambient air. No water is used in the process. | Only applicable to grate furnaces.<br>There may be technical restrictions that prevent retrofitting to existing incineration plants. |

| BAT No. | BAT Criterion |
|---|---|
| 34 |  BAT 34. In order to reduce emissions to water from FGC and/or from the storage and treatment of slags and bottom ashes, BAT is to use an appropriate combination of the techniques given below, and to use secondary techniques as close as possible to the source in order to avoid dilution. |

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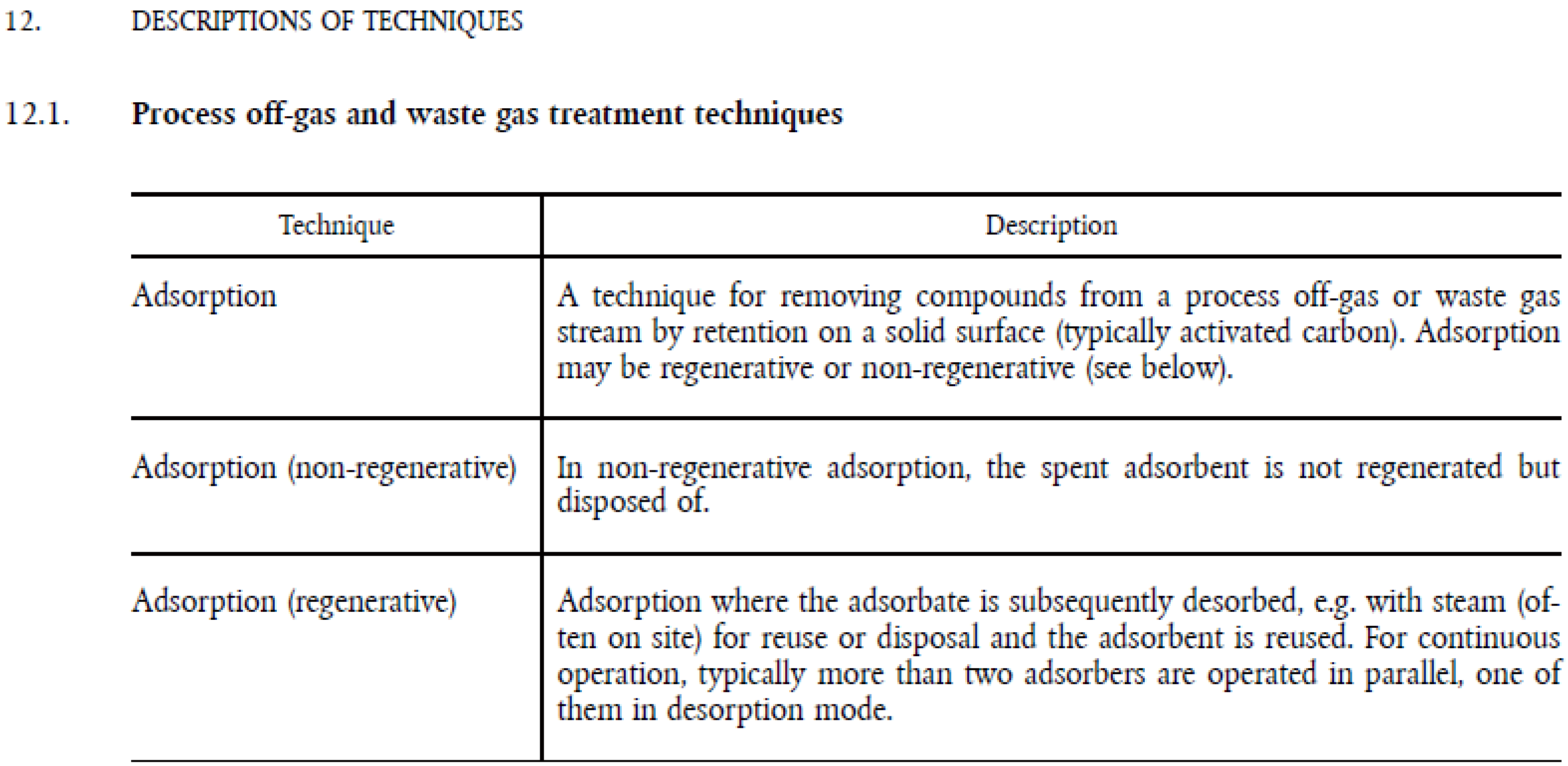
|  | Technique | Typical pollutants targeted |
|---|---|---|
| Primary techniques |  |  |
| (a) | Optimisation of the incineration process (see BAT 14) and/or of the FGC system (e.g. SNCR/SCR, see BAT 29(f)) | Organic compounds including PCDD/F, ammonia/ammonium |
| Secondary techniques (¹) |  |  |
| *Preliminary and primary treatment* |  |  |
| (b) | Equalisation | All pollutants |
| (c) | Neutralisation | Acids, alkalis |
| (d) | Physical separation, e.g. screens, sieves, grit separators, primary settlement tanks | Gross solids, suspended solids |
| *Physico-chemical treatment* |  |  |
| (e) | Adsorption on activated carbon | Organic compounds including PCDD/F, mercury |
| (f) | Precipitation | Dissolved metals/metalloids, sulphate |
| (g) | Oxidation | Sulphide, sulphite, organic compounds |
| (h) | Ion exchange | Dissolved metals/metalloids |
| (i) | Stripping | Purgeable pollutants (e.g. ammonia/ammonium) |
| (j) | Reverse osmosis | Ammonia/ammonium, metals/metalloids, sulphate, chloride, organic compounds |
| *Final solids removal* |  |  |
| (k) | Coagulation and flocculation | Suspended solids, particulate-bound metals/metalloids |
| (l) | Sedimentation |  |
| (m) | Filtration |  |
| (n) | Flotation |  |

(¹) The descriptions of the techniques are given in Section 2.3.

| BAT No. | BAT Criterion |
|---|---|
| | |

## 5.2 General techniques

### 5.2.1 Emissions to air - LVOC



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.<br>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 °C. One 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. |

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|---|---|
| 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. |

## 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. |

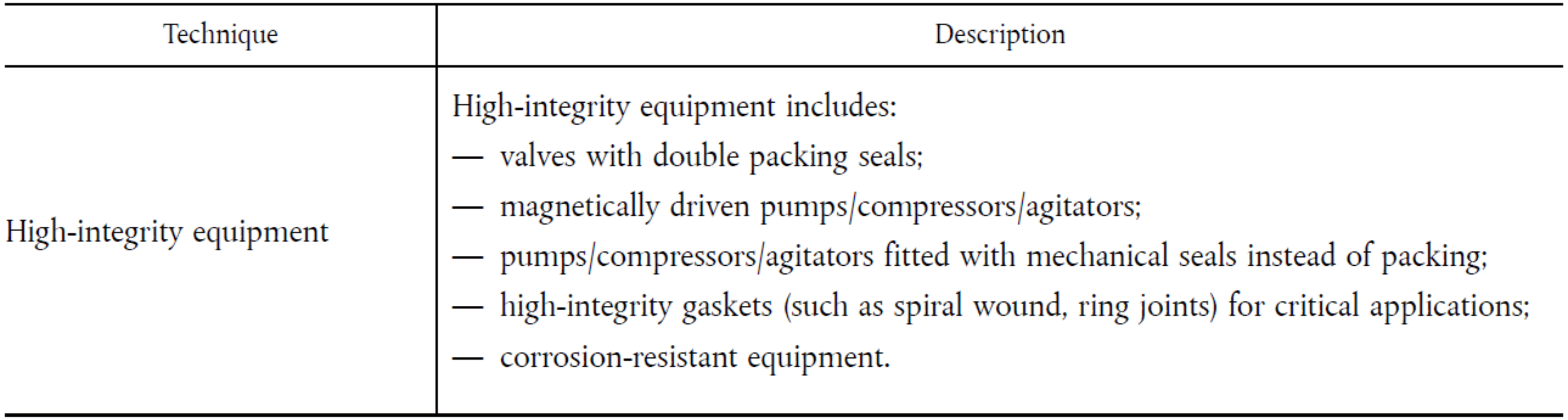
## 5.2.2 Emissions to air - Waste Incineration

| Technique | Description |
|---|---|
| Bag filter | Bag or fabric filters are constructed from porous woven or felted fabric through which gases are passed to remove particles. The use of a bag filter requires the selection of a fabric suitable for the characteristics of the flue-gas and the maximum operating temperature. |
| Boiler sorbent injection | The injection of magnesium- or calcium-based absorbents at a high temperature in the boiler post-combustion area, to achieve partial abatement of acid gases. The technique is highly effective for the removal of $SO_X$ and HF, and provides additional benefits in terms of flattening emission peaks. |
| Catalytic filter bags | Filter bags are either impregnated with a catalyst or the catalyst is directly mixed with organic material in the production of the fibres used for the filter medium. Such filters can be used to reduce PCDD/F emissions as well as, in combination with a source of $NH_3$, to reduce $NO_X$ emissions. |
| Direct desulphurisation | The addition of magnesium- or calcium-based absorbents to the bed of a fluidised bed furnace. |
| Dry sorbent injection | The injection and dispersion of sorbent in the form of a dry powder in the flue-gas stream. Alkaline sorbents (e.g. sodium bicarbonate, hydrated lime) are injected to react with acid gases (HCl, HF and $SO_X$). Activated carbon is injected or co-injected to adsorb in particular PCDD/F and mercury. The resulting solids are removed, most often with a bag filter. The excess reactive agents may be recirculated to decrease their consumption, possibly after reactivation by maturation or steam injection (see BAT 28(b)). |

| | |
|---|---|
| Electrostatic precipitator | Electrostatic precipitators (ESPs) 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. The abatement efficiency may depend on the number of fields, residence time (size), and upstream particle removal devices. They generally include between two and five fields. Electrostatic precipitators can be of the dry or of the wet type depending on the technique used to collect the dust from the electrodes. Wet ESPs are typically used at the polishing stage to remove residual dust and droplets after wet scrubbing. |
| Fixed- or moving-bed adsorption | The flue-gas is passed through a fixed- or a moving-bed filter where an adsorbent (e.g. activated coke, activated lignite or a carbon-impregnated polymer) is used to adsorb pollutants. |

| Technique | Description |
|---|---|
| Flue-gas recirculation | Recirculation of a part of the flue-gas to the furnace to replace a part of the fresh combustion air, with the dual effect of cooling the temperature and limiting the $O_2$ content for nitrogen oxidation, thus limiting the $NO_X$ generation. It implies the supply of flue-gas from the furnace into the flame to reduce the oxygen content and therefore the temperature of the flame.<br>This technique also reduces the flue-gas energy losses. Energy savings are also achieved when the recirculated flue-gas is extracted before FGC, by reducing the gas flow though the FGC system and the size of the required FGC system. |
| Selective catalytic reduction (SCR) | Selective reduction of nitrogen oxides with ammonia or urea in the presence of a catalyst. The technique is based on the reduction of $NO_X$ to nitrogen in a catalytic bed by reaction with ammonia at an optimum operating temperature that is typically around 200–450 ° C for the high-dust type and 170–250 °C for the tail-end type. In general, ammonia is injected as an aqueous solution; the ammonia source can also be anhydrous ammonia or a urea solution. Several layers of catalyst may be applied. A higher $NO_X$ reduction is achieved with the use of a larger catalyst surface, installed as one or more layers. 'In-duct' or 'slip' SCR combines SNCR with downstream SCR which reduces the ammonia slip from SNCR. |
| Selective non-catalytic reduction (SNCR) | Selective reduction of nitrogen oxides to nitrogen with ammonia or urea at high temperatures and without catalyst. The operating temperature window is maintained between 800 °C and 1 000 °C for optimal reaction.<br>The performance of the SNCR system can be increased by controlling the injection of the reagent from multiple lances with the support of a (fast-reacting) acoustic or infrared temperature measurement system so as to ensure that the reagent is injected in the optimum temperature zone at all times. |
| Semi-wet absorber | Also called semi-dry absorber. An alkaline aqueous solution or suspension (e.g. milk of lime) is added to the flue-gas stream to capture the acid gases. The water evaporates and the reaction products are dry. The resulting solids may be recirculated to reduce reagent consumption (see BAT 28(b)).<br>This technique includes a range of different designs, including *flash-dry* processes which consist of injecting water (providing for fast gas cooling) and reagent at the filter inlet. |
| Wet scrubber | Use of a liquid, typically water or an aqueous solution/suspension, to capture pollutants from the flue-gas by absorption, in particular acid gases, as well as other soluble compounds and solids.<br>To adsorb mercury and/or PCDD/F, carbon sorbent (as a slurry or as carbon-impregnated plastic packing) can be added to the wet scrubber.<br>Different types of scrubber designs are used, e.g. jet scrubbers, rotation scrubbers, Venturi scrubbers, spray scrubbers and packed tower scrubbers. |

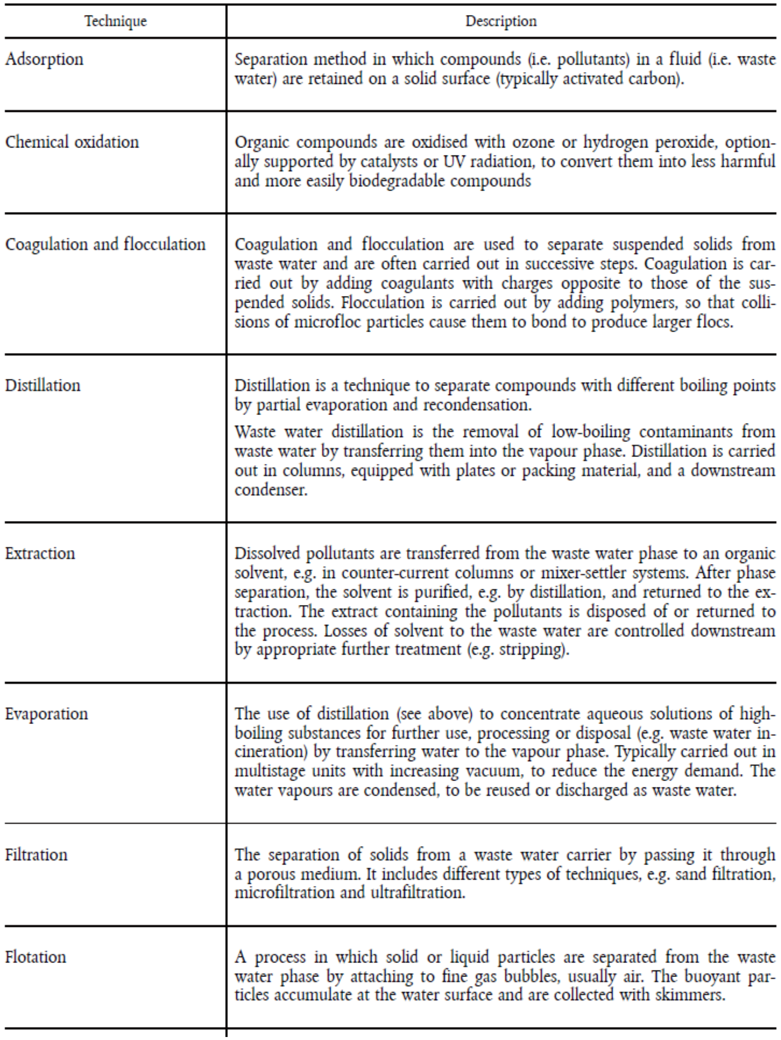
### 5.2.3 Diffuse VOCs - CWWWGT



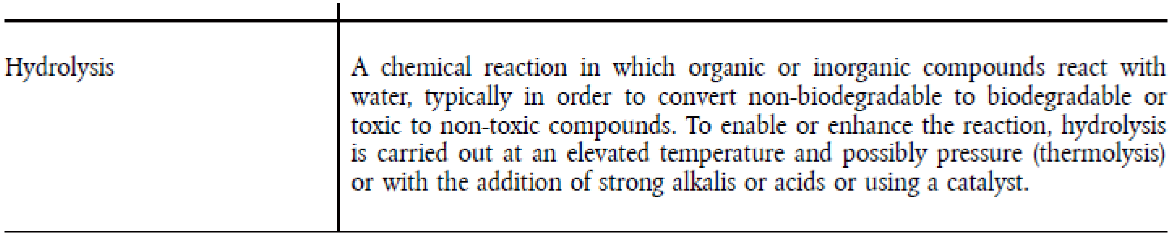
| Technique | Description |
|---|---|
| High-integrity equipment | High-integrity equipment includes:<br>— valves with double packing seals;<br>— magnetically driven pumps/compressors/agitators;<br>— pumps/compressors/agitators fitted with mechanical seals instead of packing;<br>— high-integrity gaskets (such as spiral wound, ring joints) for critical applications;<br>— corrosion-resistant equipment. |

| | |
|---|---|
| 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.<br>**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.<br>**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:<br>(i) obtaining a certified high quality gasket, e.g. according to EN 13555;<br>(ii) calculating the highest possible bolt load, e.g. according to EN 1591-1;<br>(iii) obtaining a qualified flange-assembling equipment;<br>(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.<br>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.<br>**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.<br>**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. |

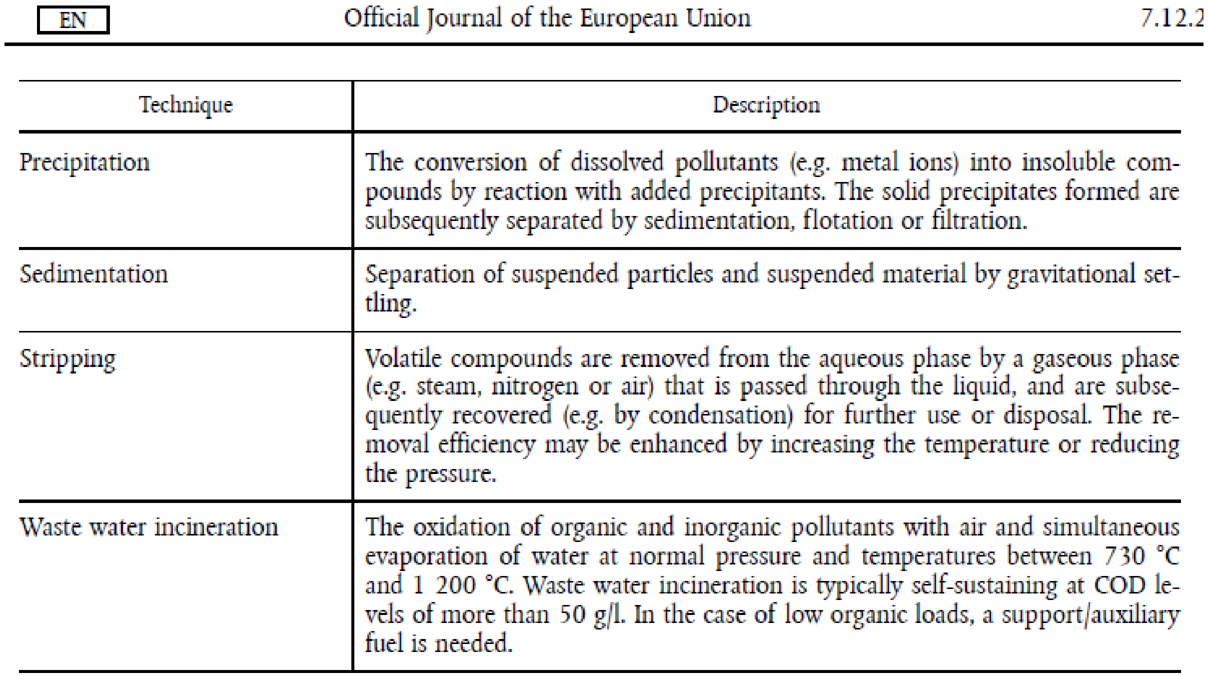
## 5.2.4 Emissions to water - LVOC



| 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.<br>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. |



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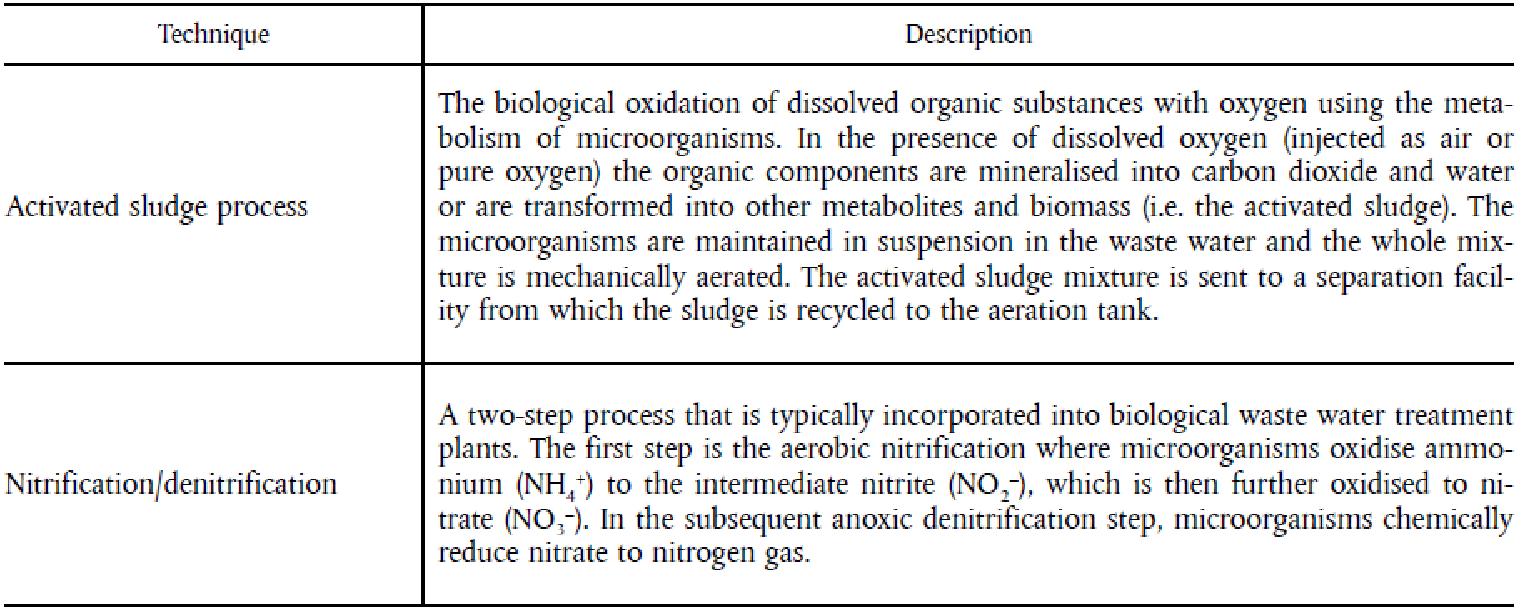
| Technique | Description |
|---|---|
| Precipitation | The conversion of dissolved pollutants (e.g. metal ions) into insoluble compounds by reaction with added precipitants. The solid precipitates formed are subsequently separated by sedimentation, flotation or filtration. |
| Sedimentation | Separation 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 °C. Waste 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. |

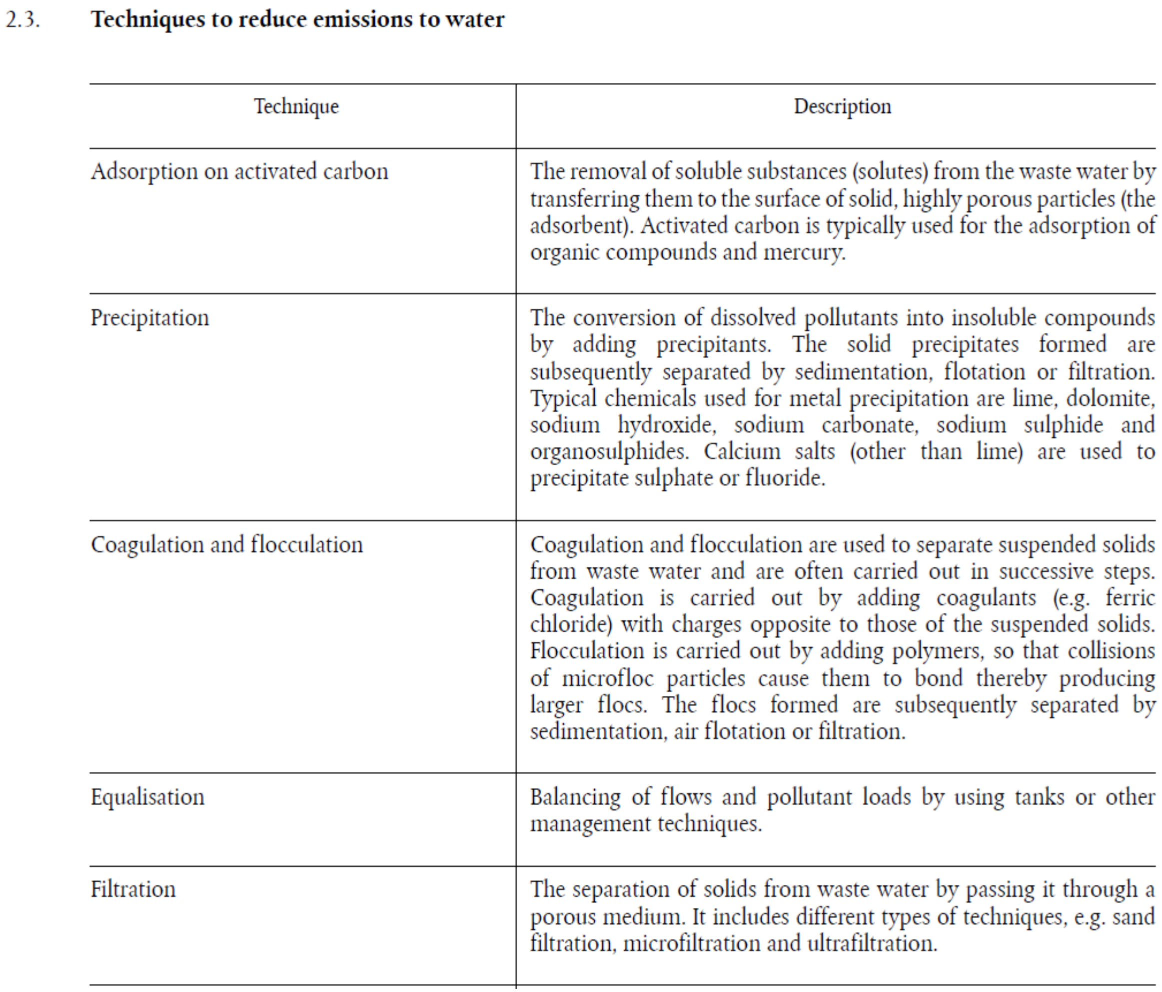
## 5.2.5 Emissions to water - CWWWGT



| 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. |

| | |
|---|---|
| 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. |

## 5.2.6 Emissions to water - Waste Incineration



### 2.3. Techniques to reduce emissions to water

| Technique | Description |
|---|---|
| Adsorption on activated carbon | The removal of soluble substances (solutes) from the waste water by transferring them to the surface of solid, highly porous particles (the adsorbent). Activated carbon is typically used for the adsorption of organic compounds and mercury. |
| Precipitation | The conversion of dissolved pollutants into insoluble compounds by adding precipitants. The solid precipitates formed are subsequently separated by sedimentation, flotation or filtration. Typical chemicals used for metal precipitation are lime, dolomite, sodium hydroxide, sodium carbonate, sodium sulphide and organosulphides. Calcium salts (other than lime) are used to precipitate sulphate or fluoride. |
| 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 (e.g. ferric chloride) 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 thereby producing larger flocs. The flocs formed are subsequently separated by sedimentation, air flotation or filtration. |
| Equalisation | Balancing of flows and pollutant loads by using tanks or other management techniques. |
| Filtration | The separation of solids from waste water by passing it through a porous medium. It includes different types of techniques, 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. |
| Ion exchange | The retention of ionic pollutants from waste water and their replacement by more acceptable ions using an ion exchange resin. The pollutants are temporarily retained and afterwards released into a regeneration or backwashing liquid. |
| Neutralisation | The adjustment of the pH of the waste water to a neutral value (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 used to decrease the pH. The precipitation of some substances may occur during neutralisation. |
| Oxidation | The conversion of pollutants by chemical oxidising agents to similar compounds that are less hazardous and/or easier to abate. In the case of waste water from the use of wet scrubbers, air may be used to oxidise sulphite ($SO_3^{2-}$) to sulphate ($SO_4^{2-}$). |
| Reverse osmosis | A membrane process in which a pressure difference applied between the compartments separated by the membrane causes water to flow from the more concentrated solution to the less concentrated one. |

| Technique | Description |
|---|---|
| Sedimentation | The separation of suspended solids by gravitational settling. |
| Stripping | The removal of purgeable pollutants (e.g. ammonia) from waste water by contact with a high flow of a gas current in order to transfer them to the gas phase. The pollutants 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. |