5 BEST AVAILABLE TECHNIQUES (BAT) CONCLUSIONS FOR THE SURFACE TREATMENT OF METALS AND PLASTICS

[This chapter has been completely rewritten compared to the 2006 STM BREF.]

Scope

These BAT conclusions concern the following activities specified in Annex I to Directive 2010/75/EU ([1]) of the European Parliament and of the Council ~~as amended by Directive (EU) 2024/1785~~:

2.6. Surface treatment of metals or plastic materials using an electrolytic or chemical process where the volume of the treatment vats exceeds 30 m^3.

6.11 Independently operated treatment of waste water not covered by Directive (EU) 2024/3019 of the European Parliament and of the Council ([2]) ~~91/271/EEC~~, provided that the main pollutant load originates from the activities covered by these BAT conclusions.

These BAT conclusions cover the porcelain (vitreous) enamelling of metals falling under activity 2.6 of Annex I to Directive 2010/75/EU. They ~~and~~ also cover the following:

- The manufacturing of semiconductors covered by the activit~~y~~ies describ~~ed~~ ~~ption~~ in points 2.6 and/or 6.7 of Annex I to Directive 2010/75/EU ~~as amended by Directive (EU) 2024/1785~~.
- The combined treatment of waste water from different origins, provided that the main pollutant load originates from the activities covered by these BAT conclusions and that the waste water treatment is not covered by Directive (EU) 2024/3019 ~~91/271/EEC[1]~~.
- On-site combustion processes directly associated with the activities covered by these BAT conclusions provided that the gaseous products of combustion are put into direct contact with material.

These BAT conclusions do not cover the following:

- Waste water from indirect cooling systems. This may be covered by the BAT conclusions for industrial cooling systems (ICS).
- On-site combustion plants generating ~~hot~~ flue-gases that are not used for direct contact heating, drying or any other treatment of objects or materials. These may be covered by the BAT conclusions for large combustion plants (LCP) or by Directive (EU) 2015/2193 of the European Parliament and of the Council[3].
- Surface treatment of ferrous metals using electrolytic or chemical processes where the volume of the treatment vats exceeds 30 m^3, when covered under the scope of the FMP BAT conclusions.
- Surface treatment processes which are carried out as part of activities subject to point 6.7 of Annex I to Directive 2010/75/EU when covered under the scope of the STS BAT conclusions (e.g. vehicle body electroplating or chemical pretreatment in coil coating).

[1] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (OJ L 334, 17.12.2010, pp. 17–119), ELI: http://data.europa.eu/eli/dir/2010/75/oj.

[2] Directive (EU) 2024/3019 of the European Parliament and of the Council of 27 November 2024 concerning urban wastewater treatment (recast) (OJ L, 2024/3019, 12.12.2024), ELI: http://data.europa.eu/eli/dir/2024/3019/oj. ~~Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (OJ L 135, 30.5.1991, p. 40).~~

[3] Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants (OJ L 313, 28.11.2015, p. 1), ELI: http://data.europa.eu/eli/dir/2015/2193/oj.

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

- Surface Treatment sing Organic Solvents (STS);
- Ferrous Metals Processing (FMP)
- Waste Treatment (WT);
- Monitoring of Emissions to Air and Water from IED Installations (ROM);
- Economics and Cross-Media Effects (ECM);
- Emissions From Storage (EFS);
- Energy Efficiency (ENE).

These BAT conclusions apply without prejudice to other relevant Union legislation, e.g. on the registration, evaluation, authorisation and restriction of chemicals (REACH), on classification, labelling and packaging of substances and mixtures (CLP), on energy efficiency (energy efficiency first principle), or on the European Union emissions trading system.

Definitions

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

General terms	
Term used	**Definition**
Advanced semiconductor manufacturing	The manufacturing of logic semiconductors with a technology node of 14 nm or smaller. Semiconductor manufacturing processes associated to the manufacturing of Micro-Electro-Mechanical Systems (MEMS) and the manufacturing of semiconductor components based on substrates other than silicon are not considered advanced semiconductor manufacturing.
Benchmarks	Benchmarks as defined in point 13b of Article 3 of Directive 2010/75/EU ~~as amended by Directive (EU) 2024/1785~~.
Channelled emissions	Emissions of pollutants into the environment through any kind of duct, pipe, stack, etc.
Class 1	Refers to the cleanliness classification of a semiconductor manufacturing facility or specific clean room. The classification system is based on the number of particles per cubic metre of air in a specific size range, as defined by the International Organization for Standardization (ISO) and SEMI standards. Class 1 represents the highest level of cleanliness, with a maximum of 10 particles (0.1 µm or larger) per cubic metre of air.
Continuous measurement	Measurement using an automated measuring system permanently installed on site.
Diffuse emissions	Non-channelled emissions to air. Diffuse emissions include both fugitive and non-fugitive emissions. Fugitive emissions are ~~non-channelled emissions to air~~ caused by loss of tightness of equipment which is designed or assembled to be tight. Non-fugitive emissions may arise from, for example, atmospheric vents, bulk storage~~,~~ or loading/unloading systems~~for example~~.
Direct discharge	Discharge to a receiving water body without further downstream waste water treatment.
E-coating	Coating process where paint particles dispersed in a water-based solution are deposited on immersed substrates under the influence of an electric field (electrophoretic deposition).
Existing plant	A plant that is not a new plant.
Fossil-free energy	Energy (e.g. heat, electricity) generated from fossil-free energy sources, including renewable energy as defined in Directive (EU) 2018/2001, as amended by Directive (EU) 2023/2413 ([1]).
Hazardous waste	Hazardous waste as defined in point 2 of Article 3 of Directive 2008/98/EC of the European Parliament and of the Council ([2]).
Hazardous substances	Hazardous substances as defined in point 18 of Article 3 of Directive 2010/75/EU ~~as amended by Directive (EU) 2024/1785~~.
~~Indirect discharge~~	~~A discharge that is not a direct discharge (e.g. a discharge of waste water to a sewer with or without pretreament).~~
Major plant upgrade	A major change in the design or technology of a plant with major adjustments or replacements of the process and/or abatement technique(s) and associated equipment.
New plant	A plant first permitted at the site of the installation following the publication of these BAT conclusions or a complete replacement of a plant following the publication of these BAT conclusions.
Periodic measurement	Measurement at specified time intervals using manual or automated methods.
Plant	All parts of an installation that carry out the activities covered by the scope of these BAT conclusions and any other directly associated activities which have an effect on environmental performance (e.g. consumption) and/or emissions. Plants may be new plants or existing plants. Different process lines may be part of the same plant.

Point-of-use abatement	Point-of-use (POU) abatement systems are specialised environmental protection units installed directly at the source of emissions—typically individual manufacturing tools in semiconductor manufacturing installations—to destroy or neutralise toxic, flammable or hazardous gases before being combined with other off-gas streams or being released.
Process chemicals	Substances and/or mixtures as defined in Article 3 of Regulation EC/1907/2006 of the European Parliament and of the Council (3) and used in the process(es). Process chemicals may contain hazardous substances.
Technology node	A designated generation of a semiconductor manufacturing process, identified by a numeric value (expressed in nanometres), which defines the design rules and parameters for fabricating integrated circuits.
Residue	Substance or object generated by the activities covered by the scope of these BAT conclusions as waste or by-product.
Rinsing cycle	The rinsing of a workpiece leaving a treatment bath, which can involveone or a number of tanks or steps.
Surface run-off water	Water from precipitation that flows over land or impervious surfaces, such as paved streets, storage areas and rooftops, and does not soak into the ground.
Valid hourly (or half-hourly) average	An hourly (or half-hourly) average is considered valid when there is no maintenance or malfunction of the automated measuring system.

(1) Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652, OJ L, 2023/2413, 31.10.2023, ELI: http://data.europa.eu/eli/dir/2023/2413/oj

(2) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (OJ L 312, 22.11.2008, pp. 3–30), ELI: http://data.europa.eu/eli/dir/2008/98/oj ~~Directive 2008/98/EC on waste and repealing certain Directives~~.

(3) Regulation EC/1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ L 396, 30.12.2006, p. 1) ELI: http://data.europa.eu/eli/reg/2006/1907/oj.

Pollutants and parameters	
Term used	**Definition**
Ag	The sum of silver and its compounds, dissolved or bound to particles, expressed as Ag (in water).
Al	The sum of aluminium and its compounds, dissolved or bound to particles, expressed as Al (in water).
AOX	Adsorbable organically bound halogens, expressed as Cl, include adsorbable organically bound chlorine, bromine and iodine.
As	The sum of arsenic and its compounds, dissolved or bound to particles, expressed as As (in water).
B	The sum of boron and its compounds, dissolved or bound to particles, expressed as B (in water).
BOD_5	Biochemical oxygen demand. Amount of oxygen needed for the biochemical oxidation of organic and/or inorganic matter in 5 (BOD_5) days.
Cd	The sum of cadmium and its compounds, dissolved or bound to particles, expressed as Cd (in water).
~~CMR~~	~~Carcinogenic, mutagenic, toxic for reproduction. This includes CMR substances of categories 1A, 1B and 2, in accordance with Annex I to Regulation (EC) No 1272/2008[4] as amended (CLP).~~
CO	Carbon monoxide.
Co	The sum of cobalt and its compounds, dissolved or bound to particles, expressed as Co (in water).

[4] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (OJ L 353, 31.12.2008, p. 1) ELI: http://data.europa.eu/eli/reg/2008/1272/oj.

Pollutants and parameters	
Term used	**Definition**
COD	Chemical oxygen demand. Amount of oxygen needed for the total chemical oxidation of the organic matter to carbon dioxide using dichromate. COD is an indicator for the mass concentration of organic compounds.
Cr	The sum of chromium and its compounds, dissolved or bound to particles, expressed as Cr (in water). The sum of chromium and its compounds, expressed as Cr (in air).
Cr(VI)	The sum of chromium(VI) and its compounds, dissolved or bound to particles, expressed as Cr(VI) (in water). The sum of chromium(VI) and its compounds, expressed as Cr(VI) (in air).
Cu	The sum of copper and its compounds, dissolved or bound to particles, expressed as Cu (in water). The sum of copper and its compounds, expressed as Cu (in air).
Cyanide	Free cyanide, expressed as CN^-.
Dust	Total particulate matter (in air).
EDTA	Ethylenediaminetetraacetic acid.
Fe	The sum of iron and its compounds, dissolved or bound to particles, expressed as Fe (in water).
Fluorides	Dissolved fluoride, expressed as F.
~~HCl~~Gaseous chlorides	All inorganic gaseous chlori~~n~~de compounds, expressed as HCl.
~~HF~~Gaseous fluorides	All inorganic gaseous fluorid~~n~~e compounds, expressed as HF.
GHG	Greenhouse gas.
HCN	Hydrogen cyanide.
~~Hg~~	~~The sum of mercury and its compounds, dissolved or bound to particles, expressed as Hg.~~
HOI	Hydrocarbon oil index. The sum of compounds extractable with a hydrocarbon solvent (including long-chain or branched aliphatic, alicyclic, aromatic or alkyl-substituted aromatic hydrocarbons).
NH_3	Ammonia.
Ni	The sum of nickel and its compounds, dissolved or bound to particles, expressed as Ni (in water). The sum of nickel and its compounds, expressed as Ni (in air).
NO_X	The sum of nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as NO_2.
Pb	The sum of lead and its compounds, dissolved or bound to particles, expressed as Pb (in water). The sum of lead and its compounds, expressed as Pb (in air).
PFAS	Per- and polyfluoroalkyl substances. Sum of PFAS: For the purposes of this document, this includes only the following substances: PFBA, PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFBS, PFPS, PFHxS, PFHpS, PFOS, PFNS, PFDS, PFUnDS, PFTrS, 6:2 FTS, F53B, PFPeA, PFPeS, PFTeDA, PFHxDA, PFODA, HFPO-DA, ADONA, PFHpS, 6:2 FTOH, 8:2 FTOH, C6O4 and PTFE. Short-chain PFAS: Any per- and polyfluoroalkyl substances with 1 to 5 carbon atoms. Long-chain PFAS: Any per- and polyfluoroalkyl substances with 6 or more carbon atoms.
Phenol index	The sum of phenolic compounds, expressed as phenol concentration and measured according to EN ISO 14402.
Sb	The sum of antimony and its compounds, dissolved or bound to particles, expressed as Sb (in water).
Se	The sum of selenium and its compounds, dissolved or bound to particles, expressed as Se (in water).
Sn	The sum of tin and its compounds, dissolved or bound to particles, expressed as Sn (in water).
SO_X	The sum of sulphur dioxide (SO_2), sulphur trioxide (SO_3), and sulphuric acid aerosols, expressed as SO_2.

Pollutants and parameters	
Term used	**Definition**
Sulphides, easily released	The sum of dissolved sulphides and of those undissolved sulphides that are easily released upon acidification, expressed as S^{2-}.
TOC	Total organic carbon, expressed as C (in water), includes all organic compounds.
Total nitrogen	Total nitrogen, expressed as N, includes free ammonia and ammonium nitrogen (NH_4-N), nitrite nitrogen (NO_2-N), nitrate nitrogen (NO_3-N) and organically bound nitrogen.
Total phosphorus	Total phosphorus, expressed as P, includes all inorganic and organic phosphorus compounds, dissolved or bound to particles.
TSS	Total suspended solids. Mass concentration of all suspended solids (in water), measured via filtration through glass fibre filters and gravimetry.
TVOC	Total volatile organic carbon, expressed as C (in air).
VOC	Volatile organic compound as defined in Article 3(45) of Directive 2010/75/EU ~~as amended by Directive (EU) 2024/1785~~.
Zn	The sum of zinc and its compounds, dissolved or bound to particles, expressed as Zn (in water). The sum of zinc and its compounds, expressed as Zn (in air).

Acronyms

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

Acronym	**Definition**
CMS	Chemicals management system.
CVD	Chemical vapour deposition.
EMS	Environmental management system.
ET	Emerging technique(s). ~~as defined in Article 3(14) of Directive 2010/75/EU.as amended by Directive (EU) 2024/1785.~~
HEPA	High-efficiency particle air.
IED	Industrial Emissions Directive (2010/75/EU) ~~as amended by Directive (EU) 2024/1785~~.
OTNOC	Other than normal operating conditions.
PCB	Printed circuit board.
PFC	Perfluorocarbon.
PVD	Physical vapour deposition.
ULPA	Ultra-low penetration air.

General considerations

Best Available Techniques and Emerging Techniques

The best available techniques (BAT) and emerging techniques (ET) listed and described in these BAT conclusions are neither prescriptive nor exhaustive. Other techniques may be used that ensure at least an equivalent level of environmental protection including human health and climate protection.

Unless otherwise stated, the BAT conclusions are generally applicable.

[NOTE: Whilst cross-references are provided to other parts of this document in order to aid the work of the TWG, they will not be included in the final BAT conclusions themselves. Such cross-references are consequently displayed in italics in square brackets.]

[NOTE: In order to avoid repetition, this section contains general considerations that are essential to the understanding of the BAT conclusions taken as a stand-alone document, such as:
- *reference conditions for emissions to air (e.g. dry gas, standard temperature/pressure);*
- *averaging periods;*
- *sampling times;*
- *conversions to reference conditions;*
- *units in which environmental performance levels are expressed.]*

Emission levels associated with the best available techniques (BAT-AELs)

Emission levels associated with the best available techniques (BAT-AELs) for emissions to air

The BAT-AELs for emissions to air given in these BAT conclusions refer to concentrations (mass of emitted substances per volume of waste gas) under the following standard conditions: dry gas at a temperature of 273.15 K and a pressure of 101.3 kPa, without correction to a reference oxygen level, and expressed in the unit mg/Nm^3.

For averaging periods of BAT-AELs for channelled emissions to air, the following definitions apply:~~.~~

Type of measurement	Averaging period	Definition
Continuous	Daily average	Average over a period of ~~1~~ one day based on valid hourly or half-hourly averages.
Periodic	Average over the sampling period	Average value of three consecutive samplings/measurements of at least 30 minutes each (1).
(1) For any parameter where, due to sampling or analytical limitations and/or due to operational conditions (e.g. batch processes), a 30-minute sampling/measurement and/or an average of three consecutive samplings/measurements is inappropriate, a more representative sampling/measurement procedure may be employed.		

When the waste gases of two or more sources are discharged through a common stack, the BAT-AELs apply to the combined discharge from the stack.

Emission levels associated with the best available techniques (BAT-AELs) for emissions to water

The BAT-AELs for emissions to water given in these BAT conclusions refer to concentrations (mass of emitted substances per volume of water), expressed in mg/l or µg/l.

The BAT-AELs for emissions to water refer to either of the following averaging periods:

Type of discharge	Averaging period	Definition
Continuous	Daily average	24-hour flow-proportional composite samples.
Batch	Average over the release duration	Average value over the release duration taken as a flow-proportional composite sample or, provided that the effluent is appropriately mixed and homogeneous, a spot sample taken before discharge.

Time-proportional composite samples can be used provided that sufficient flow stability is demonstrated. Alternatively, spot samples may be taken, provided that the effluent is appropriately mixed and homogeneous.

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

Environmental performance levels associated with the best available techniques (BAT-AEPLs) and benchmarks

BAT-AEPLs ~~and benchmarks~~ for specific net energy consumption

The BAT-AEPLs ~~and benchmarks~~ for specific net energy consumption refer to yearly averages calculated using the following equation:

$$\text{specific net energy consumption} = \frac{\text{energy consumption rate}}{\text{activity rate}}$$

where:

energy consumption rate: total amount of heat (excluding electric heating~~generated from primary energy sources~~) and electricity consumed by the relevant process(es) expressed in kWh/year; and

activity rate: either:

- ~~total amount of workpieces treated expressed in t/year, or~~
- total ~~surface of~~ treated surface expressed in m^2/year, or
- total amount of coil coated expressed in t/year, or
- total surface of treated layer expressed in m^2/year, or
- total surface of wafer processed expressed in m^2/year,

depending on the sector.

BAT-AEPLs and benchmarks for specific net water consumption

The BAT-AEPLs and benchmarks for specific net water consumption refer to yearly averages calculated using the following equation:

$$\text{specific net water consumption} = \frac{\text{water consumption rate}}{\text{activity rate}}$$

where:

water consumption rate: total amount of water consumed by the plant or by a given process within it, excluding:

- recycled and reused water, and
- cooling water used in once-through cooling systems, and
- water for domestic usage,

expressed in m^3/year;

and

activity rate: either:

- ~~total amount of workpieces treated expressed in t/year, or~~
- total ~~surface of~~ treated surface expressed in m^2/year, or
- total amount of coil coated expressed in t/year, or
- total surface of treated layer expressed in m^2/year, or
- total surface of wafer processed expressed in m^2/year,

depending on the sector.

~~Environmental management system (EMS)~~

~~The minimum requirements of the EMS are listed in Article 14a (2) of Directive 2010/75/EU as amended by Directive (EU) 2024/1785. In order to complement Article 14a (2) of the Directive, the additional elements of the EMS are given in Section of these BAT conclusions.~~

[This section appears in strikethrough as the whole of Section 5.4 is in strikethrough]

5.1 General BAT conclusions

5.1.1 Overall environmental performance

[The following BAT was moved and updated from Section 5.4.1]

[EMS proposal based on IED 2.0. The outcome of the Environment Omnibus to be considered at a later stage]

BAT 0.a In order to improve the overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS) that incorporates all of the following features:

i. Commitment, leadership, and accountability of the management, including senior management, for the implementation of an effective EMS.
ii. An analysis that includes the determination of the organisation's context, the identification of the needs and expectations of interested parties, the identification of characteristics of the installation that are associated with possible risks for the environment and human health as well as of the applicable legal requirements relating to the environment and human health.
iii. Determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed.
iv. Ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g. by providing information and training).
v. Internal and external communication on the environmental performance of the installation.
vi. Fostering employee involvement in good environmental management practices.
vii. Establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records.
viii. Effective operational planning and process control.
ix. Implementation of appropriate maintenance programmes.
x. Emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations.
xi. When (re)designing a (new) installation or a part thereof, consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning.
xii. Implementation of a monitoring and measurement programme; if necessary, information can be found in the Reference Report on Monitoring of Emissions to Air and Water from IED Installations.
xiii. Application of sectoral benchmarking on a regular basis.
xiv. Following and taking into account the development of cleaner techniques.

Specifically for the surface treatment of metals and plastics, the following features are covered in the EMS:

xv. an inventory of inputs and outputs (see BAT 0.b);
xvi. a chemicals management system (see BAT 0.c);
xvii. an OTNOC management plan (see BAT 0.d);
xviii. a plan for the prevention and control of leaks and spillages (see BAT 0.e);
xix. an energy efficiency plan (see BAT 6.bis);
xx. a water management plan (see BAT 8.0);
xxi. a residues management plan (see BAT 10 ter);
xxii. a noise management plan (see BAT 16 bis);
xxiii. an odour management plan (see BAT 15 bis).

A benchmark for the surface treatment of metals and plastics is included in **Table 5-12**.

Applicability
The level of detail and the degree of formalisation of the EMS will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have. The EMS may be integrated in the overall EMS of a larger installation (e.g. for iron and steel production).

[The following BAT was moved and updated from Section 5.4.2]

BAT 0.b In order to improve the overall environmental performance supporting the preparation and implementation of the EMS, BAT is to set up, implement and regularly review (including when a significant change occurs) an inventory of inputs and outputs. The inventory of inputs and outputs incorporates at least the following features:

i.(i) information about the production processes, including:
- (a) simplified process flow sheets that show the origin of the emissions to air, water and soil and the associated emission point(s);
- (b) descriptions of process-integrated techniques and waste water/waste gas treatment techniques to prevent or reduce emissions, including their performance (e.g. abatement efficiency);

(ii) information about the quantity and characteristics of raw materials and fuels used;
(iii) information about water consumption and usage (e.g. flow diagrams and water mass balances);
(iv) information about energy consumption and usage;
(v) information about the characteristics of the waste water streams, such as:
- (a) average values and variability of flow, pH, temperature and conductivity;
- (b) average concentration and mass flow values of relevant substances/parameters (e.g. total suspended solids, TOC or COD, hydrocarbon oil index, metals) and their variability;
- (c) presence of substances fulfilling the criteria referred to in Article 57 of Regulation (EC) No 1907/2006; the presence of such substances may for example be assessed according to the criteria of Regulation (EC) No 1272/2008 (CLP);

(vi) information about the quantity and characteristics of the process chemicals used (e.g. PFAS), such as:
- (a) the identity and the characteristics of process chemicals, including properties with adverse effects on the environment and/or human health;
- (b) the quantities of process chemicals used and the location of their use;

(vii) information about the characteristics of the waste gas streams, such as:
- (a) average values and variability of flow and temperature;
- (b) average concentration and mass flow values of relevant substances (e.g. dust, alkaline/acidic emissions, NO_X, SO_X, metals) and their variability;
- (c) presence of other substances that may affect the waste gas treatment system (e.g. oxygen, nitrogen, water vapour) or installation safety;
- ~~(d) information about the quantity and origin of greenhouse gas (GHG) emissions;~~
- (e) presence of substances classified as fulfilling the criteria referred to in Article 57 of Regulation (EC) No 1907/2006; the presence of such substances may for example be assessed according to the criteria of Regulation (EC) No 1272/2008 (CLP);

(viii) information about the quantity and characteristics of residues generated.

Applicability
The level of detail and the degree of formalisation of the inventory will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

[The following BAT was moved and updated from Section 5.4.3]

BAT 0.c. In order to improve the overall environmental performance supporting the preparation and implementation of the EMS, BAT is to set up, implement and regularly review a chemicals management system (CMS). The CMS incorporates at least the following features:

i. A policy to reduce the consumption of and the environmental and health risks associated with process chemicals, including a procurement policy to select less harmful process chemicals in collaboration with suppliers with the aim of minimising the use of and risks associated with hazardous substances. Special regard is given to the substances fulfilling the criteria for substances of very high concern (in Article 57 of Regulation (EC) No 1907/2006 and substances addressed in restrictions referred to in its Annex XVII) as well as to avoid the use of an excess amount of hazardous process chemicals. The level of detail of the evaluation and characterisation of chemicals is related to the level of hazardousness of the chemicals, as well as their persistence in the environment. The selection of process chemicals is based on the following:
   a) The analysis of environmentally relevant substance characteristics such as bioeliminability/biodegradability, ability to bioaccumulate, mobility, human and eco-toxicity in order to identify hazardous process chemicals which may have the potential to be released into the environment. The analysis could be based on available information, e.g. on safety data sheets.
   b) The characterisation of the risks associated with the process chemicals, based on the chemicals' hazard classification, pathways through the plant, potential release and related level of exposure;
   c) The potential for recovery and reuse (see BAT 10).
   d) The regular (e.g. annual) analysis of the potential for substitution with the aim to identify potentially new available and safer alternatives to the use of hazardous substances; this may be achieved by changing process(es) or using other process chemicals with no or lower impacts on the environment and/or human health (see BAT 10).
   e) The anticipatory monitoring of regulatory changes related to relevant hazardous substances, and the safeguarding of compliance with applicable legal requirements.

The inventory of process chemicals (see BAT 0.b xv) may be used to provide and keep the information needed for the selection of process chemicals.

ii. Goals and action plans to avoid or reduce the use of and risks associated with hazardous substances.

iii. Development and implementation of procedures for the procurement, handling, storage and use of process chemicals, disposal of waste containing process chemicals and return of unused process chemicals, to prevent or reduce emissions to the environment (e.g. BAT 10).

Applicability

The level of detail and the degree of formalisation of the CMS will generally be related to the nature, scale and complexity of the installation. Where elements included in the CMS have already been developed in accordance with other relevant Union legislation, these can be used for the purpose of this BAT.

[The following BAT was moved and updated from Section 5.4.4]

BAT 0.d. In order to improve the overall environmental performance supporting the preparation and implementation of the EMS, BAT is to set up, implement and regularly review a risk-based OTNOC management plan. The risk-based OTNOC management plan includes at least the following features:

i. identification of potential OTNOC (e.g. failure of equipment critical to the protection of the environment ('critical equipment')), of their root causes and of their potential consequences;
ii. appropriate design of critical equipment (e.g. off-gas treatment, waste water treatment);
iii. set-up and implementation of an inspection plan and preventive maintenance programme for critical equipment (see BAT 0.a ix);
iv. monitoring (i.e. estimating or, where possible, measuring) and recording of emissions during OTNOC and of associated circumstances;
v. periodic assessment of the emissions occurring during OTNOC (e.g. frequency of events, duration, amount of pollutants emitted) and implementation of corrective actions if necessary;
vi. regular review and update of the list of identified OTNOC under point i following the periodic assessment of point v.;
vii. implementation of backup systems (where appropriate) and regular testing of them.

Applicability
The level of detail and the degree of formalisation of the OTNOC management plan will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

[The following BAT was moved and updated from Section 5.4.5]

BAT 0.e In order to improve the overall environmental performance supporting the preparation and implementation of the EMS, BAT is to set up, implement and regularly review a plan for the prevention and control of leaks and spillages. The plan for prevention and control of leaks and spillages includes at least the following features:

– site incident plans for small and large spillages;
– identification of the roles and responsibilities of persons involved;
– ensuring staff are environmentally aware and trained to prevent and deal with spillage incidents;
– identification of areas at risk of spillage and/or leaks of hazardous materials and substances, and ranking them according to the risk;
– identification of suitable spillage containment and clean-up equipment and regularly ensuring it is available, in good working order and close to points where these incidents may occur;
– waste management guidelines for dealing with waste arising from spillage control;
– regular inspections (at least on a monthly basis) of storage and handling areas, testing and calibration (at least on an annual basis) of leak detection equipment and prompt repair of leaks from valves, glands, flanges, etc.

5.1.1.1 Emissions to soil and groundwater

BAT 1. In order to prevent or reduce emissions to soil and groundwater, BAT is to use all of the techniques given below.

	Technique	Description	Applicability
a.	Structuring and management of process areas and raw material storage areas	This includes techniques such as: • impermeable (e.g. cemented) floors for process and storage areas; • containment bunds for storage tanks; • double-walled storage tanks; • automated detection of possible leakages/spillages in retentions; • separate storage for various types of raw materials, close to the process lines; this can be achieved using, for example, compartments or boxes in the storage areas, bunkers.	Generally applicable.
b.	Prevention of contamination of surface run-off water	Process areas and/or areas where process chemicals, fuels, residues or waste are stored or handled are protected against surface run-off water. This is achieved by using at least the following techniques: • drainage channels and/or an outer kerb bund around the plant; • roofing with roof guttering of process and/or storage areas.	
c.	Collection of potentially contaminated surface run-off water	Surface run-off water from areas that are potentially contaminated is collected separately and only discharged after appropriate measures are taken, e.g. monitoring, treatment, reuse.	
d.	Safe handling and storage of process chemicals and other input materials	This includes techniques such as: ~~the following:~~ • Storage of chemicals in roofed and well-ventilated areas with floors impermeable to the chemicals concerned and sufficient retention volume to retain the maximum volume of liquid chemicals that can accumulate in the storage or production area. • Use of oil-tight trays or cellars for hydraulic stations and oil- or grease-lubricated equipment. • Immediate collection of spilled liquids. Materials used for spill cleaning that are contaminated with hazardous substances are handled as hazardous waste. • The production hall and ~~L~~loading/unloading areas, e.g. for fuels, process chemicals, lubricants, coatings, are designed and constructed in such a way that potential leaks and spillages are contained and either reused or sent to on-site treatment (see BAT 20) or off-site treatment. Facilities for loading/unloading of substances fulfilling the criteria referred to in Article 57 of Regulation (EC) No 1907/2006 are equipped with vapour recovery systems. • Acids are stored separately from alkalis and cyanides (to avoid generation of free cyanide). • Flammable chemicals are stored separately from oxidising agents. • Chemicals that are spontaneously combustible when damp are stored in dry conditions. The loading and unloading areas, as well as process and storage areas for these chemicals, are marked appropriately to avoid the use of water in fire-fighting.	

Technique		Description	Applicability
		• Organic peroxides are stored separately from other materials such as acids, alkalis, amines, accelerators, combustible materials, metals, and reducing agents. • Contaminated process or rinsing water is transported via pipeline or in closed containers from the production area to the water treatment plant.	
e.	Good housekeeping	A set of measures to prevent or reduce the generation of emissions (e.g. regular maintenance and cleaning of equipment, work surfaces, floors and transport routes, containment and rapid clean-up of any spillages).	

*[This BAT conclusion is based on information given in BREF Section **Error! Reference source not found.**]*

5.1.1.2 Retention and handling of spent fire extinguishing material

BAT 2. In order to reduce emissions to soil and groundwater and to minimise the concentration of pollutants in waste water flows as well as the generation of hazardous waste, BAT is to collect and separately store spent fire extinguishing water and/or foam prior to its appropriate handling.

Description

Equipment and procedures are in place for the separate collection of contaminated firefighting water and/or foam, its storage in watertight storage basins indoors or outdoors, and its appropriate handling (treatment or disposal). For example, in electrolytic and chemical plating, automatic firefighting water bulkheads are installed for sealing of process or storage areas. ~~and t~~ The capacity of the retention system is based on the volume of all liquids potentially released in case of fire (e.g. from production, storage and waste water treatment areas in addition to ~~treatment vats, and~~ the estimated volume of firefighting water and/or foam).

*[This BAT conclusion is based on information given in BREF Section **Error! Reference source not found.**]*

5.1.1.3 Reduction of reworking

BAT 3. In order to reduce the consumption of raw materials, energy and water as well as to reduce the generation of residues, BAT is to define precise process specifications and implement ~~rigorous~~ comprehensive process control.

Description

The right process specifications are defined and followed (e.g. according to quality and environmental management systems), to ensure that the production quality is as stable as possible. This is complemented by appropriate process control to achieve optimal production quality and avoid reworking.

5.1.2 Monitoring

5.1.2.1 Monitoring of environmental performance

BAT 4. BAT is to monitor the following parameters with a minimum monitoring frequency of once every year and expressed as yearly averages.

<table>
<tr><th rowspan="2">Parameter</th><th colspan="7">Sector</th><th></th></tr>
<tr><th>Electrolytic & chemical plating / All processes</th><th>Steel coil continuous coating</th><th>Aluminium ~~coil, sheet~~ conversion coating and anodising</th><th>Sheet processing for aluminium lithographic plates</th><th>Porcelain (vitreous) enamelling of metals</th><th>PCB manufacturing</th><th>Semiconductor manufacturing</th><th>Monitoring associated with</th></tr>
<tr><td>Water consumption</td><td>m^3/m^2 of ~~workpieces~~ treated surface</td><td rowspan="2">m^3/t of coil coated</td><td colspan="3" rowspan="2">m^3/m^2 of treated surface</td><td rowspan="2">m^3/m^2 of treated layer ~~final product~~</td><td rowspan="2">m^3/m^2 of wafer processed ~~surface~~</td><td rowspan="2">BAT 8
BAT 24
BAT 35</td></tr>
<tr><td>~~Waste water discharge~~</td><td>~~m^3/m^2 of workpieces treated per rinsing cycle~~</td></tr>
<tr><td>Energy consumption</td><td>kWh/m^2 of ~~workpieces~~ treated surface</td><td>kWh/t of coil coated</td><td colspan="3">kWh/m^2 of treated surface</td><td>kWh/m^2 of treated layer ~~final product~~</td><td>kWh/m^2 of wafer processed ~~surface~~</td><td>BAT 7
BAT 28
BAT 33
BAT 37</td></tr>
<tr><td>Process chemicals consumption</td><td rowspan="2">kg/m^2 of ~~workpieces~~ treated surface</td><td rowspan="2">kg/t of coil coated</td><td colspan="3" rowspan="2">kg/m^2 of treated surface</td><td rowspan="2">kg/m^2 of treated layer ~~final product~~</td><td rowspan="2">kg/m^2 of wafer processed ~~surface~~</td><td>BAT 9</td></tr>
<tr><td>~~Materials recovered, recycled and/or reused~~</td><td>~~BAT 9~~</td></tr>
<tr><td>Waste sent for ~~to~~ disposal</td><td>g/m^2 of ~~workpieces~~ treated surface</td><td>g/t of coil coated</td><td colspan="3">g/m^2 of treated surface</td><td>g/m^2 of treated layer ~~final product~~</td><td>g/m^2 of wafer processed ~~surface~~</td><td rowspan="2">BAT 11</td></tr>
<tr><td>~~Residues generated~~</td><td>~~kg/m^2 of workpieces treated~~</td><td>~~kg/t of coil coated~~</td><td colspan="3">~~Kg/m^2 of treated surface~~</td><td>~~kg/m^2 of final product~~</td><td>~~kg/m^2 of wafer surface~~</td></tr>
<tr><td>~~CO_2 equivalent emissions generated~~</td><td>~~$t\ CO_{2eq}/m^2$ of workpieces treated surface~~</td><td>~~$t\ CO_{2eq}/t$ of coil coated~~</td><td colspan="3">~~$t\ CO_{2eq}/m^2$ of treated surface~~</td><td>~~$t\ CO_{2eq}/m^2$ of final product~~</td><td>~~$t\ CO_{2eq}/m^2$ of wafer surface~~</td><td>~~BAT 7~~</td></tr>
</table>

Description

Monitoring preferentially includes direct measurements. Calculations or recording, e.g. using suitable meters or invoices, can also be used. The monitoring is broken down to the most appropriate level (e.g. to process or plant level) and considers any significant changes in the process or plant. In the event that the surface treatment activity is carried out within a larger installation (e.g. iron and steel production), monitoring may be integrated into the monitoring plan of the larger installation.

5.1.2.2 Monitoring of emissions to air

BAT 5. BAT is to monitor channelled emissions to air 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.

Sectors:
- **(A) Electrolytic or chemical plating**
- **(B) Aluminium ~~coil / sheet~~ conversion coating/anodising**
- **(C) Continuous steel coil coating**
- **(D) Porcelain (vitreous) enamelling**
- **(E) PCB manufacturing**
- **(F) Semiconductor manufacturing**

Substance/ Parameter		**Sector**	**EN Standard(s)**	**Minimum monitoring frequency** (1)	**Monitoring associated with**
NH_3 (2)		(A), (E), (F)	EN ISO 21877	Once every year	BAT 22 ~~BAT 35~~ BAT 34 BAT 40
~~Acidic emissions (2)~~		~~(A), (B)~~	~~Various EN standards~~		-
~~Alkaline emissions (2)~~		~~(A), (B), (C)~~	~~Various EN standards~~		-
Dust (2)		(A), (B), (C), (F)	EN 13284-1		BAT 22 BAT 26 BAT 29
Gaseous chlorides, expressed as HCl (2)		(A), (C), (E), (F)	EN 1911		BAT 22 BAT 26 ~~BAT 35~~ BAT 34
Gaseous fluorides, expressed as HF (2)		(A), (B), (F)	~~ISO 15713/2006~~ ~~EN/TS 17340~~ No EN standards available		BAT 22 BAT 29 BAT 39
HCN (2)		(A)	No EN standards available		BAT 22
Metals	Cr (2)	(A), (B), (C)	EN 14385		BAT 22 BAT 26 BAT 29
	Cr_(VI) (2)	(A), (B), (C)		~~Once every 6 months~~ Once every year	BAT 22 BAT 26 BAT 29
	Cu (2)	(A)		Once every year	BAT 22
	Ni (2)	(A), (B), (C)			BAT 22 BAT 26 BAT 29
	Zn (2)	(A), (C)			BAT 22 BAT 26
NO_X		(A), (F)	EN 14792		BAT 23 BAT 40
SOx (2)		(A)	EN 14791		BAT 22
TVOC (2)		(A), (B)	EN 12619 ~~EN ISO 13199~~		BAT 22 BAT 29
TVOC		(E), (F)			BAT 34

(1) To the extent possible, the measurements are carried out at the highest expected emission state under normal operating conditions.
(2) The monitoring only applies when the substance/parameter concerned is identified as relevant in the waste gas stream based on the inventory of inputs and outputs mentioned in BAT 0.b ~~Section~~

[This BAT conclusion is based on information given in BREF Section ***Error! Reference source not found.****]*

5.1.2.3 Monitoring of emissions to water

BAT 6. BAT is to monitor emissions to water with at least the frequency given below, and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Sectors:
- **(A) Electrolytic or chemical plating**
- **(B) Aluminium ~~coil/sheet~~ conversion coating/anodising**
- **(C) Continuous steel coil coating**
- **(D) Porcelain (vitreous) enamelling**
- **(E) PCB manufacturing**
- **(F) Semiconductor manufacturing**
- **(G) Sheet processing for aluminium lithographic plates**

	Substance/ Parameter	Sector	Standard(s)	Minimum monitoring frequency (1) (2)	Monitoring associated with
	~~BOD_5~~	~~(F)~~	~~EN 1899-2~~ ~~EN ISO 5815~~	Once every 3 months	BAT 20
	COD (3)	(A), (B), (C), (D), (E), (F), (G)	No EN standard available		
	TOC (3)		EN 1484, EN ISO 9562		
	TSS		EN 872		
	Chlorides (4)		EN ISO 15682		
	Fluorides (4)		EN ISO 10304-1		
	AOX (4)		EN ISO 9562		
	Cyanides (free) (4)	(A)~~, (B), (E), (F)~~	EN ISO ~~10304~~14403-1 EN ISO ~~10304~~14403-2		
	HOI (4)	(A), (B), ~~(C),~~ (D)~~, (E)~~	EN ISO 9377-2		
Metals and metalloids	Ag (4)	(A), (E), (F)	Various EN standards available (e.g. EN ISO 11885, EN ISO 17294-2, EN ISO 17852)		
	Al (4)	(A), (B), (F)			
	As (4)	(A), ~~(B),~~ (E), (F)			
	B (4)	(A)~~ (F)~~			
	Cd (4)	(A)~~, (B), (C), (E), (F)~~			
	Co (4)	(A), (B), (C), (E), (F)			
	Cu (4)	(A), ~~(B), (C),~~ (E), (F)			
	Cr (4)	(A), (B), (C)			
	Cr(VI) (4)	(A), (B), (C)~~, (D), (E), (F), (G)~~			
	Fe (4)	(A), (C), (E), (F)			
	~~Hg (4)~~	~~(A), (B), (C), (F)~~			
	Pb (4)	(A), ~~(C),~~ (E), (F)			
	Ni (4)	(A), (B), (C), (D), (E), (F)			

	Se (4)	(A)~~, (B), (C), (E), (F)~~			
	Sn (4)	(A), (B), (C), ~~(D),~~ (E), (F), ~~(G)~~			
	Zn (4)	(A), (B), (C), (E), (F)			
Total phosphorus (4)		(A), (B), (C), (E), (F)	EN ISO 11885 EN ISA 6878		
Sum of PFAS (4)		(A), (B), (C) (E), (F)~~, (D), (G)~~	~~No EN standard available~~ EN 17892:2024 Part A		
~~PFAS~~		~~(E), (F)~~			
~~Surfactants (4)~~		~~(A), (B), (C), (D), (E), (F), (G)~~	~~Various EN standards available (e.g. EN ISO 18857-1 and EN ISO 18857-2 for alkylphenol, EN 903 for anionic surfactants)~~		
Total nitrogen (4)		(A), (B), (C), (D), (E), (F), (G)	~~EN 12260 EN ISO 11905-1~~ Various EN standards available (e.g. EN ISO 20236, EN ISO 11905-1)		
~~Toxicity (4)~~		~~(A), (B), (C), (D), (E), (F), (G)~~	~~Various EN standards available (e.g. EN ISO 15088, EN ISO 6341, EN ISO 11348-1, EN ISO 11348-2, EN ISO 11348-3, EN ISO 20079, EN ISO 20227, EN ISO 8692, EN ISO 10253, and EN ISO 10710)~~	~~To be decided based on a risk assessment, after effluent characterisation~~	
Sulphides~~,~~ easily released (S^{2-}) (4)		(A), (B), (C), (D), (E), (F), (G)	No EN standard available	Once every 3 months	

(1) In the case of batch discharge less frequent than the minimum monitoring frequency, monitoring is carried out once per batch.
(2) The minimum monitoring frequency may be reduced to once every year if the emission levels are proven to be sufficiently stable.
(3) Either COD or TOC is monitored. TOC monitoring is the preferred option because it does not rely on the use of very toxic substances ~~compounds~~.
(4) The monitoring only applies when the substance/parameter is identified as relevant in the waste water stream based on the inventory of inputs and outputs mentioned in BAT 0.b ~~Section~~.

[This BAT conclusion is based on information given in BREF Section ***Error! Reference source not found.****]*

5.1.3 Energy efficiency

[The following BAT was moved and updated from Section 5.4.6]

BAT 6.bis In order to optimise energy use and to improve the overall environmental performance, supporting the preparation and implementation of the EMS, BAT is to set up and implement an energy efficiency plan, energy audits and energy balance record.

Description
The energy efficiency plan entails defining and monitoring the specific net energy consumption of the plant/process (e.g. kWh/m^2 of treated surface), setting objectives in terms of energy efficiency and implementing actions to achieve these objectives. The energy efficiency plan may be integrated in the overall energy efficiency plan of a larger installation (e.g. installation carrying out activities covered by the ferrous metals processing BAT conclusions).

Audits are carried out at least once every year to ensure that the objectives of the energy efficiency plan are met and the audit recommendations are followed up and implemented.

An energy balance record is drawn up once every year which provides a breakdown of the energy consumption and generation (including energy export) by type of energy source, for example:

- energy consumption: electricity, natural gas, renewable energy, imported heat and/or cooling;
- energy generation: electricity and/or steam.

This includes:

- definition of the energy boundaries of the process(es);
- information on energy consumption in terms of delivered energy;
- information on energy exported from the plant;
- energy flow information (e.g. Sankey diagrams or energy balances) showing how the energy is used throughout the process(es).

Applicability
The BAT does not apply to installations concerned by Article 11 of Directive 2023/1791/EU ([5]). The level of detail of the energy efficiency plan, of the audits and of the energy balance record will generally be related to the nature, scale and complexity of the installation and the types of energy sources used.

BAT 7. In order to increase the overall energy efficiency ~~of the plant~~, BAT is to use all of the techniques given below.

[5] Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast) OJ L 231, 20.9.2023, pp. 1–111, ELI: http://data.europa.eu/eli/dir/2023/1791/oj

Technique		Description	Applicability
Equipment selection and process optimisation			
a.	Use of general energy-saving techniques	This includes techniques such as: • burner maintenance and control; • use of energy-efficient equipment (e.g. motors, lights); • use of optimised steam and compressed air distribution systems; • regular inspection and maintenance of the steam distribution systems and of equipment in the electrical supply system; • use of process control systems and optimisation of process solutions; • use of variable speed drives; • use of optimised air conditioning and building heating; • minimisation of heat losses, e.g. thermal insulation of heated process treatment vats, pipe insulation, use of double-walled or pre-insulated containers, temperature control of heating treatment vats; • reduction of heat losses from the surface of process treatment vats using floating spheres or lids for example.	Generally applicable.
b.	Optimised design and handling of voltage supply and current demands	Effective management of incoming supplies to ensure that they align with the production phases, minimising reactive energy losses during voltage reduction and efficiently meeting the current demand required in the process.	
c.	Process line optimisation	See Section 5.3.1.	
d.	Adjustment of electroplating current	Each workstation is equipped with its own current rectifier to regulate the electroplating current and adjust it to the process specifications.	
e.	Optimisation of process solution agitation, conductivity and composition	See Section 5.3.1.	
Heating and cooling techniques			
f.	Combined heat and power generation (cogeneration)	See Section 5.3.1.	Applicability may be restricted by the lack of a suitable heat demand~~,~~ or the low temperature of the excess heat. In existing plants, applicability may be restricted by lack of space.
g.	Heat recovery	See Section 5.3.1.	~~Generally applicable.~~ Applicability may be restricted by the lack of a suitable heat demand. In existing plants, applicability may be restricted by lack of space.
h.	Use of passive cooling systems	This includes techniques such as: • ambient cooling using outside air in cold weather conditions (e.g. below 7 °C); • cooling using the thermal capacity of ground water.	Applicability may be ~~limited due to~~ restricted by the prevailing climatic conditions or local site geography.

i.	Workspace temperature optimisation ~~(1)~~	Optimisation of workspace temperature, e.g. lower temperature during winter period and higher during summer period.	Applicability may be restricted by product specifications.
Techniques promoting industrial symbiosis			
j.	Use of excess heat in another plant or for district heating	This includes techniques such as: • use of excess heat generated by one plant at another plant that requires heat; • use of excess heat generated for space heating and hot water supply in nearby buildings.	Applicability may be restricted by the lack of a suitable heat demand or the low temperature of the excess heat.
~~(1) This technique also contributes to decarbonisation.~~			

Further sector-specific techniques to increase energy efficiency are given in Sections 5.2.1.3, 5.2.2.3, 5.2.6.3 and 5.2.7.3 of these BAT conclusions.

BAT-AEPLs for specific net energy consumption are given in **Table 5-3** (Section 5.2.1.3), **Table 5-7** (Section 5.2.2.3), **Table 5-10** (Section 5.2.3.3), **Table 5-13** (Section 5.2.6.3) and **Table 5-17** (Section 5.2.7.35.2.7.1).

[This BAT conclusion is based on information given in BREF Section ***Error! Reference source not found.****]*

5.1.4 Water consumption and waste water discharge

[The following BAT was moved and updated from Section 5.4.8]

BAT 7.bis. In order to improve the overall environmental performance supporting the preparation and implementation of the EMS, BAT is to set up, implement and regularly review a water management plan and audits.

Description
A water management plan is part of the EMS (see BAT 0.a) and includes:

- flow diagrams of processes and water mass balances of the plant as part of the inventory of inputs and outputs mentioned in BAT 0.b;
- establishment of water efficiency objectives;
- implementation of water optimisation techniques (e.g. control of water usage, reuse/recycling, detection and repair of leaks).

Audits (e.g. internal audits) are carried out at least once every year to ensure that the objectives of the water management plan are met and the audit recommendations are followed up and implemented.

Applicability
The level of detail and the degree of formalisation of the water management plan and audits will generally be related to the nature, scale and complexity of the installation.

BAT 8. In order to reduce water consumption and the amount of waste water generated as well as to improve water reuse and recyclability, BAT is to use all of the techniques given below.

	Technique	Description	Applicability
Equipment selection and process optimisation ~~techniques~~			
~~a.~~	~~Segregation of water streams~~	~~Water streams are collected separately (see BAT 23), based on the pollutant content and on the required treatment (see BAT 20). Waste water streams that can be recycled without treatment are segregated (e.g. cooling water) from waste water streams that require treatment.~~	Generally applicable.
b.	Use of general water-saving techniques	This includes techniques such as: • use of automatic valves to prevent leaks; • use of high-pressure water cleaning systems; • ~~recycling/reuse of spent process water;~~ • advanced process monitoring and control systems (see Section 5.3.2); • automatic systems for the preparation and dosing of process chemicals (see Section 5.3.3); • process line optimisation (see Section 5.3.1); • collection and use of rainwater in the processes.	
c.	Prevention of contamination of surface run-off water	See BAT 1.~~e~~b.	
d.	Structuring and management of process areas and raw material storage areas	See BAT 1.~~b~~a.	
e.	Water reuse and/or recycling	Water streams (e.g. process water, effluents from rinsing and wet scrubbing, cooling water) are reused and/or recycled in closed or semi-closed circuits, if necessary after treatment (see BAT 20). This may include: • recirculating rinsing water from etching and surface treatment to treatment vats (see Section 5.3.2); • reusing purified water from evaporation; • returning the rinse water from the first rinse to the process solution; • recycling of degreasing solutions for pH adjustment in rinsing; • using spent treatment solutions with high acidity or alkalinity for on-site physico-chemical waste water neutralisation; • using the etching solution from the main etching tank for pre-etching.	The degree of water reuse and/or recycling ~~is~~may be limited by the water balance of the plant, the content of impurities and/or the characteristics of the ~~waste~~ water streams.
f.	Drag-in reduction	See Section 5.3.2.	Generally applicable.
g.	Drag-out reduction		
h.	Rinsing optimisation	This includes techniques such as: • using multiple rinsing with rinsing water recirculation (see Section 5.3.2);	

		• using eco-rinse (pre-dip) (see Section 5.3.3); eco-rinse can be combined with other rinse stages to increase the effectiveness of the multiple rinsing system; • using spray rinsing; • using vacuum evaporation; • regenerating and reusing/recycling rinsing water.	
~~i.~~	~~Closing the loop~~ *[Technique moved in BAT 9]*	~~Closing the loop by applying at process/line level:~~ ~~• reduction of drag-out (see technique (h) above);~~ ~~• optimising rinsing (see technique (i) above);~~ ~~• concentrating the returning drag-out or receiving solutions (using, for example, ion exchange, membrane filtration, evaporation).~~	~~Applicability may be restricted by the chemical composition of the process water.~~
Techniques to promote industrial symbiosis			
j.	Exchange of waste water among plants	The technique involves the sharing between different plants of specific waste water streams of one plant that can be used for waste water treatment in another plant. ~~of specific waste water flows that are used in waste water treatment.~~. Care is taken to avoid any dilution from the combination of these waste water streams.	Generally applicable as long as the waste water sources and treatment facilities are compatible.

Further sector-specific techniques to reduce net water consumption ~~and waste water discharge~~ are given in Sections 5.2.2.1 and 5.2.7.1 of these BAT conclusions.

BAT-AEPLs for specific net water consumption are given in **Table 5-2** (Section 5.2.1.1), **Table 5-6** (Section 5.2.2.1), **Table 5-9** (Section 5.2.3.1), **Table 5-13** (Section 5.2.6.1) and **Table 5-16** (Section 5.2.7.1). A benchmark for specific net water consumption is given in **Table 5-12** (Section 5.2.5.1).

*[This BAT conclusion is based on information given in BREF Section **Error! Reference source not found.**]*

5.1.5 Material efficiency

BAT 9. In order to increase material efficiency, to reduce the consumption of raw materials including chemicals and to reduce the amount of waste generated, BAT is to use an appropriate combination of the techniques given below.

Technique		Description	Applicability
Techniques relevant to raw materials inputs and storage			
a.	Prevention of corrosion and degradation of metal workpieces/substrates	This includes techniques such as: • shortening of the storage time; • controlling the corrosivity of the atmosphere during storage and transport, e.g. by adjusting the humidity, temperature, composition and air ventilation; • using either an anticorrosive coating or anticorrosive packaging (e.g. use of oil and/or grease).	Use of anticorrosive coating or packaging may be restricted in the case of high-volume production.
b.	Timely use of process chemicals	Criteria associated for example with shortening the storage time of process chemicals are clearly established, and storage time is ~~parameters are~~ monitored ~~to avoid process chemicals perishing~~.	Generally applicable.
c.	Optimised packaging of chemicals	Process chemicals packaging is selected to facilitate its complete emptying, where technically feasible (e.g. considering the size of the packaging aperture or the nature of the packaging material).	
d.	Return of unused process chemicals	Unused process chemicals (i.e. which remain in their original containers) are returned to their suppliers.	~~Generally applicable.~~ Applicability may be restricted by the capacity of the supplier to take back unused chemicals.
Equipment selection and process optimisation techniques			
e.	Minimisation of the use of chemicals, especially those containing hazardous substances	This includes techniques such as: • the use of alternatives to chemical cleaning treatment, e.g. ultrasonic cleaning or mechanical pre-cleaning by centrifuging; • the substitution of chemicals containing hazardous substances (see BAT 10); • the use of solutions with a lower concentration of hazardous substances, e.g. chromium in passivation.	Applicability may be restricted by product specifications.
f.	Use of an automatic system for the preparation and dosing of process chemicals	See Section 5.3.3.	Generally applicable.
g.	Advanced process monitoring and control systems	See Section 5.3.2.	
h.	Optimisation of process solution agitation, conductivity and composition	See Section 5.3.1.	

i.	Optimisation of degreasing	This includes techniques such as ~~the use of~~: • cascade (multiple) use of degreasing solution (see Section 5.3.3); • high-performance degreasing systems.	
j.	Maintenance of process solutions	This includes techniques such as: • filtration of process solutions, e.g. sulphuric-acid-containing solutions and phosphate-containing solutions; • electrodialysis, e.g. for organic decomposition products in electroless nickel plating solutions; • retardation, e.g. acid resin sorption; • crystallisation of carbonates and metal sulphates; • anodising caustic etch recovery; • activated carbon treatment for organic decomposition products; • use of an oil separator or ultrafiltration for degreasing solutions; • use of diffusion dialysis for pickling solutions.	
k.	Recovery of process metals	This includes techniques such as: • electrolytic recovery: an electric current is applied to electrodes submerged in the process solution, causing metal ions to deposit onto the cathode; • use of ion-exchange resins and filtration, e.g. for chromium plating treatment vats; • precipitation.	~~Generally applicable.~~ Applicability may be restricted by the concentration, the economic value and/or the reuseability of metals.
l.	Recovery and use of leftover process chemicals	Residual process chemicals are recovered (e.g. by thoroughly purging pipes or completely emptying packaging) and used in the process.	Applicability may be restricted by the content of impurities and the perishability of the process chemicals.
m.	Collection of leakages or spills	Fixed and temporary pumps, hydraulic fluid systems and filters over mobile tanks or drip trays with sufficient capacity to retain leakage and spills are used. Pipe ends are kept over the process tank or drip trays. This enables liquid residues to be collected and returned to the correct process solutions or dealt with as a waste or waste water.	Generally applicable.
n.	Prolonging the lifetime of ion-exchange resins	Regular ~~(e.g. twice per year)~~ chemical cleaning of the resins of the ion exchanger.	Applicability may be restricted by product specifications.
o.	Drag-in reduction	See Section 5.3.2.	Generally applicable.

p.	Drag-out reduction		
q.	Rinsing optimisation	This includes: • using multiple rinsing with rinsing water recirculation (see Section 5.3.2); • using eco-rinse (pre-dip) (see Section 5.1.5.2) can be combined with other rinse stages to increase the effectiveness of the multiple rinsing system (see Section 5.3.3); • using spray rinsing; • use of vac~~e~~uum evaporation; • regeneration and reuse/recycling of rinsing water.	
r.	Closing the process chemicals loop *[Technique moved here from BAT 8]*	Closing the loop by applying at process/line level: • reduction of drag-out (see technique (h) above); • optimising rinsing (see technique (i) above); • concentrating the returning drag-out or receiving solutions (using, for example, ion exchange, membrane filtration, evaporation).	Applicability may be restricted by the chemical composition of the process water.

[This BAT conclusion is based on information given in BREF Section ***Error! Reference source not found.****]*

Further sector-specific techniques to increase material efficiency are given in Sections 5.2.1.2 5.2.2.2, 5.2.3.2, 5.2.5.2, 5.2.6.2 and 5.2.7.2 of these BAT conclusions.

5.1.6 Substitution and minimisation of the use of hazardous substances

BAT 10. In order to improve the overall environmental performance and to reduce the risks associated with the use of hazardous substances, BAT is to use technique (a) and an appropriate combination of techniques (b) to (g) given below.

	Technique	Description	Applicability
a.	Minimisation of the use of hazardous substances	This includes techniques such as: • regularly reviewing the inventory of process chemicals (see BAT 0.b~~Section 5.4.3~~) and optimising the formulation of chemicals used; • substitution of chemicals containing hazardous substances with non- or less hazardous ones (based on the analysis in BAT 0.b ~~Section 5.4.3, ii.d~~); • optimisation of the quantity of chemicals used (see BAT 9); • use of a closed loop to recover/reuse chemicals (see BAT 9 r.).	The substitution of chemicals containing hazardous substances may be restricted by the availability of a suitable alternative.
b.	Minimisation of the use of metallic salts	The anode consumption is regularly monitored and the anode is promptly renewed in Cu-, Sn-,	Generally applicable.

		Ni- and Ag-containing solutions, to avoid the addition of metallic salts.	
~~e.~~	~~Substitution of Cr(VI) with non- or less hazardous substances and/or use of alternative processes~~	~~This includes:~~ • ~~use of Cr(III)-salts-based solutions such as chloride-based or sulphate-based solutions in passivation and plating;~~ • ~~use of Cr-free options, e.g.:~~ ○ ~~use of potassium permanganate and phosphoric acid for plastic etching;~~ ○ ~~zinc-based solution;~~ ○ ~~tin-cobalt alloy;~~ ○ ~~platinum-plated titanium anodes in pre-treatment, phosphating, passivation, plating, etching for example;~~ ○ ~~use of electroplated nickel-tungsten, electroless nickel or nickel alloy deposits (NiL35) in plating;~~ • ~~use of alternative processes, e.g.:~~ ○ ~~High Velocity Oxygen Fuel (HVOF) process;~~ ○ ~~Physical Vapour Deposition (PVD);~~ ○ ~~plasma nitriding;~~ ○ ~~Laser Metal Deposition (LMD);~~ ○ ~~Extreme High-speed Laser metal deposition (EHLA).~~	~~Applicability may be restricted by product specifications.~~
d.	Substitution of cyanide with non- or less hazardous substances	Use of cyanide-free solutions, e.g.: • copper-based solutions in degreasing; • alkaline silver-based solutions in plating.	~~Applicability may be restricted by product specifications.~~ The substitution of chemicals containing hazardous substances may be restricted by the availability of a suitable alternative.
e.	Minimisation of the use of solvents containing hazardous substances	This includes techniques such as: • use of aqueous degreasing solutions; • use of solvents not containing hazardous substances, e.g modified alcohol degreasing agents in closed systems to substitute tetrachloroethylene (PER).	
f.	Substitution of ethylenediaminetetraacetic acid (EDTA) with non- or less hazardous substances	Use of gluconic-acid-based substances.	
g.	~~Use of PFAS-free surfactants~~ Avoidance of PFAS use or substitution of PFAS with non- or less hazardous substances	This includes: • use of Cr(VI)-free processes that make the use of PFAS unnecessary, e.g. replacing chromium layers with nickel-based layers~~,~~ and alternative hardening techniques on steel (see BAT 10 bis)~~instead of plating with chromium(VI), and alternative plastic etching using for example manganese (III)-based compounds;~~ • use of fluorine-free alternatives to substitute the current mist/fume suppressant 6:2 fluorotelomer sulphonic acid (6:2 FTS).	

*[This BAT conclusion is based on information given in BREF Section **Error! Reference source not found.**]*

BAT 10 bis. In order to improve the overall environmental performance and to reduce the risks associated with the use of Cr(VI), BAT is to use one of the techniques given below.

	Technique	Description	Applicability
a.	Use of Cr(III)-salts-based solutions instead of Cr(VI)-salts-based solutions	This includes techniques such as: • use of sulphate-based solutions in passivation and plating, e g. mixed metal oxide (MMO) anodes based on titanium; • use of trivalent chromium coating technology (TCCT) for packaging steel; • use of chloride-based solutions, e.g. chromium chloride, ammomium chloride or mixed solutions based on sulphate/chloride.	Applicability may be restricted by product specifications.
b.	Use of Cr-free options	This includes techniques such as: • use of potassium permanganate and phosphoric acid for plastic etching; • use of chromium-free passivation alternative (CFPA) for the tin layer of packaging steel; • use of zinc-based solution; • use of low-tin steel (LTS) in metal packaging; • use of tin-cobalt alloy; • use of platinum-plated titanium anodes in pre-treatment, phosphating, passivation, plating, etching for example; • use of electroplated nickel-tungsten, electroless nickel or nickel alloy deposits (NiL35) in plating.	
c.	Use of alternative (chromium-free) processes	This includes: • high velocity oxygen fuel (HVOF) process; • physical vapour deposition (PVD); • plasma nitriding; • laser metal deposition (LMD); • extreme high-speed laser metal deposition (EHLA).	
d.	Closed-loop electroplating	Design and operation of hexavalent Cr(VI) plating as a closed loop for chromium and PFAS recycling by using a combination of powerful exhaust air systems, cascade rinsing, ion exchange and spray tower evaporators.	Applicability to existing plants may be restricted by the plant layout.

*[This BAT conclusion is based on information given in BREF Section **Error! Reference source not found.**]*

5.1.7 Residues and circular economy

[The following BAT was moved and updated from Section 5.4.7]

BAT 10.ter In order to improve the overall environmental performance, BAT is to set up, implement and regularly review a residues management plan.

Description

The residues management plan is part of the EMS (see BAT 0.a) and comprises a set of measures aiming to:

- minimise the generation of residues;
- optimise the reuse, recycling and/or recovery of residues;
- ensure the proper disposal of waste.

The residues management plan may be integrated in the overall residues management plan of a larger installation (e.g. ferrous metal processing activities).

Applicability

The level of detail and the degree of formalisation of the residues management plan will generally be related to the nature, scale and complexity of the installation.

BAT 11. In order to reduce the amount of waste sent for disposal and to enhance circularity, BAT is to use technique (a) and an appropriate combination of the techniques (b) to (k) given below.

	Technique	Description	Applicability
Process optimisation			
a.	Process line optimisation	See Section 5.3.2. and Section 5.3.3 ~~5.3.6~~	Generally applicable.
b.	Automatic systems for the preparation and dosing of process chemicals	See Section 5.3.2. and Section 5.3.3 ~~5.3.6~~	
c.	Advanced process monitoring and control systems	See Section 5.3.2. and Section 5.3.3 ~~5.3.6~~.	
d.	Reduction, reuse and recycling of packaging	For product packaging, this includes techniques such as: • use of light and high-capacity packaging to reduce the specific consumption of packaging materials (e.g. high-expansion plastic films); • use of reusable packaging (e.g. reusable pallets, metal boxes); • use of recycled plastic films; • use of a reduced amount of printed plastic films (e.g. printed banderole) to facilitate downstream recycling. For the packaging of chemical substances and mixtures, this includes techniques such as: • storage, preferably in large containers; • reuse of packaging; • return to the supplier; • sending for material recycling.	Applicability may be restricted by safety requirements for the handling and transportation of products and/or chemicals.

Technique		Description	Applicability
e.	Timely use of process chemicals	See BAT 9 (b).	Generally applicable.
f.	Optimised sludge handling	This is achieved by, for example, reducing the discharges from rinsing and treatment vats so that the quantity of sludge generated is minimised, or by using sludge dewatering, drying or stabilisation.	
g.	Recovery of process metals ~~Electrolytic recovery of metals~~	See BAT 9 (k).~~Metals are recovered by making use of their properties, e.g. selective recovery of metal zinc and iron chloride from spent pickling acids generated in galvanising processes.~~	Applicability may be restricted by the concentration, the economic value and the reuseablity of metals.
h.	Separate collection and storage of wastes contaminated with hazardous substances	Wastes containing hazardous substances are collected and stored separately, with special regard given to the substances fulfilling the criteria referred to in Article 57 of Regulation (EC) No 1907/2006 and substances addressed in restrictions referred to in Annex XVII to Regulation (EC) No 1907/2006 (e.g. sludges, ~~and~~ filter cakes, ~~aqueous~~ rinsing liquids).	Generally applicable.
i.	Contained areas for plating with hazardous substances	Areas where plating with hazardous substances (e.g. Cd, Cr(VI)) takes place are contained to avoid cross-contamination. Waste water streams from these areas are collected separately and treated according to their content (see BAT 20).	Generally applicable.
Techniques promoting industrial symbiosis			
j.	External recovery of materials from waste	This includes the recovery of metals from metal-containing sludges.~~ (e.g. dewatered aluminium hydroxide sludge).~~	~~Generally applicable.~~Applicability may be restricted by a lack of suitable demand.
k.	Reuse of anodes	Spent anodes are reused, e.g. tin anodes in a hot-dip galvani~~z~~sing plant.	

*[This BAT conclusion is based on information given in BREF Section **Error! Reference source not found.** and **Error! Reference source not found.**]*

5.1.8 Emissions to air

~~5.1.8.1 Diffuse emissions to air~~

BAT 12. In order to prevent or, where that is not practicable, to reduce diffuse emissions to air from treatment vats ~~and from internal transportation~~, BAT is to use all of the techniques given below.

Technique		Description	Applicability
Prevention of emissions			
a.	Use of additives	Use of non-fluorinated additives in the treatment vat that can reduce the generation of gases and aerosols, e.g. Cr(VI) aerosols, HF, NO_X.	Only applicable when additives are compatible with the applied solution chemistry.
b.	Covered process treatment vats	Treatment vats generating gases and aerosols containing hazardous substances, not equipped with a fume exhaust system, are covered using lids for example and are maintained ~~in~~ under negative pressure.	~~Generally applicable.~~ Applicability to existing plants may be restricted by a lack of space.
~~c.~~	~~Use of electric vehicle~~	~~Use of electric vehicles for on-site material transportation and handling, e.g. forklifts, trucks. Such equipment should be powered by electricity generated from fossil-free energy sources, if available.~~	~~Only applicable to new vehicles.~~
Collection of emissions			
d.	Extraction of emissions as close as possible to the emission source	See Section 5.3.4. ~~Pollutant emissions from treatment vats are captured as close as possible to the emission source and extracted using, for example, enclosures, fixed or movable extraction hoods, centralised mechanical extraction. The collected off-gases may be treated by an abatement system before being released.~~	~~Generally applicable.~~ Applicability to existing plants may be restricted by the plant layout.

*[This BAT conclusion is based on information given in BREF Section **Error! Reference source not found.** and **Error! Reference source not found.**]*

~~5.1.8.2 Channelled emissions to air~~

BAT 13. In order to facilitate the reduction of channelled emissions to air, as well as to increase energy efficiency, BAT is to combine waste gas streams with similar characteristics, thus minimising the number of emission points.

Description

The combined treatment of waste gases with similar characteristics ensures more effective and efficient treatment compared to the separate treatment of individual waste gas streams. The combination of waste gases is carried out considering plant safety (e.g. avoiding concentrations close to the lower/upper explosive limit), technical (e.g. compatibility of the individual waste gas streams, concentration of the substances concerned), environmental (e.g. maximising recovery of materials or pollutant abatement) and economic factors (e.g. distance between different process units). Care is taken that the combination of waste gases does not lead to the dilution of emissions.

Applicability

The applicability may be restricted for point-of-use abatement systems in semiconductor manufacturing.

*[This BAT conclusion is based on information given in BREF Section **Error! Reference source not found.**]*

~~**BAT 14. In order to reduce the total quantity of emissions to air, as well as to increase energy efficiency, BAT is to reduce the volume of extracted air.**~~

~~**Description**~~

~~This includes techniques such as the reduction of the free surface area above vats, applying specific airflow above the process vats, enclosure of plating lines and adjustment of air extraction operating period.~~

BAT 14. In order to reduce emissions to air, while increasing energy efficiency and reducing raw material consumption, BAT is to reduce the volume of air extracted by using one or a combination of the techniques given below. ~~In order to reduce the total quantity of emissions to air, as well as to increase energy efficiency, BAT is to reduce the volume of extracted air.~~

	Technique	Description	Applicability
a	Reduction of the free surface area above process vats	This includes techniques such as:: - use of lids protecting the free surface area, either fixed to and moved with the flight bar or moveable by the transporter; - use of floating spheres. (See also BAT 7 a.)	Generally applicable.
b	Use of dedicated airflows above the process vats	The system involves both 'push' and 'pull' airflows (extraction hoods opposite blowing ducts) to create an effective ventilation system that captures and removes contaminants from the workspace.	Generally applicable.
c	Enclosure of plating lines	Plating lines are installed inside enclosures that keep the plating lines segregated from other areas (e.g. loading/unloading).	Applicability to existing plants may be restricted by the design of the plating line.

d	Adjustment of air extraction operating period	Air extraction operates when conditions require it, such as when process solutions are heated and used.	Generally applicable.

BAT 15. In order to prevent or reduce emissions to air from thermal processes (e.g. treatment vat heating), BAT is to use ~~either electric~~ heating with electricity generated from fossil-free energy sources ([1]) (preferably renewable energy), if available, or to use both of the techniques given below. ~~or technique (a) and one or both of the techniques (b) and (c) given below.~~

Technique		Description	Applicability
~~a~~	~~Optimised combustion~~ Combustion optimisation	See Section 5.3.4.	Generally applicable.
~~b~~	Fuel choice	The use of fuel (including support/ auxiliary fuel) with, for example, ~~a low content of potential pollution-generating compounds (~~a low sulphur, ash, nitrogen, fluorine or chlorine content ~~in the fuel)~~.	~~Generally applicable.~~ Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State.
~~c~~	~~Low NO_X burners~~	~~See Section 5.3.4.~~	~~Applicability to existing plants may be restricted by furnace design and/or operational constraints.~~

([1]) The use of electricity generated from fossil-free energy sources also contributes to decarbonisation.

Further sector-specific techniques to reduce emissions to air are given in Sections 5.2.1.4, 5.2.2.4, ~~5.1.1.1~~5.2.3.4, 5.2.6.4 and 5.2.7.5 of these BAT conclusions.

*[This BAT conclusion is based on information given in BREF Section **Error! Reference source not found.** and **Error! Reference source not found.**]*

5.1.9 Odour

[The following BAT was moved and updated from Section 5.4.10]

BAT 15.bis In order to prevent or, where that is not practicable, to reduce odour emissions supporting the preparation and implementation of the EMS, BAT is to set up, implement and regularly review an odour management plan. The odour management plan includes at least the following features:

i. A protocol containing appropriate actions and timelines.
ii. A protocol for conducting odour monitoring as set out in BAT 16. The protocol may be complemented by measurement/estimation of odour exposure or estimation of odour impact.
iii. A protocol for response to identified odour incidents, e.g. managing complaints and/or taking corrective actions.
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.

Applicability

The applicability is restricted to cases where an odour nuisance at sensitive receptors is expected and/or has been substantiated.

BAT 16. BAT is to periodically perform odour monitoring.

Description
Odour can be monitored using the following:

- EN standards (e.g. dynamic olfactometry according to EN 13725 in order to determine the odour concentration and/or EN 16841-1 or -2 in order to determine the odour exposure).
- Alternative methods (e.g. estimation of odour impact) for which no EN standards are available. In such a case, ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality can be used.

The monitoring frequency is determined in the odour management plan (see BAT 15.bis ~~Section~~).

Applicability
The applicability is restricted to cases where an odour nuisance at sensitive receptors is expected and/or has been substantiated.

[This BAT conclusion is based on information given in BREF Section ***Error! Reference source not found.****]*

5.1.10 Noise

[The following BAT was moved and updated from Section 5.4.9]

BAT 16.bis In order to prevent or, where that is not practicable, to reduce noise emissions supporting the preparation and implementation of the EMS, BAT is to set up, implement and regularly review a noise management plan. The noise management plan includes at least the following features:

i. a protocol containing appropriate actions and timelines;
ii. a protocol for monitoring of noise emissions;
iii. a protocol for responding to identified noise events, e.g. managing complaints and/or taking corrective actions;
iv. a noise reduction programme designed to identify the source(s), to measure/estimate noise exposure, to characterise the contributions of the sources to the overall noise emissions and to implement prevention and/or reduction measures (see BAT 17).

Applicability
The applicability is restricted to cases where a noise nuisance at sensitive receptors is expected and/or has been substantiated.

BAT 17. In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques given below.

	Technique	Description	Applicability
a.	Appropriate location of equipment and buildings	Noise levels can be reduced by techniques such as: • increasing the distance between the emitter and the receiver; • using buildings as noise screens; • relocating equipment and/or building openings (e.g. exits or entrances of the buildings).	For existing plants, the relocation of equipment and openings of the buildings may not be applicable due to a lack of space and/or excessive costs.
b.	Operational measures	This includes techniques such as: • inspection and maintenance of equipment; • closing of doors and windows of enclosed areas, if possible, or use of self-closing doors; • equipment operation by experienced staff; • avoidance of noisy activities at night, if possible; • provisions for noise control during production and maintenance activities, transport and handling of raw materials, e.g. reducing the number of material transfer operations, reducing the height from which pieces fall onto hard surfaces.	Generally applicable.
c.	Low-noise equipment	This includes direct drive motors; low-noise compressors, pumps and fans; low-noise transportation equipment.	
d.	Noise control equipment	This includes techniques such as: • use of noise reducers; • use of acoustic insulation of equipment; • enclosure of noisy equipment and processes (e.g. unloading of raw materials, fans); • use of building materials with good sound insulation properties (e.g. for walls, roofs, windows, doors).	Applicability to existing plants may be restricted by a lack of space.
e.	Noise abatement	Inserting obstacles between emitters and receivers (e.g. protection walls, embankments).	Only applicable to existing plants, as the design of new plants should make this technique unnecessary. For existing plants, the insertion of obstacles may not be applicable due to a lack of space.

[This BAT conclusion is based on information given in BREF Section ***Error! Reference source not found.****]*

5.1.11 Emissions to water

BAT 18. In order to reduce the amount of waste water generated, to prevent or reduce the pollutant loads directed to the waste water treatment and the emissions to water, BAT is to use an integrated strategy for waste water management and treatment that includes ~~an appropriate combination of~~ the techniques given below with the following order of priority:

- process-integrated techniques and techniques to recover and reuse process flows (see BAT 8 and BAT 9);
- separate collection of waste water streams containing pollutants that need dedicated treatment; these waste water streams are either treated before being mixed with other waste water streams (see BAT 20) or handled as waste (see BAT 11);
- final waste water treatment techniques (see BAT 20).

Description

The integrated waste water management and treatment strategy is based on the information provided by the inventory of inputs and outputs (see BAT 0.b ~~Section~~).

[This BAT conclusion is based on information given in BREF Section 4.2.10.2]

BAT 19. In order to reduce emissions of hazardous substances, (e.g. toxic metals, free cyanide~~CN, PFAS~~) or substances of concern (e.g. PFAS) to water, BAT is to collect waste water streams containing hazardous substances separately and appropriately pretreat them before mixing with other waste water streams.

Description

Waste water streams containing hazardous substances (e.g. toxic metals, free cyanide~~CN, PFAS~~) or substances of concern (e.g. PFAS) are collected separately from other waste water streams and pretreated according to their content using, for example, chemical precipitation, chemical reduction, adsorption, filtration, ion exchange (see BAT 20), before any mixing with other waste water streams. The pretreatment of these waste water streams is generally carried out as close as possible to the source in order to avoid dilution.

Applicability

Applicability to existing plants may be restricted by the layout of the water collection system.

[This BAT conclusion is based on information given in BREF Sections 4.1.7.1 and 4.1.7.2]

BAT 20. In order to reduce emissions to water, BAT is to treat waste water using an appropriate combination of the techniques given below.

	Technique [1]	Typical pollutants targeted
Preliminary, primary and general treatment, e.g.		
a.	Equalisation	All pollutants
b.	Neutralisation	Acids, alkalis
c.	Physical separation through, for example, screens, sieves, grit separators, grease separators, ~~hydrocyclones~~, oil-water separators or primary settlement tanks	Gross solids, suspended solids, oil/grease
Physico-chemical treatment, e.g.		
d.	Adsorption (e.g. activated carbon, acid (resin) sorption)	Adsorbable dissolved non-biodegradable or inhibitory pollutants, e.g. hydrocarbons, mercury, AOX, ~~6:2 FTS or other~~ long-chain and hydrophobic PFAS, or organic micro-pollutants and COD
e.	Chemical oxidation (e.g. electrolytic/anodic, radiation-assisted)	Cyanides~~N~~, metals, phenols, sulphides and organosulphides, hydrogen peroxide, sodium hypochlorite, nitrite
f.	~~Chemical p~~Precipitation	Precipitable dissolved non-biodegradable or inhibitory pollutants, e.g. metals, fluorides
g.	Chemical reduction	Cr(VI)
h.	Crystallisation	Anions and cations, fluorides and chlorides
i.	Electrodialysis	Anions and cations, e.g. metals, sulphates, fluorides, phosphates
j.	Electrolysis	Anions and cations, e.g. metals, sulphates, fluorides, phosphates
k.	Evaporation (e.g. vacuum evaporation)	Soluble contaminants, e.g. salts, metals, volatile PFAS, chlorides, fluorides, phosphates and nitrogen
l.	Ion exchange (e.g. liquid/liquid or resins)	Metals, ~~6:2 FTS or other~~ short-chain PFAS, sulphates, fluorides, phosphates, cyanides
m.	Nitrification/denitrification	Nitrogen
Biological treatment, e.g.		
m.	Activated sludge process	Biodegradable organic compounds
Solids removal, e.g.		
o.	Coagulation and~~,~~ flocculation~~ and precipitation~~	Suspended solids ~~and~~ including particulate-bound metals
p.	Sedimentation	Suspended solids ~~and~~ including particulate-bound metals or non-biodegradable or inhibitory pollutants
q.	Filtration, e.g. gravel or sand filtration	Suspended solids ~~and~~ (including particulate-bound metals), chlorides, sulphates, low-molecular-weight organic compounds (including certain PFAS), dissolved salts, multi- and monovalent ions
r.	Membrane microfiltration, ultrafiltration, nanofiltration and reverse osmosis	
s.	Flotation	

([1]) The descriptions of the techniques are given in Section 5.3.5.

[This BAT conclusion is based on information given in BREF Section ***Error! Reference source not found.****]*

Table 5-1: BAT-associated emission levels (BAT-AELs) and information on circumstances allowing the achievement of lower emission levels within the BAT-AEL range for emissions to water ~~discharges~~

Sectors: (A) Electrolytic or chemical plating; (B) Aluminium ~~coil/sheet~~ conversion coating/anodising; (C) Continuous steel coil coating; (D) Porcelain (vitreous) enamelling; (E) PCB manufacturing; (F) Semiconductor manufacturing				
Substance/ parameter	**Sector(s)**	**BAT-AEL(1a) ~~(Average over the sampling period)~~**	**Unit**	**Information on circumstances allowing the achievement of lower emission levels within the ~~strictest end of the~~ BAT-AEL range**
~~BOD_5~~	~~(F)~~	~~25 – 75 (1) (2)~~		~~The strictest end of the range is typically achieved when using a combination of techniques including coagulation, flocculation and biological treatment.~~
COD	(A), (B), (C), (D), (E), (F)	~~30–150~~ 80 – 150 ~~(2)~~ (3) (5) (6)		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using chemical oxidation/reduction, ~~and~~ neutralisation~~,~~ and flotation.
TOC	(A), (B), (C), (D), (E), (F)	~~10 – 50~~ 25 – 50 ~~(2)~~ (3) (5) (7)		
TSS	(A), (B), (C), (D), (E), (F)	~~5 – 30~~ 15 – 30 ~~(2)~~ (5)		~~The strictest end of the range is typically achieved when using coagulation, flocculation and filtration.~~
Fluorides	(A), (B), ~~(C), (D), (E),~~ (F)	2 – 10 (4) (8)		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using precipitation and ion exchange resins ~~neutralisation~~.
AOX	(A)~~, (B), (C), (D), (E), (F)~~	0.1 – 1 (4) (9)	mg/l	~~The strictest end of the range is typically achieved when using adsorption, chemical reduction and neutralisation.~~ Lower emission levels within the BAT-AEL range are expected with the use of a dedicated abatement technique (e.g. adsorption).
Cyanides (free)	(A)~~, (B), (E), (F)~~	~~0.05 – 0.2~~ 0.1 – 0.2 (4)		~~The strictest end of the range is typically achieved when using a combination of techniques including adsorption, chemical oxidation, chemical reduction and neutralisation.~~
HOI	(A), (B), ~~(C),~~ (D)~~, (E)~~	~~0.5 – 4~~ 1 – 4 (4) (5)		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using ~~adsorption and~~ a combination of coagulation and flocculation, oil/water separation, filtration and sedimentation.
Metals: Ag	(A)~~, (F)~~	~~0.05 – 0.1~~ 0.05 – 0.2 (4) (10)		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range

					are expected when using ion-exchange resin, coagulation, flocculation and filtration.
	Al	(A)	0.5 – 2 ([4]) ([11])		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using ion-exchange resin, coagulation, flocculation and filtration.
		(B)	1 – 5 ([4])		~~The strictest end of the range is typically achieved when using ion-exchange resin, coagulation, flocculation and filtration~~
		(F)	0.1 – 0.2 ([4]) ([12])		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using ion-exchange resin, coagulation, flocculation and filtration.
	As	(A), ~~(B), (C),~~ (E), (F)	~~0.005 – 0.03~~ 0.01 – 0.03 ([4])		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using ion-exchange resin, coagulation, flocculation and filtration.
	B	(A)~~, (B), (E), (F)~~	~~0.5-2 ([4])~~ 1.5 – 4 ([4]) ([13])		~~The strictest end of the range is typically achieved when using ion-exchange resin, coagulation, flocculation and filtration~~
	Cd	(A)~~, (B), (C), (E), (F)~~	~~0.001-0.005~~ 0.005 – 0.04 ([4])		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using ion-exchange resin, coagulation, flocculation and filtration.
	Co	(A), (B), (C), (E), (F)	~~0.001-0.01~~ 0.02 – 0.1 ([4]) ([14])		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using ~~ion-exchange resin~~ coagulation, flocculation and biological treatment ~~filtration~~.
	Cu	(A), ~~(B), (C), (D), (E),~~ (F)	~~0.05 – 0.2~~ 0.15 – 0.45([4]) ([15])		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using a combination of techniques including ion-exchange resin, coagulation, flocculation and filtration.
		(E)	0.5 – 1.5 ([4])		
	Cr	(A), (B), (C)~~, (D), (E), (F)~~	~~0.05 – 0.2~~ 0.1 – 0.5 ([4]) ([16])		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using a combination of techniques including ion-exchange resin, coagulation, flocculation and filtration.
	Cr(VI)	(A), (B), (C)~~, (F)~~	~~0.01 – 0.05~~ 0.03 – 0.05 ([4])		

	Fe	(A), (C), (E), (F)	0.5 – 2 (4) (17)		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using ion-exchange resin, coagulation, flocculation and filtration.
	~~Hg~~	~~(A), (F)~~	~~0.0005-0.005 (4)~~		~~The strictest end of the range is typically achieved when using ion-exchange resin, coagulation, flocculation and filtration.~~
	Pb	(A), ~~(B), (C),~~ (E), (F)	~~0.02-0.1~~ 0.1 – 0.4 (4)		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using ion-exchange resin, coagulation, flocculation and filtration.
	Ni	(A), (B), (C), (D), (E), (F)	0.1 – 0.5 (4) (18)		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using precipitation, coagulation and flocculation, sedimentation, filtration, plus ion exchange in combination with evaporation and/or electrolysis ~~ion exchange resin, coagulation, flocculation and filtration.~~
	Se	(A), ~~(F)~~	~~0.001-0.01~~ 0.03 – 0.10 (4)		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using ion-exchange resin, coagulation, flocculation and filtration.
	Sn	(A), (B), (C), (E), (F)	0.1 – 1 (4) (19)		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using ion-exchange resin, coagulation, flocculation and filtration.
	Zn	(A), (C)	~~0.2-1~~ 0.4 – 1.5 (4) (20)		~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using ion-exchange resin, coagulation, flocculation and filtration.
		(B), (E), (F)	0.2 – 0.5 (4)		
		~~(E), (F)~~	~~0.1-0.4 (4)~~		
~~Total~~ Sum of PFAS		(A), (B), (C), (E), (F)	~~≤ 0.1~~ 0.1 – 0.5 (4) (21)	µg/l	Lower emission levels within the BAT-AEL range are expected when only one PFAS or only long-chain PFAS are present in the waste water stream.
Total phosphorus		(A), (B), (C), (E), (F)	~~0.5 – 3~~ 1 – 3 ~~(2)~~ (4) (5) (22)	mg/l	~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when using precipitation ~~chemical reduction and chemical oxidation~~.

~~(1) No BAT-AEL applies for biochemical oxygen demand (BOD_5) for the sectors (A), (B), (C), (D) and (E). As an indication, for these sectors, the yearly average BOD_5 level in the effluent from a biological waste water treatment plant will generally be ≤ 20 mg/l.~~

~~(2) For indirect emissions to water, the upper end of the BAT-AEL range may be higher, without prejudice to the provisions of Article 15 (1) of Directive 2010/75/EU as amended by Directive (EU) 2024/1785.~~

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

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

(4) The BAT-AEL only applies when the substance/parameter concerned is identified as relevant in the waste water stream based on the inventory of inputs and outputs mentioned in BAT 0.b ~~Section~~.

(5) The BAT-AEL only applies to direct discharges.

(6) The upper end of the BAT-AEL range may be higher and up to 250 mg/l for plants fulfilling at least one of the following conditions:

- specific net water consumption ≤ 8 l/m² per rinsing cycle,
- operate multiple process lines with several (e.g. ≥4) metals used,
- have high organic loads, e.g. photoresist developing or photoresist stripping in Sector (E).

(7) The upper end of the BAT-AEL range may be higher and up to 80 mg/l for plants fulfilling at least one of the following conditions:

- specific net water consumption < 8 l/m² per rinsing cycle,
- operate multiple process lines with several (e.g. ≥4) metals used,
- have high organic loads, e.g. photoresist developing or photoresist stripping in Sector (E).

(8) The upper end of the BAT-AEL range may be higher and up to 15 mg/l for plants fulfilling at least one of the following conditions:

- specific net water consumption ≤ 8 l/m² per rinsing cycle,
- operate multiple process lines with several (e.g. ≥4) metals used,
- use caustic soda for precipitation,
- do not use calcium hydroxide for precipitation in order to facilitate the recovery of metal(s) from waste water sludge.

(9) The upper end of the BAT-AEL range may be higher and up to 4 mg/l for plants fulfilling at least one of the following conditions:

- specific net water consumption ≤ 8 l/m² per rinsing cycle,
- operate multiple process lines with several (e.g. ≥4) metals used,
- operate autocatalytic plating, or use HCl in the waste water treatment processes.

(10) The upper end of the BAT-AEL range may be higher and up to 0.5 mg/l for plants with a specific net water consumption ≤ 8 l/m² per rinsing cycle, and/or operating multiple process lines with several (e.g.>4) metals used.

(11) The upper end of the BAT-AEL range may be higher and up to 5 mg/l for plants fulfilling at least one of the following conditions:

- specific net water consumption ≤ 8 l/m² per rinsing cycle,
- operate multiple process lines with several (e.g. ≥4) metals used,
- use aluminium as a flocculant in waste water treatment processes,

(12) The upper end of the BAT-AEL range may be higher and up to 0.5 mg/l in advanced semiconductor manufacturing, or up to 1 mg/l for plants using aluminium as a flocculant in waste water treatment processes.

(13) The upper end of the BAT-AEL range may be higher and up to 15 mg/l for plants fulfilling both of the following conditions:

- boron substitution is not possible due to product specifications in Ni, acidic Zn and Cr(III) electroplating, and
- high waste water volume is generated, e.g. >20m^3 per hour which does not allow the use of an evaporator.

(14) The upper end of the BAT-AEL range may be higher and up to 0.5 mg/l for plants using nickel electrolytes in Sector (C) and/or cobalt-based passivation in Sector (A).

(15) The upper end of the BAT-AEL range may be higher and up to 1.5 mg/l for plants fulfilling at least one of the following conditions:

- specific net water consumption ≤ 8 l/m² per rinsing cycle,
- operate multiple process lines with several (e.g. ≥4) metals used,
- in advanced semiconductor manufacturing in Sector (F),
- Cu is used as substrate in Sector (A) .

(16) The upper end of the BAT-AEL range may be higher and up to 1 mg/l for plants with a specific net water consumption ≤ 8 l/m² per rinsing cycle, and/or operating multiple process lines with several (e.g. >4) metals used.

(17) The upper end of the BAT-AEL range may be higher and up to 5 mg/l for plants fulfilling at least one of the following conditions:

- specific net water consumption 8 l/m² per rinsing cycle,
- operate multiple process lines with several (e.g. ≥4) metals used,
- in Sector F for advanced semiconductor manufacturing when using Fe as a flocculant in waste water treatment.

(18) The upper end of the BAT-AEL range may be higher and up to 2 mg/l for plants with a specific net water consumption ≤ 8 l/m² per rinsing cycle, and/or operating multiple process lines with several (e.g. ≥4) metals used.

(19) The upper end of the BAT-AEL range may be higher and up to 2 mg/l for plants with a specific net water consumption ≤ 8 l/m² per rinsing cycle, and/or operating multiple process lines with several (e.g. ≥4) metals used.

(20) The upper end of the BAT-AEL range may be higher and up to 2 mg/l for plants with a specific net water consumption ≤ 8 l/m² per rinsing cycle, and/or operating multiple process lines with several (e.g. ≥4) metals used.

([21]) The BAT-AEL does not apply if it is proven that PFAS emissions are only related to the presence of PFAS in the water input and no PFAS are used or have been used in the installation. ([22]) The upper end of the BAT-AEL range may be higher and up to 10 mg/l for plants fulfilling at least one of the following conditions: • specific net water consumption ≤ 8 l/m² per rinsing cycle, • operating multiple process lines with several metals used e.g. ≥ 4, • carrying out phosphating, autocatalytic plating or etching of plastics in Sector (A), • carrying out aluminium brightening treatments in Sector (B), • in advanced semiconductor manufacturing in Sector (F).

The associated monitoring is given in BAT 6.

5.1.11.1 Emerging techniques for waste water treatment

ET 1. In order to reduce PFAS emissions to water, the following emerging techniques have been identified.

Technique		Description	Typical pollutant targeted
a.	Supercritical water oxidation	Aqueous organic compounds including PFAS are oxidised at temperatures and pressures above the critical point of water in the presence of oxygen.	Short- and long-chain PFAS
b.	Non-thermal plasma (NTP) treatment	NTP treatment generates reactive species (e.g., radicals, electrons, ions) at near-ambient temperatures, enabling the breakdown of PFAS compounds without the need for high-energy thermal processes.	Long-chain PFAS
c.	Electrochemical degradation using graphene sponge electrodes	A synthesised boron-doped graphene sponge anode is used for electrochemical oxidation of PFAS-containing waste water flows.	Long-chain PFAS
d.	Closed-Circuit Reverse Osmosis (CCRO)	Semi-batch reverse osmosis configuration in which the feed water is pumped into a closed loop that contains the membrane module and a small-volume concentrate tank. The system runs through a series of repeated cycles to abate PFAS.	Short- and long-chain PFAS
e.	Surface Active Foam Fractionation (SAFF)	A treatment process in which PFAS molecules migrate to the air-water interface of rising air bubbles and become concentrated in the foam that forms at the surface. The foam contains a highly concentrated PFAS load and is then separated from the bulk water, leaving treated water with a reduced PFAS content.	Long-chain PFAS
f.	UV-based photochemical destruction	UV photochemical processes, e.g. high-energy direct photolysis, advanced oxidation or photocatalysis, are used for destroying PFAS across the entire chain-length spectrum.	Long-chain PFAS

[This BAT conclusion is based on information given in BREF Section ***Error! Reference source not found.****]*

5.2 Sector-specific c~~C~~onclusions on ~~sector-specific~~ BAT and emerging techniques

5.2.1 BAT conclusions for electrolytic or chemical plating

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 5.1.

5.2.1.1 Water consumption ~~and waste water discharge~~

The environmental performance level for specific net water consumption given below are associated with the general BAT conclusions given in Section 5.1.4.

Table 5-2: BAT-associated environmental performance levels (BAT-AEPL~~s~~) for specific net water consumption ~~at plant level~~ for electrolytic or chemical plating

Processes	Unit	BAT-AEPL (Yearly average)
Sum of all processes	m^3/m^2 of surface ~~workpieces~~ treated	~~0.05 – 0.9~~ 0.05 – 0.25

The associated monitoring is given in BAT 4.

5.2.1.2 Material efficiency

BAT 21. In order to reduce the quantity of materials used and the quantity of residues generated in electrolytic or chemical plating, BAT is to use all of the techniques given below.

	Technique	Description	Applicability
a.	Process-integrated automated plating	In large-scale plating of uniform cylindrical workpieces, the anode is shaped to fit around the workpiece and spin it rapidly, creating a high field intensity that allows fast plating. An automated sealed system delivers and removes the electrolyte, while a central processing system handles returned electrolytes, keeping the production line waste-free and minimising waste water.	Applicability may be restricted by product specifications.
b.	Switching the polarisation of the electrodes to minimise consumption	The polarisation of electrodes in electrolytic degreasing and in electrolytic pickling processes is switched at regular time intervals.	Only applicable in plants with bipolar electrodes.
c.	Reduction of drag-out in jig (rack) processing	Drag-out reduction, e.g. by: • optimised position of workpieces to avoid retention of process liquids; • adjustment of draining time when withdrawing the jigs; • regular inspection and maintainance of jigs to avoid fissures retaining process solution.	Generally applicable.
		Optimisation of workpieces to minimise spaces trapping process solution.	Applicability may be restricted by product specifications.
d.	Reduction of drag-out in barrel processing	Drag-out reduction, e.g. by: • appropriate choice of barrel materials, e.g. hydrophobic plastic; • regular inspection and maintainance of barrels for worn areas, damage, recesses or bulges that may retain process solution; • withdrawing slowly to minimise the volume of liquid dragged out; • ~~withdrawing slowly to maximise drag-out;~~ • rotating intermittently; • rinsing using a pipe inside the barrel.	Generally applicable.
		Drag-out reduction, e.g. by: • ensuring the bores of holes in the barrel bodies have sufficient cross-sectional area in relation to the required thickness of the panels to minimise capillary effects; • ensuring that the proportion of holes in the barrel bodies is the highest for allowing drainage ~~while retaining mechanical strength~~; • replacing holes with mesh plugs; • fitting drainage ledges between tanks ~~canted~~ tilted back to the process tank; • inclining the barrel from one end.	Applicability may be restricted by product specifications.

5.2.1.3 Energy efficiency

The environmental performance level for specific net energy consumption given below is associated with the general BAT conclusions given in Section 5.1.3.

Table 5-3: BAT-associated environmental performance level (BAT-AEPL) for specific net energy consumption ~~at plant level~~ for electrolytic or chemical plating

Processes	Unit	BAT-AEPL (Yearly average)
Sum of all processes	kWh/m^2 of treated surface	25 – 200

The associated monitoring is given in BAT 4.

5.2.1.4 Emissions to air

BAT 22. In order to prevent or reduce emissions to air of NH_3, dust, HCl, HF, HCN, Cr, Cr(VI), Cu, Ni, Zn, SOx and TVOC in electrolytic or chemical plating, BAT is to collect the emissions using technique (a) and to treat the off-gases using one or ~~an appropriate~~ combination of the techniques (b) to (i) given below.

	Technique	Description	Typical substance/parameter targeted	Applicability
a.	~~Off-gas~~ ~~e~~Extraction of emissions as close as possible to the emission source	~~Off-gas extraction using, for example, enclosure, edge or lip extraction.~~ See Section 5.3.4.	All pollutants	Generally applicable
b.	Adsorption	See Section 5.3.4.	Organic compounds (e.g. TVOC, HCN)	Generally applicable
c.	Aerosol/droplet separator		Dust, aerosols, acidic/alkaline emissions	Generally applicable
~~d.~~	~~Biofilter~~		~~Organic compounds~~	~~Generally applicable~~
e.	Cyclone		Dust, particulate-bound metals	Generally applicable
f.	Fabric filter		Dust, ~~and~~ particulate-bound metals	Generally applicable
g.	Demister ~~(mist filter)~~		~~Particulate-bound metals,~~ Dust, liquid droplets, aerosols, mists, acidic/alkaline emissions	Generally applicable
h.	Wet scrubber		Dust, particulate-bound metals, acidic/alkaline emissions	Generally applicable
i.	Thermal oxidation		Organic compounds (e.g. TVOC)	Applicability may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases. The applicability of recuperative and regenerative thermal

				oxidation to existing plants may be restricted by design and/or operational constraints.

The associated emission levels for emissions to air given below are also associated with the general BAT conclusions given in Section 5.1.8.

Table 5-4: BAT-associated emission levels (BAT-AELs) and information on circumstances allowing the achievement of lower emission levels within the BAT-AEL range for channelled emissions to air of NH_3, dust, HCl, HF, HCN, Cr, Cr(VI), Cu, Ni, Zn, SO_X and TVOC for electrolytic or chemical plating

Substance/ parameter	Associated processes	BAT-AEL (Average over the sampling period) (1)	Unit	Information on circumstances allowing the achievement of ~~the strictest end~~ lower emission levels within ~~of~~ the BAT-AEL range
Organics				
TVOC	Drying, pickling, activation, degreasing, stripping, heat treatment	10 – 20	mgC/Nm³	~~The strictest end of the range is typically achieved when using~~ Lower emission levels within the BAT-AEL range are expected with the use of thermal oxidation.
Acid/alkali				
NH_3	Degreasing, etching, pickling, plating, stripping~~, rinsing~~	~~0.3 – 2~~ 0.5 – 3 (2)	mg/Nm³	~~The strictest end of the range is typically achieved when using~~ Lower emission levels within the BAT-AEL range are expected with the use of a wet scrubber.
Gaseous chlorides expressed as HCl	Degreasing, etching, pickling, plating, stripping~~, rinsing~~	~~2 – 10~~ 2 – 5		
Gaseous fluorides expressed as HF		~~0.2 – 1~~ 0.3 – 1		
HCN	~~Degreasing, d~~Drying, ~~etching, pickling,~~ plating, stripping~~, rinsing~~	0.1 – 0.5		
SO_X	~~Degreasing, etching, pickling, p~~Plating, stripping~~, rinsing~~	1 – 10		
Particulate matter and metals/metalloids				
Dust	Abrasive blasting, degreasing, drying, ~~etching,~~ heat treatment, pickling, plating, stripping~~, rinsing~~	~~2 – 4~~ 2 – 5	mg/Nm³	~~The strictest end of the range is typically achieved when using~~ Lower emission levels within the BAT-AEL range are expected with the use of a wet scrubber or fabric filter.
Cr	Abrasive blasting~~, degreasing~~, drying, etching, heat treatment, pickling, plating, stripping~~, rinsing~~	0.02 – 0.1		
Cr(VI)		0.01 – 0.05		
Cu		0.01 – 0.1		
Ni		0.01 – 0.1		
Zn		0.1 – 0.5		

(1) The BAT-AEL only applies when the substance/parameter concerned is identified as relevant in the waste gas stream based on the inventory of inputs and outputs mentioned in BAT 0.b ~~Section~~

(2) The upper end of the BAT-AEL range may be higher and up to 5 mg/Nm³ in the case of autocatalytic (e.g. electroless) Ni plating.

The associated monitoring is given in BAT 5.

BAT 23. In order to reduce NO_X emissions in waste gases while limiting CO emissions from the thermal treatment of off-gases in electrolytic or chemical plating, BAT is to use technique (a) or both of the techniques given below.

	Technique	Description	Applicability
a.	~~Optimised combustion~~Combustion optimisation	See Section 5.3.4	Generally applicable
b.	~~Use of l~~Low-NO_X burners		Applicability to existing plants may be restricted by design and/or operational constraints.

Table 5-5: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of NO_X from the thermal treatment of off-gases in electrolytic or chemical plating

Parameter	Associated process	Unit	BAT-AEL (~~Daily average or a~~Average over the sampling period)	~~Circumstances allowing the achievement of the strictest end of the BAT-AEL range~~
NO_X	Thermal treatment of off-gases	mg/Nm^3	~~20 – 100~~ 30 – 100	~~The strictest end of the range is typically achieved when using low-NOX burners~~

The associated monitoring is given in BAT 5.

5.2.2 BAT conclusions for continuous steel coil coating

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 5.1.

5.2.2.1 Water consumption ~~and waste water discharge~~

BAT 24. In order to reduce water consumption and the amount of waste water generated in continuous steel coil coating, BAT is to use all of the techniques given below.

	Technique	Description	Applicability
a.	Recycling of quenching water	To produce a bright finish on the product following flow melting in tin plating, the strip is cooled using quenching water ~~via a water quench~~. This water is recycled and reused until it is disposed of when the build-up of tin is too high.	Generally applicable.
b.	Use of condensate recovery steam pipes	Condensate recovery steam pipes are used in steam systems to collect and return condensed steam (condensate) back to the boiler for reuse.	Applicability may be restricted by the steam composition and temperature.
~~c.~~	~~Recirculation of rinsing water~~	~~In multiple rinsing, rinsing water from the subsequent rinsing steps is used in the previous rinsing steps.~~	~~Generally applicable.~~
~~d.~~	~~Recirculation of rinsing water from etching and surface treatment to the treatment baths~~	~~Rinsing water from etching and surface treatment is collected and undergoes treatment to remove contaminants. The treated water is then returned as water input to the treatment vats.~~	
e.	Use of closed cooling systems	See Section 5.3.2.	Generally applicable.

The environmental performance level for specific net water consumption given below is~~are~~ also associated with the general BAT conclusions given in Section 5.1.4.

Table 5-6: BAT-associated environmental performance level (BAT-AEPL~~s~~) for specific net water consumption ~~at plant level~~ for continuous steel coil coating

Processes	Unit	BAT-AEPL (Yearly average)
Sum of all processes	m^3/t of coil coated	0.5 – 3

The associated monitoring is given in BAT 4.

5.2.2.2 Material efficiency

BAT 25. In order to reduce the quantity of materials used and the quantity of residues generated in continuous steel coil coating, BAT is to use all of the techniques given below.

	Technique	Description	Applicability
a.	Advanced process monitoring and control systems	See Section 5.3.2.	Generally applicable.
b.	Squeeze rolls	The remaining solution~~s~~ or rinsing water on the steel strip ~~are~~ is removed from the strip by squeezing the rolls before ~~it~~ they leave each section. This ensures that the drag-out of solution into the next section is minimised, as is the loss of chemicals and contamination of rinse water.	
c.	Electrolytic strip cleaning	Before coating, the strip must be perfectly clean. Oil from the previous step (temper mill) is removed by an electrolytic process. See also (j).	
d.	Use of ultrafiltration to regenerate degreasing solution	Electrolyte used for strip cleaning is recirculated in a closed loop; before reuse, the oil residues contained are filtrated. See also BAT 9 (j).	
e.	Cascade (multiple) use of degreasing solution	See Section 5.3.3. Strip degreasing typically involves two or three electrolytic cells. A shared electrolyte solution is utilised. Fresh electrolyte is introduced in the final cell and a backward counterflow mechanism enables its reuse in the preceding cells.	
f.	Control of the acidity in the pickling section	See also BAT 9(g). This includes adjusting the concentration, temperature and flow rate of the acid solution.	
g.	Ultrasonic cleaning	Cleaning using high-frequency vibrations to loosen the adhered contamination.	Applicability may be restricted by the type of process, the substrate or equipment to be cleaned and the type of contamination.
h.	Control and management of electrolyte consumption	See also BAT 9(g). In tin plating: Following the plating section, the strip passes through a rinsing section. To minimise the loss of electrolyte, the electrolyte is spray-rinsed with a dilute solution of PSA and tin. It is then returned to an electrolyte recirculation tank. An evaporator system is then used to condense the dilute electrolyte solution through evaporation, and it is then returned to the process for reuse. In acid zinc plating: An evaporator in a closed loop with a wet scrubber (for the plating cells), with the zinc electrolyte tanks and the plating rinse cells, concentrates the ions (Zn^{++}, $SO4^{--}$) in the residue and produces distilled water from the steam. The concentrated ions are reused and injected into the electrolyte while the distilled water is reused and injected into the different processes.	Generally applicable.

i.	Switching the polarisation of the electrodes in the electrolytic processes	See BAT 21 (b).	Only applicable in plants with bipolar electrodes.
j.	Optimisation of the anode-cathode gap	A mechanism of adjusting the gap as a function of the strip to be processed (width-thickness-flatness).	Generally applicable.
k.	Polishing the conductor roll	Oscillating abrasive blades ~~continuously~~ polish the conductor roll's surface, where needed, avoiding zinc and or nickel build-up.	
l.	Use of edge polishers	Removal of zinc dendrites formed at the strip edges in zinc electroplating cells equipped with low anode-cathode gaps.	
m.	Using edge masks	Edge masks move between the anode and the strip to avoid zinc dendrites and zinc build-up ~~overthrow~~ (when plating one side only) at the strip edges.	Applicability may be restricted if the anode-cathode gap is not wide enough.
n.	Optimised use of oil	Use of covered electrostatic oilers where the anticorrosive or deep drawing oil is heated and electrostatically deposited on the surface. The splashed oil is collected and reused.	Applicability in existing plants may be restricted by a lack of space.
o.	Maintenance of process solutions	See also BAT 9 (j). This includes: • cleaning and recirculation of degreasing solutions; • continuous filtering (removal of iron) and reuse of the zinc solution; • cleaning and regeneration of the phosphate solution; • cleaning and regeneration of the chromate solution.	Generally applicable.
p.	Recovery of residual tin from recirculation tanks	The tin from the recirculation tanks can be recovered through the use of a filter press that separates tin sludge from electrolyte within the tin line operation. Separated tin sludge contains approximately 60% tin and can be recovered externally.	

5.2.2.3 Energy efficiency

The environmental performance level for specific net energy consumption given below is ~~are~~ associated with the general BAT conclusions given in Section 5.1.3.

Table 5-7: BAT-associated environmental performance levels (BAT-AEPL~~s~~) for specific net energy consumption ~~at plant level~~ for continuous steel coil coating

Processes	Unit	BAT-AEPL (Yearly average)
Sum of all processes	kWh/t of coil coated	100 – 400

The associated monitoring is given in BAT 4.

5.2.2.4 Emissions to air

BAT 26. In order to prevent or reduce emissions to air of dust, Cr, Cr(VI), Ni, Zn and HCl in continuous steel coil coating, BAT is to collect the emissions using technique (a) and to treat the off-gases using one or a combination of the techniques (b) to (e) given below.

	Technique	**Description**	**Typical substance/parameter targeted**	**Applicability**
a.	~~Off-gas e~~Extraction of emissions as close as possible to the emission source	~~Off-gas extraction using, for example, enclosure, edge or lip extraction.~~ See Section 5.3.4.	All pollutants	Generally applicable.
b.	Wet scrubber	See Section 5.3.4.	Dust, ~~and~~ particulate-bound metals, acidic/alkaline emissions	
~~c.~~	~~Demister (mist filter)~~		~~Particulate-bound metals, e.g. chromium, acidic/alkaline emissions~~	
d.	Cyclone		Dust, ~~and~~ particulate-bound metals	
e.	Aerosol/droplet separator ~~Cartridge filter (fabric filter~~)		Dust, aerosols, acidic/alkaline emissions	

The ~~environmental performance~~ associated emission levels for emissions to air given below are also associated with the general BAT conclusions given in Section xx0.

Table 5-8: BAT-associated emission levels (BAT-AELs) and information on circumstances allowing the achievement of lower emission levels within the BAT-AEL range for channelled emissions to air of dust, Cr, Cr(VI), Ni, Zn and HCl for ~~steel~~ continuous steel coil coating

Substance/ parameter	**Associated process(es)**	**Unit**	**BAT-AEL (~~Daily average or~~ Average over the sampling period) (1)**	**Information on circumstances allowing the achievement of ~~the strictest end~~ lower emission levels within ~~of~~ the BAT-AEL range**
Dust	Degreasing, drying, ~~e~~E-coating, pickling, plating~~, rinsing~~	mg/Nm^3	~~2 – 4~~ 2 – 5	~~The strictest end of the range is typically achieved when using~~ Lower emission levels within the BAT-AEL range are expected with the use of a wet scrubber.
Cr	~~Drying, e~~E-coating, plating, rinsing		0.02 – ~~0.06~~ 0.1	
Cr(VI)	E-coating, plating, rinsing		0.01 – 0.05	
Ni	~~Degreasing, pickling,~~ E-coating, plating~~, rinsing~~		0.02 – 0.1	
Zn	~~Degreasing, e~~E-coating~~, pickling~~, plating~~, rinsing~~		0.2 – 0.5	
Gaseous chlorides, expressed as HCl	Pickling~~, plating, rinsing~~		2 – 5	
(1) The BAT-AEL only applies when the substance/parameter concerned is identified as relevant in the waste gas stream based on the inventory of inputs and outputs mentioned in BAT 0.b ~~Section~~				

The associated monitoring is given in BAT 5.

5.2.3 BAT conclusions for aluminium ~~coil, sheet~~ conversion coating and anodising

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 5.1.

5.2.3.1 Water consumption ~~and waste water discharge~~

The environmental performance level for specific net water consumption given below is~~are~~ associated with the general BAT conclusions given in Section 5.1.4.

Table 5-9: BAT-associated environmental performance level~~s~~ (BAT-AEPL~~s~~) for specific net water consumption ~~at plant level~~ for aluminium ~~coil, sheet~~ conversion coating and anodising

Processes	Unit	BAT-AEPL (Yearly average)
Sum of all processes	m^3/m^2 of treated surface	~~0.1 – 1~~ 0.05 – 0.25

The associated monitoring is given in BAT 4.

5.2.3.2 Material efficiency

BAT 27. In order to reduce the quantity of materials used and the quantity of residues generated in aluminium ~~coil, sheet~~ conversion coating and anodising, BAT is to use all of the techniques given below.

	Technique	Description	Applicability
a.	Recovery of caustic etch solution	A regeneration system recirculates the etch solution continuously between the etch tank and a separate crystalliser tank, where the etch solution is seeded with alumina crystals in a separate crystalliser tank. It is then possible to regenerate the etch solution without scale building up. The hydrated alumina crystals formed in the crystalliser settle out in a settlement section. Regenerated etch solution, with reduced aluminium and increased free caustic levels, is returned to the etch vat directly from the top of the crystalliser. Alumina crystals are withdrawn periodically from the bottom of the crystalliser and dewatered in a vacuum filter.	May not be applicable in cases where the use of additives to achieve a specific surface specification interferes with the process or prevents the reuse of the alumina.
b.	Agitation of process solution	Agitation of process solution (e.g. with air injection or hydraulic turbulence).	Generally applicable.
c.	Automatic systems for the preparation and dosing of process chemicals	See Section 5.3.3.	

5.2.3.3 Energy efficiency

BAT 28. In order to increase energy efficiency ~~reduce energy consumption~~ in aluminium ~~coil, sheet~~ conversion coating and anodising, BAT is to use medium-temperature sealing systems for anodising of aluminium instead of using higher-temperature methods.

Description

~~The hot water sealing method typically~~ Medium-temperature sealing systems operate~~s~~ at ~~a~~ temperatures ~~range~~ of 60 °C to 90 °C ~~90 °C to 100 °C., lower than some alternative~~ while higher-temperature sealing processes ~~that~~ require temperatures no lower than 95 °C ~~of up to 160 °C~~. In addition, it can be combined with the reuse of hot water available from other processes.

Applicability

Applicability may be restricted by product specifications.

The environmental performance levels for specific net energy consumption given below ~~are~~ is also associated with the general BAT conclusions given in Section 5.1.3.

Table 5-10: BAT-associated environmental performance level~~s~~ (BAT-AEPL~~s~~) for specific net energy consumption ~~at plant level~~ for aluminium ~~coil, sheet~~ conversion coating and anodising

Processes	Unit	BAT-AEPL (Yearly average)
Sum of all processes	kWh/m² of treated surface	50 – 200

The associated monitoring is given in BAT 4.

5.2.3.4 Emissions to air

BAT 29. In order to prevent or reduce emissions to air of dust, TVOC, HF, Cr, Cr(VI) and Ni in aluminium ~~coil, sheet~~ conversion coating and anodising, BAT is to collect the emissions using technique (a) and to treat the off-gases using one or a combination of the techniques (b) to (g) ~~(c)~~ given below.

	Technique	Description	Typical substance/parameter targeted	Applicability
a.	~~Off-gas e~~Extraction of emissions as close as possible to the emission source	~~Off-gas extraction using, for example, enclosure, edge or lip extraction.~~ See Section 5.3.4.	All pollutants	Generally applicable
b.	Adsorption	See Section 5.3.4.	TVOC	
c.	Demister ~~(mist filter)~~		Dust, ~~Particulate-bound metals, e.g. chromium,~~ liquid droplets, aerosols, mists, acidic/alkaline emissions	

d.	Aerosol/droplet separator		Dust, aerosols, acidic/alkaline emissions	
e.	Wet scrubber		Dust, ~~and~~ particulate-bound metals, acidic/alkaline emissions	
f.	Fabric filter		Dust, ~~and~~ particulate-bound metals	
g.	Cyclone			

The BAT-associated emission levels given below are also associated with the general BAT conclusions given in Section 5.1.8.

Table 5-11: BAT-associated emission levels (BAT-AELs) and information on circumstances allowing the achievement of lower emission levels within the BAT-AEL range for channelled emissions to air of dust, TVOC, HF, Cr, Cr(VI) and Ni for aluminium ~~coil, sheet~~ conversion coating and anodising

Substance/ parameter	**Associated processes**	**Unit**	**BAT-AEL (~~Daily average or a~~Average over the sampling period) ([1])**	**Information on circumstances allowing the achievement of ~~the strictest end~~ lower emission levels within ~~of~~ the BAT-AEL range**
Dust	Abrasive blasting, anodising, chemical milling, degreasing, drying, etching, lacquering, mechanical polishing, pickling, plating, rinsing	mg/Nm^3	2 – 5	~~The strictest end of the range is typically achieved when using~~ Lower emission levels within the BAT-AEL range are expected with the use of a wet scrubber or fabric filter.
TVOC	Anodising, degreasing, drying, etching, ~~heat treatment,~~ plating, stripping	mgC/Nm^3	~~5 – 20~~ 10 – 20	~~The strictest end of the range is typically achieved when using~~ Lower emission levels within the BAT-AEL range are expected with the use of a wet scrubber.
Gaseous fluorides expressed as HF	Anodising, degreasing, ~~e-coating,~~ etching, pickling, stripping	mg/Nm^3	~~0.1 – 1~~ 0.3 - 1	
Cr	Abrasive blasting, anodising, degreasing, ~~e-coating,~~ etching, pickling, stripping, plating, rinsing		0.02 – 0.1	~~The strictest end of the range is typically achieved when using~~ Lower emission levels within the BAT-AEL range are expected with the use of a wet scrubber or fabric filter.
Cr(VI)	Abrasive blasting, anodising, degreasing, etching, pickling, stripping, plating, rinsing		0.01 – 0.05	
Ni	Abrasive blasting, anodising, degreasing, ~~e-coating,~~ etching, pickling, stripping, plating, rinsing		~~0.01 – 0.1~~ 0.01 –0.05	

([1]) The BAT-AEL only applies when the substance/parameter concerned is identified as relevant in the waste gas stream based on the inventory of inputs and outputs mentioned in BAT 0.b ~~Section~~

The associated monitoring is given in BAT 5.

5.2.4 BAT conclusions for ~~sheet~~ processing ~~for~~of aluminium lithographic plates

[TWG, please provide information on specific BAT that apply in this sector]

5.2.5 BAT conclusions for porcelain (vitreous) enamelling of metals

The BAT conclusions and ET in this section apply in addition to the general BAT conclusions given in Section 5.1.

5.2.5.1 Water consumption ~~and waste water discharge~~

The benchmark for specific net ~~waste~~ water consumption given below ~~are~~ is associated with the general BAT conclusions given in Section 5.1.4.

Table 5-12: Benchmark for specific net water consumption ~~at plant level~~ for porcelain (vitreous) enamelling of metals

Processes	**Unit**	**Benchmark (Yearly average)**
Sum of all processes	m^3/m^2 of treated surface	< 0.01

The associated monitoring is given in BAT 4.

5.2.5.2 Material efficiency

BAT 30. In order to reduce the quantity of materials used and the quantity of residues generated in porcelain (vitreous) enamelling of metals, BAT is to use all of the techniques given below.

Technique		**Description**
a.	Optimisation of raw material consumption	This includes: • optimisation of the use of raw materials, such as enamel powder (minimising excess powder) and metal substrates; • use of recycled enamel; • optimisation of the metal surface preparation process.
b.	Optimisation of process control	This includes: • implementing advanced process control systems and monitoring including real-time data analysis; • predictive maintenance; • process automation. See BAT 9.
c.	Improvement of pickling efficiency	Agitation of process solution (e.g. with air injection or hydraulic turbulence).
d.	Optimisation of degreasing	See BAT 9 (i). This also includes the use of oil separators for the maintenance of degreasing solutions.
e.	Recovery of acids/alkalis	Spent treatment solutions with high acidity or alkalinity are recovered and used for on-site physico-chemical waste water neutralisation.

5.2.5.3 Energy efficiency

BAT 31. In order to increase energy efficiency in porcelain (vitreous) enamelling of metals, BAT is to use all of the techniques given below

a.

	Technique	Description	Applicability
a.	Selection of an energy-efficient type of furnace	See Section 5.3.1.	Only applicable to new plants and/or major plant upgrades.
b.	Furnace automation and control		Generally applicable.
c.	Techniques for maximising the thermal efficiency of furnaces		

5.2.5.4 Emissions to air

ET 2. In order ~~addition, the following emerging technique~~ to reduce emissions of cobalt and nickel to air from porcelain (vitreous) enamelling of metals, the following ET has been identified.

Emerging technique		Description	Applicability
a.	Adherence without NiO or CoO	Adherence of enamel on both carbon steel and stainless steel is achieved by applying an inorganic primer on the substrate just before enamelling. The primer contains a mixture of metal oxides, metal salts, metals, metallates and glasses. None of the components used contain nickel or cobalt.	Applicability may be restricted by product specifications.

5.2.6 BAT conclusions for printed circuit board (PCB) manufacturing

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 5.1.

5.2.6.1 Water consumption ~~and waste water discharge~~

The environmental performance level~~s~~ for specific net water consumption given below ~~are~~ is associated with the general BAT conclusions given in Section 5.1.4.

Table 5-13: ~~Benchmark~~BAT-AEPL for specific net water consumption ~~at plant level~~ for ~~printed circuit board~~ PCB manufacturing

Processes	Unit	~~Benchmark~~ BAT-AEPL (Yearly average)
Sum of all processes	m^3/m^2 of treated layer ~~final product~~	~~1 – 5 (¹)~~ 0.4 – 0.6
~~(¹) The upper end of the benchmark may be higher and up to 10 m^3/m^2 of final product in case of multi-layer PCB.~~		

The associated monitoring is given in BAT 4.

5.2.6.2 Material efficiency

BAT 32. In order to reduce the quantity of materials used and the quantity of residues generated in ~~printed circuit board~~PCB manufacturing, BAT is to use all of the techniques given below.

	Technique	Description	Applicability
a.	Optimisation of dry resist development	Monitoring and control of the concentration and temperature of the developer solution. When necessary, the developer solution is replenished by adding fresh solution.	Generally applicable.
b.	Optimisation of PCB electroplating	Use of direct air injection (bubbling), combined with oscillation and vibration of the boards. The panel is fixed in such a way as to ensure a reliable electrical contact and ~~in the lower part of the bath to ensure~~ an optimum exchange of electrolytes inside the holes. The individual baths are served by automatic carriers.	Generally applicable.
~~c.~~	~~Optimisation of dry resist development~~	~~Control of the concentration of the developer solution by regularly checking its conductivity, and conducting laboratory analysis. When necessary replenish it by adding fresh solution.~~	Generally applicable.
d.	Optimised oxide processes using less chemicals in the manufacturing of inner layers	Use of the brown oxide process ~~that~~ which consists of hydrogen peroxide, organic additives and chloride running at approximately 30 °C.	Generally applicable.
e.	Use of oxide-alternative techniques in the manufacturing of inner layers	This includes techniques such as direct metallisation, sputtering, pulse reverse plating, and atomic layer deposition.	Applicability may be restricted by process and product specifications.
f.	Etching optimisation	This includes:	

		• online monitoring and control of acidic etchant ~~and~~ (e.g. adjustment of HCl concentration); • online monitoring and control of alkaline etchant (e.g. adjustment of NH_3 concentration); • recirculation of the rinsing water of the first cascade into the acidic etching solution while the etching parameters are kept at a constant level.	Generally applicable.
g.	Laser direct imaging	A highly focused laser beam is used to directly expose the photoresist, creating the pattern without the need for a photomask or film.	
h.	High-density interconnects (HDIs)	HDI technology produces PCBs with a higher wiring density per unit area than traditional PCBs by using sequential lamination and laser drilling to form the microvias (tiny interlayer connections).	
i.	Embedded passives	The technology includes the direct integration of resistors, capacitors and inductors into the PCB layers or structure using techniques such as laser direct imaging, additive manufacturing or plating processes.	Applicability may be restricted by~~limited due to~~ product specifications (e.g. for complex or high-density designs).
j.	Recycling of alkali etchants ~~online~~ with copper recovery	The alkaline ammonia etching solution is regenerated and the dissolved copper is recovered on site in a closed loop.	Only applicable in systems using alkali copper etchants. Applicability in existing plants may be restricted by a low quantity of alkali etchant generated in the process.
k.	Tin recovery from stripping of etch tin resist	Recovery of tin contained in the precipitated sludge that results from the treatment of rinsing water and the concentrate.	Generally applicable.

5.2.6.3 Energy efficiency

BAT 33. In order to increase energy efficiency in ~~printed circuit board~~PCB manufacturing, BAT is to use all of the techniques given below.

	Technique	Description	Applicability
a.	Selection of an energy-efficient type of furnace	See Section 5.3.1.	Only applicable to new plants and/or major plant upgrades.
b.	Furnace automation and control		Generally applicable.
c.	Techniques for maximising the thermal efficiency of furnaces		

The environmental performance level for specific net energy consumption given below is also associated with the general BAT conclusions given in Section 5.1.3.

Table 5-14: BAT-associated environmental performance levels (BAT-AEPL~~s~~) for specific net energy consumption ~~at plant level~~ for ~~printed circuit board~~ PCB manufacturing

Processes	Unit	BAT-AEPL (Yearly average)
Sum of all processes	kWh/m[2] of treated layer ~~final product~~	115 – 370 ~~100 – 1 000~~

The associated monitoring is given in BAT 4.

5.2.6.4 Emissions to air

BAT 34. In order to prevent or reduce emissions to air of TVOC, HCl and NH_3 in PCB~~printed circuit board~~ manufacturing, BAT is to use techniques (a) (c) and ~~:~~

- ~~**use technique (a);**~~
- ~~**collect the emissions using technique (c); and**~~
- **~~treat the off-gases using~~ one or a combination of the techniques ~~(c)~~ (d) to ~~(e)~~ (f) given below.**

	Technique	Description	Typical substance/ parameter targeted	Applicability
a.	Substitution of high-VOC resins in the application of solder mask	Substitution of high-VOC resins with alternatives that have a low VOC~~—~~/high solid content or are VOC-free.	TVOC	~~Generally applicable~~ Applicability may be restricted by product specifications.
~~b.~~	~~Optimisation of solvent emissions from the application of solder mask~~	~~Use of lacquer systems with high solid content or the treatment of off-gases using, for example, condensation, thermal oxidation or biofiltration.~~	~~TVOC~~	
c.	~~Off-gas e~~Extraction of emissions as close as possible to the emission source	~~Off-gases are extracted using, for example, full enclosure, edge or lip extraction.~~ See section 5.3.4.	All pollutants	Generally applicable
d.	Wet scrubber	See Section 5.3.4.	~~Dust and particulate-bound metals,~~ Acidic/alkaline emissions	
e.	Biofilter		TVOC	
f.	Adsorption			

The BAT-associated emission levels given below are also associated with the general BAT conclusions given in Section 5.1.8.

Table 5-15: BAT-associated emission levels (BAT-AELs) and information on circumstances allowing the achievement of lower emission levels within the BAT-AEL range for channelled emissions to air of TVOC, HCl and NH_3 for ~~printed circuit board~~ PCB manufacturing

Substance/ parameter	Associated processes	Unit	BAT-AEL (~~Daily average or a~~Average over the sampling period)	Information on circumstances allowing the achievement of ~~the strictest end~~ lower emission levels within ~~of~~ the BAT-AEL range
TVOC	Cleaning, conditioning, degreasing, photoresist application, solder mask application, plating, photoresist developing, heat treatment	mg C/Nm³	~~3 – 10~~ 5 - 15	~~The strictest end of the range is typically achieved when using~~ Lower emission levels within the BAT-AEL range are expected with the use of low-VOC or VOC-free alternatives~~, or when using a wet scrubber~~.
Gaseous chlorides expressed as HCl	Descaling, etching, pickling, plating	mg/Nm³	2 – 5 (1)	~~The strictest end of the range is typically achieved when using a wet scrubber.~~
NH_3	Degreasing, descaling, etching, pickling, plating		~~3 – 10~~ 3 – 5 (1)	

(1) The BAT-AEL only applies when the substance/parameter concerned is identified as relevant in the waste gas stream based on the inventory of inputs and outputs mentioned in BAT 0.b ~~Section~~

The associated monitoring is given in BAT 5.

5.2.7 BAT conclusions for semiconductor manufacturing

The BAT conclusions in this section apply in addition to the general BAT conclusions given in Section 5.1.

5.2.7.1 Water consumption ~~and waste water discharge~~

BAT 35. In order to reduce water consumption and the quantity of waste water generated in semiconductor manufacturing, BAT is to use both of the techniques given below.

	Technique	Description
a.	Reuse of spent ultra-pure water	Reuse of spent ultra-pure water in other processes as cooling water (e.g. in chillers, pumps and other heat-generating processes).
b.	Use of closed cooling systems	See Section 5.3.2. ~~Water or a water-glycol mixture is circulated through a series of heat exchangers, chillers and cooling towers without the need for external water sources.~~

The environmental performance levels for specific net water consumption given below are also associated with the general BAT conclusions given in Section 5.1.4.

Table 5-16: BAT-associated environmental performance levels (BAT-AEPLs) for specific net water consumption ~~at plant level~~ for semiconductor manufacturing

Processes	Technology node	Unit	BAT-AEPLs (1) (yearly average)
Sum of all processes	> 22 nm	m^3/m^2 of wafer processed	50 – 130
	7 – 22 nm		80 – 210
	< 7 nm		150 – 400
(1) The BAT-AEPLs do not apply when the production volume is less than 35% of the production capacity.			

The associated monitoring is given in BAT 4.

5.2.7.2 Material efficiency

BAT 36. In order to reduce the quantity of materials used and the quantity of residues generated in semiconductor manufacturing, BAT is to use all of the techniques given below.

	Technique	Description
a.	Process optimisation	This includes: • optimisation of cleaning processes to reduce the consumption of acids, ~~and~~ ammonia and PFCs; • optimisation of etching processes to reduce the consumption of acids and PFCs; • optimisation of polishing processes to reduce the consumption of slurries and the generation of slurry~~ies~~ waste; • optimisation of physical vapour deposition (PVD) processes to reduce the consumption of gases ~~and liquids~~; • optimisation of chemical vapour deposition (CVD) processes to reduce the consumption of gases ~~and liquids~~; • optimisation of stripping processes to reduce the consumption of strippers; • automatic systems for the preparation and dosing of process chemicals.
b.	Maintenance of process solutions	See BAT 9 (j).
c.	Recovery of process metals	See BAT 9 (k).

5.2.7.3 Energy efficiency

BAT 37. In order to increase energy efficiency in semiconductor manufacturing, BAT is to use sealed containers.

Description

Use of specialised sealed containers (front-opening unified pods for 300 mm wafers or a standard mechanical interface) to transfer and store silicon wafers in enclosed clean conditions (class 1) without being exposed to the surrounding airflow. In this way, less energy is needed compared to maintaining the entire surrounding environment at class 1 conditions.

Applicability

Applicability of a standard mechanical interface may be restricted by the type of process chemicals used, by operational constraints (e.g. physical failure for thinned wafers) or by the type of wafer substrate used (e.g. silicon carbide (SiC), gallium nitride (GaN) or gallium arsenide (GaAs)).

The environmental performance level for specific net energy consumption given below is ~~are~~ also associated with the general BAT conclusions given in Section5.1.3.

Table 5-17: BAT-associated environmental performance level~~s~~ (BAT-AEPL~~s~~) for specific net energy consumption ~~at plant level~~ for semiconductor manufacturing

Processes	Unit	BAT-AEPL ([1]) (Yearly average)
Sum of all processes	MWh/m^2 of wafer processed	~~1 – 9~~ 5 – 20

([1]) The BAT-AEPL does not apply when the production volume is less than 50% of the production capacity.

The associated monitoring is given in BAT 4.

5.2.7.4 Substitution of hazardous substances

BAT 38. In order to reduce the environmental and health risks associated with the use of hazardous substances in semiconductor manufacturing, BAT is to use all of the techniques given below.

	Technique	Description	Applicability
a.	Use of lead-free alternatives	Lead-free solders typically containing tin (Sn), silver (Ag) and copper (Cu) as the primary components, with various additional elements such as bismuth (Bi), indium (In) and antimony (Sb), are used to improve properties like melting temperature, wetting and mechanical strength.	Applicability may be restricted by product specifications.
b.	Cyanide substitution	This includes the use of the following: • Thiourea(CH_4N_2S)-based processes. These involve the formation of soluble thiourea complexes, which can be easily separated from the metal ions and regenerated for reuse. • Thiosulphate-based processes. Sodium thiosulphate ($Na_2S_2O_3$) is used for the dissolution of gold and silver. The thiosulphate complexes can be reduced to elemental metal using a suitable reducing agent. • Ionic liquids. Room-temperature ionic liquids (RTILs) can be used as non-aqueous media for the dissolution of gold and silver. • Electrochemical processes, such as electroless deposition and electrodeposition. These involve the transfer of metal ions between an anode and cathode in an electrolyte solution, with the metal ions selectively deposited onto the cathode surface.	Generally applicable.
c.	Remote plasma chamber cleaning	A remote plasma is generated using an electric discharge in a chamber filled with NF_3 gas. The plasma breaks down the NF_3 molecules, generating highly reactive fluorine radicals that react with and remove organic and inorganic contaminants from the process chamber surface.	Applicability to existing plants may be restricted by design and/or operational constraints

5.2.7.5 Emissions to air

BAT 39. In order to prevent or reduce emissions of dust, TVOC, HCl, HF and NH_3 in semiconductor manufacturing, BAT is to collect the emissions using technique (a) and to treat the off-gases using one or a combination of the techniques (b) to (e) given below.

	Technique	Description	Typical substance/parameter targeted
a.	~~Off-gas e~~Extraction of emissions as close as possible to the emission source	~~Off-gases from various processes (e.g. solvent use, photoresist development) are extracted using local exhaust ventilation or general exhaust systems.~~ See section 5.3.4. Depending on ~~their~~ the emissions composition, extracted off-gases are treated separately (point-of-use abatement) and/or combined ~~at~~ in a centralised abatement system.	All pollutants

b.	Wet scrubber	See Section 5.3.4.	Dust ~~and particulate-bound metals~~, acidic/alkaline emissions
c.	Thermal oxidation		Organic compounds (e.g. TVOC, GHGs)
d.	Adsorption		TVOC
e.	Absolute filter		Dust

The BAT-associated emission levels given below are also associated with the general BAT conclusions given in Section 5.1.8.

Table 5-18: BAT-associated emission levels (BAT-AELs) and information on circumstances allowing the achievement of lower emission levels within the BAT-AEL range for channelled emissions to air of dust, TVOC, HCl, HF and NH_3 for semiconductor manufacturing

Substance / Parameter	Associated process	Unit	BAT-AEL (~~Daily average or a~~Average over the sampling period)	Information on circumstances allowing the achievement of ~~the strictest end~~ lower emission levels within ~~of~~ the BAT-AEL range
Dust	Back grinding, planarisation, ~~lithography,~~ metal plating, wet etching	mg/Nm^3	~~1–3~~ 2 – 4 (1)	~~The strictest end of the range is typically achieved when using a wet scrubber.~~ Lower emission levels within the BAT-AEL range are expected for new installations.
TVOC	~~Diffusion functional area, l~~Lithography, etching, chemical vapour deposition~~,~~ ~~metal plating~~	mg C/Nm^3	5 – 15	~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when ~~using~~ thermal oxidation is used ~~or a wet scrubber~~.
Gaseous chlorides expressed as HCl	Diffusion functional area, etching~~,~~ ~~lithography, metal plating~~	mg/Nm^3	~~0.2 – 2~~ 1 – 4 (1)	~~The strictest end of the range is typically achieved~~ Lower emission levels within the BAT-AEL range are expected when ~~using a~~ wet scrubber is used.
Gaseous fluorides expressed as HF	Chemical vapour deposition, etching, cleaning of equipment, metal plating, thermal oxdidation of PFCs	mg/Nm^3	0.1 – 0.5 (1)	
NH_3	Chemical vapour deposition, diffusion functional area, lithography, metal plating, etching	mg/Nm^3	~~0.2 – 2~~ 0.2 – 2.5 (1)	

(1) The BAT-AEL only applies when the substance/parameter concerned is identified as relevant in the waste gas stream based on the inventory of inputs and outputs mentioned in BAT 0.b ~~Section~~

The associated monitoring is given in BAT 5.

BAT 40. In order to reduce NO_X emissions in waste gases while limiting CO emissions from the thermal treatment of off-gases in semiconductor manufacturing, BAT is to use technique (a) or both of the techniques given below.

	Technique	Description	Applicability
a.	~~Optimised combustion~~Combustion optimisation	See Section 5.3.4.	Generally applicable.
b.	Use of low-NO_X burners		Applicability to existing plants may be restricted by design and/or operational constraints. May not be applicable to point-of-use abatement.

Table 5-19: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of NO_X for semiconductor manufacturing

Parameter	Associated process	Unit	BAT-AEL ~~(Daily average or~~ ~~a~~Average over the sampling period)	~~Circumstances allowing the achievement of the strictest end of the BAT-AEL range~~
NO_X	Thermal treatment of off-gases	mg/Nm^3	~~20~~ 30 – 100 (1)	~~The strictest end of the range is typically achieved when using a low-NO_X burner.~~

(1) For existing plants with point-of-use abatement systems, the higher end of the BAT-AEL range may be higher and up to 200 mg/Nm^3.

The associated monitoring is given in BAT 5.

5.3 Descriptions of techniques

5.3.1 Techniques to increase energy efficiency

Technique	Description
Cogeneration	Combined generation of heat and electricity where the heat (mainly from the steam that leaves the turbine) is used for producing hot water/steam to be used in industrial processes/activities or in a district heating/cooling network.
Furnace automation and control	The heating process is optimised by using a computer system controlling key parameters such as furnace and feedstock temperature, air to fuel ratio and the furnace pressure.
Heat recovery	This includes: • recovery of excess heat from cooling systems such as chillers and cooling towers to be used, for example, for space heating or evaporation of waste water; • recovery of excess heat from once-through cooling water to utilise the heat gained, for instance in rinsing prior to drying; • recovery of excess heat from processes (e.g. coating ovens) to be used to heat the building; • recovery of excess heat from exhaust gases (e.g. regenerative catalytic thermal oxidation) to be used used to preheat incoming off-gases. In aluminium anodising, the heat of spent sealing solutions can be used to heat the water used for a new sealing process, either by using a heat exchanger or by piping the incoming cold water through the hot sealing solution.
Optimisation of process solution agitation, conductivity and composition	This includes: • reducing the surface treatment duration by process solution agitation using, for example, hydraulic turbulence; • reducing the heating temperature by substituting chemicals, e.g. galvanic chemicals; • increasing the conductivity of the process solution by using additives or by process solution maintenance.
Process line optimisation	Optimisation of process line operation, i.e. calculating the inputs required and outputs generated (use of raw materials, energy and water; emissions to water and residues generation) and adjusting the process parameters appropriately. This may include the use of software modelling tools, e.g. software simulation for jigging or barrel processing.
Selection of an energy-efficient type of furnace	Furnace energy efficiency is taken into consideration for the furnace selection, e.g. furnaces that allow the preheating and drying of incoming charge before it enters the main processing (e.g. melting, curing) zone. ~~prior to the melting zone.~~
Techniques for maximising the thermal efficiency of furnaces	Measures taken to maximise the efficiency of energy conversion furnaces while minimising emissions. This is achieved by applying a series of process optimisation measures according to the furnace type including optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and residence time in the combustion zone, and use of furnace automation and control (see above).

5.3.2 Techniques to reduce water consumption and waste water discharge

Technique	Description
Advanced process monitoring and control systems	The regular monitoring and control of processes by collecting and analysing key process parameters to reach optimal process conditions (e.g. optimal uptake of process chemicals, electrolytic cleaning with pH control). This is carried out by, for example, on-line automated systems equipped with sensors and controllers and/or sampling and laboratory analysis. Key process parameters include: • level, pH, temperature and conductivity of the treatment vats; • chemical composition of the treatment vats.

Drag-in reduction	Techniques to reduce drag-in include the use of: • the eco-rinse (or pre-dip) technique (see Section 5.3.3); • air knives or wiper rollers to remove as much rinsing water as possible from sheet and coil substrates.
Drag-out reduction	Techniques to reduce drag-out include the use of: • the eco-rinse (or pre-dip) technique (see Section 5.3.3); • evaporation using either the surplus internal energy released from the process tank or additional heat; • electrodialysis (electric dialysis); anions and cations are removed from solutions ~~with an applied~~ by applying an electric field in cells with alternating anion- and cation-permeable membranes; • 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; • closed-loop system, e.g. for Cr(VI) and PFAS recycling in chromium plating (see Section 5.1.6~~1.5.3~~); • compatible chemicals (use of the same acid in pickling or activating the surface prior to an acid-based plating process); • proper arrangement of workpieces at the jigs; • specific processes in barrel processing, e.g. proper design of the perforated area, intermittent rotation of the barrel above the process tank while draining, application of draining ledges within the barrels, blowing excess solution out of the barrel while draining over the treatment vat.
Multiple rinsing with rinsing water recirculation	In multiple rinsing, rinsing water from the subsequent rinsing steps is returned to be used in the previous rinsing steps.
~~Recirculation of rinsing water from etching and surface treatment to the treatment vats~~	~~Rinsing water from etching and surface treatment is collected and undergoes treatment to remove contaminants. The treated water is then returned to the treatment vats.~~
Use of closed cooling systems	~~Closed cooling systems use a secondary system, such as refrigeration, for cooling the recirculating coolant in the primary system.~~ Use of cooling systems in which the coolant circulates in a sealed loop and is not exposed to the atmosphere or continuously consumed during operation.

5.3.3 Techniques to increase material efficiency

Technique	Description
Advanced process monitoring and control systems	See Section 5.3.2.
Automatic systems for the preparation and dosing of process chemicals	Automatic systems are used for weighing, dosing, dissolving, measuring and dispensing process chemicals.
Cascade (multiple) use and/or reuse of degreasing solution	Reuse of the degreasing solution, or use of the degreasing solution in a cascade mode, to extend its lifetime. The solution from the electrolytic degreasing section is reused once a certain oil level is reached, either in the spray section of coil lines, or in the first degreasing section of other lines. The spent degreasing solution of the spray section can be regenerated.
Closed loop for Cr(VI) and PFAS recycling	Design and operation of hexavalent Cr(VI) plating as a closed-loop system for chromium and PFAS recycling by using a combination of powerful exhaust air systems, cascade rinsing, ion exchange and spray tower evaporators.
Drag-in reduction	See Section 5.3.2.
Drag-out reduction	See Section 5.3.2.
Eco-rinse (or pre-dip)	Drag-out from process solutions working at (but not limited to) ambient temperature can be partially recovered through a single rinse station in which the workload is dipped before and after being processed.

5.3.4 Techniques to reduce emissions to air

Technique	Description
Absolute filter	Absolute filters, also referred to as high-efficiency particle air (HEPA) filters or ultra-low penetration air (ULPA) filters, are constructed from glass cloth or fabrics of synthetic fibres through which gases are passed to remove particles. Absolute filters show higher efficiencies than fabric filters. The classification of HEPA and ULPA filters according to their performance is given in EN 1822-1.
Adsorption	The removal of pollutants from a process off-gas or waste gas stream by retention on a solid surface (activated carbon is typically used as the adsorbent). Adsorption may be regenerative or non-regenerative. Adsoption may also be used as a technique to concentrate TVOC emissions before further abatement.
Aerosol/droplet separator	A filler material is used to condense aerosols and droplets. Condensate is usually treated in a waste water treatment plant.
Biofilter	The waste gas stream is passed through a bed of organic material (such as peat, heather, compost, root wood, tree bark, softwood and different ~~kinds of~~ combinations of these) or some inert material (such as clay, activated carbon, and polyurethane), where it is biologically oxidised by naturally occurring microorganisms into carbon dioxide, water, inorganic salts and biomass.
Catalytic oxidation	Abatement technique which oxidises combustible compounds in a waste gas stream with air or oxygen on a catalyst bed. The catalyst enables oxidation at lower temperatures and in smaller equipment compared to thermal oxidation. The typical oxidation temperature is between 200 °C and 600 °C.
~~Optimised combustion~~ Combustion optimisation	Measures taken to maximise the efficiency of energy conversion while minimising emissions. Good design of the combustion chambers, burners and associated equipment/devices is combined with the optimisation of combustion conditions (e.g. the temperature and residence time in the combustion zone, flame stability, efficient mixing of the fuel and combustion air) and the regular planned maintenance of the combustion system according to suppliers' recommendations. Combustion conditions control is based on the continuous monitoring and automated control of appropriate combustion parameters (e.g. O_2, CO, fuel to air ratio, and unburnt substances).~~Good design of the combustion chambers, burners and associated equipment/devices is combined with optimisation of combustion conditions (e.g. the temperature and residence time in the combustion zone, efficient mixing of the fuel and combustion air) and regular planned maintenance of the combustion system according to suppliers' recommendations.~~
Cyclone	Equipment for the removal of dust from an off-gas stream based on imparting centrifugal forces, usually within a conical chamber. Cyclones are mainly used as a pretreatment before further dust abatement or abatement of organic compounds. Multic~~C~~yclones may also be used.~~ can be applied alone or as multicyclones.~~
Demister	Demisters are filter devices that remove entrained liquid droplets from a gas stream. They consist of a woven structure of metal or plastic wires, with a high specific surface area. Through their momentum, small droplets present in the gas stream impinge against the wires and coalesce into bigger drops.
Extraction of emissions as close as possible to the emission source	Emissions are captured and extracted using, for example, full enclosure, fixed or movable extraction hoods, lids or edge extraction. The collected emissions may be treated by an abatement system before being released.
Fabric filter	Fabric filters, often referred to as bag filters, are constructed from porous woven or felted fabric through which gases are passed to remove particles. Fabric filters can be in the form of sheets, cartridges or bags with a number of individual fabric filter units housed together in a group. The use of a fabric filter requires the selection of a fabric suitable for the characteristics of the waste gas and the maximum operating temperature.
Furnace automation and control	See Section 5.3.1.
~~Low-NO~~$\cancel{_X}$ ~~burner~~	~~The technique (including ultra-low-NO~~$\cancel{_X}$ ~~burners) is based on the principles of reducing peak flame temperatures. The air to fuel ratio adjustment reduces the availability of oxygen and reduces the peak flame temperature, thus retarding the~~

	~~conversion of fuel-bound nitrogen to NO_X and the formation of thermal NO_X, while maintaining high combustion efficiency.~~
Selection of an appropriate furnace type	Selection of (an) appropriate furnace type(s) based on the level of emissions and technical criteria, e.g. type of process such as continuous or batch production, furnace capacity, type of castings, availability of raw materials, flexibility depending on raw materials' cleanliness and alloy change. The energy efficiency of the furnace is also considered (see technique 'Selection of an energy-efficient type of furnace' in Section 5.3.1).
Thermal oxidation	Abatement technique which oxidises combustible compounds in a 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. The typical combustion temperature is between 800 °C and 1 000 °C. Several types of thermal oxidation are operated: • Straight thermal oxidation: thermal oxidation without energy recovery from the combustion. • Recuperative thermal oxidation: thermal oxidation using the heat of the waste gases by indirect heat transfer. • Regenerative thermal oxidation: thermal oxidation where the incoming waste gas stream is heated when passing through a ceramic-packed bed 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.
Wet scrubber	The removal of gaseous or particulate pollutants from a process off-gas or waste gas stream via mass transfer to a suitable liquid, often water or an aqueous solution. It may involve a chemical reaction (e.g. in an acid or alkaline scrubber).

5.3.5 Techniques to reduce emissions to water

Technique	Description
Activated sludge process	In the activated sludge process, the microorganisms are maintained as a 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.
Adsorption	The removal of soluble substances (solutes) from the waste water by transferring them to the surface of solid, highly porous particles (typically activated carbon).
Chemical oxidation	Chemical oxidation is the conversion of pollutants by chemical-oxidising agents other than oxygen/air or bacteria into similar but less harmful or hazardous compounds and/or to short-chained and more easily degradable or biodegradable organic components. Ozone is one example of a chemical-oxidising agent applied.
Chemical precipitation	The conversion of dissolved pollutants into ~~an~~ insoluble compounds 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.
Chemical reduction	The conversion of pollutants by chemical reducing agents into similar but less harmful or hazardous compounds. The reduction of Cr(VI) is achieved at pH values under 2.5. The most common reducing agent is sodium hydrogen sulphite (bisulphite).
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.
Crystallisation	Waste water treatment technique used to separate and remove dissolved solids by converting them into solid crystals. It involves controlled cooling, evaporation, or

	chemical reactions to promote the formation of crystals, which are removed from the water through filtration or sedimentation
Electrodialysis	Use of electric potential difference properties to transport salt ions from one solution to another solution through ion-exchange membranes.
Electrolysis	Passage of a direct electric current through an ionic substance, resulting in chemical reactions at the electrodes. The ionic substance is either molten or dissolved in a suitable solvent.
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.
Evaporation	Evaporation of waste water is a distillation process where water is the volatile substance, leaving the concentrate as bottom residue to be handled (e.g. recycled or disposed of). The aim of this operation is to reduce the volume of waste water or to concentrate mother liquors. The volatile steam is collected in a condenser and the condensed water is, if necessary after subsequent treatment, recycled. There are many types of evaporators: natural circulation evaporators; short-tube vertical evaporators; basket-type evaporators; falling film evaporators; agitated thin film evaporators. Typical pollutants targeted are soluble contaminants (e.g. salts).
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.
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.
Membrane bioreactor (MBR)	A MBR consists of the combination of a membrane process (e.g. microfiltration or ultrafiltration) with a suspended growth bioreactor. In a MBR system for biological waste water treatment, the secondary clarifier and the tertiary filtration step of a traditional aerated sludge system are replaced by membrane filtration (the separation of sludge and suspended solids).
Nanofiltration	A filtration process in which membranes with pore sizes of approximately 1 nm are used.
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.
Nitrification/ denitrification	Part of the organic nitrogen is transformed into ammonium. Ammonium is oxidised by nitrifying bacteria into nitrite and nitrate. By implementing ~~applying~~ anaerobic periods, the nitrate can be transformed into N_2 in the presence of organic carbon. In a secondary basin, the sludge settles, with part of it being reused in the aeration basin. The residue can be used as fertiliser (composted or not) after concentration.
Physical separation	The separation of gross solids, suspended solids or metal particles from the waste water using for example screens, sieves, grit separators, grease separators, hydrocyclones, oil-water separation or primary settlement tanks.
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.
Sedimentation	The separation of suspended particles and suspended material by gravitational settling.
Segregation of water streams	Water streams (e.g. surface run-off water, process water) are collected separately, based on the pollutant content and on the required treatment techniques. Waste water streams that can be recycled without treatment are segregated from waste water streams that require treatment.

~~5.3.6 Techniques to reduce waste generation and promote circular economy~~

~~Technique~~	~~Description~~
~~Advanced process monitoring and control systems~~	~~See Section 5.3.2.~~
~~Automatic systems for the preparation and dosing of process chemicals~~	~~See Section 5.3.3.~~
~~Process line optimisation~~	~~See Section 5.3.1.~~

[The whole section is strikethrough. The following contents are moved to their corresponding sections above]

~~5.4 Content of the Environmental Management System (EMS)~~

[This section was moved and updated in Section 5.1.1 – See BAT 0.a]

~~According to Articles 14a (1) and 14a (2) of the Industrial Emissions Directive, the EMS shall include the following elements and shall comply with relevant BAT conclusions that determine aspects to be covered in the EMS:~~

- ~~(a) environmental policy objectives for the continuous improvement of the environmental performance and safety of the installation, which shall include measures to:~~
  - ~~(i) prevent the generation of waste;~~
  - ~~(ii) optimise resource and energy use and water reuse;~~
  - ~~(iii) prevent or reduce the use or emissions of hazardous substances;~~
- ~~(b) objectives and performance indicators in relation to significant environmental aspects, which shall take into account benchmarks set out in the relevant BAT conclusions;~~
- ~~(c) for installations covered by the obligation to conduct an energy audit or implement an energy management system pursuant to Article 8 of Directive 2012/27/EU, inclusion of the results of that audit or implementation of the energy management system pursuant to Article 8 of and Annex VI to that Directive and of the measures to implement their recommendations;~~
- ~~(d) a chemicals inventory of the hazardous substances present in or emitted from the installation as such, as constituents of other substances or as part of mixtures, with special regard given to the substances fulfilling the criteria referred to in Article 57 of Regulation (EC) No 1907/2006 and substances addressed in restrictions referred to in Annex XVII to Regulation (EC) No 1907/2006, and a risk assessment of the impact of such substances on human health and the environment, as well as an analysis of the possibilities for substituting them with safer alternatives or reducing their use or emissions;~~
- ~~(e) measures taken to achieve the environmental objectives and avoid risks for human health or the environment, including corrective and preventive measures where needed;~~
- ~~(f) a transformation plan as referred to in Article 27d.~~

~~The aspects in the following sections are to be covered in the EMS, in addition to the elements listed above.~~

~~According to Article 14a (3), the level of detail of the EMS shall be consistent with the nature, scale and complexity of the installation, and the range of environmental impacts it could have. Where elements required to be included in the EMS, including objectives, performance indicators or measures, have already been developed in accordance with other relevant Union legislation and comply with this Article 14a, a reference in the EMS to the relevant documents shall be sufficient.~~

~~5.4.1 General aspects~~

~~The following general aspects are to be covered in the environmental management system (EMS):~~

- ~~i. Commitment, leadership, and accountability of the management, including senior management, for the implementation of an effective EMS.~~

ii. ~~An analysis that includes the determination of the organisation's context, the identification of the needs and expectations of interested parties, the identification of characteristics of the installation that are associated with possible risks for the environment and human health as well as of the applicable legal requirements relating to the environment and human health.~~
iii. ~~Determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed.~~
iv. ~~Ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g. by providing information and training).~~
v. ~~Internal and external communication on the environmental performance of the installation.~~
vi. ~~Fostering employee involvement in good environmental management practices.~~
vii. ~~Establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records.~~
viii. ~~Effective operational planning and process control.~~
ix. ~~Implementation of appropriate maintenance programmes.~~
x. ~~Emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations.~~
xi. ~~When (re)designing a (new) installation or a part thereof, consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning.~~
xii. ~~Implementation of a monitoring and measurement programme; if necessary, information can be found in the Reference Report on Monitoring of Emissions to Air and Water from IED Installations.~~
xiii. ~~Application of sectoral benchmarking on a regular basis.~~
xiv. ~~Following and taking into account the development of cleaner techniques.~~

~~5.4.1.1 Benchmarks for the surface treatment of metals and plastics industry~~

~~Benchmarks for the surface treatment of metals and plastics industry are included in **Table 5-12:**~~ **Benchmark for specific net water consumption ~~at plant level~~ for porcelain (vitreous) enamelling of metals**

~~and **Table 5-13**.~~

[This section was moved and updated in Section 5.1.1 – See BAT 0.a]

~~5.4.2 Inventory of inputs and outputs~~

[This section was moved and updated in Section 5.1.1 – See BAT 0.b]

~~In order to improve the overall environmental performance, an inventory of inputs and outputs is set up, implemented and regularly reviewed. The inventory of inputs and outputs incorporates at least the following features:~~

~~(i) information about the production processes, including:~~
~~(a) simplified process flow sheets that show the origin of the emissions to air, water and soil and the associated emission point(s);~~

~~(b) descriptions of process integrated techniques and waste water/waste gas treatment techniques to prevent or reduce emissions, including their performance (e.g. abatement efficiency);~~

~~(ii) information about the quantity and characteristics of raw materials and fuels used;~~

~~(iii) information about water consumption and usage (e.g. flow diagrams and water mass balances);~~

~~(iv) information about energy consumption and usage;~~

~~(v) information about the characteristics of the waste water streams, such as:~~

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

~~(b) average concentration and mass flow values of relevant substances/parameters (e.g. total suspended solids, TOC or COD, hydrocarbon oil index, metals) and their variability;~~

~~(c) presence of substances classified as CMR 1A, CMR 1B or CMR 2; the presence of such substances may for example be assessed according to the criteria of Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP);~~

~~(vi) information about the quantity and characteristics of the process chemicals used (e.g. PFAS):~~

~~(a) the identity and the characteristics of process chemicals, including properties with adverse effects on the environment and/or human health;~~

~~(b) the quantities of process chemicals used and the location of their use;~~

~~(vii) information about the characteristics of the waste gas streams, such as:~~

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

~~(b) average concentration and mass flow values of relevant substances (e.g. dust, alkaline:acidic emissions,~~ ~~NO_X, SO_X, metals) and their variability;~~

~~(c) presence of other substances that may affect the waste gas treatment system (e.g. oxygen, nitrogen, water vapour) or installation safety;~~

~~(d) information about the quantity and origin of greenhouse gas (GHG) emissions;~~

~~(e) presence of substances classified as CMR 1A, CMR 1B or CMR 2; the presence of such substances may for example be assessed according to the criteria of Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP);~~

~~(viii) information about the quantity and characteristics of residues generated.~~

~~5.4.3 Chemicals management system~~

[This section was moved and updated in Section 5.1.1 – See BAT 0.c]

~~In order to improve the overall environmental performance, a chemicals management system (CMS) is set up, implemented and regularly reviewed. The CMS incorporates at least the following features:~~

i. ~~Information about the quantity and characteristics of the process chemicals used:~~
   ~~(a) the identity and the characteristics of the process chemicals, including properties with adverse effects on the environment and/or human health;~~
   ~~(b) the quantities of the process chemicals used and the location of their use.~~

ii. ~~A policy to reduce the consumption of and risks associated with process chemicals, including a procurement policy to select less harmful process chemicals and their suppliers with the aim of minimising the use of and risks associated with hazardous substances, with special regard given to the substances fulfilling the criteria referred to in Article 57 of Regulation (EC) No 1907/2006 and substances addressed in restrictions referred to in Annex XVII to Regulation (EC) No 1907/2006, as well as to avoid the procurement of an excess amount of process chemicals. The selection of process chemicals is based on:~~

a) ~~the comparative analysis of their bioeliminability/biodegradability, eco-toxicity and potential to be released into the environment in order to reduce emissions to the environment;~~

b) ~~the characterisation of the risks associated with the process chemicals, based on the chemicals' hazard classification, pathways through the plant, potential release and level of exposure and including the requirements of Article 14a 2 (d);~~

c) ~~the potential for recovery and reuse (see BAT 10);~~

d) ~~the regular (e.g. annual) analysis of the potential for substitution with the aim to identify potential new available and safer alternatives to the use of hazardous substances; this may be achieved by changing process(es) or using other process chemicals with no or lower impacts on the environment and/or the human health (see BAT 10) and including the requirements of Article 14a 2 (d);~~

e) ~~the anticipatory monitoring of regulatory changes related to hazardous substances, and the safeguarding of compliance with applicable legal requirements.~~

~~The inventory of process chemicals (see Section) may be used to provide and keep the information needed for the selection of process chemicals.~~

iii. ~~Goals and action plans to avoid or reduce the use of and risks associated with hazardous substances.~~

iv. ~~Development and implementation of procedures for the procurement, handling, storage and use of process chemicals, disposal of waste containing process chemicals and return of unused process chemicals, to prevent or reduce emissions to the environment (e.g. see).~~

~~5.4.4 Risk-based OTNOC management plan~~

[This section was moved and updated in Section 5.1.1 – See BAT 0.d]

~~In order to improve the overall environmental performance, a risk management plan is set up, implemented and regularly reviewed. The risk-based OTNOC management plan includes at least the following features:~~

i. ~~identification of potential OTNOC (e.g. failure of equipment critical to the protection of the environment ('critical equipment')), of their root causes and of their potential consequences;~~

ii. ~~appropriate design of critical equipment (e.g. off-gas treatment, waste water treatment);~~

iii. ~~set-up and implementation of an inspection plan and preventive maintenance programme for critical equipment (see Section 5.4.1 ix.);~~

iv. ~~monitoring (i.e. estimating or, where possible, measuring) and recording of emissions during OTNOC and of associated circumstances;~~

v. ~~periodic assessment of the emissions occurring during OTNOC (e.g. frequency of events, duration, amount of pollutants emitted) and implementation of corrective actions if necessary;~~

vi. ~~regular review and update of the list of identified OTNOC under point i. following the periodic assessment of point v.;~~

vii. ~~implementation of backup systems (where appropriate) and regular testing of them.~~

~~5.4.5 Plan for the prevention and control of leaks and spillages~~

[This section was moved and updated in Section 5.1.1 – See BAT 0.e]

~~In order to improve the overall environmental performance, a plan for the prevention and control of leaks and spillages is set-up, implemented and regularly reviewed. The plan for prevention and control of leaks and spillages includes at least the following features:~~

- ~~site incident plans for small and large spillages;~~
- ~~identification of the roles and responsibilities of persons involved;~~
- ~~ensuring staff are environmentally aware and trained to prevent and deal with spillage incidents;~~
- ~~identification of areas at risk of spillage and/or leaks of hazardous materials and substances, and ranking them according to the risk;~~
- ~~identification of suitable spillage containment and clean-up equipment and regularly ensuring it is available, in good working order and close to points where these incidents may occur;~~
- ~~waste management guidelines for dealing with waste arising from spillage control;~~
- ~~prompt repair of leaks from valves, glands, flanges, etc.;~~
- ~~regular inspections (at least on a monthly basis) of storage and handling areas, testing and calibration (at least on an annual basis) of leak detection equipment and prompt repair of leaks from valves, glands, flanges, etc.~~

~~5.4.6 Energy efficiency plan~~

[This section was moved and updated in Section 5.1.3 – See BAT 7.0]

~~In order to improve the overall environmental performance, an energy efficiency plan is set-up, implemented and regularly reviewed. The energy efficiency plan entails defining and monitoring the specific energy consumption/usage of the plant/process (e.g. kWh/t of workpieces treated), setting objectives in terms of energy efficiency and implementing actions to achieve these objectives.~~

~~5.4.7 Residues management plan~~

[This section was moved and updated in Section 5.1.7 – See BAT 10 ter]

~~In order to improve the overall environmental performance, a residues management plan is set-up, implemented and regularly reviewed. The residues management plan entails defining and monitoring the quantity and characteristics of residues generated by the plant/process (e.g. kg/t of workpieces treated).~~

~~The residues management plan comprises a set of measures aiming to:~~

- ~~minimise the generation of residues;~~
- ~~optimise the reuse~~, recycling and/or recovery of residues;
- ~~ensure the proper disposal of waste.~~

~~5.4.8 Water management plan~~

[This section was moved and updated in Section 5.1.4 – See BAT 8.0]

~~In order to improve the overall environmental performance, a water management plan is set-up, implemented and regularly reviewed. The water management plan entails defining and~~

~~monitoring the specific water consumption/usage of the plant/process (e.g. m^3/t of workpiece treated) and incorporates at least the following features:~~

- ~~flow diagrams and water mass balances of the plant as part of the inventory of inputs and outputs mentioned in Section;~~
- ~~establishment of water efficiency~~ objectives;
- ~~implementation~~ of water optimisation techniques (e.g. control of water usage, reuse/recycling, detection and repair of leaks).

~~5.4.9 Noise management plan~~

[This section was moved and updated in Section 5.1.10 – See BAT 16 bis]

~~As part of the EMS and in order to improve the overall environmental performance, a noise management plan is set up, implemented and regularly reviewed. The noise management plan includes at least the following features:~~

- ~~a protocol containing appropriate actions and timelines;~~
- ~~a protocol for monitoring of noise emissions;~~
- ~~a protocol for responding to identified noise events, e.g. managing complaints and/or taking corrective actions;~~
- ~~a noise reduction programme designed to identify the source(s), to measure/estimate noise exposure, to characterise the contributions of the sources to the overall noise emissions and to implement prevention and/or reduction measures.~~

~~Applicability~~
~~The applicability is restricted to cases where a noise nuisance at sensitive receptors is expected and/or has been substantiated.~~

~~5.4.10 Odour management plan~~

[This section was moved and updated in Section 5.1.9 – See BAT 15 bis]

~~As part of the EMS and in order to improve the overall environmental performance, an odour management plan is set up, implemented and regularly reviewed. An odour management plan includes at least the following features:~~

- ~~A protocol containing appropriate actions and timelines.~~
- ~~A protocol for conducting odour monitoring. The protocol may be complemented by measurement/estimation of odour exposure or estimation of odour impact.~~
- ~~A protocol for response to identified odour incidents, e.g. managing complaints and/or taking corrective actions.~~
- ~~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.~~

~~Applicability~~
~~The applicability is restricted to cases where an odour nuisance at sensitive receptors is expected and/or has been substantiated.~~