4 REVISED BEST AVAILABLE TECHNIQUES (BAT) CONCLUSIONS FOR COMMON WASTE GAS MANAGEMENT AND TREATMENT SYSTEMS IN THE CHEMICAL SECTOR (APRIL 2021)

Colour code used in this document

Black: Text from Draft 1 (D1)
~~Orange:~~ Text deleted in the revised draft BAT conclusions

Blue: New text in the revised draft BAT conclusions for the TWG Final Meeting taking into account the comments received on D1

[Black italics and highlighted in yellow]: Explanatory notes and comments for the attention of the TWG

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Scope

These BAT conclusions concern the following activity specified in Annex I to Directive 2010/75/EU: 4. Chemical industry.

More specifically, these BAT conclusions focus on emissions to air from the aforementioned activity.

These BAT conclusions cover the following in particular:

- Channelled emissions to air from the production of the following chemicals in continuous processes where the total production capacity of those chemicals exceeds 20 kt/yr:
    - aromatics: production of benzene, toluene, ortho-, meta- and para-xylene as well as cyclohexane from the pygas by-product of steam crackers and from reformate/naphtha produced in catalytic reformers;
    - ethylbenzene;
    - styrene monomer, produced either by ethylbenzene dehydrogenation or by co-production with propylene oxide;
    - ethanolamines.
- Channelled emissions to air of nitrogen oxides (NO_X) and carbon monoxide (CO) from thermal treatment.
- This includes channelled emissions from thermal treatment of waste gases originating from the production of large volume organic chemicals covered by the BAT conclusions for the Production of Large Volume Organic Chemicals (LVOC).
- Channelled emissions to air from process furnaces/heaters with a total rated thermal input equal to or greater than 1 MW, where this is part of the activity specified in Annex I to Directive 2010/75/EU: 4. Chemical industry.
- Emissions to air from the storage, transfer and handling of liquids, liquefied gases and solids, where these are directly associated with the activity specified in Annex I to Directive 2010/75/EU: 4. Chemical industry.

These BAT conclusions do not address the following:

1. Emissions to air from the production of chlorine, hydrogen, and sodium/potassium hydroxide by the electrolysis of brine. This is covered by the BAT conclusions for the Production of Chlor-alkali (CAK).

2. Channelled emissions to air from the production of the following chemicals in continuous processes where the total production capacity of those chemicals exceeds 20 kt/yr:

- lower olefins using the steam cracking process;
- ~~aromatics: production of benzene, toluene, ortho-, meta- and para-xylene as well as cyclohexane from the pygas by-product of steam crackers and from reformate/naphtha produced in catalytic reformers;~~
- ~~ethlybenzene using either the zeolite- or $AlCl_3$-catalysed alkylation process;~~
- ~~styrene monomer either by ethylbenzene dehydrogenation or by co-production with propylene oxide;~~
- formaldehyde;
- ethylene oxide and ethylene glycols;
- phenol from cumene;
- ~~ethanolamines;~~

- dinitrotoluene from toluene, toluene diamine from dinitrotoluene, toluene diisocyanate from toluene diamine, methylene diphenyl diamine from aniline, methylene diphenyl diisocyanate from methylene diphenyl diamine;
- ethylene dichloride (EDC) and vinyl chloride monomer (VCM);
- hydrogen peroxide.

This is covered by the BAT conclusions for the Production of Large Volume Organic Chemicals (LVOC).

~~However, channelled emissions to air of nitrogen oxides (NO_X) and carbon monoxide (CO) from thermal treatment of waste gases (i.e. using thermal or catalytic oxidation) originating from the aforementioned production processes are included in the scope of these BAT conclusions.~~

3. Emissions to air from the production of the following inorganic chemicals:

- ammonia;
- ammonium nitrate;
- calcium ammonium nitrate;
- calcium carbide;
- calcium chloride;
- calcium nitrate;
- carbon black;
- ferrous chloride;
- ferrous sulphate (i.e. copperas and related products);
- hydrofluoric acid;
- inorganic phosphates;
- nitric acid;
- nitrogen-, phosphorus- or potassium-based fertilisers (simple or compound fertilisers);
- phosphoric acid;
- precipitated calcium carbonate;
- sodium carbonate (i.e. soda ash);
- sodium chlorate;
- sodium silicate;
- sulphuric acid;
- synthetic amorphous silica;
- titanium dioxide;
- urea;
- urea-ammonium nitrate.

This may be covered by the BAT conclusions for the Production of Large Volume Inorganic Chemicals (LVIC).

4. Emissions to air from steam reforming as well as from the physical purification and reconcentration of spent sulphuric acid, provided that these processes are directly associated with a production process listed under the aforementioned points 2 or 3.

5. Emissions to air from the production of magnesium oxide using the dry process route. This may be covered by the BAT conclusions for the Production of Cement, Lime and Magnesium Oxide (CLM).

6. Emissions to air from the following:

   - Combustion units other than process furnaces/heaters. This may ~~may~~ be covered by the BAT conclusions for Large Combustion Plants (LCP), the BAT conclusions for the Refining of Mineral Oil and Gas (REF) and/or by Directive (EU) 2015/2193 of the European Parliament and of the Council[1].
   - Process furnaces/heaters with a total rated thermal input below 1 MW.
   - Process furnaces/heaters used in lower olefins, ethylene dichloride and/or vinyl chloride monomer production referred to in point 2 above. This is covered by the BAT conclusions for the production of Large Volume Organic Chemicals (LVOC).

7. Emissions to air from waste incineration plants. This may be covered by the BAT conclusions for Waste Incineration (WI).

8. Emissions to air from the storage, transfer and handling of liquids, liquefied gases and solids, where these are not directly associated with the activity specified in Annex I to Directive 2010/75/EU: 4. Chemical industry. This may be covered by the BAT conclusions for Emissions from Storage (EFS).

   ~~However, emissions to air from the storage, transfer and handling of liquids, liquefied gases and solids are included in the scope of these BAT conclusions provided that these processes are directly associated with the chemical production process.~~

9. Emissions to air from indirect cooling systems. This may be covered by the BAT conclusions for Industrial Cooling Systems (ICS).

Other BAT conclusions which are complementary for the activities covered by these BAT conclusions include Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW).

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

- Production of Chlor-alkali (CAK);
- Manufacture of Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers (LVIC-AAF);
- Manufacture of Large Volume Inorganic Chemicals – Solids and Others Industry (LVIC-S);
- Production of Large Volume Organic Chemicals (LVOC);
- Manufacture of Organic Fine Chemicals (OFC);
- Production of Polymers (POL);
- Production of Speciality Inorganic Chemicals (SIC);
- Refining of Mineral Oil and Gas (REF);
- Economics and Cross-media Effects (ECM);
- Emissions from Storage (EFS);

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[1] 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).

- Energy Efficiency (ENE);
- Industrial Cooling Systems (ICS);
- Large Combustion Plants (LCP);
- Monitoring of Emissions to Air and Water from IED installations (ROM);
- Waste Incineration (WI);
- Waste Treatment (WT).

These BAT conclusions apply without prejudice to other relevant legislation, e.g. on the registration, evaluation, authorisation and restriction of chemicals (REACH), on classification, labelling and packaging of substances and mixtures (CLP).

Definitions

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

General terms	
Term used	**Definition**
Channelled emissions to air	Emissions of pollutants ~~in~~to ~~the~~ air through an emission point such as a stack ~~or a chimney~~.
Combustion unit	Any technical apparatus in which fuels are oxidised in order to use the heat thus generated. Combustion units include boilers, engines, turbines and process furnaces/heaters, but do not include ~~thermal treatment of waste gases (i.e. using~~ thermal or catalytic ~~oxidation~~ oxidisers~~)~~.
Continuous measurement	Measurement using an automated measuring system permanently installed on site.
Continuous process	A process in which the raw materials are fed continuously into the reactor with the reaction products then fed into connected downstream separation and/or recovery units.
Diffuse emissions	Non-channelled emissions to air. Diffuse emissions include fugitive and non-fugitive emissions.
Emissions to air	Generic term for emissions of pollutants to air including both channelled and diffuse emissions.
Ethanolamines	Collective term for monoethanolamine, diethanolamine and triethanolamine, or mixtures thereof.
Ethylene glycols	Collective term for monoethylene glycol, diethylene glycol and triethylene glycol, or mixtures thereof.
Existing plant	A plant that is not a new plant.
Existing process furnace/heater	A process furnace/heater that is not a new process furnace/heater.
Flue-gas	The exhaust gas exiting a combustion unit.
Fugitive emissions	Non-channelled emissions to air caused by loss of tightness of equipment which is designed or assembled to be tight. Fugitive emissions can arise from: • moving equipment, such as agitators, compressors, pumps, valves (manual and automatic); • static equipment, such as flanges and other connections, open-ended lines, sampling points.
Lower olefins	Collective term for ethylene, propylene, butylene and butadiene, or mixtures thereof.
Major plant upgrade	A major change in the design or technology of a plant with major adjustments or replacements of the process and/or abatement units and associated equipment.
Mass flow	The mass of a given substance or parameter which is emitted over a defined period of time.
New plant	A plant first permitted on the site of the installation following the publication of these BAT conclusions or a complete replacement of a plant following the publication of these BAT conclusions.
New process furnace/heater	A process furnace/heater in a plant first permitted following the publication of these BAT conclusions or a complete replacement of a process furnace/heater following the publication of these BAT conclusions.
Non-fugitive emissions	Diffuse emissions other than fugitive emissions. Non-fugitive emissions may arise from, for example, atmospheric vents, bulk storage, loading/unloading systems, vessels and tanks (on opening), open gutters, sampling systems, tank venting, waste, sewers and~~waste~~ water treatment plants~~, flares or other than normal operating conditions (OTNOC)~~.

NO_X precursors	Nitrogen-containing compounds (e.g. acrylonitrile, ammonia, nitrous gases, nitrogen-containing organic compounds) in the input to thermal or catalytic oxidation that lead to NO_X emissions. Elementary nitrogen is not included.
Operational constraint	Limitation or restriction connected, for example, to: • ~~process design~~ substances used (e.g. substances that cannot be substituted, very corrosive substances); • operating conditions (e.g. very high temperature or pressure); • the functioning of the plant; • resource availability (e.g. availability of spare parts when replacing a piece of equipment, availability of qualified manpower); • expected environmental benefits (e.g. giving priority to maintenance, repair or replacement actions with the highest environmental benefit).
Periodic measurement	Measurement at specified time intervals using manual or automated methods.
Polymer grade	For each type of polymer, there are different product qualities (i.e. grades) which vary in structure and molecular mass, and are optimised for specific applications. In the case of polyolefins, these may vary regarding the use of co-polymers such as EVA. In the case of PVC, they may vary in the average length of the polymer chain and in the porosity of the particles.
Process furnace/heater	Process furnaces or heaters are: • combustion units used for the treatment of objects or feed material through direct contact, e.g. in drying processes or chemical reactors; or • combustion units whose radiant and/or conductive heat is transferred to objects or feed material through a solid wall without using an intermediary heat transfer fluid, e.g. furnaces or reactors heating a process stream used in the (petro-)chemical industry. ~~such as steam cracker furnaces.~~ As a consequence of the application of good energy recovery practices, some of the process furnaces/heaters may have an associated steam/electricity generation system. This is an integral design feature of the process furnace/heater that cannot be considered in isolation.
Process off-gas	The gas leaving a process which is further treated for recovery and/or abatement.
Solvent	Organic solvent as defined in Article 3(46) of Directive 2010/75/EU.
Solvent input	The total quantity of organic solvents used as defined in Part 7 of Annex VII to Directive 2010/75/EU.
Solvent mass balance	A mass balance exercise conducted at least on an annual basis according to Part 7 of Annex VII to Directive 2010/75/EU.
Thermal treatment	Treatment of waste gases using thermal or catalytic oxidation.
Total emissions	The sum of channelled and diffuse emissions.
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.

Substances/Parameters	
Term used	**Definition**
$AlCl_3$	Aluminium trichloride.
Cl_2	Elementary chlorine.
CO	Carbon monoxide.
CS_2	Carbon disulphide.
Dust	Total particulate matter (in air). Unless specified otherwise, dust includes $PM_{2.5}$ and PM_{10}.
EDC	Ethylene dichloride (1,2-Dichloroethane).
HCl	Hydrogen chloride.
HCN	Hydrogen cyanide.

HF	Hydrogen fluoride.
H_2S	Hydrogen sulphide.
NH_3	Ammonia.
Ni	Nickel.
NMVOC	Non-methane volatile organic compound.
N_2O	Dinitrogen oxide (also referred to as nitrous oxide).
NO_X	The sum of nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as NO_2.
Pb	Lead.
PCDD/F	Polychlorinated dibenzo-*p*-dioxins and -furans.
$PM_{2.5}$	Particulate matter which passes through a size-selective inlet with a 50 % efficiency cut-off at 2.5 µm aerodynamic diameter as defined in Directive 2008/50/EC.
PM_{10}	Particulate matter which passes through a size-selective inlet with a 50 % efficiency cut-off at 10 µm aerodynamic diameter as defined in Directive 2008/50/EC.
SO_2	Sulphur dioxide.
SO_X	The sum of sulphur dioxide (SO_2), sulphur trioxide (SO_3), and sulphuric acid aerosols, expressed as SO_2.
TVOC	Total volatile organic carbon, expressed as C.
VCM	Vinyl chloride monomer.
VOC	Volatile organic compound as defined in Article 3(45) of Directive 2010/75/EU.

Acronyms

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

Acronym	Definition
CLP	Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures.
CMR	Carcinogenic, mutagenic or toxic for reproduction.
CMR 1A	CMR substance of category 1A as defined in Regulation (EC) No 1272/2008 as amended, i.e. carrying the hazard statements H340, H350, H360.
CMR 1B	CMR substance of category 1B as defined in Regulation (EC) No 1272/2008 as amended, i.e. carrying the hazard statements H340, H350, H360.
CMR 2	CMR substance of category 2 as defined in Regulation (EC) No 1272/2008 as amended, i.e. carrying the hazard statements H341, H351, H361.
DIAL	Differential absorption LIDAR.
EMS	Environmental Management System.
EPS	Expandable polystyrene.
E-PVC	PVC produced by emulsion polymerisation.
EVA	Ethylene-vinyl acetate.
GPPS	General-purpose polystyrene.
HDPE	High-density polyethylene.
HEAF	High-efficiency air filter.
HEPA	High-efficiency particle air.
HIPS	High-impact polystyrene.
IED	Directive 2010/75/EU on industrial emissions.
I-TEQ	International toxic equivalent – derived by using the equivalence factors in Part 2 of Annex VI to Directive 2010/75/EU.
LDAR	Leak detection and repair.
LDPE	Low-density polyethylene.
LIDAR	Light detection and ranging.
LLDPE	Linear low-density polyethylene.
OGI	Optical gas imaging.
OTNOC	Other than normal operating conditions.
PP	Polypropylene.
PVC	Polyvinyl chloride.
REACH	Regulation (EC) No 1907/2006 concerning the registration, evaluation, authorisation and restriction of chemicals.
SCR	Selective catalytic reduction.
SNCR	Selective non-catalytic reduction.
SOF	Solar occultation flux.
S-PVC	PVC produced by suspension polymerisation.
ULPA	Ultra-low penetration air.

General considerations

Best Available Techniques

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

Unless otherwise stated, the BAT conclusions are generally applicable.

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

The ~~emission levels associated with the best available techniques (~~BAT-AELs~~)~~ and the indicative emission levels for channelled emissions to air given in these BAT conclusions refer to values of concentration, expressed as mass of emitted substance per volume of waste gas under standard conditions (dry gas at a temperature of 273.15 K, and a pressure of 101.3 kPa), without correction for oxygen content and expressed in the unit mg/Nm^3, µg/Nm^3 or ng I-TEQ/Nm^3.

~~When a mass flow threshold is indicated, the BAT-AELs only apply if the mass flow of the given substance or parameter emitted from the emission point is above the associated mass flow threshold.~~

~~The~~ For averaging periods ~~associated with the~~ of BAT-AELs and ~~with the~~ indicative emission levels for channelled emissions to air, the following definitions apply. ~~are defined as follows.~~

Type of measurement	Averaging period	Definition
Continuous	Daily average	Average over a period of 1 day based on valid hourly or half-hourly averages.
Periodic	Average over the sampling period	Average 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 ~~suitable~~ procedure may be employed. For PCDD/F, ~~a~~ one sampling period of 6 to 8 hours is used.

For the purpose of calculating the mass flows in relation to BAT 8, BAT 11 (Table 4.1), BAT 14 (Table 4.3), BAT 16 (Table 4.4), BAT 18 (Table 4.6), BAT 26, BAT 29 (Table 4.10), BAT 33 and BAT 36 (Table 4.17), where waste gases from one type of source (e.g. process furnaces/heaters) discharged through two or more separate stacks could, in the judgement of the competent authority, taking technical and economic factors into account, be discharged through a common stack, these stacks shall be considered as a single stack.

BAT-AELs for diffuse VOC emissions to air

For diffuse VOC emissions from the use of solvents or the reuse of recovered solvents, the BAT-AELs in these BAT conclusions are given as a percentage of the solvent input, calculated on an annual basis according to Part 7 of Annex VII to Directive 2010/75/EU.

BAT-AELs for total emissions to air for the production of polymers or synthetic rubbers

Production of polyolefins or synthetic rubbers

For total emissions to air of ~~a substance or parameter~~ VOCs from the production of ~~polymers~~ polyolefins or synthetic rubbers, the BAT-AELs in these BAT conclusions are given as specific emission loads calculated on an annual basis by dividing the total VOC emissions by a sector-dependent production rate ~~(i.e. mass of the emitted substance or parameter per production output)~~, expressed in the unit g C/kg of product.

~~The BAT-AELs for total emissions to air from the production of polymers refer to yearly averages. The total emissions include channelled and diffuse emissions from the storage, transfer and handling of VOCs and polymer products, as well as from polymerisation and finishing.~~

~~Channelled emissions to air are monitored according to BAT 8.~~

Production of PVC

For total emissions to air of VCM from the production of PVC, the BAT-AELs in these BAT conclusions are given as specific emission loads calculated on an annual basis by dividing the total VCM emissions by a sector-dependent production rate, expressed in the unit g/kg of product.

Total emissions also include the VCM concentration in the PVC.

Production of viscose

For the production of viscose, the BAT-AEL in these BAT conclusions is given as a specific emission load calculated on an annual basis by dividing the total S emissions by the production rate of staple fibres or casing, expressed in the unit g/kg of product.

4.1 General BAT conclusions

4.1.1 Environmental management systems

[Note to the TWG: the following description of the general EMS features is based on standard text agreed at the level of the IED Article 13 Forum and used in recent documents such as the BAT conclusions for FDM, WI, STS and FMP. The possibilities for changes are therefore limited to the section dealing specifically with WGC issues]

BAT 1. 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 (or human health) as well as of the applicable legal requirements relating to the environment;
iii. development of an environmental policy that includes the continuous improvement of the environmental performance of the installation;
iv. establishing objectives and performance indicators in relation to significant environmental aspects, including safeguarding compliance with applicable legal requirements;
v. planning and implementing the necessary procedures and actions (including corrective and preventive actions where needed), to achieve the environmental objectives and avoid environmental risks;
vi. determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed;
vii. 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);
viii. internal and external communication;
ix. fostering employee involvement in good environmental management practices;
x. establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records;
xi. effective operational planning and process control;
xii. implementation of appropriate maintenance programmes;
xiii. emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations;
xiv. 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;
xv. 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;
xvi. application of sectoral benchmarking on a regular basis;
xvii. periodic independent (as far as practicable) internal auditing and periodic independent external auditing in order to assess the environmental performance and to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;
xviii. evaluation of causes of nonconformities, implementation of corrective actions in response to nonconformities, review of the effectiveness of corrective actions, and determination of whether similar nonconformities exist or could potentially occur;

xix. periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness;
xx. following and taking into account the development of cleaner techniques.

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

xxi. an inventory of channelled and diffuse emissions to air (see BAT 2);
xxii. an OTNOC management plan for emissions to air (see BAT 3);
xxiii. an integrated waste gas management and treatment strategy for channelled emissions to air (see BAT 4);
xxiv. a management system for diffuse VOC emissions to air (see BAT 19).

Note
Regulation (EC) No 1221/2009 establishes the European Union eco-management and audit scheme (EMAS), which is an example of an EMS consistent with this BAT.

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.

[This BAT conclusion is based on information given in Section 3.1.1]

BAT 2. In order to facilitate the reduction of emissions to air, BAT is to establish, maintain and regularly review (including when a substantial change occurs) an inventory of channelled and diffuse emissions to air, as part of the environmental management system (see BAT 1), that incorporates all of the following features:

i. information, as comprehensive as is reasonably possible, about the chemical production process(es), including:
  a. chemical reaction equations, also showing side products;
  b. simplified process flow sheets that show the origin of the emissions;

ii. information, as comprehensive as is reasonably possible, about channelled emissions to air, such as:
  a. emission point(s);
  b. average values and variability of flow and temperature;
  c. average concentration and mass flow values of relevant substances/parameters and their variability (e.g. TVOC, CO, NO_X~~X~~, SO_X~~X~~, Cl_2~~2~~, HCl);
  d. presence of other substances that may affect the waste gas treatment system(s) or plant safety (e.g. oxygen, nitrogen, water vapour, dust);
  e. techniques used to prevent and/or reduce channelled emissions to air;
  f. flammability, lower and higher explosive limits, reactivity;
  g. monitoring methods (see BAT 8);
  h. presence of substances classified as CMR 1A, CMR 1B or CMR 2.

iii. information, as comprehensive as is reasonably possible, about diffuse emissions to air, such as:
  a. identification of the emission source(s);
  b. characteristics of each emission source (e.g. fugitive or non-fugitive; static or moving; accessibility of the emission source; included in an LDAR programme or not);
  c. the characteristics of the gas or liquid in contact with the emission source(s), including:

    1) physical state;
    2) vapour pressure of the substance(s) in the liquid, pressure of the gas;
    3) temperature;
    4) composition (by weight for liquids or by volume for gases);
    5) hazardous properties of the substance(s) or mixtures, including ~~CMR~~ substances or mixtures classified as CMR 1A, CMR 1B or CMR 2 ~~properties.~~;
  d. techniques used to prevent and/or reduce diffuse emissions to air;
  e. monitoring (see BAT 20, BAT 21 and BAT 22).

~~Description~~ Note for diffuse emissions

The information about diffuse emissions covers all emission sources in contact with:

- liquids containing more than 20 wt-% organic substances with a vapour pressure greater than 0.3 kPa at 293.15 K; or
- gases containing more than 10 vol-% organic substances with a vapour pressure greater than 0.3 kPa at 293.15 K.

Sources of diffuse emissions connected to pipes whose diameter is smaller than 12.7 mm (i.e. 0.5 inch) may be excluded from the inventory.

Equipment operated under subatmospheric pressure may be excluded from the inventory.

~~Note~~

The information about diffuse emissions to air is particularly relevant to the production of pharmaceuticals~~–activities producing large volumes of organic chemicals~~ or activities using large amounts of solvents~~ (e.g. for the production of pharmaceuticals)~~.

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.

4.1.2 Other than normal operating conditions (OTNOC)

BAT 3. In order to reduce the frequency of the occurrence of OTNOC and to reduce emissions to air during OTNOC, BAT is to set up and implement a risk-based OTNOC management plan as part of the environmental management system (see BAT 1) that includes all of the following features:

i. identification of potential OTNOC (e.g. failure of equipment critical to the control of channelled emissions to air, or equipment critical to the prevention of accidents or incidents that could lead to emissions to air (‘critical equipment’)), of their root causes and of their potential consequences;

ii. appropriate design of critical equipment (e.g. equipment modularity and compartmentalisation, backup systems, techniques to obviate the need to bypass waste gas treatment during start-up and shutdown, high-integrity equipment, etc.);

iii. set-up and implementation of a preventive maintenance plan for critical equipment (see BAT 1 xii.);

iv. monitoring (i.e. estimating or, where this is possible, measuring) and recording of emissions and associated circumstances during OTNOC ~~(see BAT 7 and BAT 8)~~;

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

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

vii. regular testing of backup systems.

4.1.3 Channelled emissions to air

4.1.3.1 General techniques

BAT 4. In order to reduce channelled emissions to air, BAT is to use an integrated waste gas management and treatment strategy that includes, in order of priority, process-integrated recovery and abatement techniques.

Description
The integrated waste gas management and treatment strategy is based on the inventory of channelled ~~and diffuse~~ emissions to air (see BAT 2). It takes into account factors such as greenhouse gas emissions, the consumption or reuse of energy, water and materials associated with the use of the different techniques.

BAT 5. In order to facilitate the recovery of materials and the reduction of channelled emissions to air, as well as to increase energy efficiency, BAT is to ~~limit~~ optimise 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 extent to which the number of emission points can be limited depends on~~ The optimisation is carried out considering plant safety (e.g. avoiding concentrations close to the lower explosive limit), technical (e.g. compatibility of the individual waste gas streams), environmental (e.g. maximising recovery of materials or pollutant abatement) and economic factors (e.g. ~~geographical~~ distance between different production units).

BAT 6. In order to reduce channelled emissions to air, BAT is to ensure that the waste gas treatment systems are appropriately designed (e.g. considering the maximum flow rate and pollutant concentrations), operated within their design ranges, and maintained (through preventive, corrective, regular and unplanned maintenance) so as to ensure optimal availability, effectiveness and efficiency of the equipment.

4.1.3.2 Monitoring

BAT 7. BAT is to continuously monitor key process parameters (~~including~~ e.g. waste gas flow and temperature) of waste gas streams being sent to pretreatment and/or final treatment.

BAT 8. 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.

Substance/Parameter (1)	Process(es)/ Source(s)	Emission points	Standard(s)	Minimum monitoring frequency	Monitoring associated with
Ammonia (NH_3)	Use of SCR/SNCR	~~All emission points~~ Any stack	~~No EN standard available~~ EN 21877	Once every year (2) (3) (6)	BAT 17
	All other processes/sources				BAT 18
Benzene	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year ~~6 months~~ (2) ~~(4)~~ (6)	BAT 11
1,3-Butadiene	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year ~~6 months~~ (2) ~~(4)~~ (6)	BAT 11
Carbon monoxide (CO)	Thermal treatment	~~All emission points~~ Any stack with a CO mass flow of ≥ 2 kg/h	Generic EN standards (5)	Continuous	BAT 16
		~~All emission points~~ Any stack with a CO mass flow of < 2 kg/h	EN 15058	Once every year (2) (3) (6)	
	Process furnaces/heaters	~~All emission points~~ Any stack with a CO mass flow of ≥ 2 kg/h	Generic EN standards (5)	Continuous (7)	BAT 36
		~~All emission points~~ Any stack with a CO mass flow of < 2 kg/h	EN 15058	Once every year (2) (3) (6)	
	All other processes/sources	~~All emission points~~ Any stack with a mass flow of ≥ 2 kg/h	Generic EN standards (5)	Continuous	BAT 18
		~~All emission points~~ Any stack with a CO mass flow of < 2 kg/h	EN 15058	Once every year (2) (3) (6)	

Chloromethane	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year (2) (3) (6)	BAT 11
Dichloromethane	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year (2) (3) (6)	BAT 11
Dust	All processes/sources	~~All emission points~~ Any stack	EN 13284-1	Once every year (2) (3) (6)	BAT 14
Elementary chlorine (Cl_2)	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year (2) (3) (6)	BAT 18
Ethylene dichloride (EDC)	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year ~~6 months~~ (2) ~~(4)~~ (6)	BAT 11
Ethylene oxide	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year ~~6 months~~ (2) ~~(4)~~ (6)	BAT 11
Formaldehyde	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year ~~6 months~~ (2) ~~(4)~~ (6)	BAT 11
Gaseous chlorides	All processes/sources	~~All emission points~~ Any stack	EN 1911	Once every year (2) (3) (6)	BAT 18
Gaseous fluorides	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year (2) (3) (6)	BAT 18
Hydrogen cyanide (HCN)	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year (2) (3) (6)	BAT 18
Lead and its compounds	All processes/sources	~~All emission points~~ Any stack	EN 14385	Once every year (2) (3) (6)	BAT 14
Nickel and its compounds	All processes/sources	~~All emission points~~ Any stack	EN 14385	Once every year (2) (3) (6)	BAT 14
Nitrous oxide (N_2O)	All processes/sources	~~All emission points~~ Any stack	EN ISO 21258	Once every year (2) (3) (6)	–

Nitrogen oxides (NO_X)	Thermal treatment	~~All emission points~~ Any stack with a NO_X mass flow of ≥ 5 kg/h	Generic EN standards (5)	Continuous	BAT 16
		~~All emission points~~ Any stack with a NO_X mass flow of < 5 kg/h	EN 14792	Once every year (2) (3) (6)	
	Process furnaces/heaters	~~All emission points~~ Any stack with a mass flow of ≥ 5 kg/h	Generic EN standards (5)	Continuous (7)	BAT 36
		~~All emission points~~ Any stack with a NO_X mass flow of < 5 kg/h	EN 14792	Once every year (2) (3) (6)	
	All other processes/sources	~~All emission points~~ Any stack with a NO_X mass flow of ≥ 5 kg/h	Generic EN standards (5)	Continuous	BAT 18
		~~All emission points~~ Any stack with a NO_X mass flow of < 5 kg/h	EN 14792	Once every year (2) (3) (6)	

PCDD/F	Thermal treatment	~~All emission points from catalytic and thermal oxidation of waste gases~~ Any stack	EN 1948-1, EN 1948-2, EN 1948-3	Once every year ~~6 months~~ (2) ~~(4)~~ (6)	BAT 12
PM$_{2.5}$ and PM$_{10}$	All processes/sources	~~All emission points~~ Any stack	EN ISO 23210	Once every year (2) (3) (6)	BAT 14
Propylene oxide	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year ~~6 months~~ (2) ~~(4)~~ (6)	BAT 11
Sulphur dioxide (SO$_2$)	Thermal treatment	Any stack with a SO$_2$ mass flow of ≥ 5 kg/h	Generic EN standards (5)	Continuous	BAT 16
		Any stack with a SO$_2$ mass flow of < 5 kg/h	EN 14791	Once every year (2) (3) (6)	
	Process furnaces/heaters	Any stack with a SO$_2$ mass flow of ≥ 5 kg/h	Generic EN standards (5)	Continuous (7)	BAT 18BAT 36
		Any stack with a SO$_2$ mass flow of < 5 kg/h	EN 14791	Once every year (2) (3) (6)	
	All other processes/sources	Any stack with a SO$_2$ mass flow of ≥ 5 kg/h	Generic EN standards (5)	Continuous	BAT 18
		Any stack with a SO$_2$ mass flow of < 5 kg/h	EN 14791	Once every year (2) (3) (6)	
Tetrachloromethane	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year (2) (3) (6)	BAT 11

Toluene	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year (2) (3) (6)	BAT 11
Trichloromethane	All processes/sources	~~All emission points~~ Any stack	No EN standard available	Once every year (2) (3) (6)	BAT 11
Total volatile organic carbon (TVOC)	Production of polyolefins (8)	~~All emission points~~ Any stack with a TVOC mass flow of ≥ 2 kg C/h	Generic EN standards (5)	Continuous	BAT 11, BAT 25
		~~All emission points~~ Any stack with a TVOC mass flow of < 2 kg C/h	EN 12619	Once every year (2) (3) (6)	
	Production of synthetic rubbers (9)	~~All emission points~~ Any stack with a TVOC mass flow of ≥ 2 kg C/h	Generic EN standards (5)	Continuous	BAT 11, BAT 32
		~~All emission points~~ Any stack with a TVOC mass flow of < 2 kg C/h	EN 12619	Once every year (2) (3) (6)	
	All other processes/sources	~~All emission points~~ Any stack with a TVOC mass flow of ≥ 2 kg C/h	Generic EN standards (5)	Continuous	BAT 11

		~~All emission points~~ Any stack with a TVOC mass flow of < 2 kg C/h	EN 12619	Once every year (2) (3) (6)	

(1) The monitoring only applies when the substance/parameter concerned is identified as relevant in the waste gas stream based on the inventory given in BAT 2.
(2) To the extent possible, the measurements are carried out at the highest expected emission state under normal operating conditions.
(3) The minimum monitoring frequency may be reduced to once every 3 years if the emission levels are proven to be sufficiently stable.
~~(4) The minimum monitoring frequency may be reduced to once every year if the emission levels are proven to be sufficiently stable.~~
(5) Generic EN standards for continuous measurements are EN 14181, EN 15267-1, EN 15267-2 and EN 15267-3.
(6) In the case of batch processes, measurements are carried out according to EN 15259.
(7) In the case of process furnaces/heaters with a total rated thermal input of less than 100 MW operated less than 500 hours per year, the minimum monitoring frequency may be reduced to once every year.
(8) In the case of the production of polyolefins, the monitoring of TVOC emissions from finishing steps (e.g. drying, blending) and from polymer storage may be replaced by the monitoring in BAT 24.
(9) In the case of the production of synthetic rubbers, the monitoring of TVOC emissions from finishing steps (e.g. extrusion, drying, blending) and from synthetic rubber storage may be replaced by the monitoring in BAT 31.

[This BAT conclusion is based on information given in Section 2.3]

4.1.3.3 Organic compounds

BAT 9. In order to increase resource efficiency and to reduce the mass flow of organic compounds sent to the final waste gas treatment, BAT is to recover organic compounds from process off-gases by using one or a combination of the techniques given below and to reuse them.

Technique		Description
a.	Absorption (regenerative)	See Section 4.4.1.
b.	Adsorption (regenerative)	See Section 4.4.1.
c.	Condensation	See Section 4.4.1.

Applicability

~~Applicability may be restricted where the costs are excessive due to the low concentration of the compound concerned in the process off-gas(es).~~

Recovery may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gas(es). Reuse may be restricted due to product quality specifications.

[This BAT conclusion is based on information given in Section 2.3.2]

BAT 10. In order to increase energy efficiency and to reduce the mass flow of organic compounds sent to the final waste gas treatment, BAT is to send process off-gases with a sufficient calorific value to a combustion unit that is, if possible, combined with heat recovery. BAT 9 has priority over sending process off-gases to a combustion unit.

Applicability

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

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

Technique		Description	Applicability
a.	Adsorption	See Section 4.4.1.	Generally applicable.
b.	Absorption	See Section 4.4.1.	Generally applicable.
c.	Catalytic oxidation	See Section 4.4.1.	Applicability may be restricted by the presence of catalyst poisons in the waste gases.
d.	Condensation	See Section 4.4.1.	Generally applicable.
e.	Thermal oxidation	See Section 4.4.1.	Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/or operational constraints. Straight thermal oxidation is generally applicable.
f.	Bioprocesses	See Section 4.4.1.	Only applicable to the treatment of biodegradable compounds.

Table 4.1: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of organic compounds

Substance/Parameter	BAT-AEL (mg/Nm^3) (Daily average or average over the sampling period) (12)	~~Mass flow threshold (g/h)~~
Total volatile organic carbon (TVOC)	< 1-20 (1) (2) (3) (4) (5) (6) (7)	~~200~~
~~Total volatile organic carbon (TVOC) containing substances classified as CMR 1A or 1B~~	~~< 1-5~~	~~2.5~~
~~Total volatile organic carbon (TVOC) containing substances classified as CMR 2~~	~~< 1-10~~	~~100~~
Benzene	< 0.5-1 (8)	~~2.5~~
1,3-Butadiene	< 0.5-1 (8)	~~2.5~~
Ethylene dichloride	< 0.5-1 (8)	~~2.5~~
Ethylene oxide	< 0.5-1 (8)	~~2.5~~
Propylene oxide	< 0.5-1 (8)	~~2.5~~
Formaldehyde	1-5 (8)	~~2.5~~
Chloromethane	< 0.5-1 (9) (10) (11)	~~100~~
Dichloromethane	< 0.5-1 (9) (10)	~~100~~
Tetrachloromethane	< 0.5-1 (9) (10)	~~100~~
Toluene	< 0.5-1 (9) (10)	~~100~~
Trichloromethane	< 0.5-1 (9) (10)	~~100~~

(1) TVOC is expressed in mg C/Nm^3.

(2) In the case of polymer production, the BAT-AEL may not apply to emissions from the finishing steps (e.g. extrusion, drying, blending) and from polymer storage.

(3) The BAT-AEL does not apply when the TVOC mass flow is below 200 g C/h.

(4) The upper end of the BAT-AEL range is 5 mg C/Nm^3 if both of the following conditions are fulfilled:

- the presence of substances classified as CMR 1A/1B in TVOC is identified as relevant (see BAT 2);
- the TVOC mass flow is above 2.5 g C/h.

(5) The upper end of the BAT-AEL range is 10 mg C/Nm^3 if both of the following conditions are fulfilled:

- the presence of substances classified as CMR 2 in TVOC is identified as relevant (see BAT 2);
- the TVOC mass flow is above 50 g C/h.

(6) The upper end of the BAT-AEL range may be higher and up to 40 mg/Nm^3 when using bioprocesses if both of the following conditions are fulfilled:

- the presence of substances classified as CMR 1A/1B or CMR 2 is identified as not relevant (see BAT 2);
- the TVOC abatement efficiency of the waste gas treatment system is ≥ 70 %.

(7) The upper end of the BAT-AEL range may be higher and up to 50 mg/Nm^3 when using techniques that allow the recovery of materials, if both of the following conditions are fulfilled:

- the presence of substances classified as CMR 1A/1B or CMR 2 is identified as not relevant (see BAT 2);
- the TVOC abatement efficiency of the waste gas treatment system is ≥ 95 %.

(8) The BAT-AEL does not apply when the mass flow of the substance concerned is below 2.5 g/h.

(9) The BAT-AEL does not apply when the mass flow of the substance concerned is below 50 g/h.

(10) The upper end of the BAT-AEL range may be higher and up to 20 mg/Nm^3 when using techniques that allow the recovery of materials, if the abatement efficiency of the waste gas treatment system is ≥ 95 %.

(11) The upper end of the BAT-AEL range may be higher and up to 40 mg/Nm^3 when using bioprocesses if the abatement efficiency of the waste gas treatment system is ≥ 70 %.

(12) For activities listed under points 8 and 10, Part 1 of Annex VII of the IED, the BAT-AEL ranges only apply to the extent that they lead to lower emission levels than the emission limit values in part 2 and 4 of Annex VII of the IED.

The associated monitoring is given in BAT 8.

[This BAT conclusion is based on information given in Section 2.3.2]

BAT 12. In order to reduce channelled emissions to air of PCDD/F from thermal treatment of waste gases ~~(i.e. using thermal or catalytic oxidation)~~ containing chlorine and/or chlorinated compounds, BAT is to use techniques a. and b., ~~if necessary followed by~~ and one or a combination of techniques c. to e., given below.

	Technique	Description	Applicability
Specific techniques to reduce PCDD/F emissions			
a.	Optimised catalytic or thermal oxidation	See Section 4.4.1.	Generally applicable.
b.	Rapid waste-gas cooling	Rapid cooling of waste gases from temperatures above 400 °C to below 250 °C to prevent the *de novo* synthesis of PCDD/F.	Generally applicable.
c.	Adsorption using activated carbon	See Section 4.4.1.	Generally applicable.
d.	Absorption	See Section 4.4.1.	Generally applicable.
Other techniques not primarily used to reduce PCDD/F emissions			
e.	Selective catalytic reduction (SCR)	See Section 4.4.1. When SCR is used for NO_X abatement, an adequate catalyst surface of the SCR system also provides for the partial reduction of the emissions of PCDD/F.	Applicability to existing plants may be restricted by space availability and/or by the presence of catalyst poisons in the waste gases.

Table 4.2: BAT-associated emission level (BAT-AEL) for channelled emissions to air of PCDD/F from thermal treatment of waste gases ~~(i.e. thermal or catalytic oxidation)~~ containing chlorine and/or chlorinated compounds

Substance/Parameter	BAT-AEL (ng I-TEQ/Nm^3) (Average over the sampling period)	~~Mass flow threshold (µg I-TEQ/h)~~
PCDD/F	< 0.01-0.05	~~0.25~~

The associated monitoring is given in BAT 8.

[This BAT conclusion is based on information given in Section 2.3.2.11]

4.1.3.4 Dust (including PM_{10} and $PM_{2.5}$) and particulate-bound metals

BAT 13. In order to increase resource efficiency and to reduce the mass flow of dust and particulate-bound metals sent to the final waste gas treatment, BAT is to recover materials from process off-gases by using one or a combination the techniques given below and to reuse them.

Technique		Description	~~Applicability~~
~~a.~~	~~Absolute filter~~	~~See Section 4.4.1.~~	~~Applicability may be limited in the case of sticky dust or if the waste gas after the absolute filter needs to be treated at temperatures above 150 °C.~~
b.	Cyclone	See Section 4.4.1.	~~Generally applicable.~~
c.	Fabric filter	See Section 4.4.1.	~~Applicability may be limited in the case of sticky dust. or if the waste gas after the fabric filter needs to be treated at temperatures above 250 °C.~~
d.	Absorption	See Section 4.4.1.	

Applicability

~~Applicability may be restricted where the costs are excessive due to the low content in the process off-gas(es).~~

Recovery may be restricted where the energy demand for dust purification or decontamination is excessive. Reuse may be restricted due to product quality specifications.

[This BAT conclusion is based on information given in Section 2.3.3]

BAT 14. In order to reduce channelled emissions to air of dust and particulate-bound metals, BAT is to use one or a combination of the techniques given below.

Technique		Description	~~Applicability~~
a.	Absolute filter	See Section 4.4.1.	~~Applicability may be limited in the case of sticky dust.~~
b.	Absorption	See Section 4.4.1.	~~Generally applicable.~~
c.	Fabric filter	See Section 4.4.1.	~~Applicability may be limited in the case of sticky dust.~~
d.	High-efficiency air filter	See Section 4.4.1.	~~Generally applicable.~~
e.	Cyclone	See Section 4.4.1.	
f.	Electrostatic precipitator	See Section 4.4.1.	

Table 4.3: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of dust, lead and nickel

Substance/Parameter	BAT-AEL (mg/Nm^3) (Daily average or average over the sampling period)	~~Mass flow threshold (g/h)~~
Dust	< 1-5 ~~(1)~~ (2) (3) (4) (5) (6)	~~100~~
~~Dust containing substances classified as CMR 1A or 1B~~	~~< 1-2.5~~	~~2.5~~
~~Dust containing substances classified as CMR 2~~	~~< 1-2.5~~	~~15~~
Lead and its compounds, expressed as Pb	< 0.01-~~0.5~~ 0.1	~~0.15~~
Nickel and its compounds, expressed as Ni	< 0.02-~~0.5~~ 0.1 (7)	~~0.15~~

(2) The BAT-AEL does not apply when the dust mass flow is below 100 g/h.

(3) The upper end of the BAT-AEL range is 2.5 mg/Nm^3 if both of the following conditions are fulfilled:
- the presence of substances classified as CMR 1A/1B in the dust is identified as relevant (see BAT 2);
- the dust mass flow is above 2.5 g/h.

(4) The upper end of the BAT-AEL range is 2.5 mg/Nm^3 if both of the following conditions are fulfilled:
- the presence of substances classified as CMR 2 in the dust is identified as relevant (see BAT 2);
- the dust mass flow is above 15 g/h.

~~(1) The upper end of the range is 20 mg/Nm^3 when an absolute or fabric filter is not applicable.~~

(5) In the case of the production of inorganic pigments, the upper end of the BAT-AEL range may be higher and up to 15 mg/Nm^3.

(6) In the case of water-soluble inorganic salts, the upper end of the BAT-AEL range may be higher and up to 20 mg/Nm^3.

(7) The BAT-AEL does not apply when the Ni mass flow is below 0.15 g/h.

The associated monitoring is given in BAT 8.

[This BAT conclusion is based on information given in Section 2.3.3]

4.1.3.5 Inorganic compounds

BAT 15. In order to increase resource efficiency and to reduce the mass flow of inorganic compounds sent to the final waste gas treatment, BAT is to recover inorganic compounds from process off-gases by using absorption and to reuse them.

Description
See Section 4.4.1.

Applicability
~~Applicability may be restricted where the costs are excessive due to the low concentration of the compound concerned in the process off-gas(es).~~
Recovery may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gas(es). Reuse may be restricted due to product quality specifications.

BAT 16. In order to reduce channelled emissions to air of CO, NO_X and SO_X from ~~the use of~~ thermal treatment ~~catalytic and thermal oxidation for the abatement of emissions of organic compounds~~, BAT is to use technique c. and one or a combination of the other techniques given below.

Technique		**Description**	**Main inorganic compounds targeted**	**Applicability**
a.	Choice of fuel	See Section 4.4.1.	NO_X, SO_X	Generally applicable.
b.	Low-NO_X burner	See Section 4.4.1.	NO_X	Applicability to existing plants may be restricted by design and/or operational constraints.
c.	Optimisation~~ed~~ of catalytic or thermal oxidation	See Section 4.4.1.	CO, NO_X	Generally applicable.
d.	Removal of high levels of NO_X precursors	Remove (if possible, for reuse) high levels of NO_X precursors prior to thermal or catalytic oxidation, e.g. by absorption, adsorption or condensation.	NO_X	Generally applicable.
e.	Absorption	See Section 4.4.1.	SO_X	Generally applicable.
f.	Selective catalytic reduction (SCR)	See Section 4.4.1.	NO_X	Applicability to existing plants may be restricted by space availability.
g.	Selective non-catalytic reduction (SNCR)	See Section 4.4.1.	NO_X	Applicability to existing plants may be restricted by the residence time needed for the reaction.

Table 4.4: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of NO_X~~X~~ and indicative emission level for channelled emissions to air of CO from ~~the use of catalytic or thermal oxidation~~ thermal treatment

Substance/Parameter	**BAT-AEL (mg/Nm^3) (Daily average or average over the sampling period)**	~~**Mass flow threshold (g/h)**~~
Nitrogen oxides (NO_X) from catalytic oxidation	10-~~50~~ 30 (3) (4)	~~1 000~~
Nitrogen oxides (NO_X) from thermal oxidation	10 ~~50~~-150 (3) (1)	~~1 000~~
Carbon monoxide (CO)	No BAT-AEL (2)	~~Not applicable~~

(3) The BAT-AEL does not apply when the NO_X mass flow is below 1 000 g/h.

(1) The upper end of the BAT-AEL range ~~is~~ may be higher and up to 250 mg/Nm^3 if the process off-gas(es) contain(s) high levels of NO_X precursors.

(4) The upper end of the BAT-AEL range may be higher and up 100 mg/Nm^3 if the process off-gas(es) contain(s) high levels of NO_X precursors.

(2) As an indication, the emission levels for carbon monoxide are 4-50 mg/Nm^3, as a daily average or average over the sampling period.

The associated monitoring is given in BAT 8.

The BAT-AEL~~s~~ for channelled emissions to air of SO_2~~$_x$~~ ~~and an indicative emission level for channelled emissions to air of CO:~~ is given in ~~See~~ Table 4.6.

[This BAT conclusion is based on information given in Section 2.3.4]

BAT 17. In order to reduce channelled emissions to air of ammonia from the use of selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) for the abatement of NO_X emissions, BAT is to optimise the design and/or operation of SCR or SNCR (e.g. optimised reagent to NO_X ratio, homogeneous reagent distribution and optimum size of the reagent drops).

Table 4.5: BAT-associated emission level (BAT-AEL) for channelled emissions to air of ammonia from the use of SCR or SNCR

Substance/Parameter	**BAT-AEL (mg/Nm^3)** **(Average over the sampling period)**
Ammonia (NH_3) from SCR/SNCR	< 0.5-~~8~~ 10 (1) (2)

(1) The upper end of the BAT-AEL range may be up to 30 mg/Nm^3 in the case of:
- thermal ~~or catalytic oxidation~~ treatment of waste gases containing high levels of NO_X precursors; or
- ~~if the~~ waste gases containing high levels of NO_X prior to treatment with SCR or SNCR.

(2) When using metal nitrates for the production of catalysts, the upper end of the BAT-AEL range may be up to 50 mg/Nm^3, if the efficiency of SCR or SNCR for the abatement of NO_x is ≥ 90 %.

The associated monitoring is given in BAT 8.

[This BAT conclusion is based on information given in Section 2.3.4]

BAT 18. In order to reduce channelled emissions to air of inorganic compounds other than channelled emissions to air of ammonia from the use of selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) for the abatement of NO_X emissions), channelled emissions to air of CO, NO_X and SO_X from the use of thermal treatment, and channelled emissions to air of NO_X from process furnaces/heaters, BAT is to use one or a combination of the techniques given below.

	Technique	Description	Main inorganic compounds targeted	Applicability
a.	Absorption	See Section 4.4.1.	Cl_2, HCl, HCN, HF, NH_3, NO_X, SO_X	Generally applicable.
b.	Adsorption	See Section 4.4.1. For the removal of inorganic substances, the technique is often used in combination with a dust abatement technique (see BAT 14).	HCl, HF, NH_3, SO_X	Generally applicable.
c.	Selective catalytic reduction (SCR)	See Section 4.4.1.	NO_X	Applicability to existing plants may be restricted by space availability.
d.	Selective non-catalytic reduction (SNCR)	See Section 4.4.1.	NO_X	Applicability to existing plants may be restricted by the residence time needed for the reaction.
e.	Catalytic oxidation	See Section 4.4.1.	NH_3	Generally applicable.
f.	Thermal oxidation	See Section 4.4.1.	NH_3, HCN	Generally applicable.

Table 4.6: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of inorganic compounds ~~and indicative emission level for channelled CO emissions to air~~

Substance/Parameter	BAT-AEL (mg/Nm^3) (Daily average or average over the sampling period)	~~Mass flow threshold (g/h)~~
Ammonia (NH_3)	2-~~30~~ 10 (6) (1)	~~100~~
~~Carbon monoxide (CO)~~	~~No BAT-AEL (2)~~	~~Not applicable~~
Elementary chlorine (Cl_2)	< 0.5-2 (7) (11)	~~5~~
Gaseous fluorides, expressed as HF	< 1-2 (7)	
Hydrogen cyanide (HCN)	< 0.1-~~1~~ 0.5 (7)	
Gaseous chlorides, expressed as HCl	< 1-~~10~~ 5 (8) (10)	~~50~~
Nitrogen oxides (NO_X)	~~50~~ 10-150 (9) (3) (4)	~~1 000~~
Sulphur oxides (SO_2~~x~~)	~~50~~ < 3-150 (9) (5)	

(6) The BAT-AEL does not apply when the NH_3 mass flow is below 100 g/h.
(7) The BAT-AEL does not apply when the mass flow of the substance concerned is below 5 g/h.
(8) The BAT-AEL does not apply when the HCl mass flow is below 50 g/h.
(9) The BAT-AEL does not apply when the mass flow of the substance concerned is below 1 000 g/h.
(1) The BAT-AEL does not apply to channelled emissions to air of ammonia from the use of SCR or SNCR (ammonia slip). This is covered by ~~(see~~ BAT 17~~)~~.
~~(2) As an indication, the emission levels for carbon monoxide are 20-100 mg/Nm^3, as daily average or average over the sampling period.~~
(3) The upper end of the BAT-AEL range is 300 mg/Nm^3 when NO_X is recovered from process off-gases to produce nitric acid.
(4) The BAT-AEL does not apply to channelled emissions to air of NO_X from the use of catalytic or thermal oxidation (see BAT 15) or from process furnaces/heaters (see BAT 36).
(5) The BAT-AEL does not apply in the case of physical purification or reconcentration of spent sulphuric acid.
(10) The BAT-AEL does not apply to the production of HCl via the Mannheim process, if the HCl abatement efficiency of the waste gas treatment system is ≥ 99 %.
(11) In the case of NO_X concentrations above 100 mg/Nm^3, the upper end of the BAT-AEL range may be higher and up to 3 mg/Nm^3 due to analytical interference.

The associated monitoring is given in BAT 8.

[This BAT conclusion is based on information given in Section 2.3.4]

4.1.4 Diffuse VOC emissions to air

4.1.4.1 ~~General techniques~~ Management system for diffuse VOC emissions

BAT 19. In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to elaborate and implement a management system for diffuse VOC emissions, as part of the environmental management system (see BAT 1), that includes all of the following features:

i. Estimating the annual quantity of diffuse VOC emissions (see BAT 20).
ii. Monitoring diffuse VOC emissions from the use of solvents by compiling a solvent mass balance, if applicable (see 0).
iii. Establishing and implementing a leak detection and repair (LDAR) programme for fugitive VOC emissions. The LDAR programme ~~is carried out as a campaign,~~

~~which~~ typically lasts from 1 to 5 years. The LDAR programme includes all of the following features:

a. Listing of equipment identified as relevant fugitive VOC emission sources in the inventory of diffuse VOC emissions (see BAT 2).

b. ~~Definition of~~ Definition of criteria associated with the following:

  - Leaky equipment ~~VOC concentration threshold above~~. Typical criteria could be a leak threshold, above which equipment is considered leaky, and/or the visualisation of a leak with OGI cameras. This depends on the characteristics of the emission source (e.g. accessibility) and the hazardous properties of the emitted substance(s). ~~For the first LDAR campaign, when using sniffing, the leak threshold is typically lower than or equal to 10 000 ppmv.~~
  - Maintenance and/or repair actions ~~Definition of a VOC concentration threshold above which equipment maintenance is~~ to be carried out. A typical criterion could be a VOC concentration threshold triggering the maintenance or repair action (maintenance/repair threshold). The maintenance/repair threshold is generally equal to or higher than the leak threshold ~~but~~. This depends on the characteristics of the emission source (e.g. accessibility) and the hazardous properties of the emitted substance(s). For the first LDAR programme, it is generally not higher than ~~10 000~~ 5 000 ppmv.

c. Measuring fugitive VOC emissions from equipement listed under point iii. a. (see BAT 22).

d. Carrying out maintenance and/or repair actions (see BAT 23, techniques e. and f.) where necessary according to the criteria defined in point iii. b.~~ on equipment considered leaky when the measured fugitive VOC concentration is above the maintenance/repair threshold, typically within 30 days from the date when the equipment was identified as leaky~~. Maintenance and repair actions are prioritised according to the hazardous properties of the emitted substance(s),~~ and/or~~ the significance of the emissions and/or operational constraints. The effectiveness of the maintenance and/or repair actions is verified according to point iii.c., leaving enough time after the intervention (e.g. 2 months).

e. Filling in the database mentioned in point v.

iv. Establishing and implementing a detection and reduction programme for non-fugitive VOC emissions that includes all of the following features:

a. Listing of equipment identified as relevant non-fugitive VOC emission sources in the inventory of diffuse VOC emissions (see BAT 2).

b. Monitoring ~~Measuring~~ non-fugitive VOC emissions from equipement listed under point iv. a. (see BAT 22).

c. Planning and implementing techniques to reduce non-fugitive VOC emissions (see BAT 23, techniques a., b. and g. to j.). The planning and implementation of the techniques are prioritised according to the hazardous properties of the emitted substance(s), ~~and/or~~ the significance of the emissions and/or operational constraints.

d. Filling in the database mentioned in point v.

v. Establishing and maintaining a database, for diffuse VOC emissions sources that are identified in the inventory mentioned in BAT 2, for keeping record of:

a. equipment design specifications (including the date and description of any design changes);

b. the equipment maintenance, repair, upgrade, or replacement actions, performed or planned, and their date of implementation;

c. the equipment that could not be maintained, repaired, upgraded or replaced due to operational constraints;

d. ~~if applicable,~~ the results of the measurements or monitoring, including ~~for each piece of equipment identified as~~ leaky: ~~the emitted substance(s), their hazardous properties (if relevant, e.g. CMR 1A, 1B or 2),~~ the concentration(s) of the emitted substance(s) ~~from the leaky equipment~~, the calculated leak rate (as kg/year), the recording from OGI cameras and the date ~~when the equipment was identified as leaky~~ of the measurements or monitoring;

   e. the annual quantity of diffuse VOC emissions.

vi. Reviewing and updating the LDAR programme periodically ~~for the next campaign~~. This may include~~s~~ ~~all of~~ the following:

   a. lowering the leak and/or maintenance/repair thresholds;
   b. reviewing the prioritisation of equipment to be monitored, giving higher priority to (the type of) equipment identified as leaky during the previous ~~campaign~~ LDAR programme;
   c. planning the maintenance, repair, upgrade or replacement of equipment that could not be performed during the previous ~~campaign~~ LDAR programme due to operational constraints.

vii. Reviewing and updating the detection and reduction programme for non-fugitive VOC emissions. This may include~~s~~ ~~all of~~ the following:

   a. ~~measuring~~ monitoring non-fugitive VOC emissions from equipment where maintenance, repair, upgrade or replacement actions were implemented, in order to determine if those actions were successful;
   b. planning the maintenance, repair, upgrade or replacement actions that could not be performed due to operational constraints.

Applicability

The features points iii., iv., vi. and vii. are only applicable to sources of diffuse VOC emissions for which ~~measurements~~ monitoring according to BAT 22 ~~are~~ is applicable.

The level of detail of the management system for diffuse VOC emissions will be proportionate to the nature, scale and complexity of the plant, and the range of environmental impacts it may have.

[This BAT conclusion is based on information given in Section 3.4.1]

4.1.4.2 Monitoring

BAT 20. BAT is to estimate diffuse VOC emissions to air at least once every year by using one or a combination of the techniques given below, as well as to determine the uncertainty of this estimation. The estimation distinguishes between VOCs classified as CMR 1A or 1B and VOCs that are not classified as CMR 1A or 1B.

Technique		Description	Type of emissions	~~Applicability~~
~~Diffuse emissions~~				
a.	~~Estimation of diffuse emissions from processes by using~~ Use of emission factors	~~An emission factor is a representative value that attempts to relate the quantity of a substance emitted to a process associated with the emission of that substance. Emission factors are usually expressed as the mass of a substance emitted divided by the throughput of the process emitting the substance.~~ See Section 4.4.2.	Fugitive and/or non-fugitive	~~Only applicable to processes for which emission factors have been derived according to nationally or internationally recognised guidance.~~
b.	~~Estimation of diffuse emissions from the whole plant by using~~	~~Diffuse emissions are calculated from~~ Estimation	Fugitive and/or	~~Generally applicable.~~

	Use of a mass balance	based on the difference in the mass of the substance inputs to and outputs from the plant/production unit, taking into account the generation and destruction of the substance in the plant/production unit. Mass balances are applied by plants using solvents (see 0).	non-fugitive	
c.	~~Estimation of diffuse emissions from processes or equipment by using~~ Use of thermodynamic models	Estimation using the laws of thermodynamics applied to equipment (e.g. tanks) or particular steps of a production process. The following data are generally used as input for the model: • chemical properties of the substance (e.g. vapour pressure, molecular mass); • process operating data (e.g. operating time, product quantity, ventilation); • characteristics of the emission source (e.g. tank diameter, colour, shape).	Fugitive and/or non-fugitive	~~Generally applicable.~~
	~~Fugitive emissions~~			
~~d.~~	~~Estimation of fugitive emissions from equipment leaks by using emission factors~~	~~An emission factor is a representative value that attempts to relate the quantity of a substance emitted from a type of equipment. Emission factors are usually expressed as the mass of a substance emitted per hour and per equipment.~~		~~Only applicable to types of equipment for which emission factors have been derived according to nationally or internationally recognised guidance.~~
e.	~~Estimation of fugitive emissions from gasketed circular flange connections by calculations~~ Use of EN 1591	~~Calculations according to EN 1591.~~ Estimation of fugitive emissions from gasketed circular flange connections by calculations.	Fugitive	~~Generally applicable.~~

Note

The estimation of the diffuse VOC emissions to air may take into account the results of the monitoring carried out according to BAT 21 and/or to BAT 22.

BAT 21. BAT is to monitor diffuse VOC emissions from the use of solvents by compiling, at least once every year, a solvent mass balance of the solvent inputs and outputs of the plant, as defined in Part 7 of Annex VII to Directive 2010/75/EU and to minimise the uncertainty of the solvent mass balance data by using all of the techniques given below.

Technique		Description
a.	Full identification and quantification of the relevant solvent inputs and outputs, including the associated uncertainty	This includes: • identification and documentation of solvent inputs and outputs (e.g. channelled and diffuse emissions to air, emissions to water, solvent output in waste); • substantiated quantification of each relevant solvent input and output and recording of the methodology used (e.g. measurement, estimation by using emission factors, estimation based on operational parameters); • identification of the main sources of uncertainty of the aforementioned quantification, and implementation of corrective actions to reduce the uncertainty; • regular update of solvent input and output data.
b.	Implementation of a solvent tracking system	A solvent tracking system aims to keep control of both the used and unused quantities of solvents (e.g. by weighing unused quantities returned to storage from the application area).
c.	Monitoring of changes that may influence the uncertainty of the solvent mass balance data	Any change that could influence the uncertainty of the solvent mass balance data is recorded, such as: • malfunctions of the waste gas treatment system: the date and period of time are recorded; • changes that may influence air/gas flow rates (e.g. replacement of fans): the date and type of change are recorded.

Applicability

This BAT does not apply to the production of polyolefins or synthetic rubbers.

~~The technique~~ This BAT may not be applicable to plants whose total annual consumption of solvents is lower than 50 tonnes. The level of detail of the solvent mass balance will be proportionate to the nature, scale and complexity of the plant, and the range of environmental impacts it may have, as well as to the type and quantity of solvents used.

BAT 22. BAT is to ~~measure~~ monitor diffuse VOC 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.

Type of sources of diffuse VOC emissions (1) (2)	Type of VOCs	Standard(s)	Minimum ~~measurement~~ monitoring frequency
Sources of fugitive emissions	VOCs classified as CMR 1A or 1B	EN 15446	Once every year (3) (4)
	VOCs not classified as CMR 1A or 1B		Once ~~every~~ during the period covered by each LDAR ~~campaign~~ programme (see BAT 19 point iii.)
Sources of non-fugitive emissions	VOCs classified as CMR 1A or 1B	No EN standard available	Once every year
	VOCs not classified as CMR 1A or 1B		Once every 5 years

(1) The ~~measurements~~ monitoring only appl~~y~~ies to emission sources that are identified as relevant in the inventory given in BAT 2.

(2) The ~~measurements~~ monitoring does not apply to high-integrity equipment (see BAT 23 d.) or to equipment operated under subatmospheric pressure.

(3) In the case of inaccessible sources of fugitive VOC emissions (e.g. if the ~~measurements~~ monitoring requires the removal of insulation or the use of scaffolding), the ~~measurements~~ monitoring frequency may be reduced to once ~~every~~ during the period covered by each LDAR ~~campaign~~ programme (see BAT 19 point iii.).

(4) For the production of PVC, the minimum monitoring frequency may be reduced to once every 5 years if the plant uses VCM gas detectors permanently installed on site.

Note

Optical gas imaging (OGI) is a useful complementary technique to identify sources of diffuse VOC emissions and is particularly relevant ~~to identify~~ in the case of inaccessible sources (see Section 4.4.2).

Where large amounts of VOCs are handled, the quantification of ~~total~~ VOC emissions from the plant with optical absorption-based techniques, such as differential absorption light detection and ranging (DIAL) or solar occultation flux (SOF), is a useful complementary technique (see Section 4.4.2).

Applicability

BAT 22 only applies when the annual quantity of diffuse VOC emissions from the plant estimated according to BAT 20 is greater than:

- 2 tonnes of VOCs per year in the case of VOCs classified as CMR 1A or 1B; or
- 10 tonnes of VOCs.

[This BAT conclusion is based on information given in Section 3.4]

4.1.4.3 Prevention or reduction of diffuse VOC emissions

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

Technique		Description	Applicability
Fugitive emissions and non-fugitive emissions			
a.	Limiting the number of emission sources	This includes: • minimising pipe lengths; • reducing the number of pipe connectors (e.g. flanges) and valves; • using welded fittings and connections; • using compressed air or gravity for material transfer.	Applicability may be restricted by operational constraints in the case of existing plants.
b.	Collecting~~on~~ ~~of~~ diffuse emissions and treating off-gases	Collecting diffuse VOC emissions (e.g. from compressor seals, vents and purge lines) and sending them to recovery (see BAT 9 and BAT 10) and/or abatement (see BAT 11).	Applicability may be restricted: • for existing plants; and/or • by safety concerns (e.g. avoiding concentrations close to the lower explosive limit).
Fugitive emissions			
c.	Facilitating access and/or monitoring activities ~~to potentially leaky equipment~~	To ease maintenance and/or monitoring activities, the access to potentially leaky equipment is facilitated, e.g. by installing platforms, and/or ~~using~~ drones are used for monitoring.	Applicability may be restricted by operational constraints in the case of existing plants.
d.	Use of high-integrity equipment	High-integrity equipment is selected, installed and maintained according to the type of process and the process operating conditions. High-integrity equipment includes: • valves with bellow or double packing seals or equally ~~efficient~~ effective equipment; • magnetically driven or canned pumps/compressors/agitators, or pumps/compressors/agitators using double seals and a liquid barrier; • certified high-quality gaskets (e.g. according to EN 13555) that ~~is~~ are tightened according to technique e.; ~~• corrosion-resistant equipment;.~~ • closed sampling system.	
e.	Tightening	This includes: • tightening of gaskets by personnel that is qualified according to EN 1591-4 and using the designed gasket stress (e.g. calculated according to EN 1591-1); • installing tight caps on open ends;~~.~~ • using flanges selected and assembled according to EN 13555.	Generally applicable.

f.	Replacement of leaky equipment and/or parts	This includes the replacement of: • gaskets; • sealing elements (e.g. tank lid); • packing material (e.g. valve stem packing material).	
Non-fugitive emissions			
g.	Reviewing and updat~~e~~ing ~~of~~ process design	This includes: • reducing the use of solvents and/or using solvents with lower volatility; • reducing the formation of side products containing VOCs; • lowering the operating temperature; • lowering the VOC content in the final product.	Applicability may be restricted in the case of existing plants due to operational constraints.
h.	Reviewing and updat~~e~~ing ~~of~~ operating conditions	This includes: • reducing the frequency and duration of reactor and vessel openings; • preventing corrosion by lining or coating of equipment, by painting pipes ~~to prevent~~ (for external corrosion) and by using corrosion inhibitors for materials in contact with equipment.	Generally applicable.
i.	Us~~e~~ing ~~of~~ closed systems	This includes: • vapour balancing (see Section 4.4.3); • closed systems for solid/liquid and liquid/liquid phase separations; • closed systems for cleaning operations; • closed sewers and/or waste water treatment plants; • closed sampling systems; • closed storage areas. Off-gases from closed systems are sent to recovery (see BAT 9 and BAT 10) and/or abatement (see BAT 11).	Applicability may be restricted by operational constraints in the case of existing plants and/or by safety concerns.
j.	Us~~e~~ing ~~of~~ techniques to minimise emissions from surfaces ~~areas~~	This includes: • installing oil creaming systems on open surfaces; • periodically skimming open surfaces (e.g. removing floating matter); • installing anti-evaporation floating elements on open surfaces; • treating waste water streams to remove VOCs and send ~~them~~ the VOCs to recovery (see BAT 9 and BAT 10) and/or abatement (see BAT 11); • installing floating roofs on tanks; • using fix-roof tanks connected to a waste gas treatment.	Applicability may be restricted by operational constraints in the case of existing plants.

Note

The use of techniques to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air is prioritised according to the hazardous properties of the emitted substance(s) and/or the significance of the emissions.

[This BAT conclusion is based on information given in Section 3.4]

4.1.4.4 BAT conclusions for the use of solvents or the reuse of recovered solvents

The emission levels for the use of solvents or the reuse of recovered solvents given below are associated with the general BAT conclusions given in Section 4.1.4.1 and Section 4.1.4.3.

Table 4.7: BAT-associated emission level (BAT-AEL) for diffuse VOC emissions to air from the use of solvents or the reuse of recovered solvents

Parameter	**BAT-AEL (percentage of the solvent inputs) (yearly average) ~~(1)~~ (2)**
Diffuse VOC emissions	≤ 5 %

~~(1) The BAT-AEL does not include solvents sold as part of products or mixtures in a sealed container.~~
(2) The BAT-AEL does not apply to plants whose total annual consumption of solvents is lower than 50 tonnes.

The associated monitoring is given in BAT 20, BAT 21 and BAT 22.

4.2 Polymers

The BAT conclusions presented in this section apply to the production of certain polymers. They apply in addition to the general BAT conclusions given in Section 4.1.

4.2.1 BAT conclusions for the production of polyolefins

BAT 24. BAT is to monitor the TVOC concentration in polyolefin products, at least once every year for each polyolefin grade, ~~the monomer concentration in polyolefin 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.

Polyolefin product	~~**Polyolefin monomer(s)**~~	**Standard(s)**	~~**Minimum monitoring frequency**~~	**Monitoring associated with**
HDPE, LDPE, LLDPE	~~Ethylene~~	No EN standard available	~~Once every month~~	BAT 25
~~LDPE~~				
~~LLDPE~~				
~~EVA copolymers~~	~~Ethylene and vinyl acetate~~			
PP	~~Propylene~~			
EPS, GPPS, HIPS				

Note
The measurement samples are taken at the point of transition from the closed to the open system where the polyolefin comes into contact with the atmosphere.
The closed system refers to the part of the production process where the materials (e.g. reactants, solvents, suspension agents) are not in contact with the atmosphere. It includes the polymerisation steps, the reuse and recovery of materials.
The open system refers to the part of the production process where the polyolefins come into contact with the atmosphere. It includes the finishing steps (e.g. drying, blending) as well as the transfer, handling and storage of polyolefins.

BAT 25. In order to increase resource efficiency and to reduce emissions to air of organic compounds, BAT is to use one or a combination ~~all~~ of the techniques given below.

	Technique	Description	Applicability
a.	Chemical agents with low boiling points	Solvents and suspension agents with low boiling points are used.	Applicability may be restricted by operational constraints.
b.	Lowering the VOC content in the polymer	The VOC content in the polymer is lowered, e.g. by using low-pressure separation, stripping or closed-loop nitrogen purge systems, devolatilisation extrusion (see Section 4.4.3). The techniques for lowering the VOC content depend on the type of polymer product and production process.	Devolatilisation extrusion may be restricted by product specifications for the production of HDPE, LDPE and LLDPE.
c.	Collection and treatment of process off-gases	Process off-gases arising from the use of technique b. as well as from the finishing step, e.g. extrusion and degassing silos, are collected and sent to recovery (see BAT 9 and BAT 10) and/or abatement (see BAT 11).	Applicability may be restricted by operational constraints.

[This BAT conclusion is based on information given in Section 3.5.1]

Table 4.8: BAT-associated emission levels (BAT-AELs) for total emissions to air of ~~VOC~~VOCs from the production of polyolefins expressed as specific emission loads

Polyolefin product	Unit	BAT-AEL (Yearly average)
HDPE	g ~~VOCs~~ C per kg of polyolefins produced	0.3–~~1.8~~1.0 (1)
LDPE		~~0.2–1.9~~ 0.1-1.4 (2)
LLDPE		~~0.3–1.3~~ 0.1-0.7
~~EVA copolymers~~		~~2.7–16~~
PP		~~0.2–2~~ 0.1-0.9 (1)
GPPS and HIPS		< ~~0.085~~ 0.1
EPS		< 0.6

(1) The lower end of the BAT-AEL range is typically associated with the gas-phase polymerisation process.
(2) The upper end of the BAT-AEL range may be up to 2.7 g C/kg in the case of the production of LDPE copolymers.

The associated monitoring is given in BAT 8, BAT 20, ~~and~~ BAT 22 and BAT 24. The monitoring of TVOC emissions to air includes all emissions from the following process steps, where the emissions are identified as relevant in the inventory given in BAT 2: storage and handling of raw materials, polymerisation, recovery of materials and pollutant abatement, finishing of the polymer (e.g. extrusion, drying, blending) as well as the transfer, handling and storage of polymers.

~~As an alternative to the BAT-AELs in Table 4.8, the BAT-AELs in Table 4.9 may be used.~~

~~**Table 4.9: BAT-associated emission levels (BAT-AELs) for the monomer concentration in the polyolefin**~~

~~**Polyolefin product**~~	~~**Monomer(s)**~~	~~**Unit**~~	~~**BAT-AEL (Yearly average)**~~
~~HDPE~~	~~Ethylene~~	~~g monomer per kg of polyolefin produced~~	~~< 0.5~~
~~LDPE~~			~~< 3~~
~~LLDPE~~			~~No BAT-AEL~~
~~EVA copolymers~~	~~Sum of ethylene and vinyl acetate~~		~~< 10~~
~~PP~~	~~Propylene~~		~~< 1~~
~~GPPS and HIPS~~	~~Styrene~~		~~No BAT-AEL~~
~~EPS~~			~~No BAT-AEL~~

~~Note: The monomer concentration in the polyolefin is measured after lowering the VOC content in the polymer (see BAT 25 b.).~~

~~The associated monitoring is given in BAT 24.~~

4.2.2 BAT conclusions for the production of polyvinyl chloride (PVC)

BAT 26. 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.

Substance	**Emission points**	**Standard(s)**	**Minimum monitoring frequency** (4)	**Monitoring associated with**
~~Vinyl chloride monomer~~ VCM	~~All emission points~~ Any stack with a VCM mass flow of ≥ 25 g/h	Generic EN standards (1)	Continuous	BAT 29
	~~All emission points~~ Any stack with a VCM mass flow of < 25 g/h	No EN standard available	Once every 6 months (2) (3)	

(1) Generic EN standards for continuous measurements are EN 14181, EN 15267-1, EN 15267-2 and EN 15267-3.

(2) To the extent possible, the measurements are carried out at the highest expected emission state under normal operating conditions.

(3) The minimum monitoring frequency may be reduced to once every year if the emission levels are proven to be sufficiently stable.

(4) The monitoring of VCM emissions from finishing steps (e.g. drying, blending) as well as from the transfer, handling and storage of PVC may be replaced by the monitoring in BAT 27.

[This BAT conclusion is based on information given in Section 2.6]

BAT 27. BAT is to monitor the ~~VCM~~ vinyl chloride monomer concentration in PVC products ~~with~~, at least once every year for each PVC grade, ~~the frequency given below and~~ in accordance with EN standards. ~~If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.~~

Substance	Standard(s)	~~Minimum monitoring frequency~~	Monitoring associated with
~~Vinyl chloride monomer~~ VCM	EN ISO 6401	~~Once every month~~	BAT 30

Note

The samples of the PVC slurry/latex are taken at the point of transition from the closed to the open system where the PVC slurry/latex comes into contact with the atmosphere.

The closed system refers to the part of the production process where the PVC slurry/latex is not in contact with the atmosphere. It includes the polymerisation steps, the reuse and recovery of VCM.

The open system is the part of the system where the PVC slurry/latex comes into contact with the atmosphere. It includes the finishing steps (e.g. drying and blending) as well as the transfer, handling and storage of PVC.

BAT 28. In order to increase resource efficiency and to reduce the mass flow of organic compounds sent to the final waste gas treatment, BAT is to recover the vinyl chloride monomer from process off-gases by using one or a combination of the techniques given below, and to reuse the recovered monomer.

	Technique	Description
a.	Absorption (regenerative)	See Section 4.4.1.
b.	Adsorption (regenerative)	See Section 4.4.1.
c.	Condensation	See Section 4.4.1.

Applicability

Recovery may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gas(es). ~~Applicability may be restricted where the costs are excessive due to the low concentration of VCM in the process off-gas(es).~~

BAT 29. In order to reduce channelled emissions to air of vinyl chloride monomer from the recovery of vinyl chloride monomer, BAT is to use one or a combination of the techniques given below.

	Technique	**Description**	**Applicability**
a.	Absorption	See Section 4.4.1.	Generally applicable
b.	Adsorption	See Section 4.4.1.	
c.	Condensation	See Section 4.4.1.	
d.	Thermal oxidation	See Section 4.4.1.	Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/or operational constraints. Straight thermal oxidation is generally applicable.

Table 4.10: BAT-associated emission level (BAT-AEL) for channelled emissions to air of VCM from the recovery of VCM~~production of PVC~~

Substance	**BAT-AEL (mg/Nm^3) (Daily average or average over the sampling period)**	~~**Mass flow threshold (g/h)**~~
~~Vinyl chloride monomer~~ VCM	< 0.5-1 (1)	~~2.5~~
(1) The BAT-AEL does not apply when the VCM mass flow is below 2.5 g/h.		

The associated monitoring is given in BAT 26.

BAT 30. In order to reduce ~~VCM~~ emissions to air of vinyl chloride monomer, BAT is to use all of the techniques given below.

Technique		Description
a.	Appropriate VCM storage facilities	This includes: • storing VCM in refrigerated tanks at atmospheric pressure or in pressurised tanks at ambient temperature; • using refrigerated reflux condensers or connecting tanks ~~to~~ for VCM recovery (see BAT 28) and/or abatement (see BAT 29).
b.	Vapour balancing	See Section 4.4.3.
c.	Minimisation of emissions of residual VCM from equipment	This includes: • reducing the frequency and duration of reactor openings; • venting off-gases from latex storage tanks and from connections to VCM recovery (see BAT 28) and/or abatement (see BAT 29) prior to opening the reactor ~~decoupling~~; • flushing the reactor with inert gas prior to opening and venting off-gases to VCM recovery (see BAT 28) and/or abatement (see BAT 29); • draining the liquid content of the reactor to closed vessels prior to opening the reactor; • cleaning the reactor with water prior to opening ~~the reactor~~ and draining ~~it~~ the water to the stripping system.
d.	Lowering the VCM content in the polymer by stripping	See Section 4.4.3.
e.	Collection and treatment of process off-gases	Process off-gases from the use of technique d. are collected and sent to VCM recovery (see BAT 28) and/or abatement (see BAT 29).

[This BAT conclusion is based on information given in Section 3.5.2]

Table 4.11: BAT-associated emission levels (BAT-AELs) for total emissions to air of VCM from the production of PVC expressed as specific emission loads

PVC type	Unit	BAT-AEL (Yearly average)
S-PVC	g VCM per kg of PVC produced	0.01-0.045
E-PVC		~~0.1-0.5~~0.25-0.50

The associated monitoring is given in BAT 20, BAT 22, ~~and~~ BAT 26 and BAT 27. The monitoring of VCM emissions to air includes all emissions from the following process steps or equipment, where the emissions are identified as relevant in the inventory given in BAT 2: finishing, e.g. drying and blending; transfer, handling and storage; reactor openings; gasholders; waste water treatment plants; recovery and/or abatement of VCM.

~~As an alternative to the BAT-AELs in Table 4.11, the BAT-AELs in Table 4.12 may be used.~~

Table 4.12: BAT-associated emission levels (BAT-AELs) for the VCM concentration in the PVC

PVC type	Unit	BAT-AEL (Yearly average)
S-PVC	g VCM per kg of PVC produced	~~0.001 – 0.3~~ 0.01-0.03
E-PVC		~~0.005 – 0.5~~ 0.2-0.4

~~Note: The VCM concentration in the PVC is measured after lowering the VCM content in the polymer (see BAT 30 d.).~~
The associated monitoring is given in BAT 27.

[This BAT conclusion is based on information given in Section 2.6]

4.2.3 BAT conclusions for the production of synthetic ~~solution-polymerised~~ rubbers

BAT 31. BAT is to monitor the TVOC concentration in synthetic rubbers ~~VOC concentration in solution-polymerised rubber with~~, at least once every year for each synthetic rubber grade, ~~the frequency given below and~~ in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Substance/Parameter	Standard(s)	~~Minimum monitoring frequency~~	Monitoring associated with
VOCs	No EN standard available	~~Once every month~~	BAT 32

Note
The samples are taken after lowering the VOC content in the polymer (see BAT 32 a.) where the synthetic rubber comes into contact with the atmosphere.

BAT 32. In order to reduce emissions to air of organic compounds, BAT is to use ~~both~~ one or a combination of the techniques given below.

	Technique	Description
a.	Lowering the VOC content in the polymer	The VOC content in the polymer is lowered by using stripping or devolatilisation extrusion (see Section 4.4.3).
b.	Collection and treatment of process off-gases	Process off-gases ~~from the use of technique a.~~ are collected and sent to recovery (see BAT 9 and BAT 10) and/or abatement (see BAT 11).

Table 4.13: BAT-associated emission level~~s~~ (BAT-AEL~~s~~) for total emissions to air of VOC~~s~~ ~~and 1,3-Butadiene~~ from the production of synthetic ~~solution-polymerised~~ rubbers expressed as specific emission load

Substance/Parameter	**Unit**	**BAT-AEL (Yearly average)**
TVOC~~s~~	g C~~VOCs~~ per kg of polymerised rubber produced	0.2–~~11~~ 2.3
~~1,3-Butadiene~~		~~< 0.007~~

The associated monitoring is given in BAT 8, BAT 20, ~~and~~ BAT 22 and BAT 31. The monitoring of TVOC emissions to air includes all emissions from the following process steps, where the emissions are identified as relevant in the inventory given in BAT 2: storage of raw materials, polymerisation, recovery of materials and abatement techniques, finishing of the polymer (e.g. extrusion, drying, blending) as well as the transfer, handling and storage of synthetic rubbers.

~~As an alternative to the BAT-AELs in Table 4.13, the BAT-AEL in Table 4.14 may be used.~~

~~Table 4.14: BAT-associated emission level (BAT-AEL) for the VOC concentration in the solution-polymerised rubber after treatment (see BAT 32)~~

~~Unit~~	**~~BAT-AEL (Yearly average)~~**
~~g VOCs per kg of solution-polymerised rubber produced~~	~~0.005–25~~

~~Note: The VOC concentration in the solution-polymerised rubber is measured after lowering the VOC content in the polymer (see BAT 32 a.).~~

~~The associated monitoring is given in BAT 31.~~

4.2.4 BAT conclusions for the production of viscose using CS_2

BAT 33. 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.

Substance (4)	**Emission points**	**Standard(s)**	**Minimum monitoring frequency**	**Monitoring associated with**
Carbon disulphide (CS_2)	~~All emission points~~ Any stack with a mass flow of ≥ 1 kg/h	Generic EN standards (1)	Continuous	BAT 35
	~~All emission points~~ Any stack with a mass flow of < 1 kg/h	No EN standard available	Once every year (2) (3)	
Hydrogen sulphide (H_2S)	~~All emission points~~ Any stack with a mass flow of ≥ 50 g/h	Generic EN standards (1)	Continuous	
	~~All emission points~~ Any stack with a mass flow of < 50 g/h	No EN standard available	Once every year (2) (3)	

(1) Generic EN standards for continuous measurements are EN 14181, EN 15267-1, EN 15267-2 and EN 15267-3.

(2) To the extent possible, the measurements are carried out at the highest expected emission state under normal operating conditions.

(3) The minimum monitoring frequency may be reduced to once every 3 years if the emission levels are proven to be sufficiently stable.

(4) The monitoring only applies when the substance concerned is identified as relevant in the waste gas stream based on the inventory given in BAT 2.

[This BAT conclusion is based on information given in Section 2.8]

BAT 34. In order to increase resource efficiency and to reduce the mass flow of CS_2 and H_2S sent to the final waste gas treatment, BAT is to recover CS_2 ~~from process off-gases from spinning lines~~ by using one or both ~~a combination~~ of the techniques ~~a.~~ b. and c. given below and to reuse the CS_2, or, alternatively, to use technique d.

Technique		**Description**	**Applicability**
~~a.~~	~~Absorption (regenerative)~~	~~See Section 4.4.1.~~	
b.	Adsorption (regenerative)	See Section 4.4.1.	Applicability may be restricted where the energy demand for recovery is excessive if the concentration of CS_2 in the waste gas is below 5 g/Nm^3.
c.	Condensation	See Section 4.4.1.	
d.	Production of sulphuric acid	Process off-gases containing CS_2 and H_2S are used to produce sulphuric acid.	Applicability may be restricted if the concentration of CS_2 and/or H_2S in the waste gas is below 5 g/Nm^3.

~~Applicability~~

~~Applicability may be restricted where the costs are excessive due to the low of CS_2 and H_2S in the process off-gas(es).~~

[This BAT conclusion is based on information given in Section 3.3]

BAT 35. In order to reduce channelled emissions to air of CS_2 and H_2S, BAT is to use ~~one or a combination~~ technique b. or both of the techniques given below.

	Technique	Main substance targeted	Description	Applicability
a.	Absorption	H_2S	See Section 4.4.1.	Generally applicable.
~~b.~~	~~Adsorption~~		~~See Section 4.4.1.~~	
b.	Bioprocesses	CS_2, H_2S	See Section 4.4.1.	Applicability may be restricted where the energy demand is excessive due to high waste gas volume flows (e.g. above 60 000 Nm^3/h) or low CS_2 concentration in the waste gas.
~~c.~~	~~Condensation~~		~~See Section 4.4.1.~~	
~~d.~~	~~Thermal oxidation~~		~~See Section 4.4.1.~~	

Table 4.15: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of CS_2 and H_2S from the production of viscose using CS_2

Substance	BAT-AEL (mg/Nm^3) (Daily average or average over the sampling period)	~~Mass flow threshold (g/h)~~
CS_2	150-400 (1)	~~100~~
H_2S	1-10	~~5~~

(1) The upper end of the BAT-AEL range may be higher and up to 600 mg CS_2/Nm^3 if both of the following conditions are fulfilled:
- bioprocesses (see BAT 35 b) are not applicable;
- the CS_2 recovery efficiency (see BAT 34) is ≥ 95 %.

The associated monitoring is given in BAT 33.

~~BAT-AELs for channelled emissions to air of SO_X when thermal oxidation is used: See Table 4.6.~~

Table 4.16: BAT-associated emission levels (BAT-AELs) for total emissions to air of H_2S and CS_2 from the production of staple fibres and ~~filament yarn~~ casing expressed as specific emission loads

Parameter	**Process**	**Unit**	**BAT-AEL (Yearly average)**
Sum of H_2S and CS_2 (expressed as Total S) (1)	Production of staple fibres	g Total S per kg of product	9.5-12
	~~Production of filament yarn~~		~~70-250~~
	Casing		120-250

(1) Emissions to air refer to channelled emissions only.

The associated monitoring is given in ~~BAT 20, BAT 22 and~~ BAT 33.

[This BAT conclusion is based on information given in Section 3.5.4]

4.3 Process furnaces/heaters

The BAT conclusions presented in this section apply when process furnaces/heaters with a total rated thermal input equal to or greater than 1 MW are used. They apply in addition to the general BAT conclusions given in Section 4.1.

Where the waste gases of two or more separate process furnaces/heaters are discharged through a common stack, the capacities of all individual furnaces/heaters shall be added together for the purpose of calculating the total rated thermal input.

BAT 36. In order to reduce channelled emissions to air of CO, dust, NO_X and SO_X, BAT is to use one or a combination of the techniques given below.

Technique		**Description**	**Main inorganic compounds targeted**	**Applicability**
a.	Choice of fuel	See Section 4.4.1. This includes switching from liquid to gaseous fuels, taking into account the overall hydrocarbon balance.	NO_X, SO_X, dust	The switch from liquid to gaseous fuels may be restricted by the design of the burners in the case of existing process furnaces/heaters.
b.	Low-NO_X burner	See Section 4.4.1	NO_X	For existing process furnaces/heaters, the applicability may be restricted by their design.
c.	Optimised combustion	See Section 4.4.1.	CO, NO_X	Generally applicable.
d.	Absorption	See Section 4.4.1.	SO_X, dust	Applicability may be restricted for existing process furnaces/heaters by space availability.
e.	Fabric filter or absolute filter	See Section 4.4.1.	Dust	Not applicable when only combusting gaseous fuels.
f.	Selective catalytic reduction (SCR)	See Section 4.4.1.	NO_X	Applicability to existing process furnaces/heaters may be restricted by space availability.
g.	Selective non-catalytic reduction (SNCR)	See Section 4.4.1.	NO_X	Applicability to existing process furnaces/heaters may be restricted by the temperature window (800 ~~900~~-1 100 ~~1 050~~ °C) and the residence time needed for the reaction.

Table 4.17: BAT-associated emission level (BAT-AEL) for channelled NO_X emissions to air from process furnaces/heaters

Parameter	**BAT-AEL (mg/Nm^3) (Daily average or average over the sampling period)**	~~**Mass flow threshold (g/h)**~~
Nitrogen oxides (NO_X)	10~~50~~-150 (2) (3) (1) (4)	~~1 000~~
Carbon monoxide (CO)	No BAT-AEL (5)	

(2) When the waste gases of two or more process furnaces/heaters are discharged through a common stack, the BAT-AEL applies to the combined discharge from the stack.

(3) The BAT-AEL does not apply when the NO_X mass flow is below 1 000 g/h.

(1) The ~~upper end of the~~ BAT-AEL ~~range~~ may not apply to the production of inorganic pigments when direct heating is used ~~may be up to 400 mg/Nm^3~~ and if the combustion temperature is higher than 1 000~~1 200~~ °C.

(4) The BAT-AEL may not apply to the production of catalysts using metal nitrates when direct heating is used.

(5) As an indication, the emission levels for carbon monoxide are 4-50 mg/Nm^3, as a daily average or average over the sampling period.

The associated monitoring is given in BAT 8.

BAT-AELs for channelled emissions to air of dust and SO_2~~x~~ ~~as well as an indicative emission level for channelled emissions to air of CO~~ are given in Table 4.3 and Table 4.6, respectively.

[This BAT conclusion is based on information given in Sections 2.9 and 3.3]

4.4 Description of techniques

4.4.1 Techniques to reduce channelled emissions to air

Technique	Description
Absorption	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). In the case of regenerative absorption, the compounds may be recovered from the liquid.
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. In non-regenerative adsorption, the spent adsorbent is not regenerated but disposed of. In the case of regenerative adsorption, the adsorbate is subsequently desorbed, e.g. with steam (often on site), for reuse or disposal and the adsorbent is reused. For continuous operation, typically more than two adsorbers are operated in parallel, one of them in desorption mode.
Bioprocesses	Bioprocesses include the following: • Biofiltration: the waste gas stream is passed through a bed of organic material (such as peat, heather, compost, root wood, tree bark, peat, compost, softwood and different kinds of combinations) 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. • Bioscrubbing: the removal of the pollutant compounds from a waste gas stream using a combination of wet scrubbing (absorption) and biodegradation under aerobic conditions. The scrubbing water contains a population of microorganisms suitable to oxidise biodegradable gaseous compounds. The absorbed pollutants are degraded in aerated sludge tanks. • Biotrickling: the removal of the pollutant compounds from a waste gas stream in a biological trickle-bed reactor. The pollutants are absorbed by the water phase and transported to the biofilm, where the biological transformation takes place.
Choice of fuel	The use of fuel (including support/auxiliary fuel) with a low content of potential pollution-generating compounds (e.g. low sulphur, ash, nitrogen, fluorine or chlorine content in the fuel).
Condensation	The removal of vapours of organic and inorganic compounds from a process off-gas or waste gas stream by reducing its temperature below its dew point so that the vapours liquefy. Depending on the operating temperature range required, different cooling media are used, e.g. water or brine. In cryogenic condensation, liquid nitrogen is used as a cooling medium.
Cyclone	Equipment for the removal of dust from a process off-gas or waste gas stream based on imparting centrifugal forces, usually within a conical chamber.
Electrostatic precipitator	An electrostatic precipitator (ESP) is a particulate control device that uses electrical forces to move particles entrained within a waste gas stream onto collector plates. The entrained particles are given an electrical charge when they pass through a corona where gaseous ions flow. Electrodes in the centre of the flow lane are maintained at a high voltage and generate the electrical field that forces the particles to the collector walls. The pulsating DC voltage required is in the range of 20–100 kV.
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.

High-efficiency air filter (HEAF)	A flat-bed filter in which aerosols combine into droplets. Highly viscous droplets remain on the filter fabric which contains the residues to be disposed of and separated into droplets, aerosols and dust. HEAFs are particularly suitable for treating highly viscous droplets.
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. 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.
Low-NO_X burner	The technique (including ultra-low-NO_X burner) is based on the principles of reducing peak flame temperatures. The air/fuel mixing 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. The design of ultra-low-NO_X burners includes (air/)fuel staging and exhaust/flue-gas recirculation.
Optimised combustion	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 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).
Optimisation~~ed~~ of catalytic or thermal oxidation	Optimisation of design and operation of catalytic or thermal oxidation to promote the oxidation of organic compounds including PCDD/F present in the waste gases, to prevent PCDD/F and the (re)formation of their precursors, as well as to reduce the generation of pollutants such as NO_X and CO.
Catalytic oxidation	Abatement technique which oxidises combustible compounds in a waste gas stream with air or oxygen in 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.
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.
Selective catalytic reduction (SCR)	Selective reduction of nitrogen oxides with ammonia or urea in the presence of a catalyst. The technique is based on the reduction of NO_X to nitrogen in a catalytic bed by reaction with ammonia at an optimum operating temperature that is typically around 200-450 °C. In general, ammonia is injected as an aqueous solution; the ammonia source can also be anhydrous ammonia or a urea solution. Several layers of catalyst may be applied. A higher NO_X reduction is achieved with the use of a larger catalyst surface, installed as one or more layers. 'In-duct' or 'slip' SCR combines SNCR with downstream SCR which reduces the ammonia slip from SNCR.
Selective non-catalytic reduction (SNCR)	Selective reduction of nitrogen oxides to nitrogen with ammonia or urea at high temperatures and without catalyst. The operating temperature window is maintained between 800 °C and 1 000 °C for optimal reaction.

4.4.2 Techniques to monitor diffuse emissions to air

Technique	Description
Differential absorption LIDAR (DIAL)	A laser-based technique using differential absorption LIDAR (light detection and ranging), which is the optical analogue of radio-wave-based RADAR. The technique relies on the back-scattering of laser beam pulses by atmospheric aerosols, and the analysis of the spectral properties of the returned light collected with a telescope.
Emission factor	Emission factors are numbers that can be multiplied by an activity rate (e.g. the production output), in order to estimate the emissions from the installation. Emission factors are generally derived through the testing of a population of similar process equipment or process steps. This information can be used to relate the quantity of material emitted to some general measure of the scale of activity. In the absence of other information, default emission factors (e.g. literature values) can be used to provide an estimate of the emissions. Emission factors are usually expressed as the mass of a substance emitted divided by the throughput of the process emitting the substance.
Optical gas imaging (OGI) methods	Optical gas imaging uses small lightweight hand-held cameras which enable the visualisation of gas leaks in real time, so that they appear as 'smoke' on a video recorder together with the image of the equipment concerned, to easily and rapidly locate significant VOC leaks. Active systems produce an image with a back-scattered infrared laser light reflected on the equipment and its surroundings. Passive systems are based on the natural infrared radiation of the equipment and its surroundings.
Solar occultation flux (SOF)	The technique is based on the recording and spectrometric Fourier Transform analysis of a broadband infra-red or ultraviolet/visible sunlight spectrum along a given geographical itinerary, crossing the wind direction and cutting through VOC plumes.

4.4.3 Techniques to reduce diffuse emissions

Technique	Description
Devolatilisation extrusion	When the concentrated rubber solution is further processed by extrusion, the solvent vapours (commonly cyclohexane, hexane, heptane, toluene, cyclopentane, isopentane or mixtures thereof) coming from the vent hole of the extruder are compressed and sent to recovery.
Stripping	VOCs contained in the polymer are transferred to the gaseous phase (e.g. by using steam). The removal efficiency may be optimised by a suitable combination of temperature, pressure and residence time and by maximising the ratio of free polymer surface to total polymer volume.
Vapour balancing	The vapour from a piece of receiving equipment (e.g. a tank) that is displaced during the transfer of a liquid and is returned to the delivery equipment from which the liquid is delivered.