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Best Available Techniques
UK BAT

UK Best Available Techniques

Formal Draft: BAT Conclusions for Common Waste Gas Management and Treatment Systems in the Chemical Sector

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Preface

Status of the document

This document is the formal draft of the UK Best Available Techniques (BAT) Conclusions (BATC), BAT Associated Emission Limits (BAT-AELs) and Environmental Performance Levels (BAT-AEPLs) for the for the common waste gas management and treatment systems in the chemical sector, abbreviated to WGC.

It has been developed based on the outputs from the EU BREF process, which UK representatives participated in up to 31 January 2020, along with comments and evidence provided by the UK BAT WGC Technical Working Group (TWG). It uses evidence available from current industry practice, sector activities and regulatory submissions within a UK context.

The formal draft documents were produced from the consensus reached at the formal meeting of the TWG held between 25 to 27 April and 27 to 28 June 2023. No alternative positions have been presented.

These BATC are supported by a supplementary document which explains, where relevant, the decision-making process or interpretation for the appropriate BATC.

UK BAT process

The UK BAT process was established in 2022 to organise an information exchange between UK Government, devolved administrations, regulators, industry and interested third parties, e.g. environmental non-governmental organisations (NGO's), creating a forum on BAT used to control industrial pollution. Technical Working Groups are formed for each sector under review. The TWGs work in a collaborative forum to discuss and develop BATC for the UK.

The BATC comprise of a short description of each identified technique under BAT, its applicability and where there are applicable BAT-associated emission, consumption or performance levels.

The draft UK BATC will be published for comment and public consultation. Once these have been taken into account, it will be published as a statutory instrument and used as a basis for environmental permit conditions.

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Scope of review

Scope of the review under UK legislation

The national legislation which applies is as follows:

- In **England and Wales** UK SI 2016 No.1154 The Environmental Permitting (England and Wales) Regulation 2016.
- In **Scotland** under SSI 2012 No.360 The Pollution Prevention and Control (Scotland) Regulations 2012.
- In **Northern Ireland** under Statutory Rules 2013 No.160 The Pollution Prevention and Control (Industrial Emissions) Regulations (Northern Ireland) 2013.

In each case, activities for the chemicals sector are listed in Schedule 1, Part 2, Chapter 4 of the above legislation. Activities in England and Wales are listed in Part A(1), whereas in Scotland and Northern Ireland they are listed in Part A. The lists are almost identical and so are set out below as one list with the differences indicated. The storage of chemicals is outside the scope of these BATC unless a directly associated activity of one or more of the chemical activities listed below.

SECTION 4.1: Organic Chemicals

- (a) Producing organic chemicals such as:
- i. hydrocarbons (linear or cyclic, saturated or unsaturated, aliphatic or aromatic);
 - ii. organic compounds containing oxygen (for example alcohols, aldehydes, ketones, carboxylic acids, esters, ethers, peroxides, phenols, epoxy resins);
 - iii. organic compounds containing sulphur (for example sulphides, mercaptans, sulphonic acids, sulphonates, sulphates and sulphones and sulphur heterocyclics);
 - iv. organic compounds containing nitrogen (for example amines, amides, nitrous-, nitro- or azo-compounds, nitrates, nitriles, nitrogen heterocyclics, cyanates, isocyanates, di-isocyanates and di-isocyanate prepolymers);
 - v. organic compounds containing phosphorus (for example substituted phosphines and phosphate esters);
 - vi. organic compounds containing halogens (for example halocarbons, halogenated aromatic compounds and acid halides);
 - vii. organometallic compounds (for example lead alkyls, Grignard reagents and lithium alkyls);
 - viii. plastic materials (for example polymers, synthetic fibres and cellulose-based fibres);
 - ix. synthetic rubbers;
 - x. dyes and pigments;
 - xi. surface-active agents.

The regulations for Scotland list the activities as (a) to (k) rather than (i) to (xi) and has the additional inclusion:

- (l) any other organic compounds not described in sub-paragraphs (a) to (k) above which have the potential to pollute the environment.

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SECTION 4.2: Inorganic chemicals

- (a) Producing inorganic chemicals such as:
- i.* gases (for example ammonia, hydrogen chloride, hydrogen fluoride, hydrogen cyanide, hydrogen sulphide, oxides of carbon, sulphur compounds, oxides of nitrogen, hydrogen, oxides of sulphur, phosgene);
 - ii.* acids (for example chromic acid, hydrofluoric acid, hydrochloric acid, hydrobromic acid, hydroiodic acid, phosphoric acid, nitric acid, sulphuric acid, oleum and chlorosulphonic acid);
 - iii.* bases (for example ammonium hydroxide, potassium hydroxide, sodium hydroxide);
 - iv.* salts (for example ammonium chloride, potassium chlorate, potassium carbonate, sodium carbonate, perborate, silver nitrate, cupric acetate, ammonium phosphomolybdate);
 - v.* non-metals, metal oxides, metal carbonyls or other inorganic compounds (for example calcium carbide, silicon, silicon carbide, titanium dioxide);
 - vi.* halogens or interhalogen compounds comprising two or more of halogens, or any compound comprising one or more of those halogens and oxygen.
- (b) Unless falling within any other Section, any manufacturing activity which is likely to result in the release into the air of any hydrogen halide (other than the manufacture of glass or the coating, plating or surface treatment of metal) or which is likely to result in the release into the air or water of any halogen or any of the compounds mentioned in paragraph (a)(vi) (other than the treatment of water).
- (c) Unless falling within any other Section, any manufacturing activity (other than the application of a glaze or vitreous enamel) involving the use of, or the use or recovery of, any compound of any of the following elements:
- i.* antimony,
 - ii.* arsenic,
 - iii.* beryllium,
 - iv.* gallium,
 - v.* indium,
 - vi.* lead,
 - vii.* palladium,
 - viii.* platinum,
 - ix.* selenium,
 - x.* tellurium,
 - xi.* thallium,
- where the activity may result in the release into the air of any of those elements or compounds or the release into water of any substance listed in paragraph 7(1) of Part 1 of this Schedule.
- (d) Recovering any compound of cadmium or mercury.
- (e) Unless falling within any other Section, any manufacturing activity involving the use of mercury or cadmium or any compound of either element or which may result in the release into the air of either of those elements or their compounds.
- (f) Unless falling within any other Section, any activity (other than the combustion or incineration of carbonaceous material as defined in the

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Interpretation of Part A(1) of Section 1.2) which is likely to result in the release into the air of any acid-forming oxide of nitrogen.

SECTION 4.3: Chemical fertiliser production

- (a) Producing (including any blending which is related to their production) phosphorus-, nitrogen- or potassium-based fertilisers (simple or compound fertilisers).

The regulations for Scotland do not specify “any blending which is related to their production”.

SECTION 4.4: Plant health products and biocides

- (a) Producing plant health products and biocides.

The regulations for Northern Ireland include the additional requirement: “Formulating such products if this may result in the release into water of any substance listed in paragraph 10 of Part 2 of this Schedule in a quantity which, in any period of 12 months, is greater than the background quantity by more than the amount specified in that paragraph for that substance”.

SECTION 4.5: Pharmaceutical production

- (a) Producing pharmaceutical products.

The regulations for Scotland and Northern Ireland specify the inclusion of intermediates.

SECTION 4.6: Explosives production

- (a) Producing explosives

SECTION 4.7: Manufacturing activities involving ammonia

- (a) *Any activity for the manufacture of a chemical which may result in the release of ammonia into the air other than an activity in which ammonia is only used as a refrigerant.*

The regulations for England and Wales titled “Manufacturing activities involving carbon disulphide or ammonia”, but the activity description is identical to Scotland and Northern Ireland.

Relationship with other BAT conclusions for the chemicals sector

WGC BATC are applicable to the whole of the chemicals sector and is a companion document to the CWW BATC. The WGC BATC are complementary to the process specific BATC for the chemicals sector as listed in the examples below.

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- Emissions to air from the production of chlorine, hydrogen, and sodium/potassium hydroxide by the electrolysis of brine. This is covered by the BATC for the Production of Chlor-alkali (CAK).
- 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:
 - a. lower olefins using the steam cracking process;
 - b. formaldehyde;
 - c. ethylene oxide and ethylene glycols;
 - d. phenol from cumene;
 - e. dinitrotoluene from toluene, toluene diamine from dinitrotoluene, toluene diisocyanate from toluene diamine, methylene diphenyl diamine from aniline, methylene diphenyl diisocyanate from methylene diphenyl diamine;
 - f. ethylene dichloride (EDC) and vinyl chloride monomer (VCM);
 - g. hydrogen peroxide.

These are covered by the BATC for the Production of Large Volume Organic Chemicals (LVOC).

NOTE: Channelled emissions to air of nitrogen oxides and carbon monoxide from thermal treatment of waste gases originating from the above production processes are included in the scope of the WGC BATC.

- Emissions to air from the production of the following inorganic chemicals.
 - a. ammonia;
 - b. ammonium nitrate;
 - c. calcium ammonium nitrate;
 - d. calcium carbide;
 - e. calcium chloride;
 - f. calcium nitrate;
 - g. carbon black;
 - h. ferrous chloride;
 - i. ferrous sulphate (i.e. copperas and related products, such as chloro-sulphates);
 - j. hydrofluoric acid;
 - k. inorganic phosphates;
 - l. nitric acid;
 - m. nitrogen-, phosphorus- or potassium-based fertilisers (simple or compound fertilisers);
 - n. phosphoric acid;
 - o. precipitated calcium carbonate;
 - p. sodium carbonate and sodium bicarbonate (i.e. soda ash manufacturing-processes);
 - q. sodium chlorate;
 - r. sodium silicate;
 - s. sulphuric acid;
 - t. synthetic amorphous silica;
 - u. titanium dioxide and related products;

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- v. urea;
- w. urea-ammonium nitrate.

These production processes are likely to fall under the BATC for producing large volume inorganic chemicals (LVIC).

- 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 LVOC or LVIC.

Examples of emissions to air not within the scope of WGC UK BAT

- a. Combustion units other than process furnaces/heaters. This activity is likely to fall under requirements for large or medium combustion plants, or the BATC for refining mineral oil and gas.
- b. Process furnaces/heaters with a total rated thermal input below 1 MW.
- c. Emissions to air from waste incineration plants, which are likely to fall under the BATC for waste incineration.
- d. Emissions to air from the storage, transfer and handling of liquids, liquefied gases and solids, where these are not directly associated with the activity.
- e. Emissions to air from indirect cooling systems, which are likely to be covered by the BATC for industrial cooling system.

Other relevant BATC

Other EU BREF/BATC and reference documents which could be relevant for the activities covered by these BATC include the following:

- a. Common Wastewater and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW);
- b. Production of Chlor-alkali (CAK);
- c. Manufacture of Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers (LVIC-AAF);
- d. Manufacture of Large Volume Inorganic Chemicals – Solids and Others Industry (LVIC-S);
- e. Production of Large Volume Organic Chemicals (LVOC);
- f. Manufacture of Organic Fine Chemicals (OFC);
- g. Production of Polymers (POL);
- h. Production of Specialty Inorganic Chemicals (SIC);
- i. Refining of Mineral Oil and Gas (REF);
- j. Economics and Cross-media Effects (ECM);
- k. Emissions from Storage (EFS);
- l. Energy Efficiency (ENE);
- m. Industrial Cooling Systems (ICS);
- n. Large Combustion Plants (LCP);
- o. Monitoring of Emissions to Air and Water from IED installations (ROM);
- p. Waste Incineration (WI);

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q. Waste Treatment (WT).

These EU BATC 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).

Links between UK legislation and EU directives

These draft BATCs cover the above chemicals activities as defined in UK legislation based on Annex I of the Industrial Emissions Directive (2010/75/EU) facilitated through the European Union (Withdrawal) Act (2018 c. 16).

Where references are made to other EU Regulations and Directives, these form part of the EU retained law under the same European Union (Withdrawal) Act.

The EU BAT conclusions, published on the 06 December 2022, have no legal basis in UK law.

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Definitions

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

General terms

Table 1: Definition of general terms

Term	Definition
Channelled emissions to air	Emissions of pollutants to air through an emission point such as a stack.
Combustion unit	Any technical apparatus in which fuels are oxidised to use the heat thus generated. Combustion units include boilers, engines, turbines and process furnaces/heaters, but do not include thermal or catalytic oxidisers.
Complex inorganic pigments	A stable crystal lattice of different metal cations. The most important host-lattices are rutile, spinel, zircon, and haematite/corundum, but other stable structures exist.
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 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 furnace/heater process	A process furnace/heater that is not a new process furnace/heater.
Flue-gas	The exhaust gas exiting a combustion unit.
Fugitive emissions	<p>Non-channelled emissions to air caused by loss of tightness of equipment which is designed or assembled to be tight.</p> <p>Fugitive emissions can arise from:</p> <ul style="list-style-type: none"> • moving equipment, such as agitators, compressors, pumps, valves (manual and automatic); • static equipment, such as flanges and other connections, open- ended lines, sampling points.

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Term	Definition
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.
New plant	A plant first permitted on the site of the installation following the publication of these BATC or a complete replacement of a plant following the publication of these BATC.
New process furnace/heater	A process furnace/heater in a plant first permitted following the publication of these BATC or a complete replacement of a process furnace/heater following the publication of these BATC.
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 water treatment plants.
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. Elemental nitrogen is not included.
Operational constraint	Limitation or restriction connected, for example, to: <ul style="list-style-type: none"> • 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 labour); • 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.
Plant	Any parts of an installation covered by the scope of these BATC and any other directly associated activities which may have an effect on consumption and/or emissions. Plants may be new plants or existing plants.

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Term	Definition
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	<p>Process furnaces or heaters are:</p> <ul style="list-style-type: none"> • 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. <p>Because 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.</p>
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 consumption	Consumption of solvent as defined in Article 57(9) 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.

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Acronyms

For the purposes of these BATC, the following acronyms apply:

Table 2: Acronyms

Term	Definition
CLP	Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures. The EU CLP Regulation as amended, is retained in GB law. These arrangements mean that Great Britain continues to adopt the United Nations' Globally Harmonized System of the classification and labelling of chemicals (GHS), independently of the European Union. Substances and mixtures placed on the market in Northern Ireland are subject to the EU CLP Regulation
CMR	Carcinogenic, mutagenic or reprotoxic.
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-PVS	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.

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Term	Definition
LLDPE	Linear low-density polyethylene.
OGI	Optical gas imaging.
OTNOC	Other than normal operating conditions.
PP	Polypropylene.
Ppmv	Parts per million by volume
PVC	Polyvinyl chloride.
REACH	Regulation (EC) No 1907/2006 concerning the registration, evaluation, authorisation and restriction of chemicals. EU REACH Regulation was brought into UK law on 1 January 2021 Under the European Union (Withdrawal) Act 2018. It is now known as UK REACH and retains the key principles from EU REACH while being made in a UK context. UK REACH applies to GB and under the terms of the Northern Ireland Protocol, EU REACH continues to apply in Northern Ireland.
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.

Pollutants and parameters

Table 3: Pollutants and parameters

Term	Definition
Cl ₂	Elemental 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 ₂ S	Hydrogen sulphide
NH ₃	Ammonia

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Term	Definition
Ni	Nickel
N ₂ O	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- <i>p</i> -dioxins and -furans
PM _{2.5}	Particulate matter which passes through a size-selective inlet with a 50% efficiency cut-off at 2.5µm 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 10µm 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
Total S	Sum of hydrogen sulphide (H ₂ S) and carbon disulphide (CS 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

Description of techniques

Table 4 Techniques to reduce channelled emissions to air.

Name of Technique	Description
Absolute filter	Absolute filters, also referred to as high-efficiency particle air (HEPA) filters or ultralow 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.
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.

Name of Technique	Description
Adsorption	<p>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.</p> <p>In non-regenerative adsorption, the spent adsorbent is not regenerated but disposed of.</p> <p>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.</p>
Bioprocesses	<p>Bioprocesses include the following:</p> <ul style="list-style-type: none"> • 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.

Name of Technique	Description
Catalytic oxidation	<p>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.</p> <p>For process off-gases with low VOC concentrations (e.g. < 1 g/Nm³), pre-concentration steps may be applied using adsorption (rotor or fixed bed, with activated carbon or zeolites). VOCs adsorbed in the concentrator are desorbed by using heated ambient air or heated waste gas, and the resulting volume flow with higher VOC concentration is directed to the oxidiser.</p> <p>Molecular sieves ('smoothers'), typically composed of zeolites, may be used before the concentrators or the oxidiser to level down high variations of VOC concentrations in the process off-gases.</p>
Choice of fuel	<p>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).</p>
Condensation	<p>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.</p> <p>In cryogenic condensation, liquid nitrogen is used as a cooling medium.</p>
Cyclone	<p>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.</p>
Electrostatic precipitator	<p>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.</p>
Fabric filter	<p>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.</p>

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Name of Technique	Description
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.
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.
Optimisation 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.
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)
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.

Name of Technique	Description
Thermal oxidation	<p>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.</p> <p>Several types of thermal oxidation are operated:</p> <ul style="list-style-type: none"> • 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. <p>For process off-gases with low VOC concentrations (e.g. < 1 g/Nm³), pre-concentration steps may be applied using adsorption (rotor or fixed bed, with activated carbon or zeolites). VOCs adsorbed in the concentrator are desorbed by using heated ambient air or heated waste gas, and the resulting volume flow with higher VOC concentration is directed to the oxidiser.</p> <p>Molecular sieves ('smoothers'), typically composed of zeolites, may be used before the concentrators or the oxidiser to level down high variations of VOC concentrations in the process off-gases.</p>

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Table 5 Techniques to monitor diffuse emissions to air.

Name of 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.
Leak Detection and Repair (LDAR) programme	A structured approach to reduce fugitive VOC emissions by detection and subsequent repair or replacement of leaking components. The LDAR programme consists of one or more campaigns. A campaign is usually conducted over 1 year, where a certain percentage of the pieces of equipment is monitored.
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 locate significant VOC leaks easily and rapidly. 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 infrared or ultraviolet/visible sunlight spectrum along a given geographical itinerary, crossing the wind direction and cutting through VOC plumes.
Use of emission factors	<p>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.</p> <p>Emission factors are usually expressed as the mass of a substance emitted divided by the throughput of the process emitting the substance.</p>

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Table 6 Techniques to reduce diffuse emissions.

Name of 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.

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General considerations

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

Unless otherwise stated, these BATC are generally applicable.

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

It is important to ensure that any BAT-AEL is expressed in a manner that allows consistent measurement and comparisons. This is achieved by defining the reference conditions under which monitoring should be undertaken. Emission levels associated with the best available techniques (BAT-AELs) and indicative emission levels for emissions to air given in these BATC refer to concentrations (mass of emitted substances per volume of waste gas) under the following standard conditions: dry gas at a temperature of 273.15 K and a pressure of 101.3 kPa and expressed in mg/Nm³.

The reference oxygen levels used to express BAT-AELs and indicative emission levels in these BATC are shown in the table below.

Table 7: Reference oxygen levels

Source of emissions	Reference oxygen level (O _R)
Combustion units	3 dry vol-%
All other sources	No correction for the oxygen level

For the cases where a reference oxygen level is given, the equation for calculating the emission concentration at the reference oxygen level is:

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

where:

- E_R: emission concentration at the reference oxygen level O_R;
- O_R: reference oxygen level in vol-%;
- E_M: measured emission concentration;
- O_M: measured oxygen level in vol-%.

The equation above does not apply if the combustion process(es) use oxygen-enriched air or pure oxygen or when additional air intake for safety reasons brings the oxygen level in the waste gas very close to 21 vol-%. In this case, the emission concentration at the reference oxygen level of 3 dry vol-% is calculated differently, e.g. by normalising on the basis of the carbon dioxide generated by the combustion.

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

Table 8: Averaging periods of BAT-AELs for emissions to air

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

ⁱ For any parameter where, due to sampling or analytical limitations and/or due to operational conditions, a 30-minute sampling/measurement and/or an average of three consecutive measurements is inappropriate, a more representative sampling/measurement procedure may be employed.

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

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 BATC 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 VOCs from the production of polyolefins or synthetic rubbers, the BAT-AELs in these BATC are given as specific emission loads calculated on an annual basis by dividing the total VOC emissions by a sector-dependent production rate, expressed in the unit g C/kg of product.

Production of PVC

For total emissions to air of VCM from the production of PVC, the BAT-AELs in these BATC 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.

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For the purpose of calculating specific emission loads, total emissions include the VCM concentration in the PVC.

Production of viscose

For the production of viscose, the BAT-AEL in these BATC 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 S/kg of product.

BAT-AELs for emissions to water

These BATC do not cover BAT and associated BAT-AELs for emissions to water.

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BAT conclusions - general

This section captures those overarching BATC which are associated with best practice and good environmental leadership for industrial process, but which do not directly lead to the setting of BAT-AEL's.

BAT 1: Environmental management system

To improve and maintain overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS) that incorporates all of the following features:

- a. management commitment, leadership, and accountability, including senior management, for the implementation of an effective EMS;
- b. an analysis that includes the organisation's context, the needs and expectations of interested parties, and the characteristics of the installation that are associated with possible risks for the environment including human health; as well as the applicable legal requirements relating to the environment;
- c. development of an environmental policy that includes the continuous improvement of the environmental performance of the installation;
- d. establishing objectives and performance indicators in relation to the significant environmental aspects, including safeguarding compliance with applicable legal requirements;
- e. planning and implementing the necessary procedures and actions (including corrective and preventive actions where needed), to achieve the environmental objectives and avoid environmental risks;
- f. determination of structures, roles and responsibilities in relation to the environmental aspects and objectives including the provision of the financial and human resources needed;
- g. 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);
- h. internal and external communication;
- i. fostering employee involvement in good environmental management practices;
- j. establishing and maintaining a management manual, written procedures to control activities with significant environmental impact, and records that demonstrate compliance and record non-compliances;
- k. effective operational planning and process control;
- l. implementation of appropriate maintenance programmes;
- m. emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations;
- n. 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;
- o. implementation of a monitoring and measurement programme;
- p. application of sectoral benchmarking on a regular basis;
- q. periodic internal auditing and independent external auditing in order to assess the environmental performance and to determine whether or

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- not the EMS conforms to planned arrangements and has been properly implemented and maintained;
- r. 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;
- s. periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness;
- t. following and considering the development of cleaner techniques.

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

- u. an inventory of channelled and diffuse emissions to air (see BAT 2);
- v. an OTNOC management plan for emissions to air (see BAT 3);
- w. an integrated waste gas management and treatment strategy for channelled emissions to air (see BAT 4);
- x. a management system for diffuse VOC emissions to air (see BAT 19);
- y. provisions for the systematic management of chemicals (known as a chemicals management system [CMS]) that includes an inventory of the relevant hazardous substances and substances of very high concern used in the process(es); the potential for substitution of the substances that are listed in this inventory, focusing on those substances other than raw materials, is analysed periodically (e.g. annually) in order to identify possible new available and safer alternatives, with no or lower environmental impacts.

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.

BAT 2: Inventory of emissions

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 EMS (see BAT 1), that incorporates all of the following features:

- a. information, as comprehensive as is reasonably possible, about the chemical production process(es), including:
 - i. chemical reaction equations, also showing side products;
 - ii. simplified process flow sheets that show the origin of the emissions;
- b. information, as comprehensive as is reasonably possible, about channelled emissions to air, such as:
 - i. emission point(s);
 - ii. average values and variability of flow and temperature;

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- iii. average concentration and mass flow values of relevant substances/parameters and their variability (e.g. TVOC, CO, NO_x, SO_x, Cl₂, HCl);
 - iv. presence of other substances that may affect the waste gas treatment system(s) or plant safety (e.g. oxygen, nitrogen, water vapour, dust);
 - v. techniques used to prevent and/or reduce channelled emissions to air;
 - vi. flammability, lower and higher explosive limits, reactivity;
 - vii. monitoring methods (see BAT 8);
 - viii. presence of substances classified as CMR 1A, CMR 1B or CMR 2; the presence of such substances may, for example, be assessed according to the criteria of Regulation (EC) 1272/2008 on classification, labelling and packaging (CLP).
- c. information, as comprehensive as is reasonably possible, about diffuse emissions to air, such as:
- i. identification of the emission source(s);
 - ii. 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);
 - iii. 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 substances or mixtures classified as CMR 1A, CMR 1B or CMR 2.
 - iv. techniques used to prevent and/or reduce diffuse emissions to air;
 - v. monitoring (see BAT 20, BAT 21 and BAT 22).

Note for diffuse emissions:

The information about diffuse emissions to air is particularly relevant for activities using large amounts of organic substances or mixtures (e.g. production of pharmaceuticals, production of large volumes of organic chemicals or of polymers).

The information about fugitive emissions covers all emission sources in contact with organic substances with a vapour pressure greater than 0.3 kPa at 293.15 K.

Sources of fugitive emissions connected to pipes whose diameter is small (e.g. smaller than 12.7 mm) may be excluded from the inventory.

Equipment operated under sub-atmospheric pressure may be excluded from the inventory.

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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.

BAT 3: Other than normal operating conditions (OTNOC)

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:

- a. 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;
- b. 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.);
- c. set-up and implementation of a preventive maintenance plan for critical equipment (see BAT 1, e);
- d. monitoring (i.e. estimating or, where this is possible, measuring) and recording of emissions and associated circumstances during OTNOC;
- e. periodic assessment of the emissions occurring during OTNOC (e.g. frequency of events, duration, amount of pollutants emitted as recorded in point d) and implementation of corrective actions if necessary;
- f. regular review and update of the list of identified OTNOC under point a. following the periodic assessment of point e and;
- g. regular testing of backup systems.

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BAT conclusions – process

This section captures BATC appropriate to the control of environmental impacts best controlled through good process control of the unit operations being used.

BAT 4: Integrated strategy

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 in BAT 2. It considers factors such as greenhouse gas emissions and the consumption or reuse of energy, water and materials associated with the use of the different techniques.

BAT 5: Process design

To facilitate the recovery of materials and the reduction of channelled emissions to air, as well as to increase energy efficiency, BAT is to combine waste gas streams with similar characteristics, thus minimising, where appropriate, the number of emission points.

Description

The combined treatment of waste gases with similar characteristics ensures more effective and efficient treatment compared to the separate treatment of individual waste gas streams. The combination of waste gases is carried out considering plant safety (e.g. avoiding concentrations close to the lower/upper explosive limit), technical (e.g. compatibility of the individual waste gas streams, concentration of the substances concerned), environmental (e.g. maximising recovery of materials or pollutant abatement) and economic factors (e.g. distance between different production units).

Care is taken that the combination of waste gases does not lead to the dilution of emissions.

BAT 6: Channelled emissions

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.

BAT 7: Monitoring

BAT is to continuously monitor key process parameters (e.g. waste gas flow and temperature) for waste gas streams being sent to pre-treatment and/or final treatment.

BAT 8: Monitoring channelled emissions to air – standardised methods

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

Table 9: Monitoring of channelled Emissions to Air

Substance / parameter	Specific process (es)	Emission points	Standard (s) ⁽¹⁾	Minimum monitoring frequency ⁽²⁾	Monitoring associated with
Ammonia (NH ₃)	Use of SCR/SNCR	Any stack	BS EN 21877	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 17
Ammonia (NH ₃)	All other processes / sources	Any stack	BS EN 21877	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 18
Benzene	All processes / sources	Any stack	BS EN/TS 13649	Once every 6 months ⁽³⁾	BAT 11
1,3-Butadiene	All processes / sources	Any stack	BS EN/TS 13649	Once every 6 months ⁽³⁾	BAT 11
Carbon monoxide (CO)	Thermal treatment	Any stack with a CO mass flow of ≥ 2 kg/h	Generic BS EN standards ⁽⁵⁾	Continuous	BAT 16
Carbon monoxide (CO)	Thermal treatment	Any stack with a CO mass flow of < 2 kg/h	BS EN 15058	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 16

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Substance / parameter	Specific process (es)	Emission points	Standard (s) ⁽¹⁾	Minimum monitoring frequency ⁽²⁾	Monitoring associated with
Carbon monoxide (CO)	Process furnaces / heaters	Any stack with a CO mass flow of ≥ 2 kg/h	Generic BS EN standards ⁽⁵⁾	Continuous ⁽⁶⁾	BAT 24
Carbon monoxide (CO)	Process furnaces / heaters	Any stack with a CO mass flow of < 2 kg/h	BS EN 15058	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 24
Carbon monoxide (CO)	All other processes / sources	Any stack with a CO mass flow of ≥ 2 kg/h	Generic BS EN standards ⁽⁵⁾	Continuous	BAT 18
Carbon monoxide (CO)	All other processes / sources	Any stack with a CO mass flow of < 2 kg/h	BS EN 15058	Once every year ⁽³⁾ ⁽⁷⁾	BAT 18
Chloro - methane	All processes / sources	Any stack	BS EN/TS 13649	Once every 6 months ⁽³⁾	BAT 11
Substances other than CMR substances covered elsewhere in this table ⁽⁸⁾	All other processes / sources	Any stack	BS EN/TS 13649	Once every 6 months ⁽³⁾	BAT 11
Dichloromethane	All processes/ sources	Any stack	BS EN/TS 13649	Once every 6 months ⁽³⁾	BAT 11
Dust	All processes / sources	Any stack with dust mass flow of ≥ 3 kg/h	Generic BS EN standards ⁽⁵⁾	Continuous ⁽⁹⁾	BAT 14
Dust	All processes / sources	Any stack with dust flow of < 3 kg/h	BS EN 13284-1	Once every year ⁽³⁾ ⁽⁷⁾	BAT 14

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Substance / parameter	Specific process (es)	Emission points	Standard (s) ⁽¹⁾	Minimum monitoring frequency ⁽²⁾	Monitoring associated with
Elemental chlorine (Cl ₂)	All processes / sources	Any stack	US EPA 26A	Once every year ⁽³⁾ ⁽⁷⁾	BAT 18
Ethylene dichloride (EDC)	All processes / sources	Any stack	BS EN/TS 13649	Once every 6 months ⁽³⁾	BAT 11
Ethylene oxide	All processes / sources	Any stack	BS EN/TS 13649	Once every 6 months ⁽³⁾	BAT 11
Formaldehyde	All processes / sources	Any stack	BS EN/TS 17638	Once every 6 months ⁽³⁾	BAT 11
Gaseous chlorides	All processes / sources	Any stack	US EPA 26	Once every year ⁽³⁾ ⁽⁷⁾	BAT 18
Gaseous fluorides	All processes / sources	Any stack	US EPA 26	Once every year ⁽³⁾ ⁽⁷⁾	BAT 18
Hydrogen cyanide (HCN)	All processes / sources	Any stack	US EPA OTM29	Once every year ⁽³⁾ ⁽⁷⁾	BAT 18
Lead and its compounds	All processes / sources	Any stack	BS EN 14385	Once every 6 months ⁽³⁾ ⁽¹⁰⁾	BAT 14
Nickel and its compounds	All processes / sources	Any stack	BS EN 14385	Once every 6 months ⁽³⁾ ⁽¹⁰⁾	BAT 14
Nitrous oxide (N ₂ O)	All processes / sources	Any stack	BS EN ISO 21258	Once every year ⁽³⁾ ⁽⁷⁾	Table 4 - Techniques to reduce channelled emissions to air
Nitrogen oxides (NO _x)	Thermal treatment	Any stack with a NO _x mass flow of ≥ 2.5 kg/h	Generic BS EN standards ⁽⁵⁾	Continuous	BAT 16

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Substance / parameter	Specific process (es)	Emission points	Standard (s) ⁽¹⁾	Minimum monitoring frequency ⁽²⁾	Monitoring associated with
Nitrogen oxides (NO _x)	Thermal treatment	Any stack with a NO _x mass flow of < 2.5 kg/h	BS EN 14792	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 16
Nitrogen oxides (NO _x)	Process furnaces / heaters	Any stack with a NO _x mass flow of ≥ 2.5 kg/h	Generic BS EN standards ⁽⁵⁾	Continuous ⁽⁶⁾	BAT 24
Nitrogen oxides (NO _x)	Process furnaces / heaters	Any stack with a NO _x mass flow of < 2.5 kg/h	BS EN 14792	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 24
Nitrogen oxides (NO _x)	All other processes/ sources	Any stack with a NO _x mass flow of ≥ 2.5 kg/h	Generic BS EN standards ⁽⁵⁾	Continuous	BAT 18
Nitrogen oxides (NO _x)	All other processes/ sources	Any stack with a NO _x mass flow of < 2.5 kg/h	BS EN 14792	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 18
PCDD/F	Thermal treatment	Any stack	BS EN 1948-1, BS EN 1948-2, BS EN 1948-3	Once every 6 months ⁽³⁾ ⁽¹⁰⁾	BAT 12
PM _{2.5} and PM ₁₀	All processes / sources	Any stack	BS EN ISO 23210	Once every year ⁽³⁾ ⁽⁷⁾	BAT 14
Propylene oxide	All processes / sources	Any stack	BS EN/TS 13649	Once every 6 months ⁽³⁾	BAT 11
Sulphur Dioxide (SO ₂)	Thermal treatment	Any stack with a SO ₂ mass flow of ≥ 2.5 kg/h	Generic BS EN standards ⁽⁵⁾	Continuous	BAT 16

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Substance / parameter	Specific process (es)	Emission points	Standard (s) ⁽¹⁾	Minimum monitoring frequency ⁽²⁾	Monitoring associated with
Sulphur Dioxide (SO ₂)	Thermal treatment	Any stack with a SO ₂ mass flow of < 2.5 kg/h	BS EN 14791	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 16
Sulphur Dioxide (SO ₂)	Process furnaces / heaters	Any stack with a SO ₂ mass flow of ≥ 2.5 kg/h	Generic BS EN standards ⁽⁵⁾	Continuous ⁽⁶⁾	BAT 18 and BAT 24
Sulphur Dioxide (SO ₂)	Process furnaces / heaters	Any stack with a SO ₂ mass flow of < 2.5 kg/h	BS EN 14791	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 18 and BAT 24
Sulphur Dioxide (SO ₂)	All other processes / sources	Any stack with a SO ₂ mass flow of ≥ 2.5 kg/h	Generic BS EN standards ⁽⁵⁾	Continuous	BAT 18
Sulphur Dioxide (SO ₂)	All other processes / sources	Any stack with a SO ₂ mass flow of < 2.5 kg/h	BS EN 14791	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 18
Tetrachloro-methane	All processes / sources	Any stack	BS EN/TS 13649	Once every 6 months ⁽³⁾	BAT 11
Toluene	All processes / sources	Any stack	BS EN/TS 13649	Once every 6 months ⁽³⁾	BAT 11
Trichloro-methane	All processes / sources	Any stack	BS EN/TS 13649	Once every 6 months ⁽³⁾	BAT 11
Total volatile organic carbon (TVOC)	Production of polyolefins ⁽¹¹⁾	Any stack with a TVOC mass flow of ≥ 2 kg C/h	Generic BS EN standards ⁽⁵⁾	Continuous	BAT 11 and BAT 26

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Substance / parameter	Specific process (es)	Emission points	Standard (s) ⁽¹⁾	Minimum monitoring frequency ⁽²⁾	Monitoring associated with
Total volatile organic carbon (TVOC)	Production of polyolefins ⁽¹¹⁾	Any stack with a TVOC mass flow of < 2 kg C/h	BS EN 12619	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 11 and BAT 26
Total volatile organic carbon (TVOC)	Production of synthetic rubbers ⁽¹²⁾	Any stack with a TVOC mass flow of ≥ 2 kg C/h	Generic BS EN standards ⁽⁵⁾	Continuous	BAT 11 and BAT 20
Total volatile organic carbon (TVOC)	Production of synthetic rubbers ⁽¹²⁾	Any stack with a TVOC mass flow of < 2 kg C/h	BS EN 12619	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 11 and BAT 20
Total volatile organic carbon (TVOC)	All other processes / sources	Any stack with a TVOC mass flow of ≥ 2 kg C/h	Generic BS EN standards ⁽⁵⁾	Continuous	BAT 11
Total volatile organic carbon (TVOC)	All other processes / sources	Any stack with a TVOC mass flow of < 2 kg C/h	BS EN 12619	Once every 6 months ⁽³⁾ ⁽⁴⁾	BAT 11
Flow	As applicable	Any stack	BS EN ISO 16911-1 (periodic), BS EN ISO 16911-2 (continuous)	As applicable	As applicable

¹ Measurements are carried out according to BS EN 15259. This standard describes methods to determine mass-flow.

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² 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 6.

³ To the extent possible, the measurements are carried out at the highest expected emission state under normal operating conditions.

⁴ The minimum monitoring frequency may be reduced to once every year or once every 3 years if the emission levels are proven to be sufficiently stable.

⁵ Generic BS EN standards for continuous measurements are BS EN 14181, BS EN 15267-1, BS EN 15267-2 and BS EN 15267-3.

⁶ 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. The methods and standards in the above table still apply.

⁷ The minimum monitoring frequency may be reduced to once every 3 years if the emission levels are proven to be sufficiently stable.

⁸ i.e. other than benzene, 1,3-butadiene, chloromethane, dichloromethane, ethylene dichloride, ethylene oxide, formaldehyde, propylene oxide, tetrachloromethane, toluene, trichloromethane. This means any other CMR chemicals included in the mixture of stack gas and classed as VOCs.

⁹ The minimum monitoring frequency may be reduced to once every 6 months if the emission levels are proven to be sufficiently stable.

¹⁰ The minimum monitoring frequency may be reduced to once every year if the emission levels are proven to be sufficiently stable.

¹¹ 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 complemented by the monitoring in BAT 29 if it provides a better representation of the TVOC emissions. BS EN 12619 measures emissions as total carbon, regardless of the type of VOCs measured in the stack-gas mixture. This includes any VOC CMR chemicals.

¹² 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 complemented by the monitoring in BAT 36 if it provides a better representation of the TVOC emissions.

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BAT conclusions – efficiency

These BATC will capture efficiency measures. These may include energy efficiency, waste management efficiency rates.

BAT 9: Raw material efficiency – organic compounds

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.

Table 10: Raw Material Efficiency

Technique	Description
a. Absorption (regenerative)	See table 4.
b. Adsorption (regenerative)	See Table 4.
c. Condensation	See Table 4.

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).

Reuse may be restricted due to product quality specifications.

BAT 10: Energy efficiency – organic compounds

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 technically possible, combined with heat recovery. BAT 9 has priority over sending process off-gases to a combustion unit.

Description

Process off-gases with a high calorific value are burnt as a fuel in a combustion unit (gas engine, boiler, process heater or furnace) and the heat is recovered as steam or for electricity generation, or to provide heat to the process.

For process off-gases with low VOC concentrations (e.g. $< 1 \text{ g/Nm}^3$), pre-concentration steps may be applied using adsorption (rotor or fixed bed, with activated carbon or zeolites), in order to increase the calorific value of the process off-gases.

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Molecular sieves ('smoothers'), typically composed of zeolites, may be used to level down high variations (e.g. concentration peaks) of VOC concentrations in the process off-gases.

Applicability

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

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BAT Conclusions – emissions

This section captures BATC where there is a BAT-AEL associated. Where the descriptive flow requires other non-BAT-AEL BATC can also be included here. This section should cover BATC associated with noise and odour. BAT-AELs for emissions to air can be included.

BAT 11: Channelled emissions – organic compounds

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

Table 11: Emissions of organic compounds

Technique	Description	Applicability
a. Adsorption	See Table 4	Generally applicable.
b. Absorption	See Table 4.	Generally applicable.
c. Catalytic oxidation	See Table 4.	Applicability may be restricted by the presence of catalyst poisons in the waste gases.
d. Condensation	See Table 4.	Generally applicable.
e. Thermal oxidation	See Table 4.	Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/or operational constraints. Applicability may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases.
f. Bioprocesses	See Table 4.	Only applicable to the treatment of biodegradable compounds.

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

Table 12: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of organic compounds

Substance/Parameter	BAT-AEL (mg/Nm³) (Daily average or average over the sampling period) ⁽¹⁾
Total volatile organic carbon (TVOC)	< 1-20 ⁽²⁾ ⁽³⁾ ⁽⁴⁾ ⁽⁵⁾
Sum of VOCs classified as CMR 1A or 1B	< 1-5 ⁽⁶⁾
Sum of VOCs classified as CMR 2	< 1-10 ⁽⁷⁾
Benzene	< 0.5-1 ⁽⁸⁾
1,3-Butadiene	< 0.5-1 ⁽⁸⁾
Ethylene dichloride	< 0.5-1 ⁽⁸⁾
Ethylene oxide	< 0.5-1 ⁽⁸⁾
Propylene oxide	< 0.5-1 ⁽⁸⁾
Formaldehyde	1-5 ⁽⁸⁾
Chloromethane	< 0.5-1 ⁽⁹⁾ ⁽¹⁰⁾
Dichloromethane	< 0.5-1 ⁽⁹⁾ ⁽¹⁰⁾
Tetrachloromethane	< 0.5-1 ⁽⁹⁾ ⁽¹⁰⁾
Toluene	< 0.5-1 ⁽⁹⁾ ⁽¹¹⁾
Trichloromethane	< 0.5-1 ⁽⁹⁾ ⁽¹⁰⁾

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

² TVOC is expressed in mg C/Nm³.

³ In the case of polymer production, there will be conditions when the BAT-AEL does not apply, e.g. to emissions from the finishing steps (e.g. extrusion, drying, blending) and from polymer storage.

⁴ The BAT-AEL does not apply when the TVOC mass flow is below approx. 100 g C/h if no CMR substances are identified as relevant in the waste gas stream based on the inventory given in BAT 2.

⁵ The upper end of the BAT-AEL range may be higher and up to 30 mg C/Nm³ when using techniques to recover materials (e.g. solvents, see BAT 9), if both of the following conditions are fulfilled: a. the presence of substances classified as CMR 1A/1B or CMR 2 is identified as not relevant (see BAT 2) and b. the TVOC abatement efficiency of the waste gas treatment system is ³ 95 %.

⁶ The BAT-AEL does not apply when the mass flow of the sum of the VOCs classified as CMR 1A or 1B is below approx. 1 g/h.

⁷ The BAT-AEL does not apply when the mass flow of the sum of the VOCs classified as CMR 2 is below approx. 50 g/h.

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⁸ The BAT-AEL does not apply when the mass flow of the substance concerned is below approx. 1 g/h.

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

¹⁰ The upper end of the BAT-AEL range may be higher and up to 15 mg/Nm³ when using techniques to recover materials (e.g. solvents, see BAT 9, if the abatement efficiency of the waste gas treatment system is ³ 95 %).

¹¹ The upper end of the BAT-AEL range may be higher and up to 20 mg/Nm³ when using techniques to recover toluene (see BAT 9) if the abatement efficiency of the waste gas treatment system is ³ 95%.

The associated monitoring is given in BAT 8.

BAT 12: Channelled emissions – PCDD/F

To reduce channelled emissions to air of PCDD/F from thermal treatment of waste gases containing chlorine and/or chlorinated compounds, BAT is to use techniques a. and b., and one or a combination of techniques c. to e. given below.

Table 13: Techniques to reduce PCDD/F emissions.

Technique	Description	Applicability
a. Optimisation of catalytic or thermal oxidation	See Table 4.	Generally applicable.
b. Rapid waste-gas cooling	Rapid cooling of waste gases from temperatures above 400°C to below 250°C to prevent the <i>de novo</i> synthesis of PCDD/F	Generally applicable.
c. Adsorption using activated carbon	See Table 4.	Generally applicable.
d. Absorption	See Table 4.	Generally applicable.
e. Selective catalytic reduction (SCR) ⁽¹⁾	See Table 4. 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.

¹ SCR technique is not a technique primarily used to reduce PCDD/F emissions.

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BAT-associated emission level (BAT-AEL) for channelled emissions to air of PCDD/F from thermal treatment of waste gases containing chlorine and/or chlorinated compounds

Table 14: BAT-associated emission level (BAT-AEL) for channelled emissions to air of PCDD/F from thermal treatment of waste gases containing chlorine and/or chlorinated compounds

Substance/Parameter	BAT-AEL (ng I-TEQ/Nm³) (Average over the sampling period)
PCDD/F	< 0.01-0.05

The associated monitoring is given in BAT 8.

BAT conclusions for dust and PM₁₀–PM_{2.5}

Additional BATC for dust and particulate-bound metals.

BAT 13: Recovery of particulate emissions through resource efficiency

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 of the dust reduction techniques given in table 4.

Applicability

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

BAT 14: Emissions – dust and particulate-bound metals

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.

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Table 15: Emissions of dust and particulate-bound metals

Technique	Description	Applicability
a. Absolute filter	See Table 4.	Applicability may be limited in the case of sticky dust or when the temperature of the waste gases is below the dew point.
b. Absorption	See Table 4	Generally applicable.
c. Fabric filter	See Table 4.	Applicability may be limited in the case of sticky dust or when the temperature of the waste gases is below the dew point.
d. High-efficiency air filter (HEAF)	See Table 4.	Generally applicable.
e. Cyclone	See Table 4.	Generally applicable.
f. Electrostatic precipitator	See Table 4.	Generally applicable.

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

Table 16: 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)
Dust	< 1-5 ⁽¹⁾ ⁽²⁾ ⁽³⁾ ⁽⁴⁾
Lead and its compounds, expressed as Pb	< 0.01-0.1 ⁽⁵⁾
Nickel and its compounds, expressed as Ni	< 0.02-0.1 ⁽⁶⁾

¹ The upper end of the range is 20 mg/Nm³ when either an absolute or a fabric filter is not applicable, as fabric filters typically abate emissions to levels well below this concentration. The upper limit applies when other abatement techniques are applicable, such as when the stack gas is very moist.

² The BAT-AEL does not apply when the dust mass flow is below approx. 50 g/h if no CMR substances are identified as relevant in the dust based on the inventory given in BAT 2.

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³ In the case of the production of complex inorganic pigments using direct heating, and in the case of the drying step in the production of E-PVC, the upper end of the BAT-AEL range may be higher and up to 10 mg/Nm³.

⁴ Dust emissions are expected to be towards the lower end of the BAT-AEL range (e.g. below 2.5 mg/Nm³) when the presence of substances classified as CMR 1A or 1B, or CMR 2 in the dust is identified as relevant (see BAT 2).

⁵ The BAT-AEL does not apply when the lead mass flow is below approx. 0.1 g/h.

⁶ The BAT-AEL does not apply when the Ni mass flow is below approx. 0.15 g/h.

The associated monitoring is given in BAT 8.

BAT conclusions for inorganic emissions

Additional BATC for inorganic emissions.

BAT 15: Energy efficiency – inorganic compounds

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.

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). Reuse may be restricted due to product quality specifications.

BAT 16: Emissions from thermal treatment – inorganic compounds

To reduce channelled emissions to air of CO, NO_x and SO_x from thermal treatment, BAT is to use technique c. and one or a combination of the other techniques given below.

Table 17: Techniques to reduce emissions of inorganic compounds from thermal treatment.

Technique	Description	Applicability
a. Choice of fuel	See Table 4.	Generally applicable.
b. Low-NO _x burner	See Table 4.	Applicability to existing plants may be restricted by design and/or operational constraints.

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Technique	Description	Applicability
c. Optimisation of catalytic or thermal oxidation	See Table 4.	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	Generally applicable.
e. Absorption	See Table 4. In the case of regenerative absorption, the compounds may be recovered from the liquid.	Generally applicable.
f. Selective catalytic reduction (SCR)	See Table 4.	Applicability to existing plants may be restricted by space availability.
g. Selective non-catalytic reduction (SNCR)	See Table 4.	Applicability to existing plants may be restricted by the residence time needed for the reaction.

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of NO_x and CO from thermal treatment

Table 18: BAT- AELs for channelled emissions to air of NO_x and indicative emission level of CO from thermal treatment

Substance/Parameter	BAT-AEL (mg/Nm³) (Daily average or average over the sampling period)
Nitrogen oxides (NO _x) from catalytic oxidation	5-30 ⁽¹⁾
Nitrogen oxides (NO _x) from thermal oxidation	5-130 ⁽²⁾
Carbon monoxide (CO)	No BAT-AEL ⁽³⁾

¹ The upper end of the BAT-AEL range may be higher and up to 80 mg/Nm³ if the process off-gas(es) contain(s) high levels of NO_x precursors.

² The upper end of the BAT-AEL range may be higher and up to 200 mg/Nm³ if the process off-gas(es) contain(s) high levels of NO_x precursors.

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³ As an indication, the emission levels for carbon monoxide are 4-50 mg/Nm³, as a daily average or average over the sampling period.

The associated monitoring is given in BAT 8.

The BAT-AEL for channelled emissions to air of SO₂ is given in Table 21.

BAT 17: Ammonia emissions – SCR or SNCR

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 (ammonia slip), BAT is to optimise the design and/or operation of SCR or SNCR (e.g. optimised reagent to NO_x ratio, homogeneous reagent distribution and optimum size of the reagent drops).

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of ammonia from the use of SCR or SNCR (ammonia slip)

Table 19: BAT-AELs for channelled emissions to air of ammonia from the use of SCR or SNCR (ammonia slip)

Substance/Parameter	BAT-AEL (mg/Nm³) (Average over the sampling period)
Ammonia (NH ₃) from SCR/SNCR	< 0.5-8 (¹)

¹ The upper end of the BAT-AEL range may be higher and up to 40 mg/Nm³ in the case of process off-gases containing very high levels of NO_x (e.g. above 5,000 mg/Nm³) prior to treatment with SCR or SNCR.

The associated monitoring is given in BAT 8.

BAT 18: Emissions – inorganic compounds

To reduce channelled emissions to air of inorganic compounds other than channelled emissions to air of ammonia from the use of SCR or 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.

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Table 20 Techniques to reduce emissions to air of inorganic compounds.

Technique	Technique	Main inorganic compounds targeted	Applicability
a. Absorption	See Table 4	Cl ₂ , HCl, HCN, HF, NH ₃ , NO _x , SO _x	Generally applicable
b. Adsorption	See Table 4. 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 Table 4.	NO _x	Applicability to existing plants may be restricted by space availability.
d. Selective non-catalytic reduction (SNCR)	See Table 4.	NO _x	Applicability to existing plants may be restricted by the residence time needed for the reaction.
e. Catalytic oxidation ⁽¹⁾	See Table 4.	NH ₃	Applicability may be restricted by the presence of catalyst poisons in the waste gases.
f. Thermal oxidation ⁽¹⁾	See Table 4.	NH ₃ , HCN	Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/or operational constraints. The applicability may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases.

¹ These techniques are not primarily used to reduce emissions to air of inorganic compounds.

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BAT-associated emission levels (BAT-AELs) for channelled emissions to air of inorganic compounds

Table 21: BAT-associated emission levels (BAT-AELs) for channelled emissions to air of inorganic compounds

Substance/Parameter	BAT-AEL (mg/Nm³) (Daily average or average over the sampling period)
Ammonia (NH ₃)	2-10 ⁽¹⁾ ⁽²⁾ ⁽³⁾
Elemental chlorine (Cl ₂)	< 0.5-2 ⁽⁴⁾ ⁽⁵⁾
Gaseous fluorides, expressed as HF	≤ 1 ⁽⁴⁾
Hydrogen cyanide (HCN)	< 0.1-1 ⁽⁴⁾
Gaseous chlorides, expressed as HCl	1-10 ⁽⁶⁾
Nitrogen oxides (NO _x)	10-150 ⁽⁷⁾ ⁽⁸⁾ ⁽⁹⁾ ⁽¹⁰⁾
Sulphur oxides (SO ₂)	< 3-150 ⁽⁹⁾ ⁽¹¹⁾

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 BAT 17.

² The BAT-AEL does not apply when the NH₃ mass flow is below approx. 50 g/h.

³ In the case of the drying step in the production of E-PVC, the upper end of the BAT-AEL range may be higher and up to 20 mg/Nm³, when the substitution of ammonium salts is not possible due to product quality specifications.

⁴ The BAT-AEL does not apply when the mass flow of the substance concerned is below approx. 5 g/h.

⁵ In the case of NO_x concentrations above 100 mg/Nm³, the upper end of the BAT-AEL range may be higher and up to 3 mg/Nm³ due to analytical interference.

⁶ The BAT-AEL does not apply when the HCl mass flow is below approx. 30 g/h.

⁷ In the case of the production of explosives, the upper end of the BAT-AEL range may be higher and up to 220 mg/Nm³ when regenerating or recovering nitric acid from the production process.

⁸ The BAT-AEL does not apply to channelled emissions to air of NO_x from the use of catalytic or thermal oxidation (see BAT 16) or from process furnaces/heaters (see BAT 24).

⁹ The BAT-AEL does not apply when the mass flow of the substance concerned is below approx. 500 g/h.

¹⁰ In the case of the production of caprolactam, the upper end of the BAT-AEL range may be higher and up to 200 mg/Nm³ in the case of process off-gases containing very high levels of NO_x (e.g. above 10,000 mg/Nm³) prior to treatment with SCR or SNCR, when the abatement efficiency of the SCR or SNCR is ≥ 99 %.

¹¹ The BAT-AEL does not apply in the case of physical purification or reconcentration of spent sulphuric acid.

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The associated monitoring is given in BAT 8.

Management system for diffuse VOC emissions

Additional BAT Conclusions for diffuse VOC emissions.

BAT 19: Diffuse emissions – VOC

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 EMS (see BAT 1), that includes all of the following features:

- a. Estimating the annual quantity of diffuse VOC emissions (see BAT 20).
- b. Monitoring diffuse VOC emissions from the use of solvents by compiling a solvent mass-balance, if applicable (see BAT 21).
- c. Establishing and implementing a leak detection and repair (LDAR) programme for fugitive VOC emissions. The LDAR programme typically lasts from 1 to 5 years depending on the nature, scale and complexity of the plant (5 years may correspond to large plants with a high number of emission sources).

The LDAR programme includes all of the following features:

- i. Listing of equipment identified as relevant fugitive VOC emission sources in the inventory of diffuse VOC emissions (see BAT 2).
- ii. Definition of criteria associated with the following:
 1. Leaky equipment. 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).
 2. Maintenance and/or repair actions 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. 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 5,000 ppmv for VOCs other than VOCs classified as CMR 1A or 1B, and 1,000 ppmv for VOCs classified as CMR 1A or 1B. For subsequent LDAR programmes, the maintenance/repair threshold is lowered (see point vi. a.) and not higher than 1,000 ppmv for VOCs other than VOCs classified as CMR 1A or 1B, and 500 ppmv for VOCs classified as CMR 1A or 1B, targeting 100 ppmv. Guidance and requirements for leak-detection thresholds in BS EN 15446 and BS EN 17628. LDAR programmes may be risk-based.
- iii. Measuring fugitive VOC emissions from equipment listed under point c. i. (see BAT 22).
- iv. Carrying out maintenance and/or repair actions (see BAT 23, techniques e. and f.), as soon as possible and where necessary according to the criteria defined in point c. ii. Maintenance and

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- repair actions are prioritised according to the hazardous properties of the emitted substance(s), the significance of the emissions and/or operational constraints. The effectiveness of the maintenance and/or repair actions is verified according to point c. iii., leaving enough time after the intervention (e.g. 2 months).
- v. Filling in the database mentioned in point e.
- d. Establishing and implementing a detection and reduction programme for non-fugitive VOC emissions that includes all of the following features:
 - i. Listing of equipment identified as relevant non-fugitive VOC emission sources in the inventory of diffuse VOC emissions (see BAT 2).
 - ii. Monitoring non-fugitive VOC emissions from equipment listed under point d. i. (see BAT 24).
 - iii. Planning and implementing techniques to reduce non-fugitive VOC emissions (see BAT 24, techniques a., c., and g. to j.). The planning and implementation of the techniques are prioritised according to the hazardous properties of the emitted substance(s), the significance of the emissions and/or operational constraints.
 - iv. Filling in the database mentioned in point e.
- e. Establishing and maintaining a database, for diffuse VOC emissions sources that are identified in the inventory mentioned in BAT 2, for keeping record of:
 - i. equipment design specifications (including the date and description of any design changes);
 - ii. the equipment maintenance, repair, upgrade, or replacement actions, performed or planned, and their date of implementation;
 - iii. the equipment that could not be maintained, repaired, upgraded or replaced due to operational constraints;
 - iv. the results of the measurements or monitoring, including the concentration(s) of the emitted substance(s), the calculated leak rate (as kg/year), the recording from OGI cameras (e.g. from the last LDAR programme) and the date of the measurements or monitoring;
 - v. the annual quantity of diffuse VOC emissions (as fugitive and non-fugitive emissions), including information on non-accessible sources and accessible sources not monitored during the year.
- f. Reviewing and updating the LDAR programme periodically. This may include the following:
 - i. lowering the leak and/or maintenance/repair thresholds (see point c. ii.);
 - ii. reviewing the prioritisation of equipment to be monitored, giving higher priority to (the type of) equipment identified as leaky during the previous LDAR programme;
 - iii. planning the maintenance, repair, upgrade or replacement of equipment that could not be performed during the previous LDAR programme due to operational constraints.
- g. Reviewing and updating the detection and reduction programme for non-fugitive VOC emissions. This may include the following:
 - i. monitoring non-fugitive VOC emissions from equipment where maintenance, repair, upgrade or replacement actions were implemented, to determine if those actions were successful;

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- ii. planning the maintenance, repair, upgrade or replacement actions that could not be performed due to operational constraints.

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Applicability

The features in points c., d., f. and g. are only applicable to sources of diffuse VOC emissions for which monitoring according to BAT 22 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.

BAT 20: Monitoring – VOC emissions

BAT is to estimate fugitive and non-fugitive VOC emissions to air separately 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. The table below summarises the techniques for estimating VOC emissions.

Table 22: Techniques to estimate fugitive and non-fugitive VOC emissions to air.

Technique	Description	Type of emissions
a. Use of emission factors	See Table 5.	Fugitive and/ or non-fugitive
b. Use of mass-balance	Estimation based on the difference in the mass of the substance inputs to and outputs from the plant/production unit, considering the generation and destruction of the substance in the plant/production unit. A mass-balance may also consist of measuring the concentration of VOCs in the product (e.g. raw material or solvent).	Fugitive and/ or non-fugitive

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Technique	Description	Type of emissions
c. Use of thermodynamic models	<p>Estimation using the laws of thermodynamics applied to equipment (e.g. tanks) or particular steps of a production process.</p> <p>The following data are generally used as input for the model:</p> <ul style="list-style-type: none"> • chemical properties of the substance (e.g. vapour pressure, molecular mass); • process operating data (e.g. operating time, product quantity, ventilation); <p>characteristics of the emission source (e.g. tank diameter, colour, shape).</p>	Fugitive and/ or non-fugitive

Note: The estimation of the diffuse VOC emissions to air considers the results of the monitoring carried out according to BAT 21 and/or to BAT 26.

For the purpose of the estimation, channelled emissions may be counted as non-fugitive emissions when the inherent characteristics of the waste gas stream (e.g. low velocities, variability of the flow rate and concentration) do not allow an accurate measurement according to BAT 8.

The main sources of uncertainty of the estimation are identified, and corrective actions are implemented to reduce the uncertainty.

BAT 21: Monitoring – diffuse VOC emissions from solvent mass-balance

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 the techniques given below.

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Table 23: Techniques for mass-balance calculations of VOCs.

Technique	Description
a. Full identification and quantification of the relevant solvent inputs and outputs, including the associated uncertainty	<p>This includes:</p> <ul style="list-style-type: none"> • 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	<p>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).</p>
c. Monitoring of changes that may influence the uncertainty of the solvent mass-balance data	<p>Any change that could influence the uncertainty of the solvent mass-balance data is recorded, such as:</p> <ul style="list-style-type: none"> • 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 may not apply to the production of polyolefins, PVC or synthetic rubbers.

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: Monitoring – diffuse VOC emissions

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

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Table 24: Monitoring methods for VOCs

Type of sources of diffuse VOC emissions ⁽¹⁾ ⁽²⁾	Type of VOCs	Standards	Minimum monitoring frequency
Sources of fugitive emissions	VOCs classified as CMR 1A or 1B	BS EN 17628 and BS EN 15446	Once every year ⁽³⁾ ⁽⁴⁾ ⁽⁵⁾
Sources of fugitive emissions	VOCs not classified as CMR 1A or 1B	BS EN 17628 and BS EN 15446	Once during the period covered by each LDAR programme (see BAT 19 point c) ⁽⁶⁾
Sources of non-fugitive emissions	VOCs classified as CMR 1A or 1B	BS EN 17628	Once every year
Sources of non-fugitive emissions	VOCs not classified as CMR 1A or 1B	BS EN 17628	Once every year ⁽⁷⁾

¹ The monitoring only applies to emission sources that are identified as relevant in the inventory given in BAT 6.

² The monitoring does not apply to equipment operated under sub-atmospheric pressure.

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

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 to continuously monitor VCM emissions in a way that allows an equivalent level of detection of VCM leaks.

⁵ In the case of high-integrity equipment (see BAT 23) in contact with VOCs classified as CMR 1A or 1B, a lower minimum monitoring frequency may be adopted, but in any case, at least once every five years.

⁶ In the case of high-integrity equipment (see BAT 23) in contact with VOCs other than VOCs classified as CMR 1A or 1B, a lower minimum monitoring frequency may be adopted, but in any case, at least once every eight years.

⁷ The minimum monitoring frequency may be reduced to once every five years if non-fugitive emissions are quantified by using measurements.

Note: Optical gas imaging (OGI) is a useful complementary technique to the method described in BS EN 15446 ('sniffing') in order to identify sources of fugitive VOC emissions and is particularly relevant in the case of inaccessible sources (see Table 5).

In the case of non-fugitive emissions, measurements may be complemented by the use of thermodynamic models.

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Where large amounts (e.g. above 80 t/yr) of VOCs are used/consumed, the quantification of VOC emissions from the plant with tracer correlation (TC) or 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 Table 5).

Applicability

BAT 22 only applies when the annual quantity of diffuse VOC emissions from the plant estimated according to BAT 20 or 21 is greater than the following:

For fugitive emissions:

- a. 1 tonne of VOCs per year in the case of VOCs classified as CMR 1A or 1B;
or
- b. 5 tonnes of VOCs per year in the case of other VOCs.

For non-fugitive emissions:

- a. 1 tonne of VOCs per year in the case of VOCs classified as CMR 1A or 1B;
or
- b. 5 tonnes of VOCs per year in the case of other VOCs.

BAT 23: Prevention or reduction of diffuse VOC emissions

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 in the table below, with the following order of priority.

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.

Table 25: Techniques to prevent or reduce diffuse emissions.

Technique	Description	Type of emissions	Applicability
<p>1a. Prevention techniques: Limiting the number of emission sources</p>	<p>This includes:</p> <ul style="list-style-type: none"> • 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. 	<p>Fugitive and non-fugitive emissions</p>	<p>Applicability may be restricted by operational constraints in the case of existing plants.</p>
<p>1b. Prevention techniques: Use of high-integrity equipment</p>	<p>High-integrity equipment includes, but is not limited to:</p> <ul style="list-style-type: none"> • valves with bellow or double packing seals or equally 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 BS EN 13555) that are tightened according to technique 2b; • closed sampling system; <p>The use of high-integrity equipment is especially relevant to prevent or minimise:</p> <ul style="list-style-type: none"> • emissions of CMR substances or substances with acute toxicity; and/or • emissions from equipment with high-leaking potential; and/or • leaks from processes operated at high pressures (e.g. between 300 bar and 2000 bar). <p>High-integrity equipment is elected, installed and maintained according to the type of process and the process operating conditions</p>	<p>Fugitive emissions</p>	<p>Applicability may be restricted by operational constraints in the case of existing plants.</p> <p>Generally applicable to new plants and major plant upgrades</p>

Technique	Description	Type of emissions	Applicability
1c. Prevention techniques: Collecting 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).	Fugitive and non-fugitive emissions	Applicability may be restricted: <ul style="list-style-type: none"> • for existing plants and/or; • by safety concerns (e.g. avoiding concentrations close to the lower explosive limit).
2a. Other techniques: Facilitating access and/or monitoring activities	To ease maintenance and/or monitoring the access to potentially leaky equipment is facilitated, e.g. by activities, installing platforms, and/or drones are used for monitoring.	Fugitive emissions	Applicability may be restricted by operational constraints in the case of existing plants.
2b. Other techniques: Tightening	<ul style="list-style-type: none"> • tightening of gaskets by personnel that is qualified according to BS EN 1591-4 and using the designed gasket stress (e.g. calculated according to BS EN 1591-1) and; • installing tight caps on open ends; • using flanges selected and assembled according to BS EN 13555. 	Fugitive emissions	Generally applicable.
2c. Other techniques: Replacement of leaky equipment and/or parts	This includes the replacement of: <ul style="list-style-type: none"> • gaskets; • sealing elements (e.g. tank lid); • packing material (e.g. valve stem packing material). 	Fugitive emissions	Generally applicable

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Technique	Description	Type of emissions	Applicability
2d. Other techniques: Reviewing and updating process design	<p>This includes:</p> <ul style="list-style-type: none"> 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. 	Non-fugitive emissions	Applicability may be restricted in the case of existing plants due to operational constraints.
2e. Other techniques: Reviewing and updating operating conditions	<p>This includes:</p> <ul style="list-style-type: none"> reducing the frequency and duration of reactor and vessel openings; preventing corrosion by lining or coating of equipment, by painting pipes (for external corrosion) and by using corrosion inhibitors for materials in contact with equipment. 	Non-fugitive emissions	Generally applicable
2f. Other techniques: Using closed systems	<p>This includes:</p> <ul style="list-style-type: none"> vapour balancing (see Table 6); 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). 	Non-fugitive emissions	Applicability may be restricted by operational constraints in the case of existing plants and/or by safety concerns.

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Technique	Description	Type of emissions	Applicability
2g. Other techniques: Using techniques to minimise emissions from surfaces	This includes: <ul style="list-style-type: none"> • 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 the VOCs to recovery (see BAT 9 and BAT 10) and/or abatement (see BAT 11); • installing floating roofs on tanks; • using fixed-roof tanks connected to a waste gas treatment facility. 	Non-fugitive emissions	Applicability may be restricted by operational constraints in the case of existing plants.

The emission levels for the use of solvents or the reuse of recovered solvents associated with the BAT Conclusions given in BAT 1 to BAT 23 and BAT 38 are given in the table below.

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

Table 26: 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⁾
Diffuse VOC emissions	≤ 5 %

¹ The BAT-AEL does not apply to permitted activities whose total annual consumption of solvents is lower than 50 tonnes.

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

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BAT conclusions – process furnaces/heaters

Additional BAT Conclusion for process furnaces/heaters.

The BAT Conclusion presented in this section applies when process furnaces/heaters with a total rated thermal input equal to or greater than 1 MW are used in the production processes included in the scope of these BATC. They apply in addition to the general BAT Conclusions given in BAT 1 to BAT 23.

Where the waste gases of two or more separate process furnaces/heaters are, or could, in the judgement of the competent authority, be 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 24: Emissions – process furnaces/heaters

To prevent or, where that is not practicable, to reduce channelled emissions to air of CO, dust, NO_x and SO_x, BAT is to use technique c. and one or a combination of the other techniques given below.

Table 27: Techniques to reduce channelled emissions to air of CO, dust, NO_x and SO_x

Technique	Description	Main inorganic compounds targeted	Applicability
Primary techniques: a. Choice of fuel	See Table 4. 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.
Primary techniques: b. Low-NO _x burner	See Table 4.	NO _x	For existing process furnaces/heaters, the applicability may be restricted by their design.
Primary techniques: c. Optimised combustion	See Table 4.	CO, NO _x	Generally applicable.

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Technique	Description	Main inorganic compounds targeted	Applicability
Secondary techniques: d. Absorption	See Table 4.	SO _x , dust	Applicability may be restricted for existing process furnaces/heaters by space availability.
Secondary techniques: e. Fabric filter or absolute filter	See Table 4.	Dust	Not applicable when only combusting gaseous fuels.
Secondary techniques: f. Selective catalytic reduction (SCR)	See Table 4.	NO _x	Applicability to existing process furnaces/ heaters may be restricted by space availability.
Secondary techniques: g. Selective non-catalytic reduction (SNCR)	See Table 4.	NO _x	Applicability to existing process furnaces/ heaters may be restricted by the temperature window (800-1,100 °C) and the residence time needed for the reaction.

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BAT-associated emission level (BAT-AEL) for channelled NO_x emissions to air and indicative emission level for channelled CO emissions to air from process furnaces/heaters

Table 28: BAT-AEL for channelled NO_x emissions to air and indicative emission level for channelled CO emissions to air from process furnaces/heaters

Parameter	BAT-AEL (mg/Nm³) (Daily average or average over the sampling period)
Nitrogen oxides (NO _x)	30-150 ⁽¹⁾ ⁽²⁾ ⁽³⁾
Carbon monoxide (CO)	No BAT-AEL ⁽⁴⁾

¹ In the case of the production of complex inorganic pigments, the upper end of the BAT-AEL range may be higher and up to 400 mg/Nm³ when condition b) below is met, and up to 1,000 mg/Nm³ when conditions a) and b) below are met: a. the combustion temperature is higher than 1,000 °C; b. oxygen-enriched air or pure oxygen is used.

² The BAT-AEL does not apply when the NO_x mass flow is below approx. 500 g/h.

³ The upper end of the BAT-AEL range may be higher and up to 200 mg/Nm³ when direct heating is used.

⁴ As an indication, the emission levels for carbon monoxide are 4-50 mg/Nm³, as a daily average or average over the sampling period.

The associated monitoring is given in BAT 8.

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Sub-sector BATC

This section captures BAT Conclusions specific to sub-sectors identified in the scope. Where relevant these will include the BAT-AEL. They apply in addition to the general BAT Conclusions given in BAT 1 to BAT 24.

BAT conclusions – polymers and synthetic rubbers

Additional BAT Conclusions for polymers and synthetic rubbers.

BAT 25: Monitoring – polyolefins

BAT is to monitor the TVOC concentration in polyolefin products, at least once every year for each representative polyolefin grade produced during the same year, in accordance with BS EN standards. If BS EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Table 29: Techniques to measure the TVOC content of polyolefins.

Polyolefin product	Standard(s) ⁽¹⁾	Monitoring associated with
HDPE, LDPE, LLDPE	EPA ⁽²⁾ Method 24, SCAQMD ⁽³⁾ Method 304-91	BAT 29 and BAT 35
PP	EPA ⁽²⁾ Method 24, SCAQMD ⁽³⁾ Method 304-91	BAT 29 and BAT 35
EPS, GPPS, HIPS	EPA ⁽²⁾ Method 24, SCAQMD ⁽³⁾ Method 304-91	BAT 29 and BAT 35

¹ Other methods are acceptable, if such methods provide data of an equivalent quality. There are no BS EN standards available.

² EPA means the United States Environmental Protection Agency.

³ SCAQMD means The South Coast Air Quality Management District of Orange County and the urban portions of Los Angeles, Riverside and San Bernardino counties in the USA.

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.

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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.

When the transition point between the open and the closed system cannot be clearly identified, the measurement samples are taken at an appropriate point.

Applicability

Measurements do not apply to production processes only made up of a closed system.

BAT 26: Efficiency – organic compounds

In order to increase resource efficiency and to reduce emissions to air of organic compounds, BAT is to use all of the techniques given below, as far as applicable.

Table 30: Techniques to reduce emissions of VOCs, using efficiency measures.

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 Table 6). 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 and/or due to safety concerns (e.g. avoiding concentrations close to the lower/upper explosive limit).

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The associated monitoring is given in BAT 8, BAT 20, BAT 22 and BAT 25. 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.

The table below shows the BAT-AELs for total emissions to air of VOCs from the production of polyolefins expressed as specific emission loads.

Table 31: BAT-associated emission levels (BAT-AELs) for total emissions to air of VOCs from the production of polyolefins expressed as specific emission loads.

Polyolefin product	Unit	BAT-AEL (Yearly average)
HDPE	g C per kg of polyolefins produced	0.3-1.0 ⁽¹⁾
LDPE	g C per kg of polyolefins produced	0.1-1.4 ⁽²⁾ ⁽³⁾
LLDPE	g C per kg of polyolefins produced	0.1-0.8
PP	g C per kg of polyolefins produced	0.1-0.9 ⁽¹⁾
GPPS and HIPS	g C per kg of polyolefins produced	< 0.1
EPS	g C per kg of polyolefins produced	< 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 higher and up to 2.7 g C/kg in the case of the production of EVA or other copolymers (e.g. ethyl acrylate copolymers).

³ The upper end of the BAT-AEL range may be higher and up to 4.7 g C/kg if both of the following conditions are met: thermal oxidation is not applicable; EVA or other copolymers (e.g. ethyl acrylate copolymers) are produced.

BAT Conclusions – production of polyvinyl chloride (PVC)

Additional BAT Conclusions for the production of PVC

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BAT 27: Monitoring – PVC

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

Table 32: Monitoring techniques for measuring emissions of VCM

Substance	Emission points	Standard(s)	Minimum monitoring frequency ⁽¹⁾	Monitoring associated with
VCM	Any stack with a VCM mass flow of ≥ 25 g/h	Generic BS EN standards ⁽²⁾	Continuous ⁽³⁾	BAT 30
VCM	Any stack with a VCM mass flow of < 25 g/h	BS EN/TS 13649	Once every 6 months ⁽⁴⁾ ⁽⁵⁾	BAT 30

¹ 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 28.

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

³ The minimum monitoring frequency may be reduced to once every 6 months if the emission levels are proven to be sufficiently stable.

⁴ To the extent possible, the measurements are carried out at the highest expected emission state under normal operating conditions.

⁵ The minimum monitoring frequency may be reduced to once every year if the emission levels are proven to be sufficiently stable.

BAT 28: Monitoring – vinyl chloride monomer (VCM)

BAT is to monitor the VCM concentration in PVC products, at least once every year for each representative PVC grade produced during the same year, in accordance with BS EN standards.

Table 33: Monitoring techniques for measuring VCM content of PVC.

Substance	Standard(s)	Monitoring associated with
VCM	BS EN ISO 6401	BAT 31

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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 generally 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 29: Efficiency – vinyl chloride monomer (VCM)

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.

Table 34: Techniques to recover VCM from process off-gases.

Technique	Description
a. Absorption (regenerative)	See Table 4
b. Adsorption (regenerative)	See Table 4.
c. Condensation	See Table 4.

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).

BAT 30: Emissions – vinyl chloride monomer (VCM)

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.

Table 35: Techniques for the recovery of VCM.

Technique	Description	Applicability
a. Absorption	See Table 4	Generally applicable

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Technique	Description	Applicability
	In the case of regenerative absorption, the compounds may be recovered from the liquid.	
b. Adsorption	See Table 4.	Generally applicable
c. Condensation	See Table 4.	Generally applicable
d. Thermal oxidation	See Table 4.	Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/ or operational constraints. Applicability may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases.

BAT-associated emission level (BAT-AEL) for channelled emissions to air of VCM from the recovery of VCM

Table 36: BAT-AEL for channelled emissions to air of VCM from the recovery of VCM.

Substance	BAT-AEL (mg/Nm³) (Daily average or average over the sampling period)
VCM	< 0.5-1 ⁽¹⁾ ⁽²⁾

¹ The BAT-AEL does not apply when the VCM mass flow is below approx. 1 g/h.

² The upper end of the BAT-AEL range may be higher and up to 5 mg/Nm³ if both of the following conditions are met: thermal oxidation is not applicable, and the plant is not directly associated to the production of EDC and VCM.

The associated monitoring is given in BAT 27.

BAT 31: Techniques to reduce VCM emissions

To reduce emissions to air of vinyl chloride monomer, BAT is to use all of the techniques given below.

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Table 37: Techniques to reduce or prevent VCM emissions.

Technique	Description
a. Appropriate VCM storage facilities	This includes: <ul style="list-style-type: none"> • storing VCM in refrigerated tanks at atmospheric pressure or in pressurised tanks at ambient temperature; • using refrigerated reflux condensers or connecting tanks for VCM recovery (see BAT 29) and/or abatement (see BAT 30).
b. Vapour balancing	See Table 6.
c. Minimisation of emissions of residual VCM from equipment	This includes: <ul style="list-style-type: none"> • reducing the frequency and duration of reactor openings; • venting off-gases from latex storage tanks and from connections to VCM recovery (see BAT 29) and/or abatement (see BAT 30) prior to opening the reactor; • flushing the reactor with inert gas prior to opening and venting off-gases to VCM recovery (see BAT 29) and/or abatement (see BAT 30); • draining the liquid content of the reactor to closed vessels prior to opening the reactor; • cleaning the reactor with water prior to opening and draining the water to the stripping system.
d. Lowering the VCM content in the polymer by stripping	See Table 6.
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 29) and/or abatement (see BAT 30).

BAT-associated emission levels (BAT-AELs) for total emissions to air of VCM from the production of PVC expressed as specific emission loads are shown below.

This draft document should not be used for reference until the final version is published (expected at the end of 2025).

Table 38: 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	g VCM per kg of PVC produced	0.25-0.3 ⁽¹⁾

¹ The upper end of the BAT-AEL range may be higher and up to 0.5 g VCM per kg of PVC produced if both of the following conditions are met: thermal oxidation is not applicable and the plant is not directly associated to the production of EDC and VCM.

The associated monitoring is given in BAT 8, BAT 22, BAT 27 and BAT 28. 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.

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

Table 39: 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	0.01-0.03
E-PVC	g VCM per kg of PVC produced	0.2-0.4

The associated monitoring is given in BAT 28.

BAT conclusions – production of synthetic rubbers

Additional BAT Conclusions for the production of synthetic rubbers

BAT 32: Monitoring – TVOC in synthetic rubbers

BAT is to monitor the TVOC concentration in synthetic rubbers, at least once every year for each representative synthetic rubber grade produced during the same year, in accordance with BS EN standards. If BS EN standards are not available, BAT is to use BS ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

This draft document should not be used for reference until the final version is published (expected at the end of 2025).

Note: The samples are taken after lowering the VOC content in the polymer (see BAT 33 where the synthetic rubber comes into contact with the atmosphere).

Applicability

Measurements do not apply to production processes only made up of a closed system.

BAT 33: Emissions – synthetic rubbers

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

Table 40: Techniques to reduce the VOC emissions from synthetic rubber production.

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 Table 6.
b. Collection and treatment of process off-gases	Process off-gases are collected and sent to recovery (see BAT 9 and BAT 10) and/or abatement (see BAT 11)

BAT-associated emission level (BAT-AEL) for total emissions to air of VOC from the production of synthetic rubbers expressed as specific emission load

Table 41: BAT-AEL for total emissions to air of VOC from the production of synthetic rubbers expressed as specific emission load.

Substance/Parameter	Unit	BAT-AEL (Yearly average)
TVOC	g C per kg of synthetic rubber produced	0.2-4.2

The associated monitoring is given in BAT 8, BAT 20, BAT 22 and BAT 32. 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.

This draft document should not be used for reference until the final version is published (expected at the end of 2025).

BAT conclusions – production of viscose using carbon disulphide

Additional BAT Conclusions for the production of viscose using carbon disulphide.

BAT 34: Monitoring – viscose

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

Table 42: Monitoring techniques for carbon disulphide and hydrogen sulphide

Substance ⁽¹⁾	Emission points	Standard(s)	Minimum monitoring frequency	Monitoring associated with
Carbon disulphide (CS ₂)	Any stack with a mass flow of ≥ 1 kg/h	Generic BS EN standards ⁽²⁾	Continuous ⁽³⁾	BAT 36
Carbon disulphide (CS ₂)	Any stack with a mass flow of < 1 kg/h	BS EN/TS 13649 for sampling, NIOSH 1600 for analysis	Once every year ⁽⁴⁾	BAT 36
Hydrogen sulphide (H ₂ S)	Any stack with a mass flow of ≥ 50 g/h	Generic BS EN standards ⁽²⁾	Continuous ⁽³⁾	BAT 36
Hydrogen sulphide (H ₂ S)	Any stack with a mass flow of < 50 g/h	BS EN/TS 13649 for sampling, NIOSH 6013 for analysis	Once every year ⁽⁴⁾	BAT 36

¹ 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.

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

³ In the case of the production of casing, the minimum monitoring frequency may be reduced to once every month when continuous monitoring is not possible due to analytical interference.

⁴ To the extent possible, the measurements are carried out at the highest expected emission state under normal operating conditions.

This draft document should not be used for reference until the final version is published (expected at the end of 2025).

BAT 35: Resource efficiency – viscose

To increase resource efficiency and to reduce the mass flow of CS₂ and H₂S sent to the final waste gas treatment, BAT is to recover CS₂ by using technique a. and/or technique b. or a combination of technique c. with technique(s) a. and/or b., given below and to reuse the CS₂, or, alternatively, to use technique d.

Table 43: Techniques to reduce emissions of carbon disulphide and hydrogen sulphide through resource efficiency.

Technique	Description	Main substance targeted	Applicability
a. Absorption (regenerative)	See Table 4	H ₂ S	Generally applicable for the production of casing. For other products, applicability may be restricted where the energy demand is excessive due to high waste gas volume flows (above e.g. 120,000 Nm ³ /h) or low H ₂ S concentration in the waste gas (below e.g. 0.5 g/Nm ³).
b. Adsorption (regenerative)	See Table 4.	H ₂ S, CS ₂	Applicability may be restricted where the energy demand for recovery is excessive if the concentration of CS ₂ in the waste gas is below e.g. 5 g/Nm ³ .
c. Condensation	See Table 4.	H ₂ S, CS ₂	Applicability may be restricted where the energy demand for recovery is excessive if the concentration of CS ₂ in the waste gas is below e.g. 5 g/Nm ³ .
d. Production of sulphuric acid	Process off-gases containing CS ₂ and H ₂ S are used to produce sulphuric acid.	H ₂ S, CS ₂	Applicability may be restricted if the concentration of CS ₂ and/or H ₂ S in the waste gas is below 5 g/Nm ³ .

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BAT 36: Emissions – viscose

To reduce channelled emissions to air of CS₂ and H₂S, BAT is to use one or a combination of the techniques given below.

Table 44: Techniques to reduce emissions of carbon disulphide and hydrogen sulphide.

Technique	Description	Main substance targeted	Applicability
a. Absorption	See Table 4 In the case of regenerative absorption, the compounds may be recovered from the liquid.	H ₂ S	Generally applicable.
b. Bioprocesses	See Table 4.	CS ₂ , H ₂ S	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 high CS ₂ concentration in the waste gas (e.g. above 1,000 mg/Nm ³) or too low H ₂ S concentration.
c. Thermal oxidation	See table 4.	CS ₂ , H ₂ S	Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/or operational constraints. Applicability may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases.

This draft document should not be used for reference until the final version is published (expected at the end of 2025).

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of CS₂ and H₂S from the production of viscose using CS₂

Table 45 BAT-AELs for channelled emissions to air of CS₂ and H₂S from the production of viscose using CS₂

Substance	BAT-AEL (mg/Nm³) (Daily average or average over the sampling period) ⁽¹⁾
CS ₂	5-400 ⁽²⁾ ⁽³⁾
H ₂ S	1-10 ⁽⁴⁾

¹ The BAT-AEL does not apply to the production of filament yarn.

² The upper end of the BAT-AEL range may be higher and up to 500 mg CS₂/Nm³ if both of the following conditions are fulfilled: a. bioprocesses (see BAT 36) are not applicable and, b. the CS₂ recovery efficiency (see BAT 35) is > 97 % or CS₂ recovery is not applicable.

³ The lower end of the BAT-AEL range can be achieved by using thermal oxidation or technique d. in BAT 35.

⁴ The upper end of the BAT-AEL range may be higher and up to 30 mg/Nm³, when the sum of H₂S and CS₂ (expressed as Total S) is close to the lower end of the BAT-AEL range in Table 46.

The associated monitoring is given in BAT 34.

BAT-associated emission levels (BAT-AELs) for emissions to air of H₂S and CS₂ from the production of staple fibres and casing expressed as specific emission loads

Table 46: BAT-AELs for emissions to air of H₂S and CS₂ from the production of staple fibres and casing expressed as specific emission loads

Parameter	Process	Unit	BAT-AEL (Yearly average)
Sum of H ₂ S and CS ₂ (expressed as Total S) ⁽¹⁾	Production of staple fibres	g Total S per kg of product	6-9
Sum of H ₂ S and CS ₂ (expressed as Total S) ⁽¹⁾	Casing	g Total S per kg of product	120-250

¹ Emissions to air refer to channelled emissions only.

The associated monitoring is given in BAT 34.