COMMISSION IMPLEMENTING DECISION

of 9 December 2013

establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the production of chlor-alkali

(notified under document C(2013) 8589)

(Text with EEA relevance)

(2013/732/EU)

THE EUROPEAN COMMISSION,

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

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

Whereas:

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

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

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

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

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

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

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

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

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

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

(10) In accordance with Article 13(4) of Directive 2010/75/EU, the Commission obtained the opinion of that forum on the proposed content of the BAT reference document for the production of chlor-alkali on 6 June 2013 and made it publicly available (2).

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

HAS ADOPTED THIS DECISION:

Article 1

The BAT conclusions for the production of chlor-alkali are set out in the Annex to this Decision.

Article 2

This Decision is addressed to the Member States.

Done at Brussels, 9 December 2013.

For the Commission
Janez POTOČNIK
Member of the Commission

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

(2) https://circabc.europa.eu/w/browse/d4fbf23d-0da7-47fd-a954-0ada9ca91560

ANNEX

BAT CONCLUSIONS FOR THE PRODUCTION OF CHLOR-ALKALI

SCOPE

These BAT conclusions cover certain industrial activities specified in Sections 4.2(a) and 4.2(c) of Annex I to Directive 2010/75/EU, namely the production of chlor-alkali chemicals (chlorine, hydrogen, potassium hydroxide and sodium hydroxide) by the electrolysis of brine.

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

- the storage of salt;
- the preparation, purification and resaturation of brine;
- the electrolysis of brine;
- the concentration, purification, storage and handling of sodium/potassium hydroxide;
- the cooling, drying, purification, compression, liquefaction, storage and handling of chlorine;
- the cooling, purification, compression, storage and handling of hydrogen;
- the conversion of mercury cell plants to membrane cell plants;
- the decommissioning of mercury cell plants;
- the remediation of chlor-alkali production sites.

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

- the electrolysis of hydrochloric acid for the production of chlorine;
- the electrolysis of brine for the production of sodium chlorate; this is covered by the BAT reference document on Large Volume Inorganic Chemicals – Solids and Others Industry (LVIC-S);
- the electrolysis of molten salts for the production of alkali or alkaline earth metals and chlorine; this is covered by the BAT reference document on Non-ferrous Metals Industries (NFM);
- the production of specialities such as alcoholates, dithionites and alkali metals by using alkali metal amalgam produced with the mercury cell technique;
- the production of chlorine, hydrogen or sodium/potassium hydroxide by processes other than electrolysis.

These BAT conclusions do not address the following aspects of chlor-alkali production as they are covered by the BAT reference document on Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW);

- the treatment of waste water in a downstream treatment plant;
- environmental management systems;
- noise emissions.

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

Reference document	Subject
Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector BREF (CWW)	Common waste water and waste gas treatment/management systems
Economics and Cross-Media Effects (ECM)	Economics and cross-media effects of techniques

Reference document	Subject
Emissions from Storage (EFS)	Storage and handling of materials
Energy Efficiency (ENE)	General aspects of energy efficiency
Industrial Cooling Systems (ICS)	Indirect cooling with water
Large Combustion Plants (LCP)	Combustion plants with a rated thermal input of 50 MW or more
General Principles of Monitoring (MON)	General aspects of emissions and consumption monitoring
Waste Incineration (WI)	Waste incineration
Waste Treatments Industries (WT)	Waste treatment

GENERAL CONSIDERATIONS

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

Unless otherwise stated, the BAT conclusions are generally applicable.

Emission levels associated with the best available techniques (BAT-AELs) for emissions to air given in these BAT conclusions refer to:

— concentration levels expressed as mass of emitted substances per volume of waste gas under standard conditions (273,15 K, 101,3 kPa), after deduction of the water content but without correction of the oxygen content, with the unit mg/m^3;

BAT-AELs for emissions to water given in these BAT conclusions refer to:

— concentration levels expressed as mass of emitted substances per volume of waste water, with the unit mg/l.

DEFINITIONS

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

Term used	Definition
New plant	A plant first operated at the installation following the publication of these BAT conclusions or a complete replacement of a plant on the existing foundations of the installation following the publication of these BAT conclusions.
Existing plant	A plant which is not a new plant.
New chlorine liquefaction unit	A chlorine liquefaction unit first operated at the plant following the publication of these BAT conclusions or a complete replacement of a chlorine liquefaction unit following the publication of these BAT conclusions.
Chlorine and chlorine dioxide, expressed as Cl_2	The sum of chlorine (Cl_2) and chlorine dioxide (ClO_2), measured together and expressed as chlorine (Cl_2).
Free chlorine, expressed as Cl_2	The sum of dissolved elementary chlorine, hypochlorite, hypochlorous acid, dissolved elementary bromine, hypobromite, and hypobromic acid, measured together and expressed as Cl_2
Mercury, expressed as Hg	The sum of all inorganic and organic mercury species, measured together and expressed as Hg.

BAT CONCLUSIONS

1. **Cell technique**

BAT 1: BAT for the production of chlor-alkali is to use one or a combination of the techniques given below. The mercury cell technique cannot be considered BAT under any circumstances. The use of asbestos diaphragms is not BAT.

	Technique	Description	Applicability
a	Bipolar membrane cell technique	Membrane cells consist of an anode and a cathode separated by a membrane. In a bipolar configuration, individual membrane cells are electrically connected in series.	Generally applicable.
b	Monopolar membrane cell technique	Membrane cells consist of an anode and a cathode separated by a membrane. In a monopolar configuration, individual membrane cells are electrically connected in parallel.	Not applicable to new plants with a chlorine capacity of > 20 kt/yr.
c	Asbestos-free diaphragm cell technique	Asbestos-free diaphragm cells consist of an anode and a cathode separated by an asbestos-free diaphragm. Individual diaphragm cells are electrically connected in series (bipolar) or in parallel (monopolar).	Generally applicable.

2. **Decommissioning or conversion of mercury cell plants**

BAT 2: In order to reduce emissions of mercury and to reduce the generation of waste contaminated with mercury during the decommissioning or conversion of mercury cell plants, BAT is to elaborate and implement a decommissioning plan that incorporates all of the following features:

(i) inclusion of some of the staff experienced in running the former plant at all stages of elaboration and implementation;

(ii) provision of procedures and instructions for all stages of implementation;

(iii) provision of a detailed training and supervision programme for personnel with no experience in mercury handling;

(iv) determination of the quantity of metallic mercury to be recovered and estimation of the quantity of waste to be disposed of and of the mercury contamination contained therein;

(v) provision of working areas which are:

  (a) covered with a roof;

  (b) equipped with a smooth, sloped, impervious floor to direct mercury spills to a collection sump;

  (c) well lit;

  (d) free of obstructions and debris that may absorb mercury;

  (e) equipped with a water supply for washing;

  (f) connected to a waste water treatment system.

(vi) emptying of the cells and transfer of metallic mercury to containers by:

  (a) keeping the system closed, if possible;

  (b) washing of mercury;

  (c) using gravity transfer, if possible;

    (d) removing solid impurities from mercury, if necessary;

    (e) filling the containers to ≤ 80 % of their volumetric capacity;

    (f) hermetically sealing the containers after filling;

    (g) washing of the empty cells, followed by filling with water.

(vii) carrying out of all dismantling and demolition operations by:

    (a) replacing hot cutting of equipment by cold cutting, if possible;

    (b) storing contaminated equipment in suitable areas;

    (c) frequent washing of the floor of the working area;

    (d) rapid clean-up of mercury spills by using aspiration equipment with activated carbon filters;

    (e) accounting of waste streams;

    (f) separating mercury-contaminated waste from non-contaminated waste;

    (g) decontaminating waste contaminated with mercury by using mechanical and physical treatment techniques (e.g. washing, ultrasonic vibration, vacuum cleaners), chemical treatment techniques (e.g. washing with hypochlorite, chlorinated brine or hydrogen peroxide) and/or thermal treatment techniques (e.g. distillation/retorting);

    (h) reusing or recycling decontaminated equipment, if possible;

    (i) decontaminating the cell room building by cleaning the walls and the floor, followed by coating or painting to give them an impermeable surface if the building is to be reused;

    (j) decontaminating or renewing the waste water collection systems in or around the plant;

    (k) confining the working area and treating ventilation air when high concentrations of mercury are expected (e.g. for high-pressure washing); treatment techniques for ventilation air include adsorption on iodised or sulphurised activated carbon, scrubbing with hypochlorite or chlorinated brine or adding chlorine to form solid dimercury dichloride;

    (l) treating mercury-containing waste water, including laundry wash water arising from the cleaning of protective equipment;

    (m) monitoring of mercury in air, water and waste, including for an appropriate time after the finalisation of the decommissioning or conversion;

(viii) if needed, interim storage of metallic mercury on site in storage facilities that are:

    (a) well lit and weatherproof;

    (b) equipped with a suitable secondary containment capable of retaining 110 % of the liquid volume of any single container;

    (c) free of obstructions and debris that may absorb mercury;

(d) equipped with aspiration equipment with activated carbon filters;

(e) periodically inspected, both visually and with mercury-monitoring equipment.

(ix) if needed, transport, potential further treatment and disposal of waste.

BAT 3: In order to reduce emissions of mercury to water during the decommissioning or conversion of mercury cell plants, BAT is to use one or a combination of the techniques given below.

	Technique	Description
a	Oxidation and ion exchange	Oxidising agents such as hypochlorite, chlorine or hydrogen peroxide are used to fully convert mercury into its oxidised form, which is subsequently removed by ion-exchange resins.
b	Oxidation and precipitation	Oxidising agents such as hypochlorite, chlorine or hydrogen peroxide are used to fully convert mercury into its oxidised form, which is subsequently removed by precipitation as mercury sulphide, followed by filtration.
c	Reduction and adsorption on activated carbon	Reducing agents such as hydroxylamine are used to fully convert mercury into its elemental form, which is subsequently removed by coalescence and recovery of metallic mercury, followed by adsorption on activated carbon.

The **BAT-associated environmental performance level** (1) for mercury emissions to water, expressed as Hg, at the outlet of the mercury treatment unit during decommissioning or conversion is 3 – 15 μg/l in 24-hour flow-proportional composite samples taken daily. The associated monitoring is in BAT 7.

3. Generation of waste water

BAT 4: In order to reduce the generation of waste water, BAT is to use a combination of the techniques given below.

	Technique	Description	Applicability
a	Brine recirculation	The depleted brine from the electrolysis cells is resaturated with solid salt or by evaporation and fed back to the cells.	Not applicable to diaphragm cell plants. Not applicable to membrane cell plants using solution-mined brine when abundant salt and water resources and a saline receiving water body, which tolerates high chloride emission levels, are available. Not applicable to membrane cell plants using the brine purge in other production units.
b	Recycling of other process streams	Process streams from the chlor-alkali plant such as condensates from chlorine, sodium/potassium hydroxide and hydrogen processing are fed back to various steps of the process. The degree of recycling is limited by the purity requirements of the liquid stream to which the process stream is recycled and the water balance of the plant.	Generally applicable.
c	Recycling of salt-containing waste water from other production processes	Salt-containing waste water from other production processes is treated and fed back into the brine system. The degree of recycling is limited by the purity requirements of the brine system and the water balance of the plant.	Not applicable to plants where an additional treatment of this waste water offsets the environmental benefits.

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(1) Given that this performance level does not relate to normal operating conditions, it is not an emission level associated with the Best Available Techniques in the sense of Article 3(13) of the Industrial Emissions Directive (2010/75/EU).

	Technique	Description	Applicability
d	Use of waste water for solution mining	Waste water from the chlor-alkali plant is treated and pumped back to the salt mine.	Not applicable to membrane cell plants using the brine purge in other production units. Not applicable if the mine is located at a significantly higher altitude than the plant.
e	Concentration of brine filtration sludges	Brine filtration sludges are concentrated in filter presses, rotary drum vacuum filters or centrifuges. The residual water is fed back into the brine system.	Not applicable if the brine filtration sludges can be removed as dry cake. Not applicable to plants that reuse waste water for solution mining.
f	Nanofiltration	A specific type of membrane filtration with membrane pore sizes of approximately 1 nm, used to concentrate sulphate in the brine purge, thereby reducing the waste water volume.	Applicable to membrane cell plants with brine recirculation, if the brine purge rate is determined by the sulphate concentration.
g	Techniques to reduce chlorate emissions	Techniques to reduce chlorate emissions are described in BAT 14. These techniques reduce the brine purge volume.	Applicable to membrane cell plants with brine recirculation, if the brine purge rate is determined by the chlorate concentration.

4. **Energy efficiency**

BAT 5: In order to use energy efficiently in the electrolysis process, BAT is to use a combination of the techniques given below.

	Technique	Description	Applicability
a	High-performance membranes	High-performance membranes show low voltage drops and high current efficiencies while ensuring mechanical and chemical stability under the given operating conditions.	Applicable to membrane cell plants when renewing membranes at the end of their lifetime.
b	Asbestos-free diaphragms	Asbestos-free diaphragms consist of a fluorocarbon polymer and fillers such as zirconium dioxide. These diaphragms show lower resistance overpotentials than asbestos diaphragms.	Generally applicable
c	High-performance electrodes and coatings	Electrodes and coatings with improved gas release (low gas bubble overpotential) and low electrode overpotentials.	Applicable when renewing coatings at the end of their lifetime.
d	High-purity brine	The brine is sufficiently purified to minimise contamination of the electrodes and diaphragms/membranes, which could otherwise increase energy consumption.	Generally applicable.

BAT 6: In order to use energy efficiently, BAT is to maximise the use of the co-produced hydrogen from the electrolysis as a chemical reagent or fuel.

Description

Hydrogen can be used in chemical reactions (e.g. production of ammonia, hydrogen peroxide, hydrochloric acid, and methanol; reduction of organic compounds; hydrodesulphurisation of petroleum; hydrogenation of oils and greases; chain termination in polyolefin production) or as a fuel in a combustion process to produce steam and/or electricity or to heat a furnace. The degree to which hydrogen is used depends on a number of factors (e.g. demand for hydrogen as reagent on the site, demand for steam on the site, distance to potential users).

5. **Monitoring of emissions**

BAT 7: BAT is to monitor emissions to air and water by using monitoring techniques in accordance with EN standards with at least the minimum frequency given below. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.

Environmental medium	Substance(s)	Sampling point	Method	Standard(s)	Minimum monitoring frequency	Monitoring associated with
Air	Chlorine and chlorine dioxide, expressed as Cl_2 (1)	Outlet of chlorine absorption unit	Electrochemical cells	No EN or ISO standard available	Continuous	—
			Absorption in a solution, with subsequent analysis	No EN or ISO standard available	Yearly (at least three consecutive hourly measurements)	BAT 8
Water	Chlorate	Where the emission leaves the installation	Ion chromatography	EN ISO 10304–4	Monthly	BAT 14
	Chloride	Brine purge	Ion chromatography or flow analysis	EN ISO 10304–1 or EN ISO 15682	Monthly	BAT 12
	Free chlorine (1)	Close to the source	Reduction potential	No EN or ISO standard available	Continuous	—
		Where the emission leaves the installation	Free chlorine	EN ISO 7393–1 or –2	Monthly	BAT 13
	Halogenated organic compound	Brine purge	Adsorbable organically-bound halogens (AOX)	Annex A to EN ISO 9562	Yearly	BAT 15
	Mercury	Outlet of the mercury treatment unit	Atomic absorption spectrometry or atomic fluorescence spectrometry	EN ISO 12846 or EN ISO 17852	Daily	BAT 3

Environmental medium	Substance(s)	Sampling point	Method	Standard(s)	Minimum monitoring frequency	Monitoring associated with
	Sulphate	Brine purge	Ion chromatography	EN ISO 10304–1	Yearly	—
	Relevant heavy metals (e.g. nickel, copper)	Brine purge	Inductively-coupled plasma optical emission spectrometry or inductively-coupled plasma mass spectrometry	EN ISO 11885 or EN ISO 17294-2	Yearly	—

(1) Monitoring encompasses both continuous and periodic monitoring as indicated.

6. **Emissions to air**

BAT 8: In order to reduce channelled emissions of chlorine and chlorine dioxide to air from the processing of chlorine, BAT is to design, maintain and operate a chlorine absorption unit that incorporates an appropriate combination of the following features:

(i) absorption unit based on packed columns and/or ejectors with an alkaline solution (e.g. sodium hydroxide solution) as scrubbing liquid;

(ii) hydrogen peroxide dosing equipment or a separate wet scrubber with hydrogen peroxide if necessary to reduce chlorine dioxide concentrations;

(iii) size suitable for the worst case scenario (derived from a risk assessment), in terms of produced chlorine quantity and flowrate (absorption of the full cell room production for a sufficient duration until the plant is shut down);

(iv) size of the scrubbing liquid supply and storage capacity suitable to ensure an excess at all times;

(v) in the case of packed columns, their size should be suitable to prevent flooding at all times;

(vi) prevention of ingress of liquid chlorine into the absorption unit;

(vii) prevention of backflow of scrubbing liquid into the chlorine system;

(viii) prevention of solids precipitation in the absorption unit;

(ix) use of heat exchangers to limit the temperature in the absorption unit below 55 °C at all times;

(x) supply of dilution air after chlorine absorption to prevent the formation of explosive gas mixtures;

(xi) use of construction materials which withstand the extremely corrosive conditions at all times;

(xii) use of backup equipment, such as an additional scrubber in series with the one in operation, an emergency tank with scrubbing liquid feeding the scrubber by gravity, stand-by and spare fans, stand-by and spare pumps;

(xiii) provision of an independent backup system for critical electrical equipment;

(xiv) provision of an automatic switch to the backup system in case of emergencies, including periodic tests on this system and the switch;

(xv) provision of a monitoring and alarm system for the following parameters:

  (a) chlorine in the outlet of the absorption unit and the surrounding area;

  (b) temperature of the scrubbing liquids;

(c) reduction potential and alkalinity of the scrubbing liquids;

(d) suction pressure;

(e) flowrate of scrubbing liquids.

The **BAT-associated emission level** for chlorine and chlorine dioxide, measured together and expressed as Cl_2, is 0,2 – 1,0 mg/m^3, as an average value of at least three consecutive hourly measurements performed at least once every year at the outlet of the chlorine absorption unit. The associated monitoring is in BAT 7.

BAT 9: The use of carbon tetrachloride for the elimination of nitrogen trichloride or the recovery of chlorine from tail gas is not BAT.

BAT 10: The use of refrigerants with a high global warming potential, and in any case higher than 150 (e.g. many hydrofluorocarbons (HFCs)), in new chlorine liquefaction units cannot be considered BAT.

Description

Suitable refrigerants include, for example:

— a combination of carbon dioxide and ammonia in two cooling circuits;

— chlorine;

— water.

Applicability

The refrigerant selection should take into account operational safety and energy efficiency.

7. **Emissions to water**

BAT 11: In order to reduce emissions of pollutants to water, BAT is to use an appropriate combination of the techniques given below.

	Technique	Description
a	Process-integrated techniques ([1])	Techniques that prevent or reduce the generation of pollutants
b	Waste water treatment at source ([1])	Techniques to abate or recover pollutants prior to their discharge to the waste water collection system
c	Waste water pre-treatment ([2])	Techniques to abate pollutants before the final waste water treatment
d	Final waste water treatment ([2])	Final waste water treatment by mechanical, physico-chemical and/or biological techniques before discharge to a receiving water body

([1]) Covered by BAT 1, 4, 12, 13, 14 and 15.

([2]) Within the scope of the BAT reference document on Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW BREF).

BAT 12: In order to reduce emissions of chloride to water from the chlor-alkali plant, BAT is to use a combination of the techniques given in BAT 4.

BAT 13: In order to reduce emissions of free chlorine to water from the chlor-alkali plant, BAT is to treat waste water streams containing free chlorine as close as possible to the source, to prevent stripping of chlorine and/or the formation of halogenated organic compounds, by using one or a combination of the techniques given below.

	Technique	Description
a	Chemical reduction	The free chlorine is destroyed by reaction with reducing agents, such as sulphite and hydrogen peroxide, in stirred tanks.
b	Catalytic decomposition	The free chlorine is decomposed to chloride and oxygen in catalytic fixed-bed reactors. The catalyst can be a nickel oxide promoted with iron on an alumina support.

	Technique	Description
c	Thermal decomposition	The free chlorine is converted to chloride and chlorate by thermal decomposition at approximately 70 °C. The resulting effluent requires further treatment to reduce emissions of chlorate and bromate (BAT 14).
d	Acidic decomposition	The free chlorine is decomposed by acidification, with a subsequent release and recovery of chlorine. Acidic decomposition can be carried out in a separate reactor or by recycling of the waste water to the brine system. The degree of recycling of waste water to the brine circuit is restricted by the water balance of the plant.
e	Waste water recycling	Waste water streams from the chlor-alkali plant that contain free chlorine are recycled to other production units.

The **BAT-associated emission level** for free chlorine, expressed as Cl_2, is 0,05 – 0,2 mg/l in spot samples taken at least once every month at the point where the emission leaves the installation. The associated monitoring is in BAT 7.

BAT 14: In order to reduce emissions of chlorate to water from the chlor-alkali plant, BAT is to use one or a combination of the techniques given below.

	Technique	Description	Applicability
a	High-performance membranes	Membranes showing high current efficiencies, that reduce chlorate formation while ensuring mechanical and chemical stability under the given operating conditions.	Applicable to membrane cell plants when renewing membranes at the end of their lifetime.
b	High-performance coatings	Coatings with low electrode overpotentials leading to reduced chlorate formation and increased oxygen formation at the anode.	Applicable when renewing coatings at the end of their lifetime. The applicability may be restricted by the quality requirements of the produced chlorine (oxygen concentration).
c	High-purity brine	The brine is sufficiently purified to minimise contamination of electrodes and diaphragms/membranes, which could otherwise increase the formation of chlorate.	Generally applicable.
d	Brine acidification	The brine is acidified prior to electrolysis, in order to reduce the formation of chlorate. The degree of acidification is limited by the resistivity of the equipment used (e.g. membranes and anodes).	Generally applicable.
e	Acidic reduction	Chlorate is reduced with hydrochloric acid at pH values of 0 and at temperatures higher than 85 °C.	Not applicable to once-through brine plants.
f	Catalytic reduction	In a pressurised trickle-bed reactor, chlorate is reduced to chloride by using hydrogen and a rhodium catalyst in a three-phase reaction.	Not applicable to once-through brine plants.

	Technique	Description	Applicability
g	Use of waste water streams containing chlorate in other production units	The waste water streams from the chlor-alkali plant are recycled to other production units, most typically to the brine system of a sodium chlorate production unit.	Restricted to sites that can make use of waste water streams of this quality in other production units.

BAT 15: In order to reduce emissions of halogenated organic compounds to water from the chlor-alkali plant, BAT is to use a combination of the techniques given below.

	Technique	Description
a	Selection and control of salt and ancillary materials	Salt and ancillary materials are selected and controlled to reduce the level of organic contaminants in the brine.
b	Water purification	Techniques such as membrane filtration, ion exchange, UV irradiation and adsorption on activated carbon can be used to purify process water, thereby reducing the level of organic contaminants in the brine.
c	Selection and control of equipment	Equipment, such as cells, tubes, valves and pumps, is carefully selected to reduce the potential leaching of organic contaminants into the brine.

8. **Generation of waste**

BAT 16: In order to reduce the quantity of spent sulphuric acid sent for disposal, BAT is to use one or a combination of the techniques given below. The neutralisation of spent sulphuric acid from chlorine drying with virgin reagents is not BAT.

	Technique	Description	Applicability
a	Use on site or off site	The spent acid is used for other purposes, such as to control the pH in process and waste water, or to destroy surplus hypochlorite.	Applicable to sites with an on-site or off-site demand for spent acid of this quality.
b	Reconcentration	The spent acid is reconcentrated on site or off site in closed-loop evaporators under vacuum by indirect heating or by strengthening using sulphur trioxide.	Off-site reconcentration is restricted to sites where a service provider is located nearby.

The **BAT-associated environmental performance level** for the quantity of spent sulphuric acid sent for disposal, expressed as H_2SO_4 (96 wt-%), is ≤ 0,1 kg per tonne of chlorine produced.

9. **Site remediation**

BAT 17: In order to reduce contamination of soil, groundwater and air, as well as to halt pollutant dispersion and transfer to biota from contaminated chlor-alkali sites, BAT is to devise and implement, a site remediation plan that incorporates all of the following features:

(i) implementation of emergency techniques to cut off the exposure pathways and the expansion of the contamination;

(ii) desk study to identify the origin, extent and composition of the contamination (e.g. mercury, PCDDs/PCDFs, polychlorinated naphthalenes);

(iii) characterisation of the contamination, including surveys and the preparation of a report;

(iv) risk assessment over time and space as a function of the current and approved future use of the site;

(v) preparation of an engineering project including:

  (a) decontamination and/or permanent containment;

  - (b) timetables;
  - (c) monitoring plan;
  - (d) financial planning and investment to achieve the target;

(vi) implementation of the engineering project so that the site, taking into account its current and approved future use, no longer poses any significant risk to human health or the environment. Depending on other obligations, the engineering project might have to be implemented in a more stringent manner;

(vii) site use restrictions if necessary due to residual contamination and taking into account the current and approved future use of the site;

(viii) associated monitoring at the site and in the surrounding areas to verify that the objectives are achieved and maintained.

Description

A site remediation plan is often devised and implemented after taking the decision to decommission the plant, although other requirements may dictate a (partial) site remediation plan while the plant is still in operation.

Some features of the site remediation plan can overlap, be skipped, or be carried out in another order, depending on other requirements.

Applicability

The applicability of BAT 17(v). to 17(viii) is subject to the results of the risk assessment mentioned under BAT 17(iv).

GLOSSARY

Anode	Electrode through which electric current flows into a polarised electrical device. The polarity can be positive or negative. In electrolytic cells, oxidation occurs at the positively charged anode.
Asbestos	Set of six naturally occurring silicate minerals exploited commercially for their desirable physical properties. Chrysotile (also called white asbestos) is the only form of asbestos used in diaphragm cell plants.
Brine	Solution saturated or nearly saturated with sodium chloride or potassium chloride.
Cathode	Electrode through which electric current flows out of a polarised electrical device. The polarity can be positive or negative. In electrolytic cells, reduction occurs at the negatively charged cathode.
Electrode	Electrical conductor used to make contact with a non-metallic part of an electric circuit.
Electrolysis	Passage of a direct electric current through an ionic substance, resulting in chemical reactions at the electrodes. The ionic substance is either molten or dissolved in a suitable solvent.
EN	European Standard adopted by CEN (European Committee for Standardisation).
HFC	Hydrofluorocarbon.
ISO	International Organisation for Standardisation or standard adopted by this organisation.
Overpotential	Voltage difference between a half-reaction's thermodynamically determined reduction potential and the potential at which the redox event is experimentally observed. In an electrolytic cell the overpotential leads to the consumption of more energy than thermodynamically expected to drive a reaction.
PCDD	Polychlorinated dibenzo-*p*-dioxin.
PCDF	Polychlorinated dibenzofuran.