Environmental Permit Application – Supporting Documentation Appendix D - BAT Conclusion Compliance Assessment

Sawston Pilot Plant

Immaterial Limited

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Appendices

1.0 Content of this Assessment

This document presents a demonstration of compliance with the specific BAT requirements of the sector guidance and applicable EU BAT Reference (BREF) Notes / BAT Conclusions.

Table 1 presents the details of the BREF Notes and BAT Conclusions that are applicable to the proposed process and the locations in which the BAT Compliance Assessments are presented.

Table 1: Applicable BREF Notes and BAT Conclusions

EU BAT Conclusions	Applicability to the Installation Activites	Comments	Location of Assessment
OFC - Manufacture of Organic Fine Chemicals August 2006	Applicable	Section 4.1 Part A activity. Assessed against Sector Guidance Note IPPC S4.02 - Guidance for the Speciality Organic Chemicals Sector	Appendix A Table A1
CWW Common Wastewater and Waste Gas Treatment / Management in the Chemical Sector May 2016	Applicable	Section 4.1 Part A activity	Appendix B Table B1
WGC Common Waste Gas Management and Treatment Systems in the Chemical Sector December 2022	Applicable	Section 4.1 Part A activity	Appendix C Table C1

2.0 Project Specific BAT

Immaterial is proposing to develop a pilot scale testing and production facility which is currently expected to be located at within a commercial / industrial unit at South Cambridgeshire Business Park in Sawston.

The activities proposed to be undertaken at the production facility will utilise pilot scale production equipment (reactors, blender, tray dryers) in order produce densified metal-organic framework (MOF) materials.

The plant will also be used to undertake and optimise scale up from laboratory scale testing and will also be used to gather Intellectual Property to enable the commercialisation of the proprietary process technologies and products.

The plant is intended to initially produce 6 and 12 tonnes of product per annum, with the potential for increased hours of operation increasing the production capacity up to around 20 tonnes per annum. The materials produced will be sold on for use by third parties for them to use in the development and testing of industrial scale end uses for the materials.

The scale and nature of the proposed installation activities must be taken into account when assessing BAT compliance, as many of the BAT requirements have been developed on the basis of the Installation being a full-scale industrial production facility with associated infrastructure and ancillary systems that would be expected at a such a site.

It should also be noted that as the Installation is still in the design phase, all of the site operational aspects have yet to be prepared including:

- Development of the overall site management systems including the Environmental Management System (EMS);
- Development of specific operating manuals and operating procedures;
- Development of inspection and maintenance routines and scheduling;
- Development of data monitoring and reporting plans; and
- Staff training.

All of the above design and operational management aspects will be in place prior to commencement of operation.

Appendix A Organic Fine Chemicals BATc / Production of Speciality Organic Chemicals Sector (EPR 4.02)

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Table A1: Assessment of Indicative BAT for Production of Speciality Organic Chemicals Sector (EPR 4.02)

The following table references the indicative BAT requirements contained within EPR 4.02 (now withdrawn) relative to the proposed new operations.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
1	**Managing your activities**		
1.1	**Environmental performance indicators** Monitor and benchmark your environmental performance and review this at least once a year. Your plans for minimising environmental impacts should be incorporated into on-going improvement programmes. Indicators can be derived using the Horizontal Guidance Note H1 Environmental Risk Assessment (see GTBR Annex 1). It is suggested that indicators are based on tonnes of organics produced (tOP) as they provide a good basis for measuring performance within an installation or a single company year on year.	Yes	An EMS will be prepared in accordance with the requirements of ISO14001 and will include requirements to set key environmental performance targets and review performance at least annually.
1.2	**Accident management** In addition to the guidance in Getting the Basics Right, guidance prepared in support of the COMAH Regulations may help you in considering ways to reduce the risks and consequences of accidents, whether or not they are covered by the COMAH regime.	Yes	As part of the proposed site operating systems, the site will develop an Accident Management Plan (AMP) to cover the site operations. The process design has included consideration of potential accident hazards and has included HAZOP assessments. Any changes or amendments to the processes will be subject to a Management of Change (MoC) process used alongside the HAZOP processes. Foreseeable accident and incident risks are identified within the HAZOP processes and where possible designed out, or if this is not possible suitable control measures are in place to reduce the risk to As Low As Reasonably Practicable.
1.3	**Energy efficiency:** Some large processes are major users of heat and power, and others produce energy from their exothermic reactions. For these there may be greater opportunities for optimising energy efficiency in comparison to the smaller installation in the sector and to many industrial sectors.	Yes	Note the scale of the proposed site activities which are relatively small energy consumers The plant has been designed with due consideration of energy efficiency e.g. All heating and cooling duties are supplied from centralised package units.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	Assess the environmental impact of each process and choose the one with the lowest environmental impact. (We recognise that your choice may be constrained, for example, by the integration of processes on a complex site).		Product dewatering has employed mechanical means where possible to minimise heating energy use.
1.4	**Efficient use of raw materials and water** As a general principle, you need to demonstrate the measures you take to: • reduce your use of all raw materials and intermediates; • substitute less harmful materials, or those which can be more readily abated and when abated lead to substances that are more readily dealt with; and • understand the fate of by-products and contaminants and their environmental impact. You should where appropriate: 1. Maximise heat transfer between process streams where water is needed for cooling. Use a recirculating system with indirect heat exchangers and a cooling tower in preference to a once-through cooling system. 2. Where water is used in direct contact with process materials, recirculate the water after stripping out the absorbed substances.	Yes	The plant has been designed to optimise raw materials usage and maximise yield. Whilst the Plant will be used for small scale production, it is also intended to be a pilot plant for scale up from laboratory scale product development, and is intended to be used to allow some development and optimisation of the production process upon scale up, which will include yield optimisation. Immaterial is committed to using less harmful solvents or methods of synthesis where possible, this includes the use of water-based synthesis for some products and moving away from more harmful solvents used in traditional MOF synthesis e.g. dimethylformamide (DMF), dimethyl sulfoxide (DMSO), methanol etc.. Heat transfer systems are closed loop systems. Water use in the process is limited, other than where required as part of the reaction chemistry (as a solvent for the process) or for washing within the CIP system.
1.5	**Avoidance, recovery and disposal of wastes** Waste should be recovered unless it is technically or economically impractical to do so. You should list in detail the nature and source of the waste from each activity as the response to the emissions inventory requirement of the Application. Where there are a very large number of relatively small streams it may be appropriate to aggregate similar and comparatively insignificant waste streams. You should where appropriate: 1. Demonstrate that the chosen routes for recovery or disposal represent the best environmental option. Consider avenues for recycling back into the process or reworking for another process wherever possible.	Yes	Due to the size of the site and the of the process activities, onsite waste recycling or recovery is not possible. All site waste will be sent offsite for reuse, recycling or disposal with the disposal route being selected in line with the waste hierarchy. Waste generation at the site will be reviewed annually and where necessary an appropriate improvement programme will be implemented.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	2. Provide a detailed assessment identifying the best environmental options for waste disposal where you cannot avoid disposing of waste.		
2	**Operations**		
2.1	**Design of a new process** During new project development environmental issues should be an integral part of discussion at every stage of the design, beginning with the initial concepts. At the initial stage of the development of the process there should be a formal and comprehensive study – the first stage in a formal HAZOP study – of the likely environmental consequences from: • The use of raw materials, and production of all intermediates and products • All routine emissions, discharges and solid/liquid waste streams and • Non-routine or unplanned releases and disposals. You should where appropriate: 1. Consider all potential environmental impacts from the outset in any new project for manufacturing chemicals. 2. Undertake the appropriate stages of a formal HAZOP study as the project progresses through the process design and plant design phases. The HAZOP studies should consider amongst other things the points noted above.	Yes	The design of the new process has been subject to full assessment of both safety and environmental risks through the use of HAZOP. Other Process Hazard Analysis (PHA) techniques will also be used as appropriate, e.g. SIL Assessments. And changes or amendments to the new production processes will be subject to a Management of Change (MoC) process which will be developed for use alongside the HAZOP processes.
2.2	**Storage and handling of raw materials, products and wastes** You should where appropriate: 1. Store reactive chemicals in such a way that they remain stable, such as under a steady gas stream, for example. If chemical additions are necessary then tests should be carried out to ensure the required chemical composition is maintained. Inhibitors may also be added to prevent reactions. 2. Vent storage tanks to a safe location.	Yes	A Control of Substances Hazardous to Health (COSHH) assessment will be undertaken prior to the use of chemicals, and if the chemical is found to present a hazard to health, it shall be added to the COSHH inventory. Material Safety Data Sheets (MSDS) for any potentially hazardous materials or chemicals will be kept on site together with the COSHH register. The MSDS provides information on how chemicals should be handled, stored and disposed of, and what to do in the event of an accident.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	3. Use measures to reduce the risk of contamination from large storage tanks. In addition to sealed bunds, use double-walled tanks and leak detection channels. 4. Use HAZOP studies to identify risks to the environment for all operations involving the storage and handling of chemicals and wastes. Where the risks are identified as significant, plans and timetables for improvements should be in place.		The majority of the materials stored will be dry powders in small sacks with some IBC's or drums / carboys of liquid materials. There is no bulk storage on site. Materials stored will be grouped dependant in their compatibility, with a suitable separation being provided between non-compatible materials. The storage areas for liquids will be provided with secondary containment. These storage systems will be reviewed as part of the HAZOP process.
2.3	**Plant systems and equipment** A wide range of ancillary equipment is required throughout the process, which may include ventilation, pressure relief, vacuum raising, pumps, compressors, agitators, valves, purging and heating/cooling. Some of these systems give rise to a waste stream, for example wet vacuum systems or dust extraction equipment, and all of them have the potential to give rise to fugitive emissions. You should formally consider potential emissions from plant systems and equipment. You should where appropriate: 1. Formally consider potential emissions from plant systems and equipment and have plans and timetables for improvements, where the potential for substance or noise pollution from plant systems and equipment has been identified. 2. Carry out systematic HAZOP studies on all plant systems and equipment to identify and quantify risks to the environment. 3. Choose vacuum systems that are designed for the load and keep them well maintained. Install sufficient instrumentation to detect reduced performance and to warn that remedial action should be taken.	Yes	The design of the new process has been subject to full assessment of both safety and environmental risks through the use of HAZOP etc. All potential emission from the process systems have been identified and appropriate venting systems designed to capture potential emissions. All key sources of VOC emission are abated using condensers. Full details of the potential emission sources are included in the Main technical supporting document for the Environmental Permit application. Full details of the predicted emissions and emissions abatement systems are presented in Section 9.1 of the application documentation. Potential environmental impacts have been assessed within the AERA and demonstrated to be insignificant and hence no additional treatment of the emissions is required. A noise impact assessment has been undertaken to demonstrate that the proposed site activities will not lead to any significant impacts. Vacuum pumps are installed on certain of the process units which vent to atmosphere via appropriate VOC abatement. The vacuum pumps have associated control systems linked to the overall control systems for each unit operation, these systems have integrated sensors and and alarms to warn of ineffective operation or failure.
2.3	**Plant systems and equipment – over-pressure protection systems** You should where appropriate:	Yes	The design of the new process activities has been subject to full assessment of both safety and environmental risks through the use of HAZOP etc. Overpressure safety systems (where required) have been appropriately sized and designed, although the plant has been designed minimise the potential for such systems to need to operate.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	1. Carry out a systematic HAZOP study for all relief systems, to identify and quantify significant risks to the environment from the technique chosen. 2. Identify procedures to protect against overpressure of equipment. This requires the identification of all conceivable over-pressure situations, calculation of relief rates, selection of relief method, design of the vent system, discharge and disposal considerations, and dispersion calculations. In some cases careful design can provide intrinsic protection against all conceivable over-pressure scenarios, so relief systems and their consequential emissions can be avoided. 3. Maintain in a state of readiness all equipment installed in the venting system even though the system is rarely used.		
2.3	**Plant systems and equipment – heat exchangers and cooling systems** You should where appropriate: 1. Consider leak detection, corrosion monitoring and materials of construction, preferably in a formal HAZOP study. Plans and timetables for improved procedures or replacement by higher integrity designs should be in place where the risks are identified as significant. 2. If corrosion is likely, ensure methods for rapid detection of leaks are in place and a regime of corrosion monitoring in operation at critical points. Alternatively, use materials of construction that are inert to the process and heating/cooling fluids under the conditions of operation. 3. For cooling water systems, use techniques that compare favourably with relevant techniques described in the Industrial Cooling Systems BREF.	Yes	All heating and cooling duties are supplied from centralised package units. Heat transfer systems are closed loop systems The design of the new process activities has been subject to full assessment of both safety and environmental risks through the use of HAZOP etc. Potential for corrosion has been considered in the design process. Given the scale of the site activities, the closed loop package cooling and heating systems proposed are considered appropriate.
2.3	**Plant systems and equipment – purging facilities** Assess the potential for the release to air of VOCs and other pollutants along with discharged purge gas and use abatement where necessary.	Yes	The design of the new process has been subject to full assessment of both safety and environmental risks through the use of HAZOP etc. All potential emission from the process systems have been identified and appropriate venting systems designed to capture potential emissions. This includes vents for Nitrogen used for process inertisation. All key sources of VOC emission are abated using condensers.

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			Full details of the potential emission sources are included in the Main technical supporting document for the Environmental Permit application.
2.4	**Reaction stage** It is important to consider how the chemistry and engineering options may contribute to releases to the environment from the reaction stage, both directly and as a consequence later in the process. It is also important that these considerations are made at the process design stage – before plant design and equipment selection is commenced. You should where appropriate: 1. With a clear understanding of the physical chemistry, evaluate options for suitable reactor types using chemical engineering principles. 2. Select the reactor system from a number of potentially suitable reactor designs - conventional STR, process-intensive or novel-technology - by formal comparison of costs and business risks against the assessment of raw material efficiencies and environmental impacts for each of the options. 3. Undertake studies to review reactor design options based on process-optimisation where the activity is an existing activity and achieved raw material efficiencies and waste generation suggest there is significant potential for improvement. The studies should formally compare the costs and business risks, and raw material efficiencies and environmental impacts of the alternative systems with those of the existing system. The scope and depth of the studies should be in proportion to the potential for environmental improvement over the existing reaction system. 4. Maximise process yields from the selected reactor design, and minimise losses and emissions, by the formalised use of optimised process control and management procedures (both manual and computerised where appropriate). 5. Minimise the potential for the release of vapours to air from pressure relief systems and the potential for emissions of organic solvents into air or water, by formal consideration at the design	Yes	The reaction process is undertaken on a batch basis in one of two jacketed stirred tank reactors (R101, R102). The temperature of the reactors is controlled via a heating / cooling package that regulates the temperature of the heat transfer media circulated through the reactor jackets. The activities proposed to be undertaken at the production facility will utilise pilot scale production equipment (reactors, blender, tray dryers) in order produce densified metal-organic framework (MOF) materials. The plant will also be used to undertake and optimise scale up from laboratory scale testing and will also be used to gather Intellectual Property to enable the commercialisation of the proprietary process technologies and products, and will include a degree of yield optimisation as part of the scale up activities. Batch processing in stirred reactors is the preferred technology for this type of operation. Operation of the reactors will be subject to a defined process ‘recipe’ with a combination of manual procedural controls and automated control systems used to optimise the reaction activities. All emissions of VOC from the process will feed into designed systems for emission abatement and release to atmosphere.

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	stage - or formal review of the existing arrangements if that stage has passed.		
2.4	**Minimisation of liquid losses from reaction systems** You should where appropriate: 1. Use the following features that contribute to a reduction in waste arisings from clean-outs • low-inventory continuous throughput reactors with minimum surface area for cleaning • minimum internals such as baffles and coils in the reactor • smooth reactor walls, no crevices • flush bottom outlet on reaction vessels • all associated piping to slope back to the reactor or to a drain point • sufficient headroom under the reactor for collection of all concentrated drainings in drums or other suitable vessel, if necessary • minimal pipework, designed to eliminate hold-up and to assist drainage • pipework designed to allow air or nitrogen blowing • system kept warm during emptying to facilitate draining • HAZOP studies used to assess the potential for the choking of lines by high-melting-point material • campaigns sequenced so that cleaning between batches is minimised • campaigns made as long as possible to reduce the number of product change-overs • where a complete clean is necessary, use cleaning methods that minimise the use of cleaning agents, (e.g. steam-cleaning, rotating spray jets or high-pressure cleaning) or use a solvent which can be re-used • carry out HAZOP studies to minimise the generation of wastes and to examine their treatment/disposal • consider use of disposable plastic pipe-liners	Yes	Reactors will be small pilot scale batch reactors There will be minimal internals within the reactor – only the mixer, The reactor walls will be smooth, The reactor will have a flush bottom outlet, Pipework systems will be designed to facilitate minimisation or losses of material on product changeover, Cleaning of the reactor internals between batches will be optimised. The plant has been designed to optimise yield.

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	• eliminate or minimise locations for solids to settle-out. • consider duplicate or dedicated equipment where it can reduce the need for cleaning that is difficult.		
2.4	**Reaction stage – minimisation of vapour losses** There are many techniques for minimising the potential for vapour losses and for collection and abatement of vapour displaced into vent lines. You should where appropriate: 1. Review your operating practices and review vent flows to see if improvements need to be made. 2. Consider opportunities to enhance the performance of abatement systems.	Yes	The reactors will be blanketed with nitrogen for inertisation. They will vent into dedicated vent lines via condensers for VOC capture. The flow through these systems will optimised to minimise the VOC emissions where possible.
2.5	**Separation stages – liquid-vapour separations** On completion of the reaction it is usually necessary to separate the desired product from the other components in the reaction system. You should where appropriate: 1. Choose your separation technique following a detailed process design and HAZOP study. Follow formal operating instructions to ensure effective separation and minimisation of losses. Adhere to design conditions such as heat input, reflux flows and ratios, etc. 2. Install instrumentation to warn of faults in the system, such as a temperature, pressure or low coolant-flow alarms.	Yes	Chilled water cooled condensers are provided to separate VOC's from purged nitrogen. These systems have been assessed by HAZOP The reaction and condenser systems are installed with an automated control system which includes monitoring of key parameters
2.5	**Separation stages– liquid-liquid separations** You should where appropriate: 1. Use techniques which maximise physical separation of the phases (and also aim to minimise mutual solubility) where practicable. 2. When the phases are separated, use techniques which prevent (or minimise the probability and size of) breakthrough of the organics phase into a waste-water stream. This is particularly important where the environmental consequences of subsequent releases of organics to air or into controlled waters may be	Yes	The materials within the reactor can be circulated from the reactor in use via a membrane filtration system (Z101) to remove unwanted materials from the solution which is then returned to the reactor. This system is intended to optimise yield and product quality. The filtrate is collected into IBC's and sent offsite as waste. Filtrate flow rate is monitored to identify the end point for the process.

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	significant (eg. where the effluent is treated in a DAF unit or some of the organic components are resistant to biological treatment). 3. When a separation is done by hand, use a "dead man's handle", backed-up by good management, to improve the chance of the flow being properly controlled as the phase-boundary approaches. 4. Consider if automatic detection of the interface is practicable. 5. Where you are discharging to drain, consider whether there should be an intermediate holding or "guard" tank to protect against accidental losses from the organics phase.		
2.5	**Separation stage – liquid-solid separations** Different separation techniques will be BAT for different applications, with factors like solubility, crystallisation rate and granular size being important. The main solid-liquid techniques are centrifuging, filtration, sedimentation, clarification, drying and ion exchange. You should where appropriate: 1. Use techniques to minimise, re-use and/or recycle rinse water, and to prevent breakthrough of solids. 2. Install instrumentation or other means of detecting malfunction as all of the techniques are vulnerable to solids breakthrough. 3. Consider installing "guard" filters of smaller capacity downstream which, in the event of breakthrough, rapidly 'clog' and prevent further losses. 4. Have good management procedures to minimise loss of solids, escape of volatiles to air and excessive production of wastewater.	Yes	Dewatering of the materials from the reactor is performed in a decanter centrifuge package unit with an integrated control system. The liquid waste is collected and sent offsite as waste.
2.6	**Purification stage** Waste associated with the purification stage may arise from: • impurities in the raw materials – so a change in the raw material specifications may reduce waste arisings • by-products generated by the process – so a change in reaction conditions, catalyst, solvent etc. may improve the selectivity of the reaction or eliminate by-product formation.	N/A	Not applicable – no additional purification is undertaken

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	Liquid products are usually refined by distillation, with filtration used to remove solid contaminants. Sources of loss are: • Gas entrainment. Gas or vapour flow will carry away volatile material either as vapour or as entrained droplets. Additional condenser heat-exchange area or colder heat-exchange fluid can improve the recovery rate, and coalescing demisters are relatively cheap and easy to install. • Ineffective separation. A better separation in the distillation column can be achieved by using more stages (theoretical plates) or more reflux. Modern types of packing or high-efficiency trays can often produce a marked improvement for a modest capital investment. • Filtration. Enclosed filtration is usually used and this is not normally a source of great vapour loss to air. Liquid discharged during cleaning or changing of filters should be returned to the process. Purification of solid products by washing and crystallisation. Washing and crystallising activities have the potential to produce large volumes of dilute liquors so counter-current systems of operation should be used wherever possible. During drying, the aim should be to produce the maximum concentration of solvent in the gas to allow recovery of the solvent. The use of vacuum during drying can improve both solvent recovery and energy efficiency.		
2.7	**Chemical process controls** Reaction conditions such as temperatures, pressures, rocking or stirring rates, catalyst age, input and output flow rates, addition of materials (and so on) are imperative to the efficient conversion of raw materials to product. You should where appropriate: 1. Monitor the relevant process controls and set with alarms to ensure they do not go out of the required range.	Yes	The plant operation will have some automation, with control from the Basic Process Control System (BPCS) with local unit control systems and operator interfaces. The control system will monitor key parameters for each of the processing stages and will initiate alarms should parameters go out of predetermined ranges.

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f2.8	**Analysis** You should where appropriate: 1. Analyse the components and concentrations of by products and waste streams to ensure correct decisions are made regarding onward treatment or disposal. Keep detailed records of decisions based on this analysis in accordance with management systems.	Yes	QA review of the product generated and the waste streams will be undertaken periodically. Periodic review of the process waste streams will be undertaken to ensure that they are being disposed of or sent for recovery appropriately, and that the waste hierarchy is being applied effectively in selecting the disposal route
3	**Emissions and monitoring**		
3.1	**Point source emissions - air** You should where appropriate: 1. Formally consider the information and recommendations in the BREF on Common Waste Water and Waste Gas Treatment/ Management Systems in the Chemical Sector (see Reference 1) as part of the assessment of BAT for point-source releases to air, in addition to the information in this note. 2. Identify the main chemical constituents of the emissions, including VOC speciation where practicable. 3. Assess vent and chimney heights for dispersion capability and assess the fate of the substances emitted to the environment. 4. Use the following measures to minimise emissions to air: • recover emissions rich in organics by fractionation and then recycle • recover and reuse solvents • continuously monitor off-gas concentration from reaction vessels, dryers, condensers, evaporators and scrubbers where off-gases are shown to be environmentally significant	Yes	A review of BAT against the CWW and WGC BREF has been undertaken. All process emissions to air have been identified and quantified. Appropriate channelled emissions systems have been provided to capture all key process emissions to air, and have been assessed as having insignificant emissions to the environment. Potential air quality and environmental impacts have been assessed as part of the application for Permit variation. Condensers are installed for VOC recovery from those vents to air where elevated levels of VOC could potentially be present. The recovered VOC will be collected for disposal as waste as it will not be suitable for immediate re-use in the process (Product Quality). Monitoring of process emission to air will be undertaken in line with the appropriate requirements of the WGC BREF.
3.1	**Point source emissions - water** You should where appropriate: 1. Control all emissions to avoid a breach of water quality standards as a minimum. Where another technique can deliver better results at reasonable cost it will be considered BAT and should be used. 2. Use the following measures to minimise water use and emissions to water:	N/A	There are no point source emissions direct to controlled waters. There will be no process emissions to Sewer. All liquid wastes will be collected for offsite disposal as waste.

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	• where water is needed for cooling, minimize its use by maximising heat transfer between process streams • use water in recirculating systems with indirect heat exchangers and a cooling tower rather than a once through system. (A water make-up treatment plant and a concentrated purge stream from the system to avoid the build up of contaminants are likely to be necessary.) • leaks of process fluids into cooling water in heat exchangers are a frequent source of contamination. Monitoring of the cooling water at relevant points should be appropriate to the nature of the process fluids. In a recirculatory cooling system, leaks can be identified before significant emission to the environment has occurred. The potential for environmental impact is likely to be greater from a once through system. Planned maintenance can help to avoid such occurrences • water used for cleaning can be reduced by a number of techniques, e.g. by spray leaning rather than whole vessel filling • strip process liquor and treat if necessary, then recycle/reuse • use wet air oxidation for low volumes of aqueous effluent with high levels of organic content, such as waste streams from condensers and scrubbers • neutralise waste streams containing acids or alkalis to achieve the required pH for the receiving water • strip chlorinated hydrocarbons in waste streams with air or steam and recycle by returning to process where possible • recover co-products for re-use or sale • periodically regenerate ion exchange columns • pass waste water containing solids through settling tanks, prior to disposal • treat waste waters containing chlorinated hydrocarbons separately where possible to ensure proper control and treatment of the chlorinated compounds. Contain released volatile chlorinated hydrocarbons and vent to suitably designed incineration equipment		

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	• non-biodegradable organic material can be treated by thermal incineration. However, the thermal destruction of mixed liquids can be highly inefficient and the waste should be dewatered prior to incineration.		
3.1	**Point source emissions to land** Landfill of wastes should only be contemplated after all other alternatives have been thoroughly examined and rejected. Use the following measures to minimise emissions to land: • use settling ponds to separate out sludge (Note: Sludge can be disposed of to incinerator, encapsulation, land or lagoon depending upon its make up.) • chlorinated residues should be incinerated and not released to land. (Chlorinated hydrocarbons are not to be released to the environment due to their high global warming and ozone depletion potentials.) • either recycle off spec product into the process or blend to make lower grade products where possible • many catalysts are based on precious metals and these should be recovered, usually by return to the supplier.	N/A	Not Applicable - There are no point source emissions to land.
3.2	**Fugitive emissions to air** You should where appropriate: 1. Identify all potential sources and develop and maintain procedures for monitoring and eliminating or minimising leaks and releases of VOCs from all non-process stream sources. 2. Choose vent systems to minimise breathing emissions (for example pressure/ vacuum valves) and, where relevant, should be fitted with knock-out pots and appropriate abatement equipment. 3. Use the following techniques (together or in any combination) to reduce losses from storage tanks at atmospheric pressure: • maintenance of bulk storage temperatures as low as practicable, taking into account changes due to solar heating etc. • tank paint with low solar absorbency	Yes	The process will handle VOC materials. All process stages are undertaken in processing systems that are designed to collect all releases of VOC into channelled emissions control systems with appropriate VOC abatement installed to minimise emissions. In areas where operators may be at risk of exposure to VOC's local extract ventilation systems are installed with VOC abatement provided (carbon filter) prior to venting air back into the building. There is no bulk storage associated with the operation of the process. All VOC's will be stored in sealed IBC's or Drums on site.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	• temperature control • tank insulation • inventory management • floating roof tanks • bladder roof tanks • pressure/vacuum valves, where tanks are designed to withstand pressure fluctuations • specific release treatment (such as adsorption condensation).		
3.2	**Fugitive emissions to surface water, sewer and groundwater** You should where appropriate: 1. Provide hard surfacing in areas where accidental spillage or leakage may occur, e.g. beneath prime movers, pumps, in storage areas, and in handling, loading and unloading areas. The surfacing should be impermeable to process liquors. 2. Drain hard surfacing of areas subject to potential contamination so that potentially contaminated surface run-off does not discharge to ground. 3. Hold stocks of suitable absorbents at appropriate locations for use in mopping up minor leaks and spills, and dispose of to leak-proof containers. 4. Take particular care in areas of inherent sensitivity to groundwater pollution. Poorly maintained drainage systems are known to be the main cause of groundwater contamination and surface/above-ground drains are preferred to facilitate leak detection (and to reduce explosion risks). 5. Additional measures could be justified in locations of particular environmental sensitivity. Decisions on the measures to be taken should take account of the risk to groundwater, taking into consideration the factors outlined in the Agency document, Policy and Practice for the Protection of Groundwater, including groundwater vulnerability and the presence of groundwater protection zones. 6. Surveys of plant that may continue to contribute to leakage should also be considered, as part of an overall environmental management system. In particular, you should consider	Yes	All non-flammable raw materials, other materials, products and wastes will be stored within the building, liquids will be stored over appropriate secondary containment and solids will be stored on racking. The building has impermeable concrete flooring and no internal drainage and is underlain by an impermeable membrane. Spill kits will be provided to control any losses that do occur. Flammable raw materials i.e. organic solvents (Ethanol / Methanol) will be delivered to site in 1,000 litre IBC's and will be stored in a dedicated secure flammable materials storage unit located outside the front wall of the building. This unit will also be used to store larger volumes of flammable liquid waste e.g. waste solvent. This unit will have integrated bunding. The main process activities will all be undertaken within the dedicated processing area which will be within an enclosed and walled area within the building. The building concrete flooring and the walls around the process area will act to provide containment for any spills within this area. A soil and groundwater pollution risk assessment has been undertaken as part of the Site Condition Report which includes further detail on the containment measures in place at the site.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	undertaking leakage tests and/or integrity surveys to confirm the containment of underground drains and tanks		
3.3	**Odour** The requirements for odour control will be installation-specific and depend on the sources and nature of the potential odour. You should where appropriate: 1. Manage the operations to prevent release of odour at all times. 2. Where odour releases are expected to be acknowledged in the permit, (i.e. contained and treated prior to discharge or discharged for atmospheric dispersion): • for existing installations, the releases should be modelled to demonstrate the odour impact at sensitive receptors. The target should be to minimise the frequency of exposure to ground level concentrations that are likely to cause annoyance. • for new installations, or for significant changes, the releases should be modelled and it is expected that you will achieve the highest level of protection that is achievable with BAT from the outset. • where there is no history of odour problems then modelling may not be required although it should be remembered that there can still be an underlying level of annoyance without complaints being made. • where, despite all reasonable steps in the design of the plant, extreme weather or other incidents are liable, in our view, to increase the odour impact at receptors, you should take appropriate and timely action, as agreed with us, to prevent further annoyance (these agreed actions will be defined either in the permit or in an odour management statement). 3.Where odour generating activities take place in the open, or potentially odorous materials are stored outside, a high level of management control and use of best practice will be expected. 4. Where an installation releases odours but has a low environmental impact by virtue of its remoteness from sensitive receptors, it is expected that you will work towards achieving the standards described in this guidance note, but the timescales	N/A	None of the materials processed by the site are expected to be particularly odourous. Acetic Acid may be generated by the process and emitted to air, but potential for odour impacts has been reviewed in Section 4.3 of Appendix G1 (QERA) and demonstrated to have no potential odour impact.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	allowed to achieve this might be adjusted according to the perceived risk. 5. Where further guidance is needed to meet local needs, refer to Horizontal Guidance Note H4 Odour (see GTBR).		
3.4	**Noise and vibration** You should where appropriate: 1. Install particularly noisy machines such as compactors and pelletisers in a noise control booth or encapsulate the noise source. 2. Where possible without compromising safety, fit suitable silencers on safety valves. 3. Minimise the blow-off from boilers and air compressors, for example during start up, and provide silencers.	Yes	All process activities will be undertaken within an internal processing room within the main building. A detailed noise impact assessment has been prepared as part of the Permit application which details potential noise emission sources and the predicted impacts which has demonstrated that no significant noise impacts are expected.
3.5	**Monitoring and reporting of emissions to air and water** You should where appropriate: 1. Carry out an analysis covering a broad spectrum of substances to establish that all relevant substances have been taken into account when setting the release limits. The need to repeat such a test will depend upon the potential variability in the process and, for example, the potential for contamination of raw materials. Where there is such potential, tests may be appropriate. 2. Monitor more regularly any substances found to be of concern, or any other individual substances to which the local environment may be susceptible and upon which the operations may impact. This would particularly apply to the common pesticides and heavy metals. Using composite samples is the technique most likely to be appropriate where the concentration does not vary excessively. 3. If there are releases of substances that are more difficult to measure and whose capacity for harm is uncertain, particularly when combined with other substances, then "whole effluent toxicity" monitoring techniques can be appropriate to provide direct measurements of harm, for example, direct toxicity assessment.	Yes	Proposals for emission monitoring are included in Section 9.1.4 of the Permit Application technical documentation. The proposed monitoring of emissions from the plant will be undertaken in compliance with the requirements of: • EU BAT Reference Document – Monitoring of Emissions to Air and Water from Industrial Emissions Directive Installations (ROM)- July 2008. • Environment Agency Monitoring Stack Emissions: Environmental Permits (19 December 2019) (the formerly the EA's M1 and M5 guidance notes). • BS EN 15259.
3.5	**Monitoring and reporting of waste emissions** You should where appropriate:	Yes	All waste arisings from the site will be managed in accordance with a waste procedure which will be implemented as part of the EMS.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	1. Monitor and record: • the physical and chemical composition of the waste • its hazard characteristics • handling precautions and substances with which it cannot be mixed		This will include periodic review of the nature of the waste and its characteristics, and maintaining records of all waste removed from site in line with the required Duty of Care.
3.5	**Environmental monitoring (beyond installation)** You should where environmental monitoring is needed: 1. Consider the following in drawing up proposals: • determinands to be monitored, standard reference methods, sampling protocols • monitoring strategy, selection of monitoring points, optimisation of monitoring approach • determination of background levels contributed by other sources • uncertainty for the employed methodologies and the resultant overall uncertainty of measurement • quality assurance (QA) and quality control (QC) protocols, equipment calibration and maintenance, sample storage and chain of custody/audit trail • reporting procedures, data storage, interpretation and review of results, reporting format for the provision of information.	N/A	The air quality impact assessment (AERA) undertaken in support of the Permit variation (Section 10.1) has identified that the impacts will be “insignificant”. Consequently, no monitoring (beyond the installation) is proposed.

Appendix B Common Waste Water and Waste Gas Treatment / Management Systems in the Chemical Sector BATc

Environmental Permit Application – Supporting Documentation Appendix D - BAT Conclusion Compliance Assessment

Sawston Pilot Plant

Immaterial Limited

SLR Project No.: 405.065240.00001

4 December 2024

Table B1: Assessment of BAT Compliance – Best Available Techniques Reference Document for Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector – published 9th June 2016

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
Scope	These BAT conclusions concern the activities specified in Sections 4 and 6.11 of Annex I to Directive 2010/75/EU, namely: — Section 4: Chemical industry; — Section 6.11: Independently operated treatment of waste water not covered by Council Directive 91/271/EEC and discharged by an installation undertaking activities covered under Section 4 of Annex I to Directive 2010/75/EU. These BAT conclusions also cover the combined treatment of waste water from different origins if the main pollutant load originates from the activities covered under Section 4 of Annex I to Directive 2010/75/EU. In particular, these BAT conclusions cover the following issues: — environmental management systems; — water saving; — waste water management, collection and treatment; — waste management; — treatment of waste water sludge with the exception of incineration; — waste gas management, collection and treatment; — flaring; — diffuse emissions of volatile organic compounds (VOC) to air; — odour emissions; — noise emissions.	-	The BRef document applies as the site activities is defined under Section 4.1 of Schedule 1 to the Environmental Permitting Regulations 2016 However, there will be no onsite treatment of wastewater at the Installation. There will be no direct discharge to controlled waters There will be no direct discharge of process wastewater to sewer. All liquid process waste and wastewater will be containerised for removal from site as waste and subsequent recycling, recovery, treatment or disposal offsite. The requirements of this BAT Reference Note and its associated BAT Conclusions in relation to waste water do not therefore apply to the Immaterial site.
1. Environmental Management Systems			
BATc 1	In order to improve the overall environmental performance, BAT is to implement and adhere to an environmental management system (EMS) that incorporates all of the following features: (i) commitment of the management, including senior management; (ii) an environmental policy that includes the continuous improvement of the installation by the management;	N/A	An EMS will be prepared in accordance with the requirements of ISO14001 and will include requirements to set key environmental performance targets and review performance at least annually. This EMS will fully implement the requirements of BATc 1.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	(iii) planning and establishing the necessary procedures, objectives and targets, in conjunction with financial planning and investment; (iv) implementation of procedures paying particular attention to: (a) structure and responsibility; (b) recruitment, training, awareness and competence; (c) communication; (d) employee involvement; (e) documentation; (f) effective process control; (g) maintenance programmes; (h) emergency preparedness and response; (i) safeguarding compliance with environmental legislation. (v) checking performance and taking corrective action, paying particular attention to: (a) monitoring and measurement (see also the Reference Report on Monitoring of emissions to Air and Water from IED installations — ROM); (b) corrective and preventive action; (c) maintenance of records; (d) independent (where practicable) internal or external auditing in order to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained. (vi) review of the EMS and its continuing suitability, adequacy and effectiveness by senior management (vii) following the development of cleaner technologies; (viii) consideration for the environmental impacts from the eventual decommissioning of the plant at the design stage of a new plant, and throughout its operating life; (ix) application of sectoral benchmarking on a regular basis; (x) waste management plan (see BAT 13). Specifically for chemical sector activities, BAT is to incorporate the following features in the EMS:		

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	(xi) on multi-operator installations/sites, establishment of a convention that sets out the roles, responsibilities and coordination of operating procedures of each plant operator in order to enhance the cooperation between the various operators; (xii) establishment of inventories of waste water and waste gas streams (see BAT 2). In some cases, the following features are part of the EMS: (xiii) odour management plan (see BAT 20); (xiv) noise management plan (see BAT 22). *Applicability:* The scope (e.g. level of detail) and nature of the EMS (e.g. standardised or non-standardised) will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.		
BATc 2	In order to facilitate the reduction of emissions to water and air and the reduction of water usage, BAT is to establish and to maintain an inventory of waste water and waste gas streams, as part of the environmental management system (see BAT 1), that incorporates all of the following features: (i) information about the chemical production processes, including: (a) chemical reaction equations, also showing side products; (b) simplified process flow sheets that show the origin of the emissions; (c) descriptions of process-integrated techniques and waste water/waste gas treatment at source including their performances; (ii) information, as comprehensive as is reasonably possible, about the characteristics of the waste water streams, such as: (a) average values and variability of flow, pH, temperature, and conductivity; (b) average concentration and load values of relevant pollutants/parameters and their variability (e.g. COD/TOC, nitrogen species, phosphorus, metals, salts, specific organic compounds); (c) data on bio eliminability (e.g. BOD, BOD/COD ratio, Zahn-Wellens test, biological inhibition potential (e.g. nitrification)); (iii) information, as comprehensive as is reasonably possible, about the characteristics of the waste gas streams, such as:	Yes	The site will be compliant with the requirements of BAT 2. The site has a full understanding of all emissions to air and water and the inventory of emissions. i) A full process design has been undertaken and a full set of process design information will be available on site. ii) Details of the composition and volumes of wastewater / liquid streams which will be collected for offsite disposal as waste have been included in the design and will be maintained onsite. iii) Details of the composition and flowrates of waste gas streams have been included in the design and will be maintained on site with periodic monitoring to confirm the emissions.

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>(a) average values and variability of flow and temperature;
(b) average concentration and load values of relevant pollutants/parameters and their variability (e.g. VOC, CO, NOX, SOX, chlorine, hydrogen chloride);
(c) flammability, lower and higher explosive limits, reactivity;
(d) presence of other substances that may affect the waste gas treatment system or plant safety (e.g. oxygen, nitrogen, water vapour, dust).</td><td></td><td></td></tr>
<tr><td colspan="2">2. Monitoring</td><td></td><td></td></tr>
<tr><td>BATc 3</td><td>For relevant emissions to water as identified by the inventory of waste water streams (see BAT 2), BAT is to monitor key process parameters (including continuous monitoring of waste water flow, pH and temperature) at key locations (e.g. influent to pre-treatment and influent to final treatment).</td><td>N/A</td><td>Not Applicable</td></tr>
<tr><td>BATc 4</td><td>BAT is to monitor emissions to water in accordance with EN standards with at least the minimum frequency given below. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.
<table>
<tr><th>Substance / parameter</th><th>Standard(s)</th><th>Minimum Monitoring Frequency (1) (2)</th></tr>
<tr><td>Total Organic Carbon (TOC) (3)</td><td>EN 1484</td><td rowspan="6">Daily</td></tr>
<tr><td>Chemical Oxygen Demand (COD) (3)</td><td>No EN Standard available</td></tr>
<tr><td>Total Suspended Solids (TSS)</td><td>EN 872</td></tr>
<tr><td>Total Nitrogen (TN) (4)</td><td>EN 12260</td></tr>
<tr><td>Total Inorganic Nitrogen (4) (N_{inorg})</td><td>Various EN Standards available</td></tr>
<tr><td>Total Phosphorus</td><td>Various EN Standards</td></tr>
<tr><td>Adsorbable organically bound halogens (AOX)</td><td>EN ISO 9562</td><td>Monthly</td></tr>
</table></td><td>N/A</td><td>Not Applicable</td></tr>
</table>

BATc No.	BAT Justification				Operating to BAT	Demonstration of BAT Compliance
	Metals	Cr	Various EN Standards available	Monthly		
		Cu				
		Ni				
		Pb				
		Zn				
		Other metals, if relevant				
	Toxicity (5)	Fish Eggs (*Danio rerio*)	EN ISO 15088	To be decided based on a risk assessment, after an initial characterisation		
		Daphnia (*Daphnia magna Straus*)	EN ISO 6341			
		Luminescent bacteria (*Vibrio fischeri*)	EN ISO 11348-1, EN ISO 11348-2 or EN ISO 11348-3			
		Duckweed (*Lemna minor*)	EN ISO 20079			
		Algae	EN ISO 8692, EN ISO 10253 or EN ISO 10710			
	Notes; (1) Monitoring frequencies may be adapted if the data series clearly demonstrate a sufficient stability. (2) The sampling point is located where the emission leaves the installation. (3) TOC monitoring and COD monitoring are alternatives. TOC monitoring is the preferred option because it does not rely on the use of very toxic compounds. (4) TN and Ninorg monitoring are alternatives. (5) An appropriate combination of these methods can be used.					

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
BATc 5	**Diffuse VOC's** BAT is to periodically monitor diffuse VOC emissions to air from relevant sources by using an appropriate combination of the techniques I-III or, where large amounts of VOC are handled, all of the techniques I-III. I. sniffing methods (e.g. with portable instruments according to EN 15446) associated with correlation curves for key equipment; II. optical gas imaging methods; III. Calculation of emissions based on emissions factors, periodically validated (e.g. once every two years) by measurements. Where large amounts of VOCs are handled, the screening and quantification of emissions from the installation by periodic campaigns with optical absorption-based techniques, such as Differential absorption light detection and ranging (DIAL) or Solar occultation flux (SOF), is a useful complementary technique to the techniques I to III.	Plan in Place to Comply	The plant has been designed to minimise the potential for diffuse VOC emissions. Plant VOC usage is relatively limited when compared against full scale industrial sites due to the scale of processing activities proposed at the site. Immaterial will review options for the assessment of diffuse VOC emissions. If diffuse VOC monitoring / calculation is required, then a method will be employed which will be agreed with the Environment Agency within 6 months of commencement of operation.
BATc 6	**Odour** BAT is to periodically monitor odour emissions from relevant sources in accordance with EN standards. Emissions can be monitored by dynamic olfactometry according to EN 13725. Emission complemented by measurement/estimation of odour exposure or estimation of odour impact. The applicability is restricted to cases where odour nuisance can be expected or has been substantiated.	N/A	None of the materials processed by the site are expected to be particularly odourous. Acetic Acid may be generated by the process and emitted to air, but potential for odour impacts has been reviewed in Section 4.3 of Appendix G1 (QERA) and demonstrated to have no potential odour impact. No Monitoring is therefore proposed
Emissions to Water			
BATc 7	**Water Usage and Waste Water Generation** In order to reduce the usage of water and the generation of waste water, BAT is to reduce the volume and/or pollutant load of waste water streams, to enhance the reuse of waste water within the production process and to recover and reuse raw materials.	Yes	Water use at the facility is limited to water used as a solvent in the process, and water use for cleaning via the CIP system. The use of water in both of these activities will be optimised. Wastewater from either of the main site uses will not be suitable for re-use on site (product quality), and given the nature of the site and its size all waste water will be sent offsite as waste.

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td>BATc 8</td><td>Waste Water Collection and Segregation
In order to prevent the contamination of uncontaminated water and to reduce emissions to water, BAT is to segregate uncontaminated waste water streams from waste water streams that require treatment.</td><td>N/A</td><td>Not applicable</td></tr>
<tr><td>BATc 9</td><td>In order to prevent uncontrolled emissions to water, BAT is to provide an appropriate buffer storage capacity for waste water incurred during other than normal operating conditions based on a risk assessment (taking into account e.g. the nature of the pollutant, the effects on further treatment, and the receiving environment), and to take appropriate further measures (e.g. control, treat, reuse).
The interim storage of contaminated rainwater requires segregation, which may not be applicable in the case of existing waste water collection systems.</td><td>N/A</td><td>Not Applicable</td></tr>
<tr><td>BATc 10</td><td>Waste Water Treatment
In order to reduce emissions to water, BAT is to use an integrated waste water management and treatment strategy that includes an appropriate combination of the techniques in the priority order given below.
<table>
<tr><th></th><th>Technique</th><th>Description</th></tr>
<tr><td>a</td><td>Process integrated techniques - prevent or reduce pollutants (1)</td><td>Techniques to prevent or reduce the generation of water pollutants.</td></tr>
<tr><td>b</td><td>Recovery of pollutants at source (1)</td><td>Techniques to recover pollutants prior to their discharge to the waste water collection system.</td></tr>
<tr><td>c</td><td>Waste water pre-treatment (1) (2)</td><td>Techniques to abate pollutants before the final waste water treatment. Pre-treatment can be carried out at the source or in combined streams.</td></tr>
<tr><td>d</td><td>Final waste water treatment (3)</td><td>Final waste water treatment by, for example, preliminary and primary treatment, biological treatment, nitrogen removal, phosphorus removal and/or final solids removal techniques before discharge to a receiving water body.</td></tr>
</table></td><td>N/A</td><td>Not Applicable</td></tr>
</table>

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	(1) These techniques are further described and defined in other BAT conclusions for the chemical industry. (2) See BAT 11. (3) See BAT 12. The integrated waste water management and treatment strategy is based on the inventory of waste water streams (see BAT 2).		
BATc 11	In order to reduce emissions to water, BAT is to pre-treat waste water that contains pollutants that cannot be dealt with adequately during final waste water treatment by using appropriate techniques. *Description:* Waste water pre-treatment is carried out as part of an integrated waste water management and treatment strategy (see BAT 10) and is generally necessary to: • Protect the final waste water treatment plant (e.g. protection of a biological treatment plant against inhibitory or toxic compounds); • Remove compounds that are insufficiently abated during final treatment (e.g. toxic compounds, poorly/non- biodegradable organic compounds, organic compounds that are present in high concentrations, or metals during biological treatment); • Remove compounds that are otherwise stripped to air from the collection system or during final treatment (e.g. volatile halogenated organic compounds, benzene); • Remove compounds that have other negative effects (e.g. corrosion of equipment; unwanted reaction with other substances; contamination of waste water sludge). In general, pre-treatment is carried out as close as possible to the source in order to avoid dilution, in particular for metals. Sometimes, waste water streams with appropriate characteristics can be segregated and collected in order to undergo a dedicated combined pre-treatment.	N/A	Not Applicable
BATc 12	In order to reduce emissions to water, BAT is to use an appropriate combination of final waste water treatment techniques.	N/A	Not Applicable

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>
Final waste water treatment is carried out as part of an integrated waste water management and treatment strategy (see BAT 10).
Appropriate final waste water treatment techniques, depending on the pollutant, include:
<table>
<tr><th></th><th>Technique (1)</th><th>Typical Pollutants Abated</th><th>Applicability</th></tr>
<tr><td colspan="2">Preliminary and primary treatment</td><td></td><td></td></tr>
<tr><td>(a)</td><td>Equalisation</td><td>All pollutants</td><td rowspan="3">Generally applicable.</td></tr>
<tr><td>(b)</td><td>Neutralisation</td><td>Acids, alkalis</td></tr>
<tr><td>(c)</td><td>Physical separation, e.g. screens, sieves, grit separators, grease separators or primary settlement tanks</td><td>Suspended solids, oil/grease</td></tr>
<tr><td colspan="3">Biological treatment (secondary treatment), e.g.</td><td></td></tr>
<tr><td>(d)</td><td>Activated sludge process</td><td rowspan="2">Biodegradable organic compounds</td><td rowspan="2">Generally applicable</td></tr>
<tr><td>(e)</td><td>Membrane bioreactor</td></tr>
<tr><td colspan="3">Nitrogen removal</td><td></td></tr>
<tr><td>(f)</td><td>Nitrification/denitrification</td><td>Total nitrogen, ammonia</td><td>Nitrification may not be applicable in case of high chloride concentrations (i.e. around 10 g/l) and provided that the reduction of the chloride concentration prior to nitrification would not be justified by the</td></tr>
</table>
</td><td></td><td></td></tr>
</table>

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance

			environmental benefits. Not applicable when the final treatment does not include a biological treatment.
Phosphorus removal			
(g)	Chemical precipitation	Phosphorus	Generally applicable.
Final solids removal			
(h)	Coagulation and flocculation	Suspended solids	Generally applicable.
(i)	Sedimentation		
(j)	Filtration (e.g. sand filtration, microfiltration, ultrafiltration)		
(k)	Flotation		
(1) The descriptions of the techniques are given in Section 6.1			

The BAT-associated emission levels (BAT-AELs), for emissions to water given in Table 1, Table 2 and Table 3 apply to direct emissions to a receiving water body from:

(i) the activities specified in Section 4 of Annex I to Directive 2010/75/EU;

(ii) independently operated waste water treatment plants specified in Section 6.11 of Annex I to Directive 2010/75/EU provided that the main pollutant load originates from activities specified in Section 4 of Annex I to Directive 2010/75/EU;

(iii) the combined treatment of waste water from different origins provided that the main pollutant load originates from activities specified in Section 4 of Annex I to Directive 2010/75/EU. The BAT-AELs apply at the point where the emission leaves the installation.

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>

Table 1 BAT-AELs for direct emissions of TOC, COD and TSS to a receiving water body

<table>
<tr><th>Parameter</th><th>BAT-AEL's (Yearly Average)</th><th>Conditions</th></tr>
<tr><td>Total Organic Carbon (TOC) (1)(2)</td><td>10 - 33 mg/l (3)(4)(5)(6)</td><td>The BAT-AEL applies if the emission exceeds 3.3 Te/yr</td></tr>
<tr><td>Chemical Oxygen Demand (COD) (1)(2)</td><td>30 - 100 mg/l (3)(4)(5)(6)</td><td>The BAT-AEL applies if the emission exceeds 10Te/yr</td></tr>
<tr><td>Total Suspended Solids (TSS)</td><td>5 - 35 mg/l(7)(8)</td><td>The BAT-AEL applies if the emission exceeds 3.5 Te/yr</td></tr>
</table>

(1) No BAT-AEL applies for BOD
(2) Either BAT-AEL for TOC or COD applies. TOC monitoring is the preferred option because it does not rely on the use of very toxic compounds.
(3) The lower end of the range is typically achieved when few tributary waste water streams contain organic compounds and/or the waste water mostly contains easily biodegradable organic compounds.
(4) The upper end of the range may be up to 100 mg/l for TOC or up to 300 mg/l for COD, both as yearly averages, if both of the following conditions are fulfilled:

- **Condition A: Abatement efficiency ≥ 90 % as a yearly average (including both pre-treatment and final treatment).**
- **Condition B: If a biological treatment is used, at least one of the following criteria is met:**
- **A low-loaded biological treatment step is used (i.e. ≤ 0,25 kg COD/kg of organic dry matter of sludge). This implies that the BOD5 level in the effluent is ≤ 20 mg/l.**
- **Nitrification is used.**

(5) The upper end of the range may not apply if all of the following conditions are fulfilled:

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<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>

Condition A: Abatement efficiency ≥ 95 % as a yearly average (including both pre-treatment and final treatment).
Condition B: same as Condition B in footnote (4).
Condition C: The influent to the final waste water treatment shows the following characteristics: TOC > 2 g/l (or COD > 6 g/l) as a yearly average and a high proportion of refractory organic compounds

(6) The upper end of the range may not apply when the main pollutant load originates from the production of methylcellulose.
(7) The lower end of the range is typically achieved when using filtration (e.g. sand filtration, microfiltration, ultrafiltration, membrane bioreactor), while the upper end of the range is typically achieved when using sedimentation only.
(8) This BAT-AEL may not apply when the main pollutant load originates from the production of soda ash via the Solvay process or from the production of titanium dioxide.
<hr>
Table 2. BAT-AELs for direct emissions of nutrients to a receiving water body
<table>
<tr><th>Parameter</th><th>BAT-AEL's (Yearly Average)</th><th>Conditions</th></tr>
<tr><td>Total Nitrogen (1)</td><td>5-25 mg/l (2) (3)</td><td>The BAT-AEL applies if the emission exceeds 2.5 Te/yr</td></tr>
<tr><td>Total Inorganic Nitrogen (1)</td><td>5-20 mg/l (2) (3)</td><td>The BAT-AEL applies if the emission exceeds 2.0 Te/yr</td></tr>
<tr><td>Total Phosphorus</td><td>0.5-3.0 mg/l (4)</td><td>The BAT-AEL applies if the emission exceeds 300 kg/yr</td></tr>
</table>
(1) Either the BAT-AEL for total nitrogen or the BAT-AEL for total inorganic nitrogen applies.
</td><td></td><td></td></tr>
</table>

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>
(2) The BAT-AELs for TN and N_{inorg} do not apply to installations without biological waste water treatment. The lower end of the range is typically achieved when the influent to the biological waste water treatment plant contains low levels of nitrogen and/or when nitrification/denitrification can be operated under optimum conditions.
(3) The upper end of the range may be higher and up to 40 mg/l for TN or 35 mg/l for N_{inorg}, both as yearly averages, if the abatement efficiency is ≥ 70 % as a yearly average (including both pre-treatment and final treatment).
(4) The lower end of the range is typically achieved when phosphorus is added for the proper operation of the biological waste water treatment plant or when phosphorus mainly originates from heating or cooling systems. The upper end of the range is typically achieved when phosphorus-containing compounds are produced by the installation.

Table 3. BAT-AELs for direct emission of AOX and metals to a receiving water body
<table>
<tr><th>Parameter</th><th>BAT-AEL's (Yearly Average)</th><th>Conditions</th></tr>
<tr><td>Adsorbable organically bound halogens (AOX)</td><td>0.2 - 1.0 mg/l (1) (2)</td><td>The BAT-AEL applies if the emission exceeds 100 kg/yr</td></tr>
<tr><td>Chromium (expressed as Cr)</td><td>5 - 25 µg/l (3) (4) (5) (6)</td><td>The BAT-AEL applies if the emission exceeds 2.5 kg/yr</td></tr>
<tr><td>Copper (expressed as Cu)</td><td>5 - 50 µg/l (3) (4) (5) (7)</td><td>The BAT-AEL applies if the emission exceeds 50 kg/yr</td></tr>
<tr><td>Nickel (expressed as Ni)</td><td>5 - 50 µg/l (3) (4) (5)</td><td>The BAT-AEL applies if the emission exceeds 5 kg/yr</td></tr>
<tr><td>Zinc (expressed as Zn)</td><td>20 - 300 µg/l (3) (4) (5) (8)</td><td>The BAT-AEL applies if the emission exceeds 30 kg/yr</td></tr>
</table>
</td><td></td><td></td></tr>
</table>

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	(1) The lower end of the range is typically achieved when few halogenated organic compounds are used or produced by the installation. (2) This BAT-AEL may not apply when the main pollutant load originates from the production of iodinated X-ray contrast agents due to the high refractory loads. This BAT-AEL may also not apply when the main pollutant load originates from the production of propylene oxide or epichlorohydrin via the chlorohydrin process due to the high loads. (3) The lower end of the range is typically achieved when few of the corresponding metal (compounds) are used or produced by the installation. (4) This BAT-AEL may not apply to inorganic effluents when the main pollutant load originates from the production of inorganic heavy metal compounds. (5) This BAT-AEL may not apply when the main pollutant load originates from the processing of large volumes of solid inorganic raw materials that are contaminated with metals (e.g. soda ash from the Solvay process, titanium dioxide). (6) This BAT-AEL may not apply when the main pollutant load originates from the production of chromium-organic compounds. (7) This BAT-AEL may not apply when the main pollutant load originates from the production of copper-organic compounds or the production of vinyl chloride monomer/ethylene dichloride via the oxychlorination process. (8) This BAT-AEL may not apply when the main pollutant load originates from the production of viscose fibres. The associated monitoring is in BAT 4.		
4. Waste			
BATc 13	**Waste** In order to prevent or, where this is not practicable, to reduce the quantity of waste being sent for disposal, BAT is to set up and implement a waste management plan as part of the environmental management system (see BAT 1) that, in order of priority, ensures that waste is prevented, prepared for reuse, recycled or otherwise recovered	Yes	All waste arisings from the site will be managed in accordance with a waste procedure which will be implemented as part of the EMS. This will include periodic review of the nature of the waste and its characteristics, and maintaining records of all waste removed from site in line with the required Duty of Care.

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td></td><td></td><td>Due to the size of the site and the of the process activities, onsite waste recycling or recovery is not possible.

All site waste will be sent offsite for reuse, recycling or disposal with the disposal route being selected in line with the waste hierarchy.
Waste generation at the site will be reviewed annually and where necessary an appropriate improvement programme will be implemented.</td></tr>
<tr><td>BATc 14</td><td>In order to reduce the volume of waste water sludge requiring further treatment or disposal, and to reduce its potential environmental impact, BAT is to use one or a combination of the techniques given below.

<table>
<tr><th></th><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>(a)</td><td>Conditioning</td><td>Chemical conditioning (i.e. adding coagulants and/or flocculants) or thermal conditioning (i.e. heating) to improve the conditions during sludge thickening/dewatering.</td><td>Not applicable to inorganic sludges. The necessity for conditioning depends on the sludge properties and on the thickening/dewatering equipment used</td></tr>
<tr><td>(b)</td><td>Thickening/dewatering</td><td>Thickening can be carried out by sedimentation, centrifugation, flotation, gravity belts, or rotary drums. Dewatering can be carried out by belt filter presses or plate filter presses.</td><td>Generally applicable.</td></tr>
<tr><td>(c)</td><td>Stabilisation</td><td>Sludge stabilisation includes chemical treatment, thermal</td><td>Not applicable to inorganic sludges. Not applicable for</td></tr>
</table></td><td>N/A</td><td>Not Applicable</td></tr>
</table>

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	(d) Drying: Sludge is dried by direct or indirect contact with a heat source. — Not applicable to cases where waste heat is not available or cannot be used. treatment, aerobic digestion, or anaerobic digestion. — short-term handling before final treatment.		
5. Emissions to Air			
BATc 15	**Waste Gas Collection** In order to facilitate the recovery of compounds and the reduction of emissions to air, BAT is to enclose the emission sources and to treat the emissions, where possible. The applicability may be restricted by concerns on operability (access to equipment), safety (avoiding concentrations close to the lower explosive limit) and health (where operator access is required inside the enclosure).	Yes	All process emissions to air have been identified and quantified. Appropriate channelled emissions systems have been provided to capture all key process emissions to air, and have been assessed as having insignificant emissions to the environment. Potential air quality and environmental impacts have been assessed as part of the application for Permit variation. Condensers are installed for VOC recovery from those vents to air where elevated levels of VOC could potentially be present. The recovered VOC will be collected for disposal as waste as it will not be suitable for immediate re-use in the process (Product Quality). Monitoring of process emission to air will be undertaken in line with the appropriate requirements of the WGC BREF.
BATc 16	**Waste Gas Treatment** In order to reduce emissions to air, BAT is to use an integrated waste gas management and treatment strategy that includes process-integrated and waste gas treatment techniques.	Yes	Due to the nature of the site operations and the ability of each of the main process stages to be operated independently of each other, an integrated approach the waste gas treatment is not suitable. See BAT 15 for details on the systems installed.

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>The integrated waste gas management and treatment strategy is based on the inventory of waste gas streams (see BAT 2) giving priority to process-integrated techniques.</td><td></td><td></td></tr>
<tr><td>BATc 17</td><td>Flaring
In order to prevent emissions to air from flares, BAT is to use flaring only for safety reasons or non-routine operational conditions (e.g. start-ups, shutdowns) by using one or both of the techniques given below.
<table>
<tr><th></th><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>(a)</td><td>Correct plant design</td><td>This includes the provision of a gas recovery system with sufficient capacity and the use of high-integrity relief valves.</td><td>Generally applicable to new plants. Gas recovery systems may be retrofitted in existing plants.</td></tr>
<tr><td>(b)</td><td>Plant management</td><td>This includes balancing the fuel gas system and using advanced process control.</td><td>Generally applicable.</td></tr>
</table></td><td>N/A</td><td>No flaring is undertaken on site</td></tr>
<tr><td>BATc 18</td><td>Flaring
In order to reduce emissions to air from flares when flaring is unavoidable, BAT is to use one or both of the techniques given below.
<table>
<tr><th></th><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>(a)</td><td>Correct design of flaring devices</td><td>Optimisation of height, pressure, assistance by steam, air or gas, type of flare tips (either enclosed or shielded), etc., aimed to enable smokeless and reliable operation and to ensure the efficient combustion of excess gases.</td><td>Applicable to new flares. In existing plants, applicability may be restricted due to e.g. maintenance time availability during the turnaround of the plant.</td></tr>
</table></td><td>N/A</td><td>No flaring is undertaken on site</td></tr>
</table>

<table>
<tr><th>BATc No.</th><th colspan="4">BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td colspan="4"><table><tr><td>(b)</td><td>Monitoring and recording as part of flare management</td><td>Continuous monitoring of the gas sent to flaring, measurements of gas flow and estimations of other parameters (e.g. composition, heat content, ratio of assistance, velocity, purge gas flow rate, pollutant emissions (e.g. NOX, CO, hydrocarbons, noise)). The recording of flaring events usually includes the estimated/ measured flare gas composition, the estimated/measured flare gas quantity and the duration of operation. The recording allows for the quantification of emissions and the potential prevention of future flaring events.</td><td>Generally applicable.</td></tr></table></td><td></td><td></td></tr>
<tr><td>BATc 19</td><td colspan="4">Diffuse VOC Emissions
In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to use a combination of the techniques given below. The associated monitoring is in BAT 5.<table><tr><th></th><th>Technique</th><th>Applicability</th></tr><tr><td colspan="3">Techniques related to plant design</td></tr></table></td><td>Yes</td><td>The processing plant has been designed to minimise diffuse VOC emissions where possible.
Plant VOC usage is relatively limited when compared against full scale industrial sites due to the scale of processing activities proposed at the site.
The following techniques have been applied to the process design:
b) The process has been designed to capture all VOC into channelled emission control system where possible
c) fully welded pipework and seal-less pumps have been specified for handling VOC materials where possible
d) all process plant equipment has been designed to be readily accessible for maintenance</td></tr>
</table>

BATc No.	BAT Justification			Operating to BAT	Demonstration of BAT Compliance
	(a)	Limit the number of potential emission sources	Applicability may be restricted in the case of existing plants due to operability requirements.		e) plant assembly will be subject to pre-planned installation processes and acceptance testing to minimise potential for leaks. f) plant commissioning will be subject to pre-planned testing and processes to minimise potential for leaks. g) all VOC handling equipment will be subject to pre-planned inspection and maintenance / repair I) The process has been designed to capture all VOC into channelled emission control system where possible
	(b)	maximise process-inherent containment features			
	(c)	select high-integrity equipment			
	(d)	facilitate maintenance activities by ensuring access to potentially leaky equipment			
	Techniques related to plant/equipment construction, assembly and commissioning				
	(e)	Ensure well-defined and comprehensive procedures for plant/equipment construction and assembly. This includes using designed gasket stress for flanged joint assembly			
	(f)	ensure robust plant/equipment commissioning and handover procedures in line with the design requirements			
	Techniques related to plant operation				
	(g)	Ensure good maintenance and timely	Generally applicable.		

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	<table><tr><td></td><td>replacement of equipment</td></tr><tr><td>(h)</td><td>Use a risk based leak detection and repair programme</td></tr><tr><td>(i)</td><td>As far is it is reasonable, prevent diffuse VOC emissions, collect them at source and treat them</td></tr></table> The associated monitoring is in BAT5		
BATc 20	**Odour Emissions** In order to prevent or, where that is not practicable, to reduce odour emissions, BAT is to set up, implement and regularly review an odour management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements: (i) a protocol containing appropriate actions and timelines; (ii) a protocol for conducting odour monitoring; (iii) a protocol for response to identified odour incidents; (iv) an odour prevention and reduction programme designed to identify the source(s); to measure/estimate odour exposure; to characterise the contributions of the sources; and to implement prevention and/or reduction measures. The associated monitoring is in BAT 6. The applicability is restricted to cases where odour nuisance can be expected or has been substantiated.	N/A	Not Applicable None of the materials processed by the site are expected to be particularly odourous. Acetic Acid may be generated by the process and emitted to air, but potential for odour impacts has been reviewed in Section 4.3 of Appendix G1 (QERA) and demonstrated to have no potential odour impact.
BATc 21	**Odour** In order to prevent or, where that is not practicable, to reduce odour emissions from waste water collection and treatment and from sludge treatment, BAT is to use one or a combination of the techniques given below. <table><tr><th></th><th>Technique</th><th>Description</th><th>Applicability</th></tr><tr><td>(a)</td><td>Minimise residence times</td><td>Minimise the residence time of waste water and sludge in collection and storage systems, in</td><td>Applicability may be restricted in the case of existing collection and storage systems.</td></tr></table>	N/A	Not Applicable - no wastewater treatment system or sludge production on site. None of the materials processed by the site are expected to be particularly odourous. Acetic Acid may be generated by the process and emitted to air, but potential for odour impacts has been reviewed in Section 4.3 of Appendix G1 (QERA) and demonstrated to have no potential odour impact.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	<table><tr><td></td><td></td><td>particular under anaerobic conditions.</td><td></td></tr><tr><td>(b)</td><td>Chemical treatment</td><td>Use chemicals to destroy or to reduce the formation of odorous compounds (e.g. oxidation or precipitation of hydrogen sulphide).</td><td>Generally applicable.</td></tr><tr><td>(c)</td><td>Optimise aerobic treatment</td><td>This can include: (i) controlling the oxygen content; (ii) frequent maintenance of the aeration system; (iii) use of pure oxygen; (iv) removal of scum in tanks.</td><td>Generally applicable.</td></tr><tr><td>(d)</td><td>Enclosure</td><td>Cover or enclose facilities for collecting and treating waste water and sludge to collect the odorous waste gas for further treatment.</td><td>Generally applicable.</td></tr><tr><td>(e)</td><td>End-of-pipe treatment</td><td>This can include: (i) biological treatment; (ii) thermal oxidation.</td><td>Biological treatment is only applicable to compounds that are easily soluble in water and readily bio eliminable.</td></tr></table>		
BATc 22	**Noise Emissions** In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to set up and implement a noise management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements: (i) a protocol containing appropriate actions and timelines;	Yes	A detailed noise impact assessment has been undertaken as part of the permit application documentation. This assessment has demonstrated that no significant offsite noise impacts are expected, and hence a noise management plan is not required.

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>(ii) a protocol for conducting noise monitoring;
(iii) a protocol for response to identified noise ;
(iv) a noise prevention and reduction programme designed to identify the source(s), to measure/estimate noise exposure, to characterise the contributions of the sources and to implement prevention and/or reduction measures.</td><td></td><td></td></tr>
<tr><td>BATc 23</td><td>Noise Emissions
In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques given below.
<table>
<tr><th></th><th>Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>(a)</td><td>Appropriate location of equipment and buildings</td><td>Increasing the distance between the emitter and the receiver and using buildings as noise screens.</td><td>For existing plants, the relocation of equipment may be restricted by a lack of space or excessive costs.</td></tr>
<tr><td>(b)</td><td>Operational measures</td><td>This includes: (i)improved inspection and maintenance of equipment; (ii) closing of doors and windows of enclosed areas, if possible; (iii)equipment operation by experienced staff; (iv) avoidance of noisy activities at night, if possible; (v)provisions for noise control during maintenance activities.</td><td>Generally applicable.</td></tr>
<tr><td>(c)</td><td>Low-noise equipment</td><td>This includes low-noise compressors, pumps and flares.</td><td>Applicable only when the equipment is new or replaced.</td></tr>
<tr><td>(d)</td><td>Noise-control equipment</td><td>This includes: (i) noise-reducers; (ii) equipment insulation; (iii) enclosure of noisy equipment; (iv) soundproofing of buildings.</td><td>Applicability may be restricted due to space requirements (for existing plants), health, and safety issues.</td></tr>
</table></td><td>Yes</td><td>Noise emissions from the installation will be minimised as follows:
a) All main processing systems are within the site building and within the internal main processing areas. The chiller compressor has been located on the site of the building furthest away from nearby receptors.
b) i) Process equipment will be subject to preplanned inspection and maintenance to minimise the potential for abnormal noise emissions.
ii)The building doors will be closed when operating
iii) Site staff will be appropriately trained and competent and made aware of potential noise hazards and their management.
iv) Potential noisy activities will be minimised at night.
c) All process plant equipment has been specified to achieve a pre-determined maximum noise level to ensure operator protection within the building and correspondingly minimise offsite noise emissions
d) The building will provide acoustic attenuation of noise sources within the building.</td></tr>
</table>

BATc No.	BAT Justification					Operating to BAT	Demonstration of BAT Compliance
	(e)	Noise abatement	Inserting obstacles between emitters and receivers (e.g. protection walls, embankments and buildings).	Applicable only to existing plants; since the design of new plants should make this technique unnecessary. For existing plants, the insertion of obstacles may be restricted by a lack of space.			

Appendix C Common Waste Gas Management and Treatment Systems in the Chemical Sector BATc

Environmental Permit Application – Supporting Documentation Appendix D - BAT Conclusion Compliance Assessment

Sawston Pilot Plant

Immaterial Limited

SLR Project No.: 405.065240.00001

4 December 2024

Table C1: Assessment of BAT Compliance – Common Waste Gas Management and Treatment Systems in the Chemical Sector BREF and associated BAT Conclusions (WGC BREF) - January 2023

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
Scope	These BAT conclusions concern the following activity specified in Annex I to Directive 2010/75/EU: 4. Chemical industry (i.e. all production processes included in the categories of activities listed in points 4.1 to 4.6 of Annex I, unless specified otherwise). More specifically, these BAT conclusions focus on emissions to air from the aforementioned activity. These BAT conclusions do not address the following: 1. Emissions to air from the production of chlorine, hydrogen, and sodium/potassium hydroxide by the electrolysis of brine. This is covered by the BAT conclusions for the Production of Chlor-alkali (CAK). 2. Channelled emissions to air from the production of the following chemicals in continuous processes where the total production capacity of those chemicals exceeds 20 kt/yr: — lower olefins using the steam cracking process; — formaldehyde; — ethylene oxide and ethylene glycols; — phenol from cumene; — dinitrotoluene from toluene, toluene diamine from dinitrotoluene, toluene diisocyanate from toluene diamine, methylene diphenyl diamine from aniline, methylene diphenyl diisocyanate from methylene diphenyl diamine; — ethylene dichloride (EDC) and vinyl chloride monomer (VCM); — hydrogen peroxide. This is covered by the BAT conclusions for the Production of Large Volume Organic Chemicals (LVOC). However, channelled emissions to air of nitrogen oxides (NO_X) and carbon monoxide (CO) from thermal treatment of waste gases originating from the aforementioned production processes are included in the scope of these BAT conclusions. 3. Emissions to air from the production of the following inorganic chemicals: — ammonia; — ammonium nitrate; — calcium ammonium nitrate; — calcium carbide; — calcium chloride;	-	The BRef document applies as the main site activities are defined under Section 4.1 of Schedule 1 to the Environmental Permitting Regulations 2016

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	— calcium nitrate; — carbon black; — ferrous chloride; — ferrous sulphate (i.e. copperas and related products, such as chloro-sulphates); — hydrofluoric acid; — inorganic phosphates; — nitric acid; — nitrogen-, phosphorus- or potassium-based fertilisers (simple or compound fertilisers); — phosphoric acid; — precipitated calcium carbonate; — sodium carbonate (i.e. soda ash); — sodium chlorate; — sodium silicate; — sulphuric acid; — synthetic amorphous silica; — titanium dioxide and related products; — urea; — urea-ammonium nitrate. This may be covered by the BAT conclusions for the Production of Large Volume Inorganic Chemicals (LVIC). 4. Emissions to air from steam reforming as well as from the physical purification and reconcentration of spent sulphuric acid, provided that these processes are directly associated with a production process listed under the aforementioned points 2 or 3. 5. Emissions to air from the production of magnesium oxide using the dry process route. This may be covered by the BAT conclusions for the Production of Cement, Lime and Magnesium Oxide (CLM). 6. Emissions to air from the following: — Combustion units other than process furnaces/heaters. This may be covered by the BAT conclusions for Large Combustion Plants (LCP), the BAT conclusions for the Refining of Mineral Oil and Gas (REF) and/or by Directive — Process furnaces/heaters with a total rated thermal input below 1 MW. — Process furnaces/heaters used in lower olefins, ethylene dichloride and/or vinyl chloride monomer production referred to in point 2 above. This is covered by the BAT conclusions for the production of Large Volume Organic Chemicals (LVOC).		

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	7. Emissions to air from waste incineration plants. This may be covered by the BAT conclusions for Waste Incineration (WI). 8. Emissions to air from the storage, transfer and handling of liquids, liquefied gases and solids, where these are not directly associated with the activity specified in Annex I to Directive 2010/75/EU:4. Chemical industry. This may be covered by the BAT conclusions for Emissions from Storage (EFS). However, emissions to air from the storage, transfer and handling of liquids, liquefied gases and solids are included in the scope of these BAT conclusions provided that these processes are directly associated with the chemical production process specified in the scope of these BAT conclusions. 9. Emissions to air from indirect cooling systems. This may be covered by the BAT conclusions for Industrial Cooling Systems (ICS).		
	Summary of applicability of the BAT Conclusions to the Filling Line activities proposed under this application for Variation 1.1 General BAT Conclusions - BATc 1 – 23 1.2 Polymers and Synthetic Rubbers - BATc 24 - 35 1.3 Process Furnaces / Heaters – BATc 36	-	 Applicable Not Applicable Not Applicable
Environmental Management Systems			
BATc 1	In order to improve the overall environmental performance, BAT is to elaborate and implement an environmental management system (EMS) that incorporates all of the following features: i. commitment, leadership, and accountability of the management, including senior management, for the implementation of an effective EMS; ii. an analysis that includes the determination of the organisation's context, the identification of the needs and expectations of interested parties, the identification of characteristics of the installation that are associated with possible risks for the environment (or human health) as well as of the applicable legal requirements relating to the environment; iii. development of an environmental policy that includes the continuous improvement of the environmental performance of the installation; iv. establishing objectives and performance indicators in relation to significant environmental aspects, including safeguarding compliance with applicable legal requirements;	Yes	An EMS will be prepared in accordance with the requirements of ISO14001 and will include requirements to set key environmental performance targets and review performance at least annually. This EMS will fully implement the requirements of BATc 1.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	v. planning and implementing the necessary procedures and actions (including corrective and preventive actions where needed), to achieve the environmental objectives and avoid environmental risks; vi. determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed; vii. ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g., by providing information and training); viii. internal and external communication; ix. fostering employee involvement in good environmental management practices; x. establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records; xi. effective operational planning and process control; xii. implementation of appropriate maintenance programmes; xiii. emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations; xiv. when (re)designing a (new) installation or a part thereof, consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning; xv. implementation of a monitoring and measurement programme; if necessary, information can be found in the Reference Report on Monitoring of Emissions to Air and Water from IED Installations; xvi. application of sectoral benchmarking on a regular basis; xvii. periodic independent (as far as practicable) internal auditing and periodic independent external auditing in order to assess the environmental performance and to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained; xviii. evaluation of causes of nonconformities, implementation of corrective actions in response to nonconformities, review of the effectiveness of corrective actions, and determination of whether similar nonconformities exist or could potentially occur; xix. periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness; xx. following and taking into account the development of cleaner techniques.		

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	Specifically for the chemical sector, BAT is also to incorporate the following features in the EMS: xxi. an inventory of channelled and diffuse emissions to air (see BAT 2); xxii. an OTNOC management plan for emissions to air (see BAT 3); xxiii. an integrated waste gas management and treatment strategy for channelled emissions to air (see BAT 4); xxiv. a management system for diffuse VOC emissions to air (see BAT 19); xxv. a chemicals management system that includes an inventory of the 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.		
BATc 2	In order to facilitate the reduction of emissions to air, BAT is to establish, maintain and regularly review (including when a substantial change occurs) an inventory of channelled and diffuse emissions to air, as part of the environmental management system (see BAT 1), that incorporates all of the following features: i. information, as comprehensive as is reasonably possible, about the chemical production process(es), including: a. chemical reaction equations, also showing side products; b. simplified process flow sheets that show the origin of the emissions; ii. information, as comprehensive as is reasonably possible, about channelled emissions to air, such as: a. emission point(s); b. average values and variability of flow and temperature; c. average concentration and mass flow values of relevant substances/parameters and their variability (e.g., TVOC, CO, NOX, SOX, Cl2, HCl); d. presence of other substances that may affect the waste gas treatment system(s) or plant safety (e.g., oxygen, nitrogen, water vapour, dust); e. techniques used to prevent and/or reduce channelled emissions to air;	Yes	The site will be compliant with the requirements of BAT 2. The site has a full understanding of all emissions to air and the inventory of emissions. i) A full process design has been undertaken and a full set of process design information will be available on site. ii) Details of the emission points and the expected composition and flow rates of the channelled emissions to air have been included in the design and data will be supplemented by monitoring as required under the WGC BREF. Full details of the emissions and their potential impacts are included in Section 9 of the application main supporting document and the AERA. iii) The processing plant has been designed to minimise diffuse VOC emissions where possible.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	f. flammability, lower and higher explosive limits, reactivity; g. monitoring methods (see BAT 8); h. presence of substances classified as CMR 1A, CMR 1B or CMR 2; 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). iii. information, as comprehensive as is reasonably possible, about diffuse emissions to air, such as: a. identification of the emission source(s); b. characteristics of each emission source (e.g., fugitive or non-fugitive; static or moving; accessibility of the emission source; included in an LDAR programme or not); c. the characteristics of the gas or liquid in contact with the emission source(s), including: 1) physical state; 2) vapour pressure of the substance(s) in the liquid, pressure of the gas; 3) temperature; 4) composition (by weight for liquids or by volume for gases); 5) hazardous properties of the substance(s) or mixtures, including substances or mixtures classified as CMR 1A, CMR 1B or CMR 2; d. techniques used to prevent and/or reduce diffuse emissions to air; e. monitoring (see BAT 20, BAT 21 and BAT 22).		Plant VOC usage is relatively limited when compared against full scale industrial sites due to the scale of processing activities proposed at the site. The following techniques have been applied to the process design: b) The process has been designed to capture all VOC into channelled emission control system where possible c) fully welded pipework and seal-less pumps have been specified for handling VOC materials where possible d) all process plant equipment has been designed to be readily accessible for maintenance e) plant assembly will be subject to pre-planned installation processes and acceptance testing to minimise potential for leaks. f) plant commissioning will be subject to pre-planned testing and processes to minimise potential for leaks. g) all VOC handling equipment will be subject to pre-planned inspection and maintenance / repair.
Other Than Normal Operating Conditions (OTNOC)			
BATc 3	In order to reduce the frequency of the occurrence of OTNOC and to reduce emissions to air during OTNOC, BAT is to set up and implement a risk based OTNOC management plan as part of the environmental management system (see BAT 1) that includes all of the following features: i. identification of potential OTNOC (e.g., failure of equipment critical to the control of channelled emissions to air, or equipment critical to the prevention of accidents or incidents that could lead to emissions to air (critical equipment)), of their root causes and of their potential consequences;	Yes	The site will be operated subject to management systems which will be developed prior to commencement of operation. As part of these management systems, an OTNOC management plan will be developed which will be integrated into the site operational procedures. The plan will include:

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	ii. appropriate design of critical equipment (e.g., equipment modularity and compartmentalisation, backup systems, techniques to obviate the need to bypass waste gas treatment during start-up and shutdown, high-integrity equipment, etc.); iii. set-up and implementation of a preventive maintenance plan for critical equipment (see BAT 1 xii.); iv. monitoring (i.e., estimating or, where this is possible, measuring) and recording of emissions and associated circumstances during OTNOC; v. periodic assessment of the emissions occurring during OTNOC (e.g., frequency of events, duration, amount of pollutants emitted as recorded in point iv.) and implementation of corrective actions if necessary; vi. regular review and update of the list of identified OTNOC under point i. following the periodic assessment of point v.; vii. regular testing of backup systems.		• Identification of environmentally critical plant; • Measures to be used to identify and prevent potential OTNOC; and • Actions to be taken in the event of OTNOC to minimise emissions to the environment and ensure the plant is returned to normal operating parameters safely. • Training of Staff. Following OTNOC events, these would be investigated, and corrective actions implemented where appropriate in line with the requirements of the EMS. Records of OTNOC events will be maintained and inspected. The site will also have planned preventative maintenance for critical equipment.
Channelled Emissions To Air			
BATc 4	In order to reduce channelled emissions to air, BAT is to use an integrated waste gas management and treatment strategy that includes, in order of priority, process integrated recovery and abatement techniques. The integrated waste gas management and treatment strategy is based on the inventory in BAT 2. It takes into account factors such as greenhouse gas emissions and the consumption or reuse of energy, water and materials associated with the use of the different techniques.	Yes	Due to the nature of the site operations and the ability of each of the main process stages to be operated independently of each other, an integrated approach the waste gas treatment is not suitable. All process emissions to air have been identified and quantified. Appropriate channelled emissions systems have been provided to capture all key process emissions to air. Potential air quality and environmental impacts have been assessed as part of the Environmental Permit application and have been

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
			assessed as having insignificant emissions to the environment. Condensers are installed for VOC recovery from those vents to air where elevated levels of VOC could potentially be present. The recovered VOC will be collected for disposal as waste as it will not be suitable for immediate re-use in the process (Product Quality). Monitoring of process emission to air will be undertaken in line with the appropriate requirements of the WGC BREF.
BATc 5	In order to facilitate the recovery of materials and the reduction of channelled emissions to air, as well as to increase energy efficiency, BAT is to combine waste gas streams with similar characteristics, thus minimising the number of emission points	Yes	Due to the nature of the site operations and the ability of each of the main process stages to be operated independently of each other, an integrated approach the waste gas treatment is not suitable. - See BATc 4.
BATc 6	In order to reduce channelled emissions to air, BAT is to ensure that the waste gas treatment systems are appropriately designed (e.g., considering the maximum flow rate and pollutant concentrations), operated within their design ranges, and maintained (through preventive, corrective, regular and unplanned maintenance) so as to ensure optimal availability, effectiveness and efficiency of the equipment.	Yes	Chilled water-cooled condensers are installed for VOC recovery from those vents to air where elevated levels of VOC could potentially be present. The operation of the condensers will be optimised to balance coolant flow against the required condensing duty as part of the ongoing process design. Routine maintenance on the condensers will be part of the site management controls. Periodic monitoring of the performance of the condensers will also be undertaken.
Monitoring			

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td>BATc 7</td><td>BAT is to continuously monitor key process parameters (e.g., waste gas flow and temperature) of waste gas streams being sent to pre-treatment and/or final treatment.</td><td>N/A</td><td>Condensers are installed for VOC recovery from those vents to air where elevated levels of VOC could potentially be present.
The process conditions in the upstream process units leading to each of the vent points to air will determine the temperature of the gas stream sent to the condensers – this temperature will be monitored and controlled. Gas flowrates will be dependent on the rate of addition of nitrogen to the process units for inertisation and the extraction rates of vacuum pumps where applicable – this will also be controlled and monitored.</td></tr>
<tr><td>BATc 8</td><td>BAT is to monitor channelled emissions to air with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.
<table>
<tr><th>Substance / Parameter (1)</th><th>Process(es) / Source(s)</th><th>Emission Points</th><th>Standard(s) (2)</th><th>Minimum Monitoring Frequency</th><th>Monitoring Associated With</th></tr>
<tr><td rowspan="2">Ammonia (NH_3)</td><td>Use of SCR/SNCR</td><td rowspan="2">Any stack</td><td rowspan="2">EN 21877</td><td rowspan="2">Once every 6 months (3) (4)</td><td>BAT 17</td></tr>
<tr><td>All other processes / sources</td><td>BAT 18</td></tr>
<tr><td>Benzene</td><td>All processes / sources</td><td>Any stack</td><td>No EN standard available</td><td>Once every 6 months (3)</td><td>BAT 11</td></tr>
<tr><td>1,3-Butadiene</td><td>All processes / sources</td><td>Any stack</td><td>No EN standard available</td><td>Once every 6 months (3)</td><td>BAT 11</td></tr>
<tr><td>Carbon monoxide (CO)</td><td>Thermal treatment</td><td>Any stack with a CO mass flow of ≥ 2 kg/h</td><td>Generic EN standards (5)</td><td>Continuous</td><td>BAT 16</td></tr>
</table></td><td>Yes</td><td>Proposals for monitoring of TVOC emission to air from each of the emission points are presented in Section9.1.4 of the main application supporting document.
All monitoring will comply with the requirements of BATc 8</td></tr>
</table>

BATc No.	BAT Justification						Operating to BAT	Demonstration of BAT Compliance
			Any stack with a CO mass flow of < 2 kg/h	EN 15058	Once every 6 months (3)(4)			
		Process furnace/heaters	Any stack with a CO mass flow of ≥ 2 kg/h	Generic EN standards (5)	Continuous (6)	BAT 36		
			Any stack with a CO mass flow of < 2 kg/h	EN 15058	Once every 6 months (3)(4)			
		All other processes / sources	Any stack with a CO mass flow of ≥ 2 kg/h	Generic EN standards (5)	Continuous	BAT 18		
			Any stack with a CO mass flow of < 2 kg/h	EN 15058 X	Once every 6 months (3)(7)			
	Chloromethane	All processes / sources	Any stack	No EN standard available	Once every 6 months (3)	BAT 11		
	CMR substances other than CMR substances covered elsewhere in this table ([12])	All other processes / sources	Any stack	No EN standard available	Once every 6 months (3)	BAT 11		
	Dichloromethane	All processes / sources	Any stack	No EN standard available	Once every 6 months (3)	BAT 11		
	Dust	All processes / sources	Any stack with dust mass flow ≥ 3 kg/h	Generic EN standards (5), EN 13284-1 and EN 13284-2	Continuous (8)	BAT 14		

BATc No.	BAT Justification						Operating to BAT	Demonstration of BAT Compliance
			Any stack with dust mass flow < 3 kg/h	EN 13284-1	Once every year (3)(7)			
	Elemental chlorine (Cl_2)	All other processes / sources	Any stack	No EN standard available	Once every year (3) (7)	BAT 18		
	Ethylene dichloride (EDC)	All other processes / sources	Any stack	No EN standard available	Once every 6 months (3)	BAT 11		
	Ethylene oxide	All other processes / sources	Any stack	No EN standard available	Once every 6 months (3)	BAT 11		
	Formaldehyde	All other processes / sources	Any stack	EN standard under development	Once every 6 months (3)	BAT 11		
	Gaseous chlorides	All other processes / sources	Any stack	EN 1911	Once every year (3)(7)	BAT 18		
	Gaseous fluorides	All other processes / sources	Any stack	No EN standard available	Once every year (3)(7)	BAT 18		
	Hydrogen cyanide (HCN)	All other processes / sources	Any stack	No EN standard available	Once every year (3)(7)	BAT 18		
	Lead and its compounds	All other processes / sources	Any stack	EN 14385	Once every 6 months (3)(9)	BAT 14		
	Nickel and its compounds	All other processes / sources	Any stack	EN 14385	Once every 6 months (3)(9)	BAT 14		
	Nitrous Oxide (N_2O)	All other processes / sources	Any stack	EN ISO 21258	Once every year (3)(7)	-		
	Nitrogen oxides (NO_x)	Thermal treatment	Any stack with a NO_x mass flow of ≥ 2.5 kg/h	Generic EN standards (5)	Continuous	BAT 16		
			Any stack with a NO_x mass flow of <2.5 kg/h	EN 14792	Once every 6 months (3)(4)			

BATc No.	BAT Justification						Operating to BAT	Demonstration of BAT Compliance
		Process furnace / heaters	Any stack with a NO_x mass flow of ≥ 2.5 kg/h	Generic EN standards ([5])	Continuous [6]	BAT 36		
			Any stack with a NO_x mass flow of <2.5 kg/h	EN 14792	Once every 6 months [3][4]			
		All other processes / sources	Any stack with a NO_x mass flow of ≥ 2.5 kg/h	Generic EN standards [5]	Continuous	BAT 18		
			Any stack with a NO_x mass flow of <2.5 kg/h	EN 14792	Once every 6 months [3][4]			
	PCDD/F	Thermal treatment	Any stack	EN 1948-1, XEN 1948-2, EN 1948-3	Once every 6 months [3][9]	BAT 12		
	$PM_{2.5}$ and PM_{10}	All processes / sources	Any stack	EN ISO 23210	Once every year [3][7]	BAT 14		
	Propylene oxide	All processes / sources	Any stack	No EN standards available	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 EN standards [5]	Continuous	BAT 16		
			Any stack with a SO_2 mass flow of <2.5kg/h	EN 14791	Once every 6 months [3][4]			
		Process furnaces / heaters	Any stack with a SO_2 mass flow of ≥ 2.5 kg/h	Generic EN standards [5]	Continuous [6]	BAT 18, BAT 36		
			Any stack with a SO_2 mass flow of <2.5kg/h	EN 14791	Once every 6 months [3][4]			
		All other processes / sources	Any stack with a SO_2 mass flow of ≥ 2.5 kg/h	Generic EN standards [5]	Continuous	BAT 18		

BATc No.	BAT Justification						Operating to BAT	Demonstration of BAT Compliance
			Any stack with a SO_2 mass flow of <2.5kg/h	EN 14791 X	Once every 6 months (3)(4)			
	Tetrachloromethane	All processes / sources	Any stack	No EN standards available	Once every 6 months (3)	BAT 11		
	Toluene	All processes / sources	Any stack	No EN standards available	Once every 6 months (3)	BAT 11		
	Trichloromethane	All processes / sources	Any stack	No EN standards available	Once every 6 months (3)	BAT 11		
	Total volatile organic carbon (TVOC)	Production of polyolefins (10)	Any stack with a TVOC mass flow of ≥ 2 kg C/h	Generic EN standards (5)	Continuous	BAT 11, BAT 25		
			Any stack with a TVOC mass flow of < 2 kg C/h	EN 12619	Once every 6 months (3)(4)			
		Production of synthetic rubber (11)	Any stack with a TVOC mass flow of ≥ 2 kg C/h	Generic EN standards (5)	Continuous	BAT 11, BAT 32		
			Any stack with a TVOC mass flow of < 2 kg C/h	EN 12619	Once every 6 months (3)(4)			
		All other processes / sources	Any stack with a TVOC mass flow of ≥ 2 kg C/h	Generic EN standards (5)	Continuous	BAT 11		
			Any stack with a TVOC mass flow of < 2 kg C/h	EN 12619	Once every 6 months (3)(4)			

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>(1) The monitoring only applies when the substance/parameter concerned is identified as relevant in the waste gas stream based on the inventory given in BAT 2.
(2) Measurements are carried out according to EN 15259.
(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 EN standards for continuous measurements are EN 14181, EN 15267-1, EN 15267-2 and 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.
(7) The minimum monitoring frequency may be reduced to once every 3 years if the emission levels are proven to be sufficiently stable.
(8) The minimum monitoring frequency may be reduced to once every 6 months if the emission levels are proven to be sufficiently stable.
(9) The minimum monitoring frequency may be reduced to once every year if the emission levels are proven to be sufficiently stable.
(10) 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 24 if it provides a better representation of the TVOC emissions.
(11) 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 31 if it provides a better representation of the TVOC emissions.
(12) i.e., other than benzene, 1,3-butadiene, chloromethane, dichloromethane, ethylene dichloride, ethylene oxide, formaldehyde, propylene oxide, tetrachloromethane, toluene, trichloromethane.</td><td></td><td></td></tr>
<tr><td colspan="2">Organic Compounds</td><td></td><td></td></tr>
<tr><td>BATc 9</td><td>In order to increase resource efficiency and to reduce the mass flow of organic compounds sent to the final waste gas treatment, BAT is to recover organic compounds from process off-gases by using one or a combination of the techniques given below and to reuse them.

<table><tr><th colspan="2">Techniques</th><th>Description</th></tr><tr><td>a.</td><td>Absorption (regenerative)</td><td>See Section 1.4.1.</td></tr><tr><td>b.</td><td>Adsorption (regenerative)</td><td>See Section 1.4.1.</td></tr><tr><td>c.</td><td>Condensation</td><td>See Section 1.4.1.</td></tr></table></td><td>Yes</td><td>Condensers are installed for VOC recovery from those vents to air where elevated levels of VOC could potentially be present. The recovered VOC will be collected for disposal as waste as it will not be suitable for immediate re-use in the process (Product Quality).</td></tr>
<tr><td>BATc 10</td><td>In order to increase energy efficiency and to reduce the mass flow of organic compounds sent to the final waste gas treatment, BAT is to send process off-gases with a sufficient calorific value to a combustion unit that is, if technically possible, combined with heat recovery. BAT 9 has priority over sending process off-gases to a combustion unit.</td><td>N/A</td><td>Not considered viable on site.
The levels of organic materials that could potentially be present in the extracted air are relatively low such that there is insufficient calorific value for use in energy recovery.</td></tr>
</table>

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td></td><td></td><td>Emissions from each batch process stage are handled separately as each unit operation can be operated independently.</td></tr>
<tr><td>BATc 11</td><td>In order to reduce channelled emissions to air of organic compounds, BAT is to use one or a combination of the techniques given below.

<table>
<tr><th colspan="2">Technique</th><th>Description</th><th>Applicability</th></tr>
<tr><td>a.</td><td>Adsorption</td><td>See Section 1.4.1.</td><td>Generally applicable.</td></tr>
<tr><td>b.</td><td>Absorption</td><td>See Section 1.4.1.</td><td>Generally applicable.</td></tr>
<tr><td>c.</td><td>Catalytic oxidation</td><td>See Section 1.4.1.</td><td>Applicability may be restricted by the presence of catalyst poisons in the waste gases.</td></tr>
<tr><td>d.</td><td>Condensation</td><td>See Section 1.1.1.</td><td>Generally applicable.</td></tr>
<tr><td>e.</td><td>Thermal oxidation</td><td>See Section 1.1.1.</td><td>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.</td></tr>
<tr><td>f.</td><td>Bioprocesses</td><td>See Section 1.4.1</td><td>Only applicable to the treatment of biodegradable compounds.</td></tr>
</table>

BAT-associated emission levels (BAT-AELs) for channelled emissions to air of organic compounds.</td><td>Yes</td><td>Condensers are installed for VOC recovery from those vents to air where elevated levels of VOC could potentially be present. The recovered VOC will be collected for disposal as waste as it will not be suitable for immediate re-use in the process (Product Quality).

VOC’s will be either Ethanol or Methanol, and so would be assessed as TVOC.

The process emission abatement systems are being designed to keep total VOC emissions to <100g/h (as carbon) per vent and hence the BAT-AEL for TVOC will not apply.</td></tr>
</table>

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance

Substance / Parameter	BAT-AEL (mg/Nm^3) 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/Nm^3.	

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>(3) In the case of polymer production, the BAT-AEL may not apply to emissions from the finishing steps (e.g., extrusion, drying, blending) and from polymer storage.
(4) The BAT-AEL does not apply to minor emissions (i.e., when the TVOC mass flow is below e.g., 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/Nm^3 when using techniques to recover materials (e.g., solvents, see BAT 9), if both of the following conditions are fulfilled:
• the presence of substances classified as CMR 1A/1B or CMR 2 is identified as not relevant (see BAT 2);
• the TVOC abatement efficiency of the waste gas treatment system is ≥ 95 %.
(6) The BAT-AEL does not apply to minor emissions (i.e., when the mass flow of the sum of the VOCs classified as CMR 1A or 1B is below e.g., 1 g/h).
(7) The BAT-AEL does not apply to minor emissions (i.e., when the mass flow of the sum of the VOCs classified as CMR 2 is below e.g., 50 g/h).
(8) The BAT-AEL does not apply to minor emissions (i.e., when the mass flow of the substance concerned is below e.g., 1 g/h).
(9) The BAT-AEL does not apply to minor emissions (i.e., when the mass flow of the substance concerned is below e.g., 50 g/h).
(10) The upper end of the BAT-AEL range may be higher and up to 15 mg/Nm^3 when using techniques to recover materials (e.g., solvents, see BAT 9), if the abatement efficiency of the waste gas treatment system is ≥ 95 %.
(11) The upper end of the BAT-AEL range may be higher and up to 20 mg/Nm^3 when using techniques to recover toluene (see BAT 9), if the abatement efficiency of the waste gas treatment system is ≥ 95 %.</td><td></td><td></td></tr>
<tr><td>BATc 12</td><td>In order 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><tr><th colspan="2">Technique</th><th>Description</th><th>Applicability</th></tr><tr><td colspan="4">Specific techniques to reduce PCDD/F emissions</td></tr><tr><td>a.</td><td>Optimised catalytic or thermal oxidation</td><td>See Section 1.4.1</td><td>Generally applicable.</td></tr></table></td><td>N/A</td><td>Not applicable
No PCDD/F present</td></tr>
</table>

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>
<table>
<tr><td>b.</td><td>Rapid waste-gas cooling</td><td>Rapid cooling of waste gases from temperatures above 400 ^{O}C to below 250 ^{O}C to prevent the de novo synthesis of PCDD/F.</td><td>Generally applicable.</td></tr>
<tr><td>c.</td><td>Adsorption using activated carbon.</td><td>See Section 1.4.1.</td><td>Generally applicable.</td></tr>
<tr><td>d.</td><td>Absorption</td><td>See Section 1.4.1.</td><td>Generally applicable.</td></tr>
<tr><td colspan="4">Other techniques not primarily used to reduce PCDD/F emissions</td></tr>
<tr><td>e.</td><td>Selective catalytic reduction (SCR)</td><td>See Section 1.4.1.
When SCR is used for NOX abatement, an adequate catalyst surface of the SCR system also provides for the partial reduction of the emissions of PCDD/F.</td><td>Applicability to existing plants may be restricted by space availability and/or by the presence of catalyst poisons in the waste gases.</td></tr>
</table>

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>
<tr><th>Substance / Parameter</th><th>BAT-AEL (ng I-TEQ / Nm^3)
Average over the sampling period</th></tr>
<tr><td>PCDD/F</td><td>< 0.01 - 0.05</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>BATc 13</td><td>In order to increase resource efficiency and to reduce the mass flow of dust and particulate-bound metals sent to the final waste gas treatment, BAT is to recover materials from process off-gases by using one or a combination of the techniques given below and to reuse them.</td><td>Yes</td><td>Dust will only be generated during the initial handling of powdered materials in the initial stages of the process.</td></tr>
</table>

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>
<table>
<tr><th colspan="2">Techniques</th><th>Description</th></tr>
<tr><td>a.</td><td>Cyclone</td><td>See Section 1.4.1.</td></tr>
<tr><td>b.</td><td>Fabric filter</td><td>See Section 1.4.1.</td></tr>
<tr><td>c.</td><td>Absorption</td><td>See Section 1.4.1.</td></tr>
</table>
</td><td></td><td>Handling of powdered materials will only be undertaken in a suitable ‘dust booth ‘ type enclosure with local extraction LEV.
The LEV system will include double HEPA filtration (in series) to ensure effective abatement of dusts. The air from this system will be vented back into the building with no emission to the external environment.</td></tr>
<tr><td>BATc 14</td><td>In order to reduce channelled emissions to air of dust and particulate-bound metals, BAT is to use one or a combination of the techniques given below.

<table>
<tr><th colspan="2">Techniques</th><th>Description</th><th>Applicability</th></tr>
<tr><td>a.</td><td>Absolute filter</td><td>See Section 1.4.1.</td><td>Applicability may be limited in the case of sticky dust or when the temperature of the waste gases is below the dew point.</td></tr>
<tr><td>b.</td><td>Absorption</td><td>See Section 1.4.1.</td><td>General applicable.</td></tr>
<tr><td>c.</td><td>Fabric filter</td><td>See Section 1.4.1.</td><td>Applicability may be limited in the case of sticky dust or when the temperature of the waste gases is below the dew point.</td></tr>
<tr><td>d.</td><td>High-efficiency air filter</td><td>See Section 1.4.1.</td><td>General applicable.</td></tr>
<tr><td>e.</td><td>Cyclone</td><td>See Section 1.4.1.</td><td>General applicable.</td></tr>
<tr><td>f.</td><td>Electrostatic precipitator</td><td>See Section 1.4.1.</td><td>General applicable.</td></tr>
</table>

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

<table>
<tr><th>Substance / Parameter</th><th>BAT-AEL (mg/Nm^3)
Daily average or average over the sampling period</th></tr>
<tr><td>Dust</td><td>< 1 - 5 [(1)(2)(3)(4)]</td></tr>
</table>
</td><td>Yes</td><td>As BATc 13

As there will be no emission to the external environment, the BAT-AEL’s for dust will not apply.</td></tr>
</table>

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>
<table>
<tr><td>Lead and its compounds, expressed as Pb</td><td>< 0.01 - 0.1 (5)</td></tr>
<tr><td>Nickel and its compounds, expressed as Ni</td><td>< 0.02 - 0.1 (6)</td></tr>
<tr><td colspan="2">(1) The upper end of the range is 20 mg/Nm^3 when either an absolute or a fabric filter is not applicable.
(2) The BAT-AEL does not apply to minor emissions (i.e., when the dust mass flow is below e.g., 50 g/h) if no CMR substances are identified as relevant in the dust based on the inventory given in BAT 2.
(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/Nm^3.
(4) Dust emissions are expected to be towards the lower end of the BAT-AEL range (e.g., below 2.5 mg/Nm^3) 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 to minor emissions (i.e., when the lead mass flow is below e.g., 0.1 g/h).
(6) The BAT-AEL does not apply to minor emissions (i.e., when the Ni mass flow is below e.g., 0.15 g/h).</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td colspan="2">Inorganic Compounds</td><td></td><td></td></tr>
<tr><td>BATc 15</td><td>In order to increase resource efficiency and to reduce the mass flow of inorganic compounds sent to the final waste gas treatment, BAT is to recover inorganic compounds from process off-gases by using absorption and to reuse them.</td><td>N/A</td><td>Not applicable
No emissions of Inorganic Compounds</td></tr>
<tr><td>BATc 16</td><td>In order to reduce channelled emissions to air of CO, NOx and SOx from thermal treatment, BAT is to use technique c. and one or a combination of the other techniques given below.
<table>
<tr><th colspan="2">Technique</th><th>Description</th><th>Main Inorganic Compounds Targeted</th><th>Applicability</th></tr>
<tr><td>a.</td><td>Choice of fuel</td><td>See Section 1.4.1.</td><td>NOx, SOx</td><td>Generally applicable.</td></tr>
<tr><td>b.</td><td>Low-NOx burner</td><td>See Section 1.4.1.</td><td>NOx</td><td>Applicability to existing plants may be restricted by design and/or operational constraints.</td></tr>
<tr><td>c.</td><td>Optimisation of catalytic or thermal oxidation</td><td>See Section 1.4.1.</td><td>CO, NOx</td><td>Generally applicable.</td></tr>
<tr><td>d.</td><td>Removal of high levels of NOx precursors</td><td>Remove (if possible, for reuse) high levels</td><td>NOx</td><td>Generally applicable.</td></tr>
</table>
</td><td>N/A</td><td>Not applicable
No emissions of Inorganic Compounds</td></tr>
</table>

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>
<table>
<tr><td></td><td></td><td>of NOx precursors prior to thermal or catalytic oxidation, e.g., by absorption, adsorption or condensation.</td><td></td><td></td></tr>
<tr><td>e.</td><td>Absorption</td><td>See Section 1.4.1.</td><td>SOx</td><td>Generally applicable.</td></tr>
<tr><td>f.</td><td>Selective catalytic reduction (SCR)</td><td>See Section 1.4.1.</td><td>NOx</td><td>Applicability to existing plants may be restricted by space availability.</td></tr>
<tr><td>g.</td><td>Selective non catalytic reduction (SNCR)</td><td>See Section 1.4.1.</td><td>NOx</td><td>Applicability to existing plants may be restricted by the residence time needed for the reaction.</td></tr>
</table>
BAT-associated emission levels (BAT-AELs) for channelled emissions to air of NOx and indicative level for channelled emissions to air of CO from thermal treatment
<table>
<tr><th>Substance / Parameter</th><th>BAT-AEL (mg/Nm³) (Daily average or average over the sampling period)</th></tr>
<tr><td>Nitrogen oxides (NOx) from catalytic oxidation</td><td>5 - 30 (1)</td></tr>
<tr><td>Nitrogen oxides (NOx) from thermal oxidation</td><td>5 – 130 (2)</td></tr>
<tr><td>Carbon monoxide (CO)</td><td>No BAT-AEL (3)</td></tr>
<tr><td colspan="2">(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 NOx 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 NOx precursors.
(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.</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>BATc 17</td><td>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 NOx emissions (ammonia slip), BAT is to optimise the design and/or operation of SCR or SNCR (e.g., optimised reagent to NOx ratio, homogeneous reagent distribution and optimum size of the reagent drops).</td><td>N/A</td><td>Not applicable
No combustion units or SCR or SNCR
No emissions of Inorganic Compounds</td></tr>
</table>

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>BAT-associated emission level (BAT-AEL) for channelled emissions to air of ammonia from the use of SCR or SNCR (ammonia slip)
<table>
<tr><th>Substance / Parameter</th><th>BAT-AEL (mg/Nm^3)
(Average over the sampling period)</th></tr>
<tr><td>Ammonia (NH_3) from SCR/SNCR</td><td>< 0.5 - 8 (1)</td></tr>
<tr><td colspan="2">(1) The upper end of the BAT-AEL range may be higher and up to 40 mg/Nm^3 in the case of process off-gases containing very high levels of NOX (e.g., above 5,000 mg/Nm^3) prior to treatment with SCR or SNCR.</td></tr>
<tr><td colspan="2"></td></tr>
</table></td><td></td><td></td></tr>
<tr><td>BATc 18</td><td>In order to reduce channelled emissions to air of inorganic compounds other than channelled emissions to air of ammonia from the use of selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) for the abatement of NOx emissions), channelled emissions to air of CO, NOx and SOx from the use of thermal treatment, and channelled emissions to air of NOx from process furnaces/heaters, BAT is to use one or a combination of the techniques given below.
<table>
<tr><th colspan="2">Technique</th><th>Description</th><th>Main Inorganic Compounds Targeted</th><th>Applicability</th></tr>
<tr><td colspan="5">Specific techniques to reduce emissions to air of inorganic compounds</td></tr>
<tr><td>a.</td><td>Absorption</td><td>Section 1.4.1.</td><td>Cl_2, HCl, HCN, HF, NH_3, NOx, SOx</td><td>Generally applicable.</td></tr>
<tr><td>b.</td><td>Adsorption</td><td>Section 1.4.1. For the removal of inorganic substances, the technique is often used in combination with a dust abatement technique (see BAT 14).</td><td>HCl, HF, NH. SOx</td><td>Generally applicable.</td></tr>
<tr><td>c.</td><td>Selective catalytic reduction (SCR)</td><td>Section 1.4.1.</td><td>NOx</td><td>Applicability to existing plants may be restricted by space availability.</td></tr>
</table></td><td>N/A</td><td>Not applicable
No combustion units or SCR /SNCR
No emissions of Inorganic Compounds</td></tr>
</table>

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance

D.	Selective non-catalytic reduction (SNCR)	Section 1.4.1.	NOx	Applicability to existing plants may be restricted by the residence time needed for the reaction
Other techniques not primarily used to reduce emissions to air of inorganic compounds				
e.	Catalytic oxidation	Section 1.4.1.	NH_3	Applicability may be restricted by the presence of catalyst poisons in the waste gases.
f.	Thermal oxidation	Section 1.4.1.	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.

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)

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	Hydrogen cyanide (HCN) < 0.1 – 1 (4) Gaseous chlorides, expressed as HCl 1-10 (6) Nitrogen oxides (NOx) 10 - 150 (7) (8) (9) (10) Sulphur oxides (SO_2) < 3 - 150 (11)(9) (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 to minor emissions (i.e., when the NH_3 mass flow is below e.g., 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 to minor emissions (i.e., when the mass flow of the substance concerned is below e.g., 5 g/h). (5) In the case of NOX 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 to minor emissions (i.e., when the HCl mass flow is below e.g., 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 NOx from the use of catalytic or thermal oxidation (see BAT 16) or from process furnaces/heaters (see BAT 36). (9) The BAT-AEL does not apply to minor emissions (i.e., when the mass flow of the substance concerned is below e.g., 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 NOx (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. The associated monitoring is given in BAT 8.		
Diffuse VOC Emissions to Air			
BATc 19	In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to elaborate and implement a management system for diffuse VOC emissions, as part of the environmental management system (see BAT 1), that includes all of the following features: i. Estimating the annual quantity of diffuse VOC emissions (see BAT 20).	Plan in place to comply	The plant has been designed to minimise the potential for diffuse VOC emissions. Plant VOC usage is relatively limited when compared against full scale industrial sites due to the scale of processing activities proposed at the site.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	ii. Monitoring diffuse VOC emissions from the use of solvents by compiling a solvent mass balance, if applicable (see BAT 21). iii. 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: a. Listing of equipment identified as relevant fugitive VOC emission sources in the inventory of diffuse VOC emissions (see BAT 2). b. Definition of criteria associated with the following: • 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). • 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. c. Measuring fugitive VOC emissions from equipment listed under point iii. A. (see BAT 22). d. 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 iii. B. Maintenance and 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 iii. C., leaving enough time after the intervention (e.g., 2 months). e. Filling in the database mentioned in point v.		Immaterial will review options for the assessment of diffuse VOC emissions. If diffuse VOC monitoring / calculation is required, then a method will be employed which will be agreed with the Environment Agency within 6 months of commencement of operation.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	iv. Establishing and implementing a detection and reduction programme for non-fugitive VOC emissions that includes all of the following features: a. Listing of equipment identified as relevant non-fugitive VOC emission sources in the inventory of diffuse VOC emissions (see BAT 2). b. Monitoring non-fugitive VOC emissions from equipment listed under point iv. A. (see BAT 22). c. Planning and implementing techniques to reduce non-fugitive VOC emissions (see BAT 23, 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. d. Filling in the database mentioned in point v. v. Establishing and maintaining a database, for diffuse VOC emissions sources that are identified in the inventory mentioned in BAT 2, for keeping record of: a. equipment design specifications (including the date and description of any design changes); b. the equipment maintenance, repair, upgrade, or replacement actions, performed or planned, and their date of implementation; c. the equipment that could not be maintained, repaired, upgraded or replaced due to operational constraints; d. 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; e. 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. vi. Reviewing and updating the LDAR programme periodically. This may include the following: a. lowering the leak and/or maintenance/repair thresholds (see point iii. B.); b. reviewing the prioritisation of equipment to be monitored, giving higher priority to (the type of) equipment identified as leaky during the previous LDAR programme;		

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>c. planning the maintenance, repair, upgrade or replacement of equipment that could not be performed during the previous LDAR programme due to operational constraints.

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

a. monitoring non-fugitive VOC emissions from equipment where maintenance, repair, upgrade or replacement actions were implemented, in order to determine if those actions were successful;

b. planning the maintenance, repair, upgrade or replacement actions that could not be performed due to operational constraints.</td><td></td><td></td></tr>
<tr><td>BATc 20</td><td>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.

<table>
<tr><th colspan="2">Technique</th><th>Description</th><th>Type of Emissions</th></tr>
<tr><td>a.</td><td>Use of emission factors</td><td>See Section 1.4.2</td><td rowspan="3">Fugitive and/or non-fugitive</td></tr>
<tr><td>b.</td><td>Use of a mass balance</td><td>Estimation based on the difference in the mass of the substance inputs to and outputs from the plant/production unit, taking into account the generation and destruction of the substance in the plant/production unit. A mass balance may also consist of measuring the concentration of VOCs in the product (e.g., raw material or solvent).</td></tr>
<tr><td>c.</td><td>Use of thermodynamic models</td><td>Estimation using the laws of thermodynamics applied to equipment (e.g., tanks) or particular steps of a production process. The following data are generally used as input for the model:</td></tr>
</table></td><td>Plan in place to comply</td><td>Immaterial will review options for the assessment of non-fugitive VOC emissions.

Mass balances for the plant operations are under development and will likely be the method used to estimate emissions to air, in combination with periodic monitoring of channelled emissions to air and supporting calculations.

The specific method to be employed will be agreed with the Environment Agency within 6 months of commencement of operation.</td></tr>
</table>

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td><table><tr><td></td><td></td><td>• chemical properties of the substance (e.g., vapour pressure, molecular mass);
• process operating data (e.g., operating time, product quantity, ventilation);
• characteristics of the emission source (e.g., tank diameter, colour, shape).</td><td></td></tr></table></td><td></td><td></td></tr>
<tr><td>BATc 21</td><td>BAT is to monitor diffuse VOC emissions from the use of solvents by compiling, at least once every year, a solvent mass balance of the solvent inputs and outputs of the plant, as defined in Part 7 of Annex VII to Directive 2010/75/EU and to minimise the uncertainty of the solvent mass balance data by using all of the techniques given below.<table><tr><th colspan="2">Techniques</th><th>Description</th></tr><tr><td>a.</td><td>Full identification and quantification of the relevant solvent inputs and outputs, including the associated uncertainty</td><td>This includes:
• identification and documentation of solvent inputs and outputs (e.g., channelled and diffuse emissions to air, emissions to water, solvent output in waste);
• substantiated quantification of each relevant solvent input and output and recording of the methodology used (e.g., measurement, estimation by using emission factors, estimation based on operational parameters);
• identification of the main sources of uncertainty of the aforementioned quantification, and implementation of corrective actions to reduce the uncertainty; and
• regular update of solvent input and output data.</td></tr></table></td><td>Plan in place to comply</td><td>Immaterial will review options for the assessment of diffuse VOC emissions.

Mass balances for the plant operations are under development and will be prepared with due consideration of BATc21

The implementation of solvent tracking systems and solvent monitoring will be reviewed within 6 months of commencement of operation.</td></tr>
</table>

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>
<table>
<tr><td>b.</td><td>Implementation of a solvent tracking system</td><td>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).</td></tr>
<tr><td>c.</td><td>Monitoring of changes that may influence the uncertainty of the solvent mass balance data</td><td>Any change that could influence the uncertainty of the solvent mass balance data is recorded, such as:
malfunctions of the waste gas treatment system: the date and period of time are recorded; and
changes that may influence air/gas flow rates (e.g., replacement of fans): the date and type of change are recorded.</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>BATc 22</td><td>
BAT is to monitor diffuse VOC emissions to air with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.
<table>
<tr><th>Type of Sources of Diffuse VOC Emissions (1)(2)</th><th>Type of VOCs</th><th>Standard(s)</th><th>Minimum Monitoring Frequency</th></tr>
<tr><td rowspan="2">Sources of fugitive emissions</td><td>VOCs classified as CMR 1A or 1B</td><td rowspan="2">EN 15446 (8)</td><td>Once every year (3)(4)(5)</td></tr>
<tr><td>VOCs not classified as CMR 1A or 1B</td><td>Once during the period covered by each LDAR programme (see BAT 19 point iii.) (6)</td></tr>
<tr><td rowspan="2">Sources of non-fugitive emissions</td><td>VOCs classified as CMR 1A or 1B</td><td rowspan="2">EN 17628</td><td>Once every year</td></tr>
<tr><td>VOCs not classified as CMR 1A or 1B</td><td>Once every year (7)</td></tr>
<tr><td colspan="4">(1) The monitoring only applies to emission sources that are identified as relevant in the inventory given in BAT 2.
(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 iii.).</td></tr>
</table>
</td><td>Plan in place to comply</td><td>Immaterial will review options for the monitoring of diffuse VOC emissions.

The specific method to be employed will be agreed with the Environment Agency within 6 months of commencement of operation.</td></tr>
</table>

<table>
<tr><th>BATc No.</th><th>BAT Justification</th><th>Operating to BAT</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>(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 b.) 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 5 years.
(6) In the case of high-integrity equipment (see BAT 23 b.) 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 8 years.
(7) The minimum monitoring frequency may be reduced to once every 5 years if non-fugitive emissions are quantified by using measurements.
(8) This standard may be completed by EN 17628.

Note:
Optical gas imaging (OGI) is a useful complementary technique to the method EN 15446 (‘sniffing’) in order to identify sources of fugitive VOC emissions and is particularly relevant in the case of inaccessible sources (see Section 1.4.2.) This technique is described in EN 17628.
In the case of non-fugitive emissions, measurements may be complemented by the use of thermodynamic models. 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 Section 1.4.2).</td><td></td><td></td></tr>
<tr><td>BATc 23</td><td>In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to use a combination of the techniques given below 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>
<tr><th colspan="2">Technique</th><th>Description</th><th>Type of Emissions</th><th>Applicability</th></tr>
<tr><td colspan="5">1. Prevention techniques</td></tr>
<tr><td>a.</td><td>Limiting the number of emission sources</td><td>This includes:
• minimising pipe lengths;
• reducing the number of pipe connectors (e.g., flanges) and valves;
• using welded fittings and connections;</td><td>Fugitive and non-fugitive emissions</td><td>Applicability may be restricted by operational constraints in the case of existing plants.</td></tr>
</table></td><td>Yes</td><td>The processing plant has been designed to minimise diffuse VOC emissions where possible.
Plant VOC usage is relatively limited when compared against full scale industrial sites due to the scale of processing activities proposed at the site.
The following techniques have been applied to the process design:
1a) The process has been designed to capture all VOC into channelled emission control system where possible, VOC handling systems will use fully welded pipework where possible.
1b) High integrity equipment has been specified where possible e.g. seal-less pumps have been specified for handling VOC materials.</td></tr>
</table>

BATc No.	BAT Justification					Operating to BAT	Demonstration of BAT Compliance
			• using compressed air or gravity for material transfer.				
	b.	Use of high integrity equipment	High-integrity equipment includes, but is not limited to: • bellow valves 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 EN 13555) that are tightened according to technique e.; and • closed sampling system. The use of high-integrity equipment is especially relevant to prevent or minimise: • 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 2 000 bar). High-integrity equipment is selected, installed, and maintained according to the type of process and the process operating conditions.	Fugitive emissions	Applicability may be restricted by operational constraints in the case of existing plants. Generally applicable to new plants and major plant upgrades.		2d) all process plant equipment has been designed to be readily accessible for maintenance and monitoring 2e) plant assembly will be subject to pre-planned installation processes and acceptance testing and will be undertaken by competent installers to minimise potential for leaks. 2f) all VOC handling equipment will be subject to pre-planned inspection and maintenance / repair with replacement of key components as required. 2g) the plant and process reactions are going through detailed design which includes process optimisation and minimisation of VOC usage / emissions where possible. 2h) Reactor and vessel openings will be determined by the process batch recipe – unnecessary opening of vessels will be avoided. Process plant equipment has been designed with due consideration of the corrosion risk from the processes undertaken and the materials handled. 2i) whilst the processes undertaken are not 'closed' systems, they are designed so VOC vapour generated is collected into the channelled emission control systems for abatement prior to venting to atmosphere Compliance with the BAT-AEL for diffuse VOC emissions will be reviewed as part of the completion of the process mass balances.
	c.	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	Fugitive and non-fugitive emissions	Applicability may be restricted:		Mass balances for the plant operations are under development and will likely be the method used to estimate emissions to air, in combination

BATc No.	BAT Justification					Operating to BAT	Demonstration of BAT Compliance
			(see BAT 9 and BAT 10) and/or abatement (see BAT 11).		• for existing plants; and/or • by safety concerns (e.g., avoiding concentrations close to the lower explosive limit).		with periodic monitoring of channelled emissions to air and supporting calculations. Compliance with the BAT-AEL for diffuse VOC emissions will be reviewed as part of the completion of the process mass balances. The specific method to be employed for ongoing review of compliance with the BAT-AEL will be agreed with the Environment Agency within 6 months of commencement of operation.
	2. other techniques						
	d.	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 x	Applicability may be restricted by operational constraints in the case of existing plants.		
	e.	Tightening	This includes: • tightening of gaskets by personnel that is qualified according to EN 1591-4x and using the designed gasket stress (e.g., calculated according to EN 1591-1); • installing tight caps on open ends; and • using flanges selected assembled according to EN 13555.	Fugitive emissions	Generally applicable.		
	f.	Replacement of leaky equipment and/or parts	This includes the replacement of: • gaskets; • sealing elements (e.g., tank lid); and • packing material (e.g., valve stem packing material).	Fugitive emissions	Generally applicable.		
	g.	Reviewing and updating process design	This includes: • reducing the use of solvents and/or using solvents with lower volatility; • reducing the formation of side products containing VOCs;	Non-fugitive emissions	Applicability may be restricted in the case of existing plants due to operational constraints.		

BATc No.	BAT Justification					Operating to BAT	Demonstration of BAT Compliance
			• lowering the operating temperature; and • lowering the VOC content in the final product.				
	h.	Reviewing and updating operating conditions	This includes: • reducing the frequency and duration of reactor and vessel openings; and • 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. x		
	i.	Using closed systems	This includes: • vapour balancing (see Section 1.4.3); • closed systems for solid/liquid and liquid/liquid phase separations; • closed systems for cleaning operations; • closed sewers and/or wastewater treatment plants; • closed sampling systems; • closed storage areas; and • 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.		
	j.	Using techniques to minimise emissions from surfaces	This includes: • installing oil creaming systems on open surfaces; • periodically skimming open surfaces (e.g., removing floating matter);	Non-fugitive emissions	Applicability may be restricted by operational constraints in the case of existing plants.		

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance

		• installing anti-evaporation floating elements on open surfaces; • treating wastewater 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; and • using fixed-roof tanks connected to a waste gas treatment.		

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

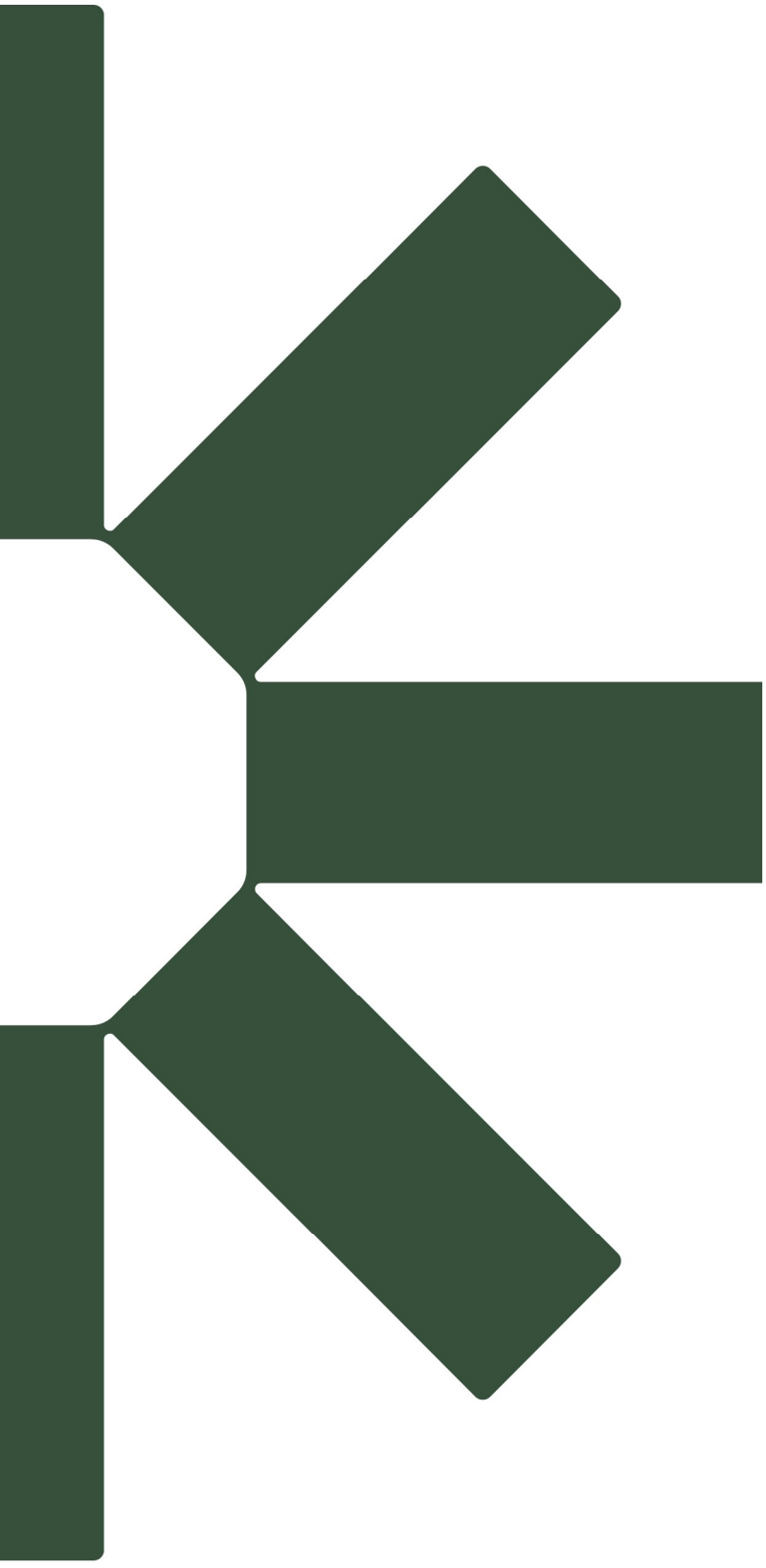
The emission levels for the use of solvents or the reuse of recovered solvents given below are associated with the general BAT conclusions given in Section 1.1 and Section 1.1.4.3.

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

Parameter	BAT-AEL (percentage of the solvent inputs) (Yearly Average) (1)
Diffuse VOC Emissions	≤ 5%

(1) The BAT-AEL does not apply to plants whose 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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