BAT Compliance Assessment - CO_2 Recovery and Liquefaction Plant

BOC Hydrogen Plant – EPR/BJ7522IJ

BOC Limited

North Tees Works, Middlesbrough, TS2 1TT

Prepared by:

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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 BREF Notes / BAT Conclusions.

EU BAT Conclusions	Applicability to the Installation Activites	Comments	Location of Assessment
LVIC-AAF Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers August 2007	Applicable	Current Activity is Section 4.2 Part A(1) (a) (i) for producing inorganic chemicals such as gases (Hydrogen). The operation of a steam methane reformer is covered under Environment Agency Sector Guidance Note IPPC S4.03 - Guidance for the Inorganic Chemicals Sector as part of the production process for ammonia	Appendix A
CWW Common Wastewater and Waste Gas Treatment / Management in the Chemical Sector May 2016	Applicable	As above	Appendix B
WGC Common Waste Gas Management and Treatment Systems in the Chemical Sector December 2022	Applicable	As above	Appendix C
Environment Agency – Draft Guidance - Emerging techniques for hydrogen production with carbon capture (2023)	Applicable	As above	Appendix D

All aspects relating to the hydrogen plant and the operation of the steam methane reformer are already covered under the existing Environmental Permit and the assessments previously submitted as part of the original Permit Application, previous Variations and responses to Improvement Conditions. It is not proposed to revisit such items as part of this review.

2.0 Project Timeline and Availability of Data

The CO_2 recovery and liquefaction plant is anticipated to be operational by September 2025.

Nothing has yet been installed on site, although some initial ground investigation works have commenced at the time of preparation of this document.

The project is currently around 90% through the detailed design phase, with the majority of the detailed process information and operating instructions / manuals still being finalised for issue.

As a result, many of the specific detailed items of technical information outlined as being required in the BAT guidance have not yet been issued for use.

In addition to this all of the site operational aspects have yet to be prepared for the CO_2 plant including:

- Updates to the overall site management systems to incorporate the CO_2 plant;
- Development of specific operating manuals and operating procedures;
- Development of inspection and maintenance routines and scheduling;
- Development of data monitoring and reporting plans;
- Staff training;
- Etc.

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

BOC is committed to ensuring that the CO_2 recovery and liquefaction plant is fully compliant with all applicable and relevant BAT requirements prior to commencement of operation and, if required, is happy to provide additional data to the Environment Agency once it is available.

Appendix A Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers BREF / Production of Inorganic Chemicals Sector (EPR 4.03)

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Table A: Assessment of Indicative BAT for the Inorganic Chemicals Sector (EPR 4.03)

The following table references the indicative BAT requirements contained within EPR 4.03 relative to the proposed new operations. Much of the 4.03 guidance relates to specified production activities, and hence this assessment has solely focussed on those aspects of the guidance applicable to the production of hydrogen (H_2) using steam methane reformer technology, with subsequent carbon dioxide (CO_2) recovery and liquefaction.

This variation is solely to cover the addition of the CO_2 recovery plant to the existing hydrogen production unit which has been authorised to operate since 2001, so this review of BAT compliance is focussed primarily on the proposed new CO_2 recovery aspects.

All aspects relating to the hydrogen plant and the operation of the steam methane reformer are already covered under the existing Environmental Permit and the assessments previously submitted as part of the original Permit Application, previous Variations and responses to Improvement Conditions. It is not proposed to revisit such items as part of this review.

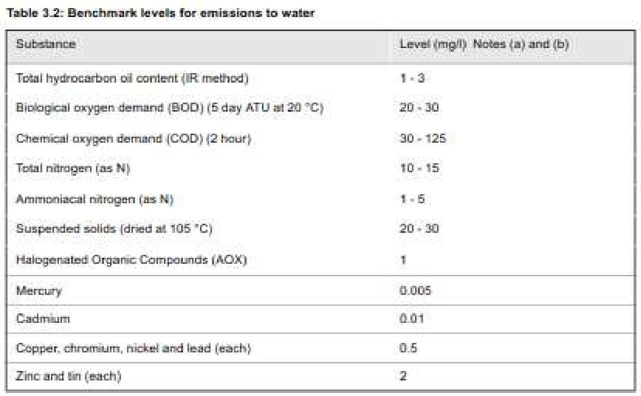
Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	Applicability		The site is currently regulated under EPR as a Section 4.2 - Inorganic Chemicals Part A(1) (a) Producing inorganic chemicals such as: (i) gases, such as … hydrogen. Hence Sector Guidance Note IPPC S4.03 - Guidance for the Inorganic Chemicals Sector is applicable.
2.1.7	**Ammonia Production**		
2.1.7.2.6	**Carbon Dioxide Absorption** After water vapour removal, the carbon dioxide component, which is ca. 17-19% of the process gases, is removed by one of the following: • absorption in a solvent, such as methanol. The absorbent is then primarily regenerated by reducing the pressure and allowing the carbon dioxide to desorb. • chemical reaction with a reagent. The most widely used reagent is monoethanolamine solution (with inhibitors to protect against excessive reagent degradation and corrosion) which is recovered by heating with low-pressure steam to reverse the reaction. This operation is a major consumer of low pressure steam.	Yes	Carbon dioxide absorption will be undertaken in a pressure swing absorber (PSA) column using an amine-based washing agent for CO_2 adsorption. The CO_2 is then recovered from the amine solution in a stripper column for further processing and liquefaction. A more detailed process description is provided in Section 4 of the main supporting document In the event that the CO_2 liquefaction part of the plant is either out of service (for maintenance etc.), or if there is no available route to sell the liquefied CO_2 into the market, then BOC will still have a contractual obligation to operate the Hydrogen production process, and under such circumstances the CO_2 recovered by the amine absorber would need to be vented to atmosphere. This would lead to emissions equivalent to

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	• physical adsorption. Pressure-swing adsorption (PSA) systems rely on the use of selective adsorbents. Individual components of the mixed gas stream are preferentially adsorbed at high pressure and then desorbed by reducing the pressure, and possibly purging, in a cyclic process. PSA systems are particularly useful where it is necessary to remove excess nitrogen as well as carbon dioxide. For new ammonia plants the following CO2 removal processes give residual CO2 concentrations in the range 100 - 1000 ppmv. and may be regarded as BAT: • AMDEA standard two-stage process, or similar. • Benfield process (HiPure, LoHeat), or similar. • Selexol or similar physical absorption processes.		those experienced historically from the operation of the H2 plant without CO_2 recovery. Assessment of the dispersion of vented CO_2 and the associated potential impacts has been undertaken as part of the plant design and is detailed in Appendix H.
2.2	**Emissions Control**		
2.2.1	**Point Source Emissions to Air**		
	1 In conjunction with information in this Guidance Note and relevant equivalent sections in the Guidance Notes for the Organics sector, information and recommendations in the BREF on Common Waste Water and Waste Gas Treatment/ Management Systems in the Chemical Sector (see Ref 1) should be formally considered as part of the assessment of BAT for point source releases to air.	Yes	The requirements of the CWW and CWG BREF Notes are presented and assessed later in this document.
	2 The benchmark values for point source emissions to air listed in Section 3.2.1 should be achieved unless alternative values are justified and agreed with the Regulator.	Yes	There are no routine emissions to air from the CO_2 plant. The only changes to the normal emissions profile at the installation will be a slight increase in the emissions of NOx from the Steam Methane Reformer (SMR) as a result of the reduction in the CO_2 content within the PSA tail gas returned to the SMR burner. This is a minor change and will not require any change in the existing SMR emissions limits for NOx or lead to any significant offsite impacts. Details of the predicted changes in NOx emissions from the SMR as a result of the addition the CO_2 plant are included in Section 8.1.1 of the main technical supporting document.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
			Under other than normal operating conditions (OTNOC), there are a number of venting systems on the CO_2 plant that could be used to ensure safe operation / shutdown of the plant – these would vent CO_2 to atmosphere and would operate very infrequently – no emission benchmark values would be applied to such venting. In the event that the H_2 plant was to operate at low load, there may be insufficient excess steam generated to allow the CO_2 liquefaction plant to operate, under which circumstances the CO_2 would need to be vented to atmosphere. Details of these venting activities are presented in Sections 7.1 and 8.1.2 of the main technical supporting document.
	3 The main chemical constituents of the emissions should be identified, including VOC and particulates speciation where practicable.	Yes	A detailed breakdown of plant emissions has been prepared and is summarised in Section 7.1 of the main technical supporting document.
	4 Vent and chimney heights should be assessed for dispersion capability and an assessment made of the fate of the substances emitted to the environment (see Section 4).	Yes	Modelling of the SMR was undertaken as part of the original EPR / PPC application. Details of the predicted changes in NOx emissions from the SMR as a result of the addition the CO_2 plant are included in Section 8.1.1 of the main technical supporting document. Modelling of CO_2 vents was undertaken to assess potential human health and occupational exposure risk during venting. The CO_2 plant design used the modelling output data to ensure that there are no significant on or offsite risks. Details of the CO_2 venting scenarios and associated modelling are presented in Sections 7.1 and 8.1.2 of the main technical supporting document.
	Control of visible particulate plumes 5 Even where particulate benchmarks are already met, the aim should be to avoid visible emissions. However, because plume visibility is extremely dependent on the particle size and reflectivity, the angle of the light, and the sky background, it is accepted that, even when BAT is employed and very low emissions are being achieved, some plumes may still be visible under particular conditions.	Yes	No particulate plumes are associated with the CO_2 plant

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	Control of visible condensed water plumes 6 The need to minimise water vapour plumes should always be considered as, in addition to possible local visual amenity issues, in severe cases, plumes can cause loss of light, fogging, icing of roads, etc. High moisture content can also adversely affect plume dispersion so, where practicable, water content of the exhaust stream should be reduced. Ideally, the exhaust should be discharged at conditions of temperature and moisture content that avoid saturation under a wide range of meteorological conditions, including cold damp conditions.	Yes	No visible condensed water plumes are expected from the CO_2 plant – see below
	7 The use of primary energy to reduce a plume simply because it is visible is not considered BAT. However, it may be appropriate to use waste or recovered heat, for example, heat in a gas stream prior to wet scrubbing can be used for re-heating the exhaust stream after scrubbing by means of a gas-gas heat exchanger. The use of energy for exhaust gas re-heat should be balanced against the benefits gained.	N/A	N/A no primary energy is used for plume reduction
	8 For cooling towers, plume abatement may be achieved by combining conductive heat exchange and evaporative cooling in the design of the tower. The degree of abatement required will depend upon local conditions and the distance from the towers to the nearest sensitive area. Plume modelling should be employed by an applicant to confirm that the visible (condensed) plume will not ground beyond the boundary fence nor reach areas of habitation at a height that will cause significant loss of light. As a guide, the width of the plume should not fill an arc which subtends an angle greater than 10° when viewed vertically from the ground.	Yes	Two cooling towers are included in the CO_2 plant design. These are mechanically assisted air-cooled evaporative cooling towers and due to the location of the site, the design of the units and the temperature loads on the system (cooling from approximately 41°C to 23°C), no offsite plumes are anticipated. The nearest residential receptors are located at 2.4km (King Georges Terrace - Middlesbrough) and 2.8km (Samphire Street – Port Clarence) and no visible plume impact is expected at these areas of habitation.
2.2.2	**Point Source Emissions to Surface Water and Sewer**		
	1 In conjunction with information in the following sections of this Guidance Note (Sections 2.2.2.1-2.2.2.9), information and recommendations in the BREF on Common Waste Water and Waste Gas Treatment/ Management Systems in the Chemical	Yes	The requirements of the CWW and CWG BREF Notes are presented and assessed later in this document.

Guidance Section No.	**Requirement**	Operating to Guidance Requirement	Demonstration of BAT Compliance
	Sector (Ref 1) should be formally considered as part of the assessment of BAT for point-source releases to surface water or sewer.		
	2 The following general principles should be applied in sequence to control emissions to water: • water use should be minimised and wastewater reused or recycled (see also Section 2.4.3) • contamination risk of process or surface water should be minimised (see also Section 2.2.5) • wherever possible, closed loop cooling systems should be used and procedures in place to ensure blow down is minimised • where any potentially harmful materials are used measures should be taken to prevent them entering the water circuit	Yes	Full details of the potential wastewater sources are presented in Section 7.2 and Appendix F of the main technical supporting document. The majority of these relate to process condensate or blowdown from the recirculating cooling water system. The plant design has sought to recover or recirculate water wherever possible so as to minimise wastewater discharge, however, inevitably some water discharge will be required. The plant design minimises the potential for harmful materials to be present in the water discharge, and where a potential risk of contamination may occur under certain operating conditions e.g. blowdown from the start up / shut down of the stripper column, operational controls will be put in place to isolate this effluent and test it for contamination prior to releasing it into the water discharge system. Should amine contamination be identified, then this water would be collected for offsite treatment and disposal.
	3 Consideration should be given to the use of filtration/osmosis or other techniques which allow the effluent water to be cleaned for release or, preferably, for return to the process. Particular consideration should be given to the fate of the concentrated residues of such techniques. These can often be returned to furnaces, evaporated, solidified, sent for incineration etc. Tankering of such residues off the site as waste, simply transfers the problem to another place unless they are sent to a facility with the genuine ability to recycle the materials.	N/A	Given the low volumes of blowdown and that such wastewater is generated by purging contaminants from the process systems, it is unlikely that such wastewater could be treated and re-used on site. it should also be noted that the site has no on-site water treatment and recovery facilities, or space for such facilities. The wastewater generated has low levels of contaminants potentially present and an assessment is underway to confirm whether these can be safely discharged to the Tees Estuary via the Sabic North Tees site drainage systems without treatment.
	4 If the pollutants in the wastewater are all readily biodegradable or the effluent contains only materials which are naturally occurring in much larger quantities in the receiving water, there may be justification for filtration/osmosis or similar techniques not being considered appropriate.	Will Comply at Commencement of Operation	The wastewater generated has low levels of contaminants potentially present and an assessment is underway to confirm whether these can be safely discharged to the Tees Estuary via the Sabic North Tees site drainage systems without treatment.
	5 Where prevention is not possible, the emissions benchmarks given in Section 3, should be achieved.	Will comply before	A detailed review of the Proposed Effluent Emissions is underway to confirm compliance.

<table>
<tr><th>Guidance Section No.</th><th>Requirement</th><th>Operating to Guidance Requirement</th><th>Demonstration of BAT Compliance</th></tr>
<tr><td></td><td>
Table 3.2: Benchmark levels for emissions to water
<table>
<tr><th>Substance</th><th>Level (mg/l) Notes (a) and (b)</th></tr>
<tr><td>Total hydrocarbon oil content (IR method)</td><td>1 - 3</td></tr>
<tr><td>Biological oxygen demand (BOD) (5 day ATU at 20 °C)</td><td>20 - 30</td></tr>
<tr><td>Chemical oxygen demand (COD) (2 hour)</td><td>30 - 125</td></tr>
<tr><td>Total nitrogen (as N)</td><td>10 - 15</td></tr>
<tr><td>Ammoniacal nitrogen (as N)</td><td>1 - 5</td></tr>
<tr><td>Suspended solids (dried at 105 °C)</td><td>20 - 30</td></tr>
<tr><td>Halogenated Organic Compounds (AOX)</td><td>1</td></tr>
<tr><td>Mercury</td><td>0.005</td></tr>
<tr><td>Cadmium</td><td>0.01</td></tr>
<tr><td>Copper, chromium, nickel and lead (each)</td><td>0.5</td></tr>
<tr><td>Zinc and tin (each)</td><td>2</td></tr>
</table></td><td>commencement of operation</td><td>Details of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are detailed in Section 7.2 of the main technical supporting document.
Appendix F presents a Surface Water Pollution Risk Assessment which includes an assessment of compliance with BAT AEL’s and published emissions benchmarks, along with an assessment of potential environmental impacts, including consideration of local nutrient neutrality in the Tees Estuary.
The emissions from the BOC site will comply with the appropriate BAT-AEL’s.</td></tr>
<tr><td></td><td>6 Where effluent is treated off-site at a sewage treatment works the above factors still apply. In particular, it should be demonstrated:
• the treatment provided at the sewage treatment works is as good as would be achieved if the emission were treated on-site, based on reduction of load (not concentration) of each substance to the receiving water. (The IPPC Environmental Assessments for BAT - H1 Software tool will assist in making this assessment.)
• that action plans are appropriate to prevent direct discharge of the waste-waters in the event of sewer bypass, (via storm/emergency overflows or at intermediate sewage pumping stations) - for example, knowing when bypass is occurring, rescheduling activities such as cleaning or even shutting down when bypass is occurring.
• that a suitable monitoring programme is in place for emissions to sewer.</td><td>N/A</td><td>N/A – no offsite treatment of effluent occurs.
Any liquid effluent that cannot be discharged to the River Tees e.g. due to contamination would be collected and removed from site as waste for offsite treatment / disposal.</td></tr>
<tr><td></td><td>7 There must be an understanding of the main chemical constituents of the treated effluent (including the make-up of the COD and the presence of any substances of particular</td><td>Will comply before commencement of operation</td><td>Details of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are detailed in Section 7.2 of the main technical supporting document.</td></tr>
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Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	concern to the aqueous environment). The fate of these chemicals in the environment should be assessed.		Appendix F presents a Surface Water Pollution Risk Assessment which includes an assessment of compliance with BAT AEL's and published emissions benchmarks, along with an assessment of potential environmental impacts, including consideration of local nutrient neutrality in the Tees Estuary.
	8 As a minimum, all emissions should be controlled to avoid a breach of water quality standards (see Section 3.2 and Section 4.1), but where another technique can deliver better results at reasonable cost it will be considered BAT and should be used (see Section 1.1). Unless reasonably self-evident, the EQS and BAT points should be demonstrated by calculations and/ or modelling in the Application.	Will comply before commencement of operation	As above
2.2.3	**Point Source Emissions to Groundwater** **Identify if there may be a discharge of any List I or List II substances and if any are identified, explain how the requirements of the Groundwater Regulations 1998 have been addressed.**		
	1 In general, there should be no permitted releases to groundwater of either a direct or indirect nature.	N/A	N/A – no releases to groundwater are proposed
	2 If there are releases to groundwater and they are to continue, the requirements of the Regulations, as summarised above, must be complied with.	N/A	N/A
2.2.4	**Control of Fugitive Emissions to Air**		
	1 Dust - The following general techniques should be employed where appropriate: • Covering of skips and vessels • Avoidance of outdoor or uncovered stockpiles (where possible) • Where dust creation is unavoidable, use of sprays, binders, stockpile management techniques, windbreaks and so on • Regular wheel and road cleaning (avoiding transfer of pollution to water and wind blow)	N/A	N/A – the CO_2 recovery plant does not involve the use of potentially dusty materials or processes.

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	• Closed conveyors, pneumatic or screw conveying (noting the higher energy needs), minimising drops. Filters on the conveyors to clean the transport air prior to release • Regular housekeeping • Enclosed silos (for storage of bulk powder materials) vented to fabric filters. The recycling of collected material should be considered under Section 2.6. • Enclosed containers or sealed bags used for smaller quantities of fine materials		
	2 VOCs • When transferring volatile liquids, the following techniques should be employed – subsurface filling via (anti-syphon) filling pipes extended to the bottom of the container, the use of vapour balance lines that transfer the vapour from the container being filled to the one being emptied, or an enclosed system with extraction to suitable abatement plant. • Vent systems should be chosen to minimise breathing emissions (for example pressure/ vacuum valves) and, where relevant, should be fitted with knock-out pots and appropriate abatement equipment. • Maintenance of bulk storage temperatures as low as practicable, taking into account changes due to solar heating etc. • The following techniques should be used (together or in any combination) to reduce losses from storage tanks at atmospheric pressure: – Tank paint with low solar absorbency – Temperature control – Tank insulation – Inventory management – Floating roof tanks – Bladder roof tanks – Pressure/vacuum valves, where tanks are designed to withstand pressure fluctuations	N/A	N/A – the CO_2 recovery plant does not involve the use of VOC's

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	– Specific release treatment (such as adsorption condensation)		
	3 For Information on Odour, see Section 2.2.6.	N/A	The CO_2 plant does not generally handle particularly odorous materials. The amine proposed for CO_2 recovery will be used within a sealed system which will be subject to an appropriate pre-planned inspection and maintenance programme. Any refiling / regeneration activities will be undertaken subject to specific controls and where possible using sealed systems (e.g. with back venting into the system), hence minimising the potential for any odour emission. Offsite odour emissions and impacts at nearby sensitive receptors are not anticipated.
2.2.5	**Fugitive Emissions to Surface Water, Sewer and Groundwater**		
	1 For subsurface structures: • establish and record the routing of all installation drains and subsurface pipework; • identify all sub-surface sumps and storage vessels; • engineer systems to minimise leakages from pipes and ensure swift detection if they do occur, particularly where hazardous (ie. Groundwater-listed) substances are involved; • provide secondary containment and/or leakage detection for sub-surface pipework, sumps and storage vessels; • establish an inspection and maintenance programme for all subsurface structures, e.g. pressure tests, leak tests, material thickness checks or CCTV	Yes	A detailed site drainage plan will be developed to record the locations of all below ground drainage and in-ground drainage sumps / chambers. A draft drainage plan for the LIC plant plot area is provided in Appendix A. Such systems will be designed to minimise the potential for leakage to occur, and will be subject to a scheduled inspection and maintenance programme during the plant operational lifetime to ensure they remain fit for purpose. Secondary containment for drainage systems is not proposed. Process pipework , or pipework transferring waste waters to the North Tees site drainage system will all be above ground.
	2 All sumps should: • be impermeable and resistant to stored materials; • be subject to regular visual inspection and any contents pumped out or otherwise removed after checking for contamination; • where not frequently inspected, be fitted with a high level probe and alarm, as appropriate;	Yes	Any sumps will be designed to meet the specified criteria i.e. • be impermeable and resistant to stored materials; • be subject to regular visual inspection and any contents pumped out or otherwise removed after checking for contamination; • where not frequently inspected, be fitted with a high level probe and alarm, as appropriate; • be subject to programmed engineering inspection (normally visual, but extending to water testing where structural integrity is in doubt).

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	• be subject to programmed engineering inspection (normally visual, but extending to water testing where structural integrity is in doubt).		
	3 For surfacing: • design appropriate surfacing and containment or drainage facilities for all operational areas, taking into consideration collection capacities, surface thicknesses, strength/reinforcement; falls, materials of construction, permeability, resistance to chemical attack, and inspection and maintenance procedures; • have an inspection and maintenance programme for impervious surfaces and containment facilities; • unless the risk is negligible, have improvement plans in place where operational areas have not been equipped with: – an impervious surface – spill containment kerbs – sealed construction joints – connection to a sealed drainage system	Yes	The main operational plant will be constructed over concrete hardstanding with drainage to concrete sumps. Such systems will be designed to appropriate current design standards and will provide an impermeable barrier to protect underlying soil and groundwater from potential pollution. An infrastructure monitoring programme will be put in place which will include periodic inspection and maintenance of site surfacing.
	4 All above-ground tanks containing liquids whose spillage could be harmful to the environment should be bunded. For further information on bund sizing and design, see the Releases to water references. Bunds should: • be impermeable and resistant to the stored materials; • have no outlet (that is, no drains or taps) and drain to a blind collection point; • have pipework routed within bunded areas with no penetration of contained surfaces; • be designed to catch leaks from tanks or fittings; • have a capacity greater than 110 percent of the largest tank or 25 percent of the total tankage, whichever is the larger; • be subject to regular visual inspection and any contents pumped out or otherwise removed under manual control after checking for contamination; • where not frequently inspected, be fitted with a high-level probe and an alarm, as appropriate;	Yes	All above ground tanks containing liquids whose spillage could be harmful to the environment will be installed within an appropriately designed secondary containment bund and will meet the specified requirements. An infrastructure monitoring programme will be put in place which will include periodic inspection and maintenance of bunds.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	• where possible, have tanker connection points within the bund, otherwise provide adequate containment; • be subject to programmed engineering inspection (normally visual, but extending to water testing where structural integrity is in doubt).		
	5 Storage areas for IBCs, drums, bags, etc, should be designed and operated to minimise the risk of releases to the environment. In particular: • Storage areas should be located away from watercourses and sensitive boundaries, (e.g. those with public access) and should be protected against vandalism. • Storage areas should have appropriate signs and notices and be clearly marked-out, and all containers and packages should be clearly labelled. • Where spillage of any stored substance could be harmful to the environment, the area should be appropriately kerbed or bunded. • The maximum storage capacity of storage areas should be stated and not exceeded, and the maximum storage period for containers should be specified and adhered to. • Appropriate storage facilities should be provided for substances with special requirements (eg. flammable, sensitive to heat or light) and formal arrangements should be in hand to keep separate packages containing incompatible substances (both “pure” and waste). • Containers should be stored with lids, caps and valves secured and in place - and this also applies to emptied containers. • All stocks of containers, drums and small packages should be regularly inspected (at least weekly). • Procedures should be in place to deal with damaged or leaking containers.	Yes	Storage areas for IBCs, drums, bags, etc, will be designed and operated to minimise the risk of releases to the environment and shall be stored within appropriate bunded / containment areas. Storage areas will be within the site area and will be located away from watercourses and protected against vandalism. Appropriate signage and labelling will be provided in all storage areas. An infrastructure monitoring programme will be put in place which will include periodic inspection and maintenance of storage areas. Management system protocols will be in place to deal with spills and leaks should they occur.
2.2.6	**Odour**	Yes	The CO_2 plant does not generally handle particularly odorous materials. The amine proposed for CO_2 recovery will be used within a sealed system which will be subject to an appropriate pre-planned inspection and maintenance programme.

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			Any refilling / regeneration activities will be undertaken subject to specific controls and where possible using sealed systems (e.g. with back venting into the system), hence minimising the potential for any odour emission. Offsite odour emissions and impacts at nearby sensitive receptors are not anticipated. Hence an Odour Management Plan is not required.
2.3	**Management**	Yes	BOC operates an Integrated Management System (IMS) which is certified to ISO 9001 and ISO 14001. The IMS contains a comprehensive set of standards covering all aspect of plant operations and the system is both audited internally and externally to ensure compliance with requirements. The site also maintains an environmental aspect and impacts register covering site operations which is updated on an annual basis. A summary of the IMS has been provided in Appendix I to the application The IMS meets all the management requirements stipulated within the S4.03 guidance and implements compliance requirements as defined in the Environmental Permit. The addition of the CO_2 plant to the overall site operations will be incorporated into the site IMS and the site operational and management procedures updated accordingly. The updated IMS components will be in place prior to commencement of operation.
	Operations and maintenance		
	1 Effective operational and maintenance systems should be employed on all aspects of the process whose failure could impact on the environment, in particular there should be: • documented procedures to control operations that may have an adverse impact on the environment • a defined procedure for identifying, reviewing and prioritising items of plant for which a preventative maintenance regime is appropriate • documented procedures for monitoring emissions or impacts	Yes	Implemented as part of IMS

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	• a preventative maintenance programme covering all plant, whose failure could lead to impact on the environment, including regular inspection of major 'non productive' items such as tanks, pipework, retaining walls, bunds ducts and filters		
	2 The maintenance system should include auditing of performance against requirements arising from the above and reporting the result of audits to top management.	Yes	Implemented as part of IMS
	Competence and training		
	3 Training systems, covering the following items, should be in place for all relevant staff which cover • awareness of the regulatory implications of the Permit for the activity and their work activities; • awareness of all potential environmental effects from operation under normal and abnormal circumstances • awareness of the need to report deviation from the Permit • prevention of accidental emissions and action to be taken when accidental emissions occur	Yes	Implemented as part of IMS
	4 The skills and competencies necessary for key posts should be documented and records of training needs and training received for these posts maintained.	Yes	Implemented as part of IMS
	5 The key posts should include contractors and those purchasing equipment and materials;	Yes	Implemented as part of IMS
	6 The potential environmental risks posed by the work of contractors should be assessed and instructions provided to contractors about protecting the environment while working on site.	Yes	Implemented as part of IMS
	7 Where industry standards or codes of practice for training exist (e.g. WAMITAB) they should be complied with.	Yes	Implemented as part of IMS where relevant
	Accidents/incidents/non-conformance		
	8 There should be an accident plan as described in Section 2.8 which: • identifies the likelihood and consequence of accidents	Yes	Implemented as part of IMS Note that the design of the CO_2 plant has included detailed safety and risk assessments including:

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	• identifies actions to prevent accidents and mitigate any consequences		HAZID, HAZOP, LOPA etc.
	9 There should be written procedures for handling, investigating, communicating and reporting actual or potential non-compliance with operating procedures or emission limits.	Yes	Implemented as part of IMS
	10 There should be written procedures for handling, investigating, communicating and reporting environmental complaints and implementation of appropriate actions	Yes	Implemented as part of IMS
	11 There should be written procedures for investigating incidents, (and near misses) including identifying suitable corrective action and following up	Yes	Implemented as part of IMS
	12 The company should conduct audits, at least annually, to check that all activities are being carried out in conformity with the above requirements. Preferably, these should be independent.	Yes	Implemented as part of IMS
	13 The company should report annually on environmental performance, objectives and targets, and future planned improvements. Preferably, these should be published environmental statements.	Yes	Implemented as part of IMS
	Organisation		
	14 The following are indicators of good performance which may impact on the Regulator’s resources, but not all will necessarily be insisted upon as Permit conditions:	Yes	Implemented as part of IMS
	15 The company should adopt an environmental policy and programme which: • includes a commitment to continual improvement and prevention of pollution; • includes a commitment to comply with relevant legislation and other requirements to which the organisation subscribes; and • identifies, sets, monitors and reviews environmental objectives and key performance indicators independently of the Permit.	Yes	Implemented as part of IMS

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	16 The company should have demonstrable procedures (eg. written instructions) which incorporate environmental considerations into the following areas: • the control of process and engineering change on the installation; • design, construction and review of new facilities and other capital projects (including provision for their decommissioning); • capital approval; and • purchasing policy	Yes	Implemented as part of IMS
	17 The company should operate a formal Environmental Management System. Preferably, this should be a registered or certified EMAS/ISO 14001 system (issued and audited by an accredited certification body).	Yes	Implemented as part of IMS
	18 The company should have a clear and logical system for keeping records of, amongst others: • policies • roles and responsibilities • targets • procedures • results of audits • results of reviews	Yes	Implemented as part of IMS
2.4.1	**Raw Materials**		
	1 The Operator should maintain a list of raw materials and their properties as noted above.	Yes	BOC maintains a list of raw materials and their properties
	2 The Operator should have procedures for the regular review of new developments in raw materials and for the implementation of any suitable ones with an improved environmental profile.	Yes	The design of the CO_2 plant has balanced the need to minimise environmental risk with ensuring that the plant will operate correctly and efficiently. Given the nature of the processes undertaken, there is limited opportunity for review of materials used in the process in order to select alternatives with an improved environmental profile. However, should such opportunities arise in the future, BOC would review their viability
	3 The Operator should have quality-assurance procedures for controlling the impurity content of raw materials	Yes	QA reviews are undertaken on the incoming natural gas feed, and on other materials used at site

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	4 The Operator should complete any longer-term studies needed into the less polluting options and should make any material substitutions identified.	Yes	See above
2.4.2	**Waste minimisation audit (minimising the use of raw materials)**		
	1 The Operator should carry out a waste minimisation audit at least every 4 years. If an audit has not been carried out in the 2 years prior to submission of the Application for a Permit and the details made known at the time of that application, then the first audit shall take place within 2 years of the issue of the Permit. The methodology used and an action plan for reducing the use of raw materials should be submitted to the Regulator within 2 months of completion of the audit. The audit should be carried out as follows: The Operator should analyse the use of raw materials, assess the opportunities for reductions and provide an action plan for improvements using the following three essential steps • process mapping • materials mass balance • action plan The use and fate of raw materials and other materials, including by-products, solvents and other support materials, such as fuels, catalysts and abatement agents, should be mapped onto a process flow diagram (see the Waste minimisation and raw materials efficiency references). This should be achieved by using data from the raw materials inventory and other company data as appropriate. Data should be incorporated for each principal stage of the operation in order to construct a mass balance for the installation.	Yes	Waste minimisation audits and KPI action planning will be undertaken as required by the Environmental Permit and in line with BOC corporate targets
	2 Using this information, opportunities for improved efficiency, changes in process and waste reduction should be generated and assessed. An action plan should then be prepared for implementing improvements to a timescale approved by the Regulator.	Yes	Waste minimisation audits and KPI action planning will be undertaken as required by the Environmental Permit and in line with BOC corporate targets
2.4.3	**Water Use**		

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	1 The Operator should carry out a regular review of water use (water efficiency audit) at least every 4 years. If an audit has not been carried out in the 2 years prior to submission of the application and the details made known at the time of the application, then the first audit should take place within 2 years of the issue of the Permit. • Flow diagrams and water mass balances for the activities should be produced. • Water-efficiency objectives should be established, with constraints on reducing water use beyond a certain level being identified (which usually will be usually installation-specific). • Water pinch techniques should be used in the more complex situations such as chemical plant, to identify the opportunities for maximising reuse and minimising use of water (see the Water efficiency references:).	Yes	Water use efficiency audits and KPI action planning will be undertaken as required by the Environmental Permit and in line with BOC corporate targets
	2 Within 2 months of completion of the audit, the methodology used should be submitted to the Regulator, together with proposals for a time-tabled plan for implementing water reduction improvements for approval by the Regulator.	Yes	As above
	3 The following general principles should be applied in sequence to reduce emissions to water: • Water-efficient techniques should be used at source where possible • Water should be recycled within the process from which it issues, by treating it first if necessary. Where this is not practicable, it should be recycled to another part of the process that has a lower water-quality requirement • In particular, if uncontaminated roof and surface water cannot be used in the process, it should be kept separate from other discharge streams, at least until after the contaminated streams have been treated in an effluent treatment system and been subject to final monitoring.	Yes	As above See response to 2.2.2
	4 Measures should be in place to minimise the risk of contamination of surface waters or groundwater by fugitive releases of liquids or solids (see Section 2.2.5).	Yes	See response to 2.2.5

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	5 The water-quality requirements associated with each use should be established, and the scope for substituting water from recycled sources identified and input into the improvement plan. Less contaminated water streams, such as cooling waters, should be kept separate from more contaminated streams where there is scope for reuse - though possibly after some form of treatment. Most wastewater streams will however need some form of treatment (see Section 2.2.2 for techniques) but for many applications, the best conventional effluent treatment can produces a water that is usable in the process directly or when mixed with fresh water. Though treated effluent quality can vary, it can often be recycled selectively - used when the quality is adequate, discharged when the quality falls below that which the system can tolerate.	Yes	See response to 2.2.2
	6 In particular, the cost of membrane technology continues to reduce, and they can be applied to individual process streams or to the final effluent from the effluent treatment plant, as appropriate. In some applications in some Sectors, they can supplement (or possibly completely replace) the ETP plant so that most water is recyclable and there is a greatly reduced effluent volume. Where the remaining, possibly concentrated, effluent stream is sufficiently small – and particularly where waste heat is available - further treatment by evaporation can lead to zero aqueous effluent. Where appropriate, the Operator should assess the costs and benefits of using membrane techniques to minimise water usage and effluent discharge.	Yes	See response to 2.2.2
	7 Water usage for cleaning and washing down should be minimised by: • vacuuming, scraping or mopping in preference to hosing down; • reusing wash water (or recycled water) where practicable; • using trigger controls on all hoses, hand lances and washing equipment.	Yes	Given the nature of the site operations i.e. a continuously operation process handling gaseous materials, there is minimal requirement for cleaning / washing down. Additional measures to minimise wash down water use are not considered to be warranted.

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	8 Fresh water consumption should be directly measured and recorded regularly at every significant usage point - ideally on a daily basis.	Yes	The primary waste use in the process is for the provision of feed water for the steam systems Within the existing H_2 plant. This water usage is monitored. The CO_2 plant has negligible additional water use and hence sub-metering of end users within the CO_2 plant is not proposed.
2.5	**Waste Handling**		
	1 A system should be in place and maintained which records the quantity, nature and origin of any waste that is disposed of or recovered - and also, where relevant, the destination, frequency of collection, mode of transport and treatment method for those wastes	Yes	All waste arisings from the CO_2 plant will be handled and disposed of in line with the existing site waste management protocols. Wastes generated on site are segregated and appropriate offsite disposal options are selected with due consideration of the waste hierarchy in the selection of the disposal route. All legally required data including waste transfer notes etc. are retained.
	2 Wastes should be segregated wherever practicable, and the disposal routes identified. Disposal should be as near to the point of generation as is practicable.	Yes	As above
	3 Records should be maintained of any waste sent off-site (Duty of Care)	Yes	As above
	4 Appropriate steps should be taken to prevent all emissions from waste storage and handling (e.g. liquid or solid spillage, dust or VOC emission, and odour) (see Section 2.2.4, Section 2.2.5 and Section 2.2.6).	Yes	As above
2.6	**Waste recovery or disposal** **Describe and justify how each waste stream is proposed to be disposed of.**	Yes	Note that the CO_2 will generate relatively small quantities of wastes for recovery / disposal. Wastes generated on site are segregated and appropriate offsite disposal options are selected with due consideration of the waste hierarchy in the selection of the disposal route.
	1 Waste should be recovered, unless it is technically or economically impractical to do so.	Yes	As above
	2 Where waste must be disposed of, the Operator should provide a detailed assessment identifying the best environmental options for waste disposal - unless the Regulator agrees that this is unnecessary. For existing	Yes	As above

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	disposal activities, this assessment may be carried out as an improvement condition to a timescale to be approved by the Regulator.		
2.7.1	**Basic energy requirements (1)** **Provide a breakdown of the energy consumption and generation by source and the associated environmental emissions.**		
	1 The Operator should provide the energy consumption information, shown in the table below, in terms of delivered energy and also, in the case of electricity, converted to primary energy consumption. For the public electricity supply, a conversion factor of 2.6 should be used. Where applicable, the use of factors derived from on-site heat and/or power generation, or from direct (non-grid) suppliers should be used. In the latter cases, the Operator should provide details of such factors. Where energy is exported from the installation, the Operator should also provide this information. All this information should be submitted in the application (in England and Wales the H1 software tool should be used to produce this information). The Operator should also provide energy flow information (such as "Sankey" diagrams or energy balances) showing how the energy is used throughout the process.	Yes	The detailed design of the CO_2 plant is still underway, and as part of this full mass balances and energy requirement calculations are being prepared. Electricity is supplied from the Northern Power Grid, and the plant will have a peak load of 515KVA. The existing H2 plant has a connection peak load of 1,650KVA. The CO_2 plant will not have any direct usage of natural gas with all steam required by the plant being provided from the existing H_2 plant. The addition of the CO_2 recovery and liquefaction plant will lead to a reduction in the energy use at the Installation, and an overall improvement in the energy efficiency of the installation. It has been designed to incorporate energy efficiency measures where appropriate which include: • Currently, approximately 10 tonnes per hour of low pressure (LP) (3.5barg) pass out steam are sent to be condensed to allow re-use of the water and some of the heat. Once the CO_2 plant is in steady state operation the amine column and reboiler within the CO_2 plant will transition to run on approximately 8 t/hr of this LP steam from the hydrogen plant. • The use of 80% of the LP steam in the CO_2 plant will therefore reduce the operating load on the LP steam condensers within the hydrogen plant. This will allow the hydrogen plant steam condenser fans to shut down saving approximately 132 MWh per year (15kw on continual duty). • The CO_2 compressors and also the ammonia compressors on the refrigeration circuits will be powered using HP steam from the

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			process, which in turn removes the need for electrical drives which would consume a further 1.5MW. - The reduction of the quantity of CO_2 within the PSA tail gas returned to the SMR for combustion will mean that less heat input to the SMR is required, as there is less gas (CO_2) to heat to the operating temperature. This will lead to a reduction in natural gas usage within the reformer of approximately 145kg/hr (1200t / year). In the event of the H_2 plant operating at significant turndown, there may be insufficient excess steam from the H2 plant to operate the CO_2 liquefaction plant, in which case the CO_2 would need to be vented to atmosphere.
	2 The Operator should provide the following Specific Energy Consumption (SEC) information. Define and calculate the SEC of the activity (or activities) based on primary energy consumption for the products or raw material inputs that most closely match the main purpose or production capacity of the installation. Provide a comparison of SEC against any relevant benchmarks available for the sector. (See BREF and Energy Efficiency Guidance)	Yes	The existing H_2 plant has a target Specific Energy Consumption which is assessed as an overall thermal efficiency target which is currently set at around 69% and is linked to the quantity of H_2 produced. The H_2 plant has continuous monitoring of natural gas usage (which is the primary thermal input) and uses this to provide continuous online feedback on the energy efficiency of the plant. Frequent monitoring of electrical usage is also undertaken and fed into the calculation of overall plant efficiency. This SEC target setting and monitoring approach will be expanded to incorporate the CO_2 plant.
	3 The Operator should provide associated environmental emissions. This is dealt with in the Operator's response to the emissions inventory using the H1 software tool.	Yes	CO_2 emissions associated with the use of electricity and gas are calculated and reported by the site as part of their UK ETS obligations.
2.7.2	**Basic energy requirements (2)** **Describe the proposed measures for improvement of energy efficiency.**		
	1 Operating, maintenance and housekeeping measures should be in place in the following areas. Indicative checklists of appropriate measures are provided in Appendix 2 of the guidance note H2 Energy efficiency for IPPC, where relevant:	Yes	Operations will be managed through the IMS and maintenance of key equipment to optimise energy use will be included in the pre-planned inspection and maintenance plans for the site.

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	• air conditioning, process refrigeration and cooling systems (leaks, seals, temperature control, evaporator/condenser maintenance) • operation of motors and drives • compressed gas systems (leaks, procedures for use) • steam distribution systems (leaks, traps, insulation) • space heating and hot-water systems • lubrication to avoid high-friction losses • boiler maintenance, e.g. optimising excess air • other maintenance relevant to the activities within the installation		Key process parameters will be monitored to allow tracking of energy efficiency and to identify aspects requiring unplanned maintenance attention.
	2 Basic, low cost, physical techniques should be in place to avoid gross inefficiencies. These should include insulation, containment methods, (such as seals and self-closing doors), and avoidance of unnecessary discharge of heated water or air (e.g. by fitting simple control systems such as timers and sensors).	Yes	The only building on the site is the control room which is a well-insulated and energy efficient structure.
	3 Energy-efficient building services should be in place to deliver the requirements of the Building Services section of the guidance note H2 Energy efficiency for IPPC. For energy intensive industries these issues may be of minor impact and should not distract effort from the major energy issues. They should nonetheless find a place in the programme, particularly where they constitute more than 5 percent of the total energy consumption.	Yes	As above
	4 Energy management techniques should be in place, according to the requirements of Section 2.3 noting, in particular, the need for monitoring of energy flows and targeting of areas for reductions.	Yes	The site operates to defined energy efficiency KPI's which combine both corporate and plant targets and initiatives. Key process parameters are monitored to allow tracking of energy efficiency and to identify aspects requiring maintenance attention. Energy efficiency is reviewed on a monthly basis with performance against targets being reviewed and targets being revised as appropriate.
	5 An energy efficiency plan should be provided that:	Yes	BOC manages energy efficiency through the IMS and compliance with corporate and site based energy efficiency targets.

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	• identifies all techniques relevant to the installation, including those listed above and in Section 2.7.3, that are applicable to the installation • estimates the CO2 savings that would be achieved by each measure over its lifetime • and, in the case where the activities are NOT covered by a CCA or DPA; provides information on the equivalent annual costs of implementation of the technique, the costs per tonne of CO2 saved and the priority for implementation. A procedure is given in the Energy Efficiency Guidance Note.		The site has continuous monitoring of natural gas usage at the site (which is the primary thermal input to the site and uses this to provide continuous online feedback on the energy efficiency of the plant. Frequent monitoring of electrical usage is also undertaken and fed into the calculation of overall plant efficiency. The site also has a pipeline of planned energy efficiency improvement projects Energy efficiency performance and the progress with improvement projects is regularly reported into the company systems, and reviewed on site on a monthly basis. Calculation and reporting of CO_2 equivalent emissions data is also undertaken in line with UK ETS requirements. The site does not maintain a separate Energy Efficiency Plan as this would be unnecessary repetition of the data already contained within the existing systems.
	6 An example format of the energy efficiency plan is shown in Table 2.	Yes	N/A
2.7.3	**Further energy-efficiency requirements** **Climate Change Agreement or Trading Agreement.**	Yes	BOC has a Climate Change Agreement - CIA/T00029 – BOC Ltd A copy of which has been provided within Appendix J.
	1 The following techniques should be implemented where they are judged to be BAT based on a cost/benefit appraisal according to the methodology provided in Appendix 4 of the Guidance Note H2 Energy efficiency for IPPC.	Yes	See Below
	Energy supply techniques 2 The following techniques should be considered: • use of Combined Heat and Power (CHP) • generation of energy from waste • use of less polluting fuels	Yes	The hydrogen plant uses natural gas as its primary fuel which is combusted within the SMR. The excess heat from the SMR is used to generate steam which is used in the plant. The steam demand for the CO_2 plant is to be provided using excess low-pressure steam generated by the operation of the SMR – See Section 2.7.1 for more details. Electricity is supplied to the site from the Northern Power Grid.

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			The nature of the H_2 plant operations are not suited to the use of the excess LP steam within a CHP process, and the proposed use of this steam within the CO_2 plant is considered to represent a much more appropriate use of the excess energy.
	3 The Operator should provide justification that the proposed or current situation represents BAT, irrespective of whether or not a CCA or DPA is in place, where there are other BAT considerations involved, eg.: • the choice of fuel impacts upon emissions other than carbon dioxide, eg. sulphur dioxide; • the potential for practical energy recovery from waste conflicts with energy efficiency requirements.	Yes	The use of natural gas as the primary fuel represents BAT, as it is the cleanest fuel available for the plant duty. The use of excess H_2 within the PSA tail gas as an additional fuel source to minimise the use of natural gas is also considered to represent BAT. The addition of the CO_2 plant will reduce the CO_2 content within the PSA tail gas, and hence improve the efficiency of the combustion systems. See Section 2.7.1 for more details.
	4 Where there is an on-site combustion plant other guidance is also relevant. For plants greater than 50MW, Operators should consult the IPC guidance on power generation (reference IPC S2 1.01 Combustion Processes: Large boilers and furnaces 50MW(th) and over and supplement IPC S3 1.01 Combustion Processes). Operators of plant of 20-50MW should consult the Local Authority Air Pollution Control guidance. On IPPC installations this guidance will be generally applicable to plant under 20MW also. (All are available from the EA website)	N/A	N/A
2.8	**Accidents** **Describe the documented system that you propose to be used to identify, assess and minimise the environmental risks and consequence of accidents.**	Yes	Implemented as part of the IMS The CO_2 plant has been designed to be compliant with the requirements of the Pressure System Safety Regulations 2000. The design of the CO_2 plant has included detailed safety and risk assessments including : HAZID, HAZOP, LOPA etc.
	1 A formal structured accident management plan should be in place which covers the following aspects:	Yes	The Installation has an existing Accident Management Plan implemented as part of the IMS. The operation of the CO_2 plant will be incorporated to this plan.

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	2 A - Identification of the hazards to the environment posed by the installation using a methology akin to a Hazop study. Areas to consider should include, but should not be limited to, the following: • transfer of substances (eg. filling or emptying of vessels); • overfilling of vessels; • emissions from plant or equipment (eg. leakage from joints, over-pressurisation of vessels, blocked drains); • failure of containment (eg. physical failure or overfilling of bunds or drainage sumps); • failure to contain firewaters; • wrong connections made in drains or other systems; • incompatible substances allowed to come into contact; • unexpected reactions or runaway reactions; • release of an effluent before adequate checking of its composition; • failure of main services (eg. power, steam, cooling water); • operator error; • vandalism.	Yes	The design of the CO_2 plant has included detailed safety and risk assessments including : HAZID, HAZOP, LOPA etc. These assessments have been undertaken to identify credible risks associated with the operation of the plant and to inform the design to effectively minimise and control such risks. These processes have also been used to identify required management controls and procedures which have then been implemented through the IMS. This process and the controls put in place meet the requirements of Section 2.8.
	3 assess the risks. Having identified the hazards, the process of assessing the risks should address six basic questions: • how likely are they to occur? (source frequency) • what gets out and how much? (risk evaluation of the event) • where does it end up? (predictions for the emission – what are the pathways and receptors?) • what are the consequences? (consequence assessment – the effects on the receptors) • what are the overall risks? (determination of the overall risk and its significance to the environment) • what can prevent or reduce the risk? (risk management – measures to prevent accidents and/or reduce their environmental consequences)	Yes	As above

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	4 The depth and type of assessment will depend on the characteristics of the installation and its location. The main factors to take into account are: • the scale and nature of the accident hazard presented by the installation and the activities • the risks to areas of population and the environment (receptors) • the nature of the installation and complexity of the activities and the relative difficulty in deciding and justifying the adequacy of the risk-control techniques	Yes	As above
	5 C - identification of the techniques necessary to reduce the risks. The following techniques are relevant to most installations: • there should be an up-to-date inventory of substances, present or likely to be present, which could have environmental consequences if they escape. This should include apparently innocuous substances that can be environmentally damaging if they escape (for example, a tanker of milk spilled into a watercourse can destroy its ecosystem). The Permit will require the Regulator to be notified of any significant changes to the inventory. • procedures should be in place for checking and handling raw materials and wastes to ensure compatibility with other substances with which they may accidentally come into contact. • storage arrangements for raw materials, products and wastes should be designed and operated to minimise risks to the environment. • there should be automatic process controls backed-up by manual supervision, both to minimise the frequency of emergency situations and to maintain control during emergency situations. Instrumentation will include, where appropriate, microprocessor control, trips and process	Yes	As above Pollution prevention measures are integrated into the plant design e.g. control system, containment systems, bunding etc. Operational risk will also be manged through the IMS and associated operating procedures etc. – See Section 2.3

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	interlocks, coupled with independent level, temperature, flow and pressure metering and high or low alarms. • physical protection should be in place where appropriate (eg. barriers to prevent damage to equipment from the movement of vehicles). • there should be appropriate secondary containment (eg. bunds, catchpots, building containment). • techniques and procedures should be in place to prevent overfilling of tanks - lliquid or powder - (eg. level measurement displayed both locally and at the central control point, independent high-level alarms, high-level cut-off, and batch metering). • where the installation is situated in a flood plain, consideration should be given to techniques which will minimise the risk of the flooding causing a pollution incident or making one worse. • security systems to prevent unauthorised access should be provided where appropriate. • there should be formal systems for the logging and recording of all incidents, near-misses, abnormal events, changes to procedures and significant findings of maintenance inspections. • there should be procedures for responding to and learning from incidents, near-misses, etc• the roles and responsibilities of personnel involved in incident management should be formally specified. • clear guidance should be available on how each accident scenario might best be managed (eg. containment or dispersion, to extinguish fires or to let them burn). • procedures should be in place to avoid incidents occurring as a result of poor communications between staff at shift change or during maintenance or other engineering work. • safe shutdown procedures should be in place. • communication channels with emergency services and other relevant authorities should be established, and available for use in the event of an incident. Procedures should include the		

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	assessment of harm following an incident and the steps needed to redress this • appropriate control techniques should be in place to limit the consequences of an accident, such as isolation of drains, provision of oil spillage equipment, alerting of relevant authorities and evacuation procedures. • personnel training requirements should be identified and training provided. • the systems for the prevention of fugitive emissions are generally relevant (Section 2.2.4 and Section 2.2.5) and in addition, for drainage systems: – procedures should be in place to ensure that the composition of the contents of a bund sump, or sump connected to a drainage system, are checked before treatment or disposal; – drainage sumps should be equipped with a high-level alarm or with a sensor and automatic pump to storage (not to discharge); – there should be a system in place to ensure that sump levels are kept to a minimum at all times; – high-level alarms and similar back-up instruments should not be used as the primary method of level control. • duplicate or standby plant should be provided where necessary, with maintenance and testing to the same standards as the main plant; • spill contingency procedures should be in place to minimise accidental release of raw materials, products and waste materials and then to prevent their entry into water. • process waters, potentially contaminated site drainage waters, emergency firewater, chemically-contaminated waters and spillages of chemicals should be contained and, where necessary, routed to the effluent system and treated before emission to controlled waters or sewer. Sufficient storage should be provided to ensure that this can be achieved. Any emergency firewater collection system should take account of the additional firewater flows and fire-fighting foams, and emergency storage lagoons may be needed to prevent		

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	contaminated firewater reaching controlled waters (see the Releases to water references). • consideration should be given to the possibility of containment or abatement of accidental emissions from vents and safety relief valves/bursting discs. Where this may be inadvisable on safety grounds, attention should be focused on reducing the probability of the emission.		
2.9	**Noise** **Describe the main sources of noise and vibration (including infrequent sources); the nearest noise sensitive locations and relevant environmental surveys which have been undertaken; and the proposed techniques and measures for the control of noise.**	Yes	Details of potential noise sources and impacts are detailed in Section 8.3 of the main technical supporting document. Appendix G2 presents details of the noise control concept for the design of the LIC plant. The design has included defined noise limits for all equipment and has been designed to achieve <85dB at 1m from the process area. Noise risk during operations will be managed through the IMS and potential sources of noise will be included in the pre-planned inspection and maintenance plans for the site. Appendix G4 presents a screening noise impact assessment. Potential offsite noise impacts have been assessed at both residential and ecological receptors, and no significant impacts are predicted.
	1 The Operator should employ basic good practice measures for the control of noise, including adequate maintenance of any parts of plant or equipment whose deterioration may give rise to increases in noise (for example, bearings, air handling plant, the building fabric, and specific noise attenuation kit associated with plant or machinery).	Yes	As above
	2 The Operator should employ such other noise control techniques necessary to ensure that the noise from the installation does not give rise to reasonable cause for annoyance, in the view of the Regulator. In particular, the Operator should justify where Rating Levels (LAeq,T) from the installation exceed the numerical value of the Background Sound Level (LA90,T).	Yes	As above
	3 Further justification will be required should the resulting field rating level (LAR,TR) exceed 50 dB by day and a facade rating	Yes	As above

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	level exceed 45 dB by night, with day being defined as 07:00 to 23:00 and night 23:00 to 07:00.		
	4 In some circumstances "creeping background" (i.e. creeping ambient) may be an issue. Where this has been identified in pre-application discussions or in previous discussions with the local authority, the Operator should employ such noise control techniques as are considered appropriate to minimise problems to an acceptable level within the BAT criteria.	Yes	As above
	5 Noise surveys, measurements, investigations (e.g. on sound power levels of individual items of plant) or modelling may be necessary for either new or for existing installations, depending upon the potential for noise problems. Where appropriate, the Operator should have a noise management plan as part of its management system.	Yes	As above
2.10	**Monitoring**		
2.10.1	**Emissions monitoring** **Describe the proposed measures for monitoring emissions, and the frequency, measurement methodology and evaluation procedure proposed.**	Will comply before commencement of operation	There are no routine emissions to air from the CO_2 plant, other than nitrogen venting from plant inertisation systems. CO_2 plant emissions would solely comprise CO_2 venting under OTNOC situations, and it is not intended that these would be sampled or analysed. Emissions to air from the SMR would continue to be monitored in line with the extant Permit requirements. Details of proposed monitoring of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are summarised in Section 11 of the main technical supporting document.
	1 Monitoring should generally be undertaken during all phases of operation (i.e. commissioning, start-up, normal operation and shutting-down) unless the Regulator agrees that it is inappropriate.	Will comply before commencement of operation	As Above

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	2 Continuous monitoring and recording (or at least sampling in the case of water) are likely to be required under the following circumstances: • Where the potential environmental impact is significant or the concentration of substance varies widely. • Where a substance is abated continuous monitoring of the substance is required to show the performance of the abatement plant. For example continuous monitoring of dust is needed after a fabric filter to show the effectiveness of the filter and indicate when maintenance is needed, or sampling BOD from an effluent treatment plant. • Where other control measures are required to achieve satisfactory levels of emission (e.g. material selection).	Will comply before commencement of operation	As Above
	3 Where effective surrogates are available, they may be used with the agreement of the Regulator (and without prejudice to legal requirements) to minimise monitoring costs.	Will comply before commencement of operation	As Above
	4 Where monitoring shows that substances are not emitted in significant quantities, it may be reasonable to reduce the monitoring frequency.	Will comply before commencement of operation	As Above
	Monitoring and reporting of emissions to air 5 Where appropriate, periodic visual and olfactory assessment of releases should be undertaken to ensure that all final releases to air should be essentially colourless, free from persistent trailing mist or fume and free from droplets.	Will comply before commencement of operation	As Above
	Monitoring and reporting of emissions to water and sewer 6 An analysis covering a broad spectrum of substances should be carried out to establish that all relevant substances have been taken into account for the purpose of setting emission limits. It should cover the substances listed in Schedule 5 of the Regulations unless it is agreed with the	Yes	Details of proposed monitoring of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are summarised in Section 11 of the main technical supporting document. All substances that could credibly be present in the water discharged have been identified and considered.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	Regulator that they are not applicable. The need to repeat such tests will depend upon the variability in the process and, for example, the variability of raw materials.		
	7 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, should also be monitored more regularly. 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	Yes	See Above
	8 In some sectors there may be releases of substances that are more difficult to measure and whose capacity for harm is uncertain, particularly when combined with other substances. "Whole effluent toxicity" monitoring techniques can therefore be appropriate to provide direct measurements of harm, for example, direct toxicity assessment. (See Section 2.2.2.)	Yes	Not Applicable – no such substances present in quantities capable of leading to harm
	Monitoring and reporting of waste emissions 9 For waste emissions, the following should be monitored and recorded: • the physical and chemical composition of the waste • its hazard characteristics • handling precautions and substances with which it cannot be mixed	Yes	All waste arisings from the CO_2 plant will be handled and disposed of in line with the existing site waste management protocols. Wastes generated on site are segregated and appropriate offsite disposal options are selected with due consideration of the waste hierarchy in the selection of the disposal route. All legally required documentation and data including waste transfer notes etc. are retained.
2.10.2	**Environmental monitoring (beyond installation)** **Describe the proposed measures for any environmental monitoring, and the frequency, measurement methodology and evaluation procedure proposed.**	Yes	The risk assessments prepared in support of the application for variation have demonstrated that no significant offsite impacts are expected. There is no intention to undertake environmental monitoring beyond the installation.
	1 The Operator should consider the need for environmental monitoring to assess the effects of emissions to controlled water, groundwater, air or land, or emissions of noise or odour.	Yes	As above
	2 Environmental monitoring may be required, for example, when: • there are vulnerable receptors	Yes	As above

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	• the emissions are a significant contributor to an Environmental Quality Standard (EQS) that may be at risk • the Operator is looking for departures from standards based on lack of effect on the environment; • to validate modelling work.		
	3 The need should be considered for: • groundwater, where it should be designed to characterise both quality and flow and take into account short- and long-term variations in both. Monitoring will need to take place both upgradient and down-gradient of the site • surface water, where consideration will be needed for sampling, analysis and reporting for upstream and downstream quality of the controlled water • air, including odour • land contamination, including vegetation, and agricultural products • assessment of health impacts • noise	Yes	As above
	4 Where environmental monitoring is needed, the following should be considered 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 for the Regulation	Yes	As above

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	5 Guidance on air quality monitoring strategies and methodologies can be found in Monitoring Guidance.	Yes	As above
2.10.3	**Monitoring of process variables** **Describe the proposed measures for monitoring those process variables that may have a significant effect on emissions.**	Yes	The plant incorporates a plc based control system which is linked to an integrated control system which allows control of the plant from the on-site control room and also from the offsite remote main control room. The plant includes monitoring of key process parameters to ensure that it operates to within its design parameters with data trending and system alarms set up to give warning of the potential for potential OTNOC scenarios such that appropriate actions can be taken to correct the plant operations.
	Some process variables may affect the environment and these should be identified and monitored as appropriate. Examples might be: • raw materials monitoring for contaminants where contaminants are likely and there is inadequate supplier information (see Section 2.4.1) • plant efficiency where it has an environmental relevance • abatement equipment performance (e.g. bag filter pressure drop) • energy consumption across the plant and at individual points-of-use in accordance with the energy plan. Frequency – normally continuous and recorded • fresh water use across the activities and at individual points-of-use should be monitored as part of the water-efficiency plan (see Section 2.4.3). Frequency – continuous and recorded	Yes	As above
2.10.4	**Monitoring standards (Standard Reference Methods)** **Use Of MCERTS**	Yes	All monitoring undertaken in relation to demonstrating compliance with the emission limits defined in the Environmental Permit will be undertaken in compliance with MCERTS.
2.10.5	**Quality assurance for CEMs**	Yes	The emissions from the SMR are monitored using CEMS and these systems are subject to the required quality assurance checks – this is unchanged by this variation.
2.11	**Closure**	Yes	The site condition at commencement of the operation of the CO_2 plant is considered in Section 3.1 of the main technical supporting document.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	Describe the proposed measures, upon definitive cessation of activities, to avoid any pollution risk and to return the site of operation to a satisfactory state (including measures relating to the design and construction of the installation, where appropriate).)		A Site condition report has been prepared in support of this Permit Variation application This comprises: • A Land Quality Risk Assessment (Desktop Study) – Presented in Appendix B1; and • A Phase 2 Site Investigation (Baseline Assessment) – Presented in Appendix B2. The pollution risk to soil and groundwater associated with the operation of the plant will be monitored throughout the Permit lifetime through a combination of: • Periodic review of the pollution risk posed by the site operations and materials handled at the site; • Infrastructure condition monitoring – to minimise the potential for a pollution pathway to occur; • And where appropriate periodic sampling of soil and groundwater at the site so as to confirm that no deterioration is occurring as a result of the site activities. This data would then be compiled into a formal Permit surrender document at time of closure. The site will also maintain a Site Closure Plan which will outline the measures to be implemented at closure to prevent pollution occurring during the closure and decommissioning process, remove the pollution risk and return the site to a satisfactory state to allow the surrender of the permit.
2.12	**Issues for multi-operator Installations**	N/A	The Installation is not multi-operator, although the overall North Tees site is.
3.1	**Emissions inventory** **Describe the nature, quantities and sources of foreseeable emissions into each medium (which will result from the techniques proposed in Section 2).**	Yes	There are no routine emissions to air from the CO_2 plant other than nitrogen venting associated with plant inertisation. The only changes to the normal emissions profile at the installation will be a slight increase in the emissions of NOx from the Steam Methane Reformer (SMR) as a result of the reduction in the CO_2 content within the PSA tail gas returned to the SMR burner. This is a minor change and will not require any change in the existing SMR emissions limits for NOx, or lead to any significant offsite impacts.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
			Under other than normal operating conditions (OTNOC), there are a number of venting systems on the CO_2 plant that could be used to ensure safe operation / shutdown of the plant – these would vent CO_2 to atmosphere and would operate very infrequently – no emission benchmark values would be applied to such venting. Details of these vents are presented in Section 7.1 of the main technical supporting document. Modelling of the SMR was undertaken as part of the original EPR / PPC application and has been reviewed in Section 8.1.1 of the main technical supporting document. Modelling of CO_2 vents has been undertaken to assess potential human health and occupational exposure risk during venting. The CO2 plant design has used modelling output data to ensure that there are no significant on or offsite risks. Details of the CO_2 venting scenarios and associated modelling are presented in Section 8.1.2 and Appendix H of the main technical supporting document. Details of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are detailed in Section 7.2 of the main technical supporting document. Appendix F presents a Surface Water Pollution Risk Assessment which includes an assessment of compliance with BAT AEL's and published emissions benchmarks, along with an assessment of potential environmental impacts, including consideration of local nutrient neutrality in the Tees Estuary.
	1 The Operator should compare the emissions with the benchmark values given in the remainder of this Section.	Yes	Details of the CO_2 plant water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are detailed in Sections 7.1 and 7.2 of the main technical supporting document. Comparison against relevant BAT-AEL's for emissions to water are presented in Appendix F. All emissions are within the published BAT-AEL values
	2 Where the benchmarks are not met, the Operator should revisit the responses made in Section 2 as appropriate and	Yes	As above

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	make proposals for improvements or justify not doing so as part of the BAT assessment.		
4	**Impact**		
4.1	**Impact Assessment** **Provide an assessment of the potential significant environmental effects (including transboundary effects) of the foreseeable emissions.**	Yes	Details of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are detailed in Section 7.2 of the main technical supporting document. Appendix F presents a Surface Water Pollution Risk Assessment which includes an assessment of compliance with BAT AEL's and published emissions benchmarks, along with an assessment of potential environmental impacts, including consideration of local nutrient neutrality in the Tees Estuary. Details of potential noise sources and impacts are detailed in Section 8.3 of the main technical supporting document. Appendix G4 presents a screening noise impact assessment. The design has included defined noise limits for all equipment and has been designed to achieve <85dB at 1m from the process area. Noise risk during operations will be managed through the IMS and potential sources of noise will be included in the pre-planned inspection and maintenance plans for the site. Potential offsite noise impacts have been assessed at both residential and ecological receptors, and no significant impacts are predicted.
	1 Provide a description, including maps as appropriate, of the receiving environment to identify the receptors of pollution. The extent of the area may cover the local, national and international (for example, transboundary effects) environment as appropriate	Yes	A detailed Ecological Assessment Report is presented in Appendix G3. This report contains the details of the key environmental receptors
	2 Identify important receptors, which may include: areas of human population including noise or odour-sensitive areas, flora and fauna (that is, Habitat Directive sites, special areas of conservation, Sites of Special Scientific Interest (SSSI or in Northern Ireland ASSI) or other sensitive areas), soil, water, that is groundwater (water below the surface of the ground in the saturation zone and in direct contact with the ground and subsoil) and watercourses (for example, ditches, streams,	Yes	As above The nearest residential receptors are located at 2.4km (King Georges Terrace - Middlesbrough) and 2.8km (Samphire Street – Port Clarence) These have been considered as part of the impact assessments detailed above.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	brooks, rivers), air, including the upper atmosphere, landscape, material assets and the cultural heritage.		
	3 Identify the pathways by which the receptors will be exposed (where not self-evident).	Yes	Potential Pathways have been identified in the specific impact assessments undertaken.
	4 Carry out an assessment of the potential impact of the total emissions from the activities on these receptors. IPPC Environmental Assessments for BAT provides a systematic method for doing this and will also identify where modelling needs to be carried out, to air or water, to improve the understanding of the dispersion of the emissions. The assessment will include comparison (see IPPC: A Practical Guide) with: • community EQS levels • other statutory obligations • non-statutory obligations • environmental action levels (EALs) and the other environmental and regulatory parameters defined in IPPC Environmental Assessments for BAT	Yes	As above – 4.1
	5 In particular it will be necessary to demonstrate that an appropriate assessment of vent and chimney heights has been made to ensure that there is adequate dispersion of the minimised emission(s) to avoid exceeding local ground-level pollution thresholds and limit national and transboundary pollution impacts, based on the most sensitive receptor, be it human health, soil or terrestrial ecosystems.	Yes	There are no routine emissions to air from the CO_2 plant other than nitrogen venting associated with plant inertisation. The only changes to the normal emissions profile at the installation will be a slight increase in the emissions of NOx from the Steam Methane Reformer (SMR) as a result of the reduction in the CO_2 content within the PSA tail gas returned to the SMR burner. This is a minor change and will not require any change in the existing SMR emissions limits for NOx, or lead to any significant offsite impacts. Under other than normal operating conditions (OTNOC), there are a number of venting systems on the CO_2 plant that could be used to ensure safe operation / shutdown of the plant – these would vent CO_2 to atmosphere and would operate very infrequently – no emission benchmark values would be applied to such venting. Details of these vents are presented in Section 7.1 of the main technical supporting document.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
			Modelling of the SMR was undertaken as part of the original EPR / PPC application and has been reviewed in Section 8.1.1 of the main technical supporting document. Modelling of CO_2 vents has been undertaken to assess potential human health and occupational exposure risk during venting. The CO_2 plant design has used modelling output data to ensure that there are no significant on or offsite risks. Details of the CO_2 venting scenarios and associated modelling are presented in Section 8.1.2 and Appendix H of the main technical supporting document.
	6 Where appropriate, the Operator should also recognise the chimney or vent as an emergency emission point and understand the likely behaviour. Process upsets or equipment failure giving rise to abnormally high emission levels over short periods should be assessed. Even if the Applicant can demonstrate a very low probability of occurrence, the height of the chimney or vent should nevertheless be set to avoid any significant risk to health. The impact of fugitive emissions can also be assessed in many cases.	Yes	As above
	7 Consider whether the responses to Sections 2 and 3 and this assessment adequately demonstrate that the necessary measures have been taken against pollution, in particular by the application of BAT, and that no significant pollution will be caused. Where there is uncertainty about this, the measures in Section 2 should be revisited as appropriate to make further improvements.	Yes	As above
	8 Where the same pollutants are being emitted by more than one permitted activity on the installation, the Operator should assess the impact both with and without the neighbouring emissions.	Yes	This has been considered
4.2	**Waste Management Licensing Regulations** **Explain how the information provided in other parts of the application also demonstrates that the requirements of the relevant objectives of the Waste Management**	N/A	Not applicable to the CO_2 plant - producer of waste only. All waste arisings from the CO_2 plant will be handled and disposed of in line with the existing site waste management protocols.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	Licensing Regulations 1994 have been addressed, or provide additional information in this respect.		Wastes generated on site are segregated and appropriate offsite disposal options are selected with due consideration of the waste hierarchy in the selection of the disposal route. All legally required documentation and data including waste transfer notes etc. are retained.
4.3	**The Habitats Regulations** **Provide an assessment of whether the installation is likely to have a significant effect on a European site in the UK and, if it is, provide an assessment of the implications of the installation for that site, for the purpose of the Conservation (Natural Habitats etc.) Regulations 1994 (SI 1994/2716)**	Yes	Consideration of potential impacts on Habitats sites has been included in the various environmental impact assessments as appropriate.

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

BAT Compliance Assessment - CO2 Recovery and Liquefaction Plant

BOC Hydrogen Plant – EPR/BJ7522IJ

BOC Limited

SLR Project No.: 416.065113.00001

9 October 2024

Table B: 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 site is currently regulated under EPR as a Section 4.2 - Inorganic Chemicals Part A(1) (a) Producing inorganic chemicals such as: (i) gases, such as … hydrogen. Hence the BRef document applies. This variation is solely to cover the addition of the CO_2 recovery plant to the existing hydrogen production unit which has been authorised to operate since 2001, so this review of BAT compliance is focussed primarily on the proposed new CO_2 recovery aspects.
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;	Yes	BOC operates an Integrated Management System (IMS) which is certified to ISO 9001 and ISO 14001. The IMS contains a comprehensive set of standards covering all aspect of plant operations and the system is both audited internally and externally to ensure compliance with requirements. The site also maintains an environmental aspect and impacts register covering site operations which is updated on an annual basis.

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: (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;		A summary of the IMS has been provided in Appendix I to the application. The IMS meets all the management requirements stipulated within BATc 1 and implements compliance requirements as defined in the Environmental Permit. The addition of the CO_2 plant to the overall site operations will be incorporated into the site IMS and the site operational and management procedures updated accordingly. The updated IMS components will be in place prior to commencement of operation. The site has management commitment and review of the IMS and Environmental Policy. Environmental performance indicators have been established and these are communicated to all employees. Employees are also encouraged to contribute to the continuous improvement programmes on site. The site has developed an Accident Management Plan in line with the requirements of the Environmental Permit. (v) The site undertakes periodic operational team meetings include a review of performance relating to environmental issues (such as loss of containment incidents), which are formally investigated, recorded and action tracked. (vi) Senior management undertakes periodic review of the IMS and associated targets. (vii) Wherever possible the site will choose cleaner technologies if possible. (viii) The site has a site closure and decommissioning plan as part of the requirements of the Environmental Permit.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	(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.		(ix) Key Performance Indicators are tracked and monitored. Sector benchmarking is undertaken where appropriate. (x) A waste management plan / protocol is in place. (xi) The site has shared security and emergency services with the wider North Tees Complex. (xii) The site maintains records of all waste water and waste gas streams. (xiii) N/A - the CO_2 plant does not handle particularly odorous materials and the amine proposed for CO_2 recovery will be within a sealed system, with any refiling / regeneration activities being undertaken subject to specific controls and where possible using sealed systems (e.g. with back venting into the system), hence minimising the potential for any odour emission. Hence an Odour Management Plan is not required. (xiv) Previous noise assessments have identified that the site activities pose no significant risk at noise sensitive receptors and hence a Noise Management Plan is not required.
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:	Yes	The site is compliant with the requirements of BAT 2. Full detailed design documentation is available for the H_2 plant, and being developed for the CO2 plant which will includes details on the H_2 production and CO_2 recovery processes which includes all the BATc 2 requirements. The site has comprehensive data on the emissions to air and water and this data in relation to the changes proposed by the Permit Variation has been provided as part of the application. This information is further supplemented by operational site data including emissions monitoring which is recorded and retained by the site.

<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, 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:
(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>Details of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are detailed in Section 7.2 of the main technical supporting document.
Appendix F presents a Surface Water Pollution Risk Assessment which includes an assessment of compliance with BAT AEL’s and published emissions benchmarks, along with an assessment of potential environmental impacts, including consideration of local nutrient neutrality in the Tees Estuary.</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>Yes</td><td>Details of proposed monitoring of emissions to water are detailed in Section 11 of the main technical supporting document.</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="2">Daily</td></tr>
<tr><td>Chemical Oxygen Demand (COD) (3)</td><td>No EN Standard available</td></tr>
</table></td><td>Yes</td><td>Emission point W2 is to the North Tees Site drainage system and then on to the River Tees.
Details of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are detailed in Section 7.2 of the main technical supporting document and the surface water pollution risk assessment presented in Appendix F.
Details of proposed monitoring of emissions to water are detailed in Section 11 of the main technical supporting document.</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 colspan="2">Total Suspended Solids (TSS)</td><td>EN 872</td><td rowspan="4"></td></tr>
<tr><td colspan="2">Total Nitrogen (TN) (4)</td><td>EN 12260</td></tr>
<tr><td colspan="2">Total Inorganic Nitrogen (4) (N_{inorg})</td><td>Various EN Standards available</td></tr>
<tr><td colspan="2">Total Phosphorus</td><td>Various EN Standards</td></tr>
<tr><td colspan="2">Adsorbable organically bound halogens (AOX)</td><td>EN ISO 9562</td><td>Monthly</td></tr>
<tr><td rowspan="6">Metals</td><td>Cr</td><td rowspan="6">Various EN Standards available</td><td rowspan="6">Monthly</td></tr>
<tr><td>Cu</td></tr>
<tr><td>Ni</td></tr>
<tr><td>Pb</td></tr>
<tr><td>Zn</td></tr>
<tr><td>Other metals, if relevant</td></tr>
<tr><td rowspan="5">Toxicity (5)</td><td>Fish Eggs (<i>Danio rerio</i>)</td><td>EN ISO 15088</td><td rowspan="5">To be decided based on a risk assessment, after an initial characterisation</td></tr>
<tr><td>Daphnia (<i>Daphnia magna Straus</i>)</td><td>EN ISO 6341</td></tr>
<tr><td>Luminescent bacteria (<i>Vibrio fischeri</i>)</td><td>EN ISO 11348-1,
EN ISO 11348-2 or
EN ISO 11348-3</td></tr>
<tr><td>Duckweed (<i>Lemna minor</i>)</td><td>EN ISO 20079</td></tr>
<tr><td>Algae</td><td>EN ISO 8692,
EN ISO 10253 or
EN ISO 10710</td></tr>
</table>
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.
</td><td></td><td>Any monitoring undertaken will be in accordance with MCERTS and the associated emissions monitoring standards listed under BATc4.</td></tr>
</table>

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	(4) TN and Ninorg monitoring are alternatives. (5) An appropriate combination of these methods can be used.		
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.	N/A	No significant diffuse VOC emission sources are anticipated.
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	N/A The CO_2 plant does not handle particularly odorous materials and the amine proposed for CO_2 recovery will be within a sealed system, with any refiling / regeneration activities being undertaken subject to specific controls and where possible using sealed systems (e.g. with back venting into the system), hence minimising the potential for any odour emission. Hence monitoring and assessment of potential odour impacts is not considered to be warranted.
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	Yes	Water use within the process is limited primarily to use in cooling systems. Wastewater is generated as condensate released from the CO_2 recovery process and cooling tower blowdown.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	reuse of waste water within the production process and to recover and reuse raw materials.		The generation of condensation effluents is minimised through appropriate control of the process and minimisation of cooling tower blowdown. Reuse of wastewater generated, is not typically possible within the process.
BATc 8	**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.	Yes	Uncontaminated condensate and cooling water are discharged directly into the North Tees Site Drainage system. Those condensate streams with the potential to contain trace pollutants are directed to the existing effluent tank on the H2 plant for neutralisation, with subsequent discharge to the North Tees Site Drainage system once the effluent is within the required specification. Clean uncontaminated water streams (e.g. rainwater) are collected separately for discharge into the North Tees Site Drainage system.
BATc 9	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.	Yes	Those condensate streams with the potential to contain trace pollutants are directed to the existing effluent tank on the H_2 plant for neutralisation, with subsequent discharge to the North Tees Site Drainage system once the effluent is within the required specification. This tank provides sufficient capacity to retain small quantities of process effluents in the event of process upsets. Should such effluent be unsuitable for discharge then the effluent will either be treated within the effluent tank prior to discharge, or collected for offsite treatment / disposal.
BATc 10	**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.	Yes	There is no opportunity for recovery of the trace pollutants present within the effluent generated, and no ability for them to be re-used in the process. Treatment of wastewater from the CO_2 plant will be limited to testing, and if necessary neutralisation of those effluent streams which contain potential pollutants. No other effluent treatment is provided on site.

<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></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>
<tr><td colspan="3">(1) These techniques are further described and defined in other BAT conclusions for the chemical industry.
(2) See BAT 11.
(3) See BAT 12.</td></tr>
</table>
The integrated waste water management and treatment strategy is based on the inventory of waste water streams (see BAT 2).</td><td></td><td>There is no integrated wastewater treatment plant on-site.
All uncontaminated or low risk process water discharges are discharged directly into the North Tees Site Drainage system.
Details of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are detailed in Section 7.2 of the main technical supporting document.
Appendix F presents a Surface Water Pollution Risk Assessment which includes an assessment of compliance with BAT AEL's and published emissions benchmarks, along with an assessment of potential environmental impacts, including consideration of local nutrient neutrality in the Tees Estuary.</td></tr>
<tr><td>BATc 11</td><td>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);</td><td>Yes</td><td>See BAT 10.</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>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).
<p>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.</p></td><td></td><td></td></tr>
<tr><td>BATc 12</td><td><p>In order to reduce emissions to water, BAT is to use an appropriate combination of final waste water treatment techniques.</p><p>Final waste water treatment is carried out as part of an integrated waste water management and treatment strategy (see BAT 10).</p><p>Appropriate final waste water treatment techniques, depending on the pollutant, include:</p>
<table>
<tr><th></th><th>Technique (1)</th><th>Typical Pollutants Abated</th><th>Applicability</th></tr>
<tr><td colspan="2"><i>Preliminary and primary treatment</i></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"><i>Biological treatment (secondary treatment), e.g.</i></td><td></td></tr>
</table></td><td>Yes</td><td>See BAT 10.</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>(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="2"><i>Nitrogen removal</i></td><td></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 environmental benefits. Not applicable when the final treatment does not include a biological treatment.</td></tr>
<tr><td colspan="2"><i>Phosphorus removal</i></td><td></td><td></td></tr>
<tr><td>(g)</td><td>Chemical precipitation</td><td>Phosphorus</td><td>Generally applicable.</td></tr>
<tr><td colspan="2"><i>Final solids removal</i></td><td></td><td></td></tr>
<tr><td>(h)</td><td>Coagulation and flocculation</td><td rowspan="4">Suspended solids</td><td rowspan="4">Generally applicable.</td></tr>
<tr><td>(i)</td><td>Sedimentation</td></tr>
<tr><td>(j)</td><td>Filtration (e.g. sand filtration, microfiltration, ultrafiltration)</td></tr>
<tr><td>(k)</td><td>Flotation</td></tr>
<tr><td colspan="4">(1) The descriptions of the techniques are given in Section 6.1</td></tr>
</table>
<p>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:</p>
<p>(i) the activities specified in Section 4 of Annex I to Directive 2010/75/EU;</p>
<p>(ii) independently operated waste water treatment plants specified in Section 6.11 of Annex I to Directive 2010/75/EU</p>
</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>
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 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:
</td><td></td><td></td></tr>
</table>

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

Table 2. BAT-AELs for direct emissions of nutrients to a receiving water body

Parameter	BAT-AEL's (Yearly Average)	Conditions
Total Nitrogen (1)	5-25 mg/l (2) (3)	The BAT-AEL applies if the emission exceeds 2.5 Te/yr
Total Inorganic Nitrogen (1)	5-20 mg/l (2) (3)	The BAT-AEL applies if the emission exceeds 2.0 Te/yr
Total Phosphorus	0.5-3.0 mg/l (4)	The BAT-AEL applies if the emission exceeds 300 kg/yr

(1) Either the BAT-AEL for total nitrogen or the BAT-AEL for total inorganic nitrogen applies.

(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.

<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>
<p>(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).</p>
<p>(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.</p>
<p>Table 3. BAT-AELs for direct emission of AOX and metals to a receiving water body</p>
<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>
<tr><td colspan="3">(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.</td></tr>
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</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>(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.</td><td></td><td></td></tr>
<tr><td colspan="2">4. Waste</td><td></td><td></td></tr>
<tr><td>BATc 13</td><td>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</td><td>Yes</td><td>All waste arisings from the CO_2 plant will be handled and disposed of in line with the existing site waste management protocols under the site Integrated Management System.
Wastes generated on site are segregated and appropriate offsite disposal options are selected with due consideration of the waste hierarchy in the selection of the disposal route.
All legally required documentation and data including waste transfer notes etc. are retained.</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</td><td>Generally applicable.</td></tr></table></td><td>N/A</td><td>Not applicable, there is no biological effluent treatment on site, and hence waste biological sludge due to the treatment techniques employed.</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>sedimentation, centrifugation, flotation, gravity belts, or rotary drums. Dewatering can be carried out by belt filter presses or plate filter presses.</td><td></td></tr>
<tr><td>(c)</td><td>Stabilisation</td><td>Sludge stabilisation includes chemical treatment, thermal treatment, aerobic digestion, or anaerobic digestion.</td><td>Not applicable to inorganic sludges. Not applicable for short-term handling before final treatment.</td></tr>
<tr><td>(d)</td><td>Drying</td><td>Sludge is dried by direct or indirect contact with a heat source.</td><td>Not applicable to cases where waste heat is not available or cannot be used.</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table></td><td></td><td></td></tr>
<tr><td colspan="2">5. Emissions to Air</td><td></td><td></td></tr>
<tr><td>BATc 15</td><td>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).</td><td>Yes</td><td>The plant is designed to operate as a sealed system in accordance with the Pressure System Safety Regulations.

There are no routine emissions to air from the CO_2 plant other than nitrogen venting associated with plant inertisation.
The only changes to the normal emissions profile at the installation will be a slight increase in the emissions of NOx from the Steam Methane Reformer (SMR) as a result of the reduction in the CO_2 content within the PSA tail gas returned to the SMR burner.
This is a minor change and will not require any change in the existing SMR emissions limits for NOx, or lead to any significant offsite impacts.

Under other than normal operating conditions (OTNOC), there are a number of venting systems on the CO_2 plant that could be used to ensure safe operation / shutdown of the plant – these would vent CO_2 to atmosphere and would</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>operate very infrequently – no emission benchmark values would be applied to such venting.
Details of these vents are presented in Section 7.1 of the main technical supporting document.
Modelling of the SMR was undertaken as part of the original EPR / PPC application and has been reviewed in Section 8.1.1 of the main technical supporting document.
Modelling of CO_2 vents has been undertaken to assess potential human health and occupational exposure risk during venting. The CO_2 plant design has used modelling output data to ensure that there are no significant on or offsite risks.
Details of the CO_2 venting scenarios and associated modelling are presented in Section 8.1.2 and Appendix H of the main technical supporting document.</td></tr>
<tr><td>BATc 16</td><td>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.
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>Yes</td><td>See BAT 15</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>
</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>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>
<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>N/A</td><td>No flaring is undertaken on site</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>BATc 19</td><td>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"><i>Techniques related to plant design</i></td></tr>
<tr><td>(a)</td><td>Limit the number of potential emission sources</td><td rowspan="4">Applicability may be restricted in the case of existing plants due to operability requirements.</td></tr>
<tr><td>(b)</td><td>maximise process-inherent containment features</td></tr>
<tr><td>(c)</td><td>select high-integrity equipment</td></tr>
<tr><td>(d)</td><td>facilitate maintenance activities by ensuring access to potentially leaky equipment</td></tr>
<tr><td colspan="3"><i>Techniques related to plant/equipment construction, assembly and commissioning</i></td></tr>
<tr><td>(e)</td><td>Ensure well-defined and comprehensive procedures for plant/equipment construction and assembly. This includes using designed gasket stress for flanged joint assembly</td><td rowspan="2"></td></tr>
<tr><td>(f)</td><td>ensure robust plant/equipment commissioning and handover procedures in line with the design requirements</td></tr>
</table>
</td><td>N/A</td><td>The CO_2 plant does not use VOC’s - No significant diffuse VOC emission sources are anticipated.</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 colspan="3">Techniques related to plant operation</td></tr>
<tr><td>(g)</td><td>Ensure good maintenance and timely replacement of equipment</td><td rowspan="3">Generally applicable.</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</td><td></td><td></td></tr>
<tr><td>BATc 20</td><td>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.</td><td>N/A</td><td>N/A
The CO_2 plant does not handle particularly odorous materials and the amine proposed for CO_2 recovery will be within a sealed system, with any refiling / regeneration activities being undertaken subject to specific controls and where possible using sealed systems (e.g. with back venting into the system), hence minimising the potential for any odour emission.
Hence an Odour Management Plan is not required.</td></tr>
<tr><td>BATc 21</td><td>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.</td><td>N/A</td><td>N/A
The CO_2 plant does not handle particularly odorous materials.
The effluent tank on the exiting hydrogen plant does not receive potentially odourous effluents.
There is no sludge generation, handling or treatment on site.</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></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 particular under anaerobic conditions.</td><td>Applicability may be restricted in the case of existing collection and storage systems.</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>
</td><td></td><td></td></tr>
<tr><td>BATc 22</td><td>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;
(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>Yes</td><td>Details of potential noise sources and impacts are detailed in Section 8.3 of the main technical supporting document.
Appendix G2 presents details of the noise control concept for the design of the LIC plant.
The design has included defined noise limits for all equipment and has been designed to achieve <85dB at 1m from the process area.
Noise risk during operations will be managed through the IMS and potential sources of noise will be included in the pre-planned inspection and maintenance plans for the site.
Appendix G4 presents a screening noise impact assessment.</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>Potential offsite noise impacts have been assessed at both residential and ecological receptors, and no significant impacts are predicted.
No detailed noise management plant is therefore considered to be required.</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>
<tr><td>(e)</td><td>Noise abatement</td><td>Inserting obstacles between emitters and receivers (e.g. protection walls, embankments and buildings).</td><td>Applicable only to existing plants; since the design of new plants should make this technique unnecessary. For existing plants, the insertion of</td></tr>
</table></td><td>Yes</td><td>See above</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></td><td>obstacles may be restricted by a lack of space.</td></tr></table></td><td></td><td></td></tr>
</table>

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

BAT Compliance Assessment - CO2 Recovery and Liquefaction Plant

BOC Hydrogen Plant – EPR/BJ7522IJ

BOC Limited

SLR Project No.: 416.065113.00001

9 October 2024

Table C: 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; — calcium nitrate;	-	The site is currently regulated under EPR as a Section 4.2 - Inorganic Chemicals Part A(1) (a) Producing inorganic chemicals such as: (i) gases, such as … hydrogen. Hence the BRef document applies. This variation is solely to cover the addition of the CO_2 recovery plant to the existing hydrogen production unit which has been authorised to operate since 2001, so this review of BAT compliance is focussed primarily on the proposed new CO_2 recovery aspects.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	— 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). 7. Emissions to air from waste incineration plants. This may be covered by the BAT conclusions for Waste Incineration (WI).		

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	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 CO2 Plant 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; 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;	Yes	BOC operates an Integrated Management System (IMS) which is certified to ISO 9001 and ISO 14001. The IMS contains a comprehensive set of standards covering all aspect of plant operations and the system is both audited internally and externally to ensure compliance with requirements. The site also maintains an environmental aspect and impacts register covering site operations which is updated on an annual basis. A summary of the IMS has been provided in Appendix I. The IMS meets all the management requirements stipulated within BATc 1 and

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	vi. determination of structures, roles and responsibilities in relation to environmental aspects and objectives and provision of the financial and human resources needed; vii. ensuring the necessary competence and awareness of staff whose work may affect the environmental performance of the installation (e.g., by providing information and training); viii. internal and external communication; ix. fostering employee involvement in good environmental management practices; x. establishing and maintaining a management manual and written procedures to control activities with significant environmental impact as well as relevant records; xi. effective operational planning and process control; xii. implementation of appropriate maintenance programmes; xiii. emergency preparedness and response protocols, including the prevention and/or mitigation of the adverse (environmental) impacts of emergency situations; xiv. when (re)designing a (new) installation or a part thereof, consideration of its environmental impacts throughout its life, which includes construction, maintenance, operation and decommissioning; xv. implementation of a monitoring and measurement programme; if necessary, information can be found in the Reference Report on Monitoring of Emissions to Air and Water from IED Installations; xvi. application of sectoral benchmarking on a regular basis; xvii. periodic independent (as far as practicable) internal auditing and periodic independent external auditing in order to assess the environmental performance and to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained; xviii. evaluation of causes of nonconformities, implementation of corrective actions in response to nonconformities, review of the effectiveness of corrective actions, and determination of whether similar nonconformities exist or could potentially occur; xix. periodic review, by senior management, of the EMS and its continuing suitability, adequacy and effectiveness; xx. following and taking into account the development of cleaner techniques. Specifically for the chemical sector, BAT is also to incorporate the following features in the EMS: xxi. an inventory of channelled and diffuse emissions to air (see BAT 2);		implements compliance requirements as defined in the Environmental Permit. The addition of the CO_2 plant to the overall site operations will be incorporated into the site IMS and the site operational and management procedures updated accordingly. The updated IMS components will be in place prior to commencement of operation.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	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; f. flammability, lower and higher explosive limits, reactivity; g. monitoring methods (see BAT 8);	Yes	The site is compliant with the requirements of BAT 2. Full detailed design documentation exists for the H_2 plant, and is being prepared for the CO_2 plant. This will include details on the H_2 production and CO_2 recovery processes which includes all the BATc 2 requirements. The site has comprehensive data on the emissions to air and water and this summary data in relation to the changes proposed by the Permit Variation has been provided as part of the application. This information is further supplemented by operational site data including emissions monitoring which is recorded and retained by the site. No significant diffuse emissions are anticipated.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	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).		
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; 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.);	Yes	The plant incorporates a plc based control system which is linked to an integrated control system which allows control of the plant from the on-site control room and also from the offsite remote main control room. The plant includes monitoring of key process parameters to ensure that it operates to within its design parameters with data trending and system alarms set up to give warning of the potential for potential OTNOC scenarios such

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	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.		that appropriate actions can be taken to correct the plant operations. The site Integrated Management System includes aspects to minimise the risk of OTNOC occurring which includes: • Identification of critical equipment; • Scheduled Inspection and Maintenance of critical plant (as well as other plant); and • Control system testing. Following OTNOC events (should they occur), these would be investigated, and corrective actions implemented where appropriate in line with the requirements of the IMS.
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	There are no routine emissions to air from the CO_2 plant, other than nitrogen venting from plant inertisation systems, and hence no integrated waste gas management and treatment strategy. The only emissions to air under normal operating conditions are the SMR flue gas from the H_2 plant. The only changes to the normal emissions profile at the installation will be a slight increase in the emissions of NOx from the Steam Methane Reformer (SMR) as a result of the reduction in the CO_2 content within the PSA tail gas returned to the SMR burner. This is a minor change and will not require any change in the existing SMR emissions limits for NOx, or lead to any significant offsite impacts.

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
			Under other than normal operating conditions (OTNOC), there are a number of venting systems on the CO_2 plant that could be used to ensure safe operation / shutdown of the plant – these would vent CO_2 to atmosphere and would operate very infrequently – no emission abatement would be applied to such venting.
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	N/A	As above - no opportunity for combination of waste streams exists.
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	As above – The plant has been correctly designed in line with best practice and will be correctly maintained.
Monitoring			
BATc 7	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.	Yes	The plant incorporates a plc based control system which is linked to an integrated control system which allows control of the plant from the on-site control room and also from the offsite remote main control room. The plant includes monitoring of key process parameters to ensure that it operates to within its design parameters with data trending and system alarms set up to give warning of the potential for potential OTNOC scenarios such that appropriate actions can be taken to correct the plant operations. There is no treatment / pretreatment of emissions to air.

<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>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 rowspan="6">Carbon monoxide (CO)</td><td rowspan="2">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 rowspan="2">BAT 16</td></tr>
<tr><td>Any stack with a CO mass flow of < 2 kg/h</td><td>EN 15058</td><td>Once every 6 months (3)(4)</td></tr>
<tr><td rowspan="2">Process furnace/heaters</td><td>Any stack with a CO mass flow of ≥ 2 kg/h</td><td>Generic EN standards (5)</td><td>Continuous (6)</td><td rowspan="2">BAT 36</td></tr>
<tr><td>Any stack with a CO mass flow of < 2 kg/h</td><td>EN 15058</td><td>Once every 6 months (3)(4)</td></tr>
<tr><td rowspan="2">All other processes / sources</td><td>Any stack with a CO mass flow of ≥ 2 kg/h</td><td>Generic EN standards (5)</td><td>Continuous</td><td rowspan="2">BAT 18</td></tr>
<tr><td>Any stack with a CO</td><td>EN 15058 X</td><td>Once every 6 months (3)(7)</td></tr>
</table>
</td><td>Yes</td><td>There are no routine emissions to air from the CO_2 plant other than nitrogen venting from plant inertisation systems.
CO_2 plant emissions would solely comprise CO_2 venting under OTNOC situations, and it is not intended that these would be sampled or analysed.

Emissions to air from the H_2 plant steam methane reformer will continue to be monitored using CEMS in line with the extant Permit requirements.
The CEMS will comply with the appropriate testing and analysis standards.</td></tr>
</table>

BATc No.	BAT Justification						Operating to BAT	Demonstration of BAT Compliance
			mass flow of < 2 kg/h					
	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		
			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		

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

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<table>
<tr><td>$PM_{2.5}$ and PM_{10}</td><td>All processes / sources</td><td>Any stack</td><td>EN ISO 23210</td><td>Once every year (3)(7)</td><td>BAT 14</td></tr>
<tr><td>Propylene oxide</td><td>All processes / sources</td><td>Any stack</td><td>No EN standards available</td><td>Once every 6 months (3)</td><td>BAT 11</td></tr>
<tr><td rowspan="6">Sulphur dioxide (SO_2)</td><td rowspan="2">Thermal treatment</td><td>Any stack with a SO_2 mass flow of ≥ 2.5 kg/h</td><td>Generic EN standards (5)</td><td>Continuous</td><td rowspan="2">BAT 16</td></tr>
<tr><td>Any stack with a SO_2 mass flow of <2.5kg/h</td><td>EN 14791</td><td>Once every 6 months (3)(4)</td></tr>
<tr><td rowspan="2">Process furnaces / heaters</td><td>Any stack with a SO_2 mass flow of ≥ 2.5 kg/h</td><td>Generic EN standards (5)</td><td>Continuous (6)</td><td rowspan="2">BAT 18, BAT 36</td></tr>
<tr><td>Any stack with a SO_2 mass flow of <2.5kg/h</td><td>EN 14791</td><td>Once every 6 months (3)(4)</td></tr>
<tr><td rowspan="2">All other processes / sources</td><td>Any stack with a SO_2 mass flow of ≥ 2.5 kg/h</td><td>Generic EN standards (5)</td><td>Continuous</td><td rowspan="2">BAT 18</td></tr>
<tr><td>Any stack with a SO_2 mass flow of <2.5kg/h</td><td>EN 14791 X</td><td>Once every 6 months (3)(4)</td></tr>
<tr><td>Tetrachloromethane</td><td>All processes / sources</td><td>Any stack</td><td>No EN standards available</td><td>Once every 6 months (3)</td><td>BAT 11</td></tr>
<tr><td>Toluene</td><td>All processes / sources</td><td>Any stack</td><td>No EN standards available</td><td>Once every 6 months (3)</td><td>BAT 11</td></tr>
<tr><td>Trichloromethane</td><td>All processes / sources</td><td>Any stack</td><td>No EN standards available</td><td>Once every 6 months (3)</td><td>BAT 11</td></tr>
<tr><td>Total volatile organic carbon (TVOC)</td><td>Production of polyolefins (10)</td><td>Any stack with a TVOC mass flow of ≥ 2 kg C/h</td><td>Generic EN standards (5)</td><td>Continuous</td><td>BAT 11, BAT 25</td></tr>
</table>
</td><td></td><td></td></tr>
</table>

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

		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)	

(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.

<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>(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>N/A</td><td>N/A – NO VOC’s are used on the CO_2 Plant</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 applicable</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>
</table></td><td>N/A</td><td>Not applicable</td></tr>
</table>

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

e.	Thermal oxidation	See Section 1.1.1.	Applicability of recuperative and regenerative thermal oxidation to existing plants may be restricted by design and/or operational constraints. Applicability may be restricted where the energy demand is excessive due to the low concentration of the compound(s) concerned in the process off-gases.
f.	Bioprocesses	See Section 1.4.1	Only applicable to the treatment of biodegradable compounds.

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

Substance / Parameter	BAT-AEL (mg/Nm^3) Daily average or average over the sampling period (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)

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

<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 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"><i>Specific techniques to reduce PCDD/F emissions</i></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>
<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"><i>Other techniques not primarily used to reduce PCDD/F emissions</i></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.</td><td>N/A</td><td>Not applicable – no thermal treatment of waste gases - 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><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.
<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>N/A</td><td>Not applicable
No dust and particulate-bound metals present</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.
</td><td>N/A</td><td>Not applicable
No dust and particulate-bound metals 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><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>
<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>Yes</td><td>The plant has been designed specifically to recover CO_2 present in the waste gases from the H_2 production process via absorption.</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>
</table>
</td><td>N/A</td><td>There is no thermal treatment of waste gases within the CO_2 plant.

The H2 plant SMR will combust the PSA tail gas returned to the SMR burner after CO_2 and H_2 separation along with Natural Gas. The SMR burner is a Low NOx Burner.

The BAT-AEL's associated with channelled emissions to air of NOx from waste gas treatment are not applicable to the SMR.</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>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 of NOx precursors prior to thermal or catalytic oxidation, e.g., by absorption, adsorption or condensation.</td><td>NOx</td><td>Generally applicable.</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 SCR or SNCR</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 SCR or SNCR</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 ($mg\text{-}Nm^3$) (Daily average or average over the sampling period)**
Ammonia (NH_3)	2 - 10 (1) (2) (3)
Elemental chlorine (Cl_2)	<0.5 - 2 (4)(5)
Gaseous fluorides, expressed as HF	≤ 1 (4)
Hydrogen cyanide (HCN)	< 0.1 – 1 (4)

<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>Gaseous chlorides, expressed as HCl</td><td>1-10 (6)</td></tr><tr><td>Nitrogen oxides (NOx)</td><td>10 - 150 (7) (8) (9) (10)</td></tr><tr><td>Sulphur oxides (SO_2)</td><td>< 3 - 150 (11)(9)</td></tr><tr><td colspan="2">(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.</td></tr></table>The associated monitoring is given in BAT 8.</td><td></td><td></td></tr>
<tr><td colspan="2">**Diffuse VOC Emissions to Air**</td><td></td><td></td></tr>
<tr><td>BATc 19</td><td>In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to elaborate and implement a management system for diffuse VOC emissions, as part of the environmental management system (see BAT 1), that includes all of the following features:
i. Estimating the annual quantity of diffuse VOC emissions (see BAT 20).
ii. Monitoring diffuse VOC emissions from the use of solvents by compiling a solvent mass balance, if applicable (see BAT 21).</td><td>N/A</td><td>Not applicable
There are no VOC’s associated with the operation of the CO_2 plant</td></tr>
</table>

BATc No.	BAT Justification	Operating to BAT	Demonstration of BAT Compliance
	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. iv. Establishing and implementing a detection and reduction programme for non-fugitive VOC emissions that includes all of the following features:		

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

<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>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:
• chemical properties of the substance (e.g., vapour pressure, molecular mass);</td></tr>
</table></td><td>N/A</td><td>Not applicable
There are no significant diffuse VOC emission sources associated with the operation of the CO_2 plant.</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>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><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></table></td><td>N/A</td><td>Not applicable
There are no significant diffuse VOC emission sources associated with the operation of the CO_2 plant.</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>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.).
(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.</td></tr>
</table></td><td>N/A</td><td>Not applicable
There are no significant diffuse VOC emission sources associated with the operation of the CO_2 plant.</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>(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"><i>1. Prevention techniques</i></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;
• ● using compressed air or gravity for material transfer.</td><td>Fugitive and non-fugitive emissions</td><td>Applicability may be restricted by operational constraints in the case of existing plants.</td></tr>
<tr><td>b.</td><td>Use of high integrity equipment</td><td>High-integrity equipment includes, but is not limited to:</td><td>Fugitive emissions</td><td>Applicability may be restricted by operational constraints in the</td></tr>
</table></td><td>N/A</td><td>Not applicable
There are no significant diffuse VOC emission sources associated with the operation of the CO_2 plant.</td></tr>
</table>

BATc No.	BAT Justification					Operating to BAT	Demonstration of BAT Compliance
			• 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.		case of existing plants. Generally applicable to new plants and major plant upgrades.		
	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 (see BAT 9 and BAT 10) and/or abatement (see BAT 11).	Fugitive and non-fugitive emissions	Applicability may be restricted: • for existing plants; and/or • by safety concerns (e.g., avoiding concentrations		

BATc No.	BAT Justification					Operating to BAT	Demonstration of BAT Compliance
					close to the lower explosive limit).		
	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; • lowering the operating temperature; and • lowering the VOC content in the final product.	Non-fugitive emissions	Applicability may be restricted in the case of existing plants due to operational constraints.		
	h.	Reviewing and updating	This includes:	Non-fugitive emissions	Generally applicable. x		

BATc No.	BAT Justification					Operating to BAT	Demonstration of BAT Compliance
		operating conditions	• 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.				
	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); • installing anti-evaporation floating elements on open surfaces; • treating wastewater streams to remove VOCs and send the VOCs to recovery (see BAT 9	Non-fugitive emissions	Applicability may be restricted by operational constraints in the case of existing plants.		

<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>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.</td><td></td><td></td></tr>
</table>
<p>BAT conclusions for the use of solvents or the reuse of recovered solvents</p>
<p>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.</p>
<p>BAT-associated emission level (BAT-AEL) for diffuse VOC emissions to air from the use of solvents or the reuse of recovered solvents</p>
<table>
<tr><th>Parameter</th><th>BAT-AEL (percentage of the solvent inputs) (Yearly Average) (1)</th></tr>
<tr><td>Diffuse VOC Emissions</td><td>≤ 5%</td></tr>
<tr><td colspan="2">(1) The BAT-AEL does not apply to plants whose annual consumption of solvents is lower than 50 tonnes.</td></tr>
</table>
<p>The associated monitoring is given in BAT 20, BAT 21 and BAT 22.</p>
</td><td></td><td></td></tr>
</table>

Appendix D Emerging Techniques for Hydrogen Production with Carbon Capture (2023)

BAT Compliance Assessment - CO2 Recovery and Liquefaction Plant

BOC Hydrogen Plant – EPR/BJ7522IJ

BOC Limited

SLR Project No.: 416.065113.00001

9 October 2024

Table D: Assessment of BAT Compliance – Emerging Techniques for Hydrogen Production with Carbon Capture – 2023

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
Scope	EA Draft Sector Guidance This variation is solely to cover the addition of the CO_2 recovery plant to the existing hydrogen production unit which has been authorised to operate since 2001, so this review of BAT compliance is focussed primarily on the proposed new CO_2 recovery aspects. All aspects relating to the hydrogen plant and the operation of the steam methane reformer are already covered under the existing Environmental Permit and the assessments previously submitted as part of the original Permit Application, previous Variations and responses to Improvement Conditions. It is not proposed to revisit such items as part of this review. The proposed CO_2 recovery plant is intended to recover a proportion of the CO_2 present in the gases currently vented from the SMR. It is not intended to act as a full CO_2 capture system.	-	

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
2.0 – Technique selection	You should consider the overall environmental performance of the selected plant's configuration, when choosing hydrogen production and carbon capture (CC) plant, including: • energy efficiency • resource efficiency • CO_2 capture efficiency • emissions to the environment	Yes	The proposed CO_2 recovery plant is intended to recover a proportion of the CO_2 present in the gases currently vented from the SMR. It is not intended to act as a full CO_2 capture system. The addition of the CO_2 plant will lead to an overall improvement in the energy efficiency of the installation and has been designed to incorporate energy efficiency measures where appropriate – see Section 9 of the main technical supporting document. The design has also identified and quantified all potential emissions to the environment and undertaken environmental impact assessments to demonstrate that no significant impacts will occur.
3.1 – Flexible operation	You must consider whether your hydrogen production plant may need to operate on a flexible basis to balance variations in demand from hydrogen users.	Yes	The existing hydrogen plant already operates flexibly to match the hydrogen demand from the end user. This will continue to remain the primary purpose of the plant, The CO_2 plant has been designed to operate at loads to match the H_2 plant operations and is understood to be able to operate across a range of operating conditions with little impact on the CO_2 removal efficiency. In the event that the H_2 plant was to operate at low load, there may be insufficient excess steam generated to allow the CO_2 liquefaction plant to operate, under which circumstances the CO_2 recovered would need to be vented to atmosphere.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	You should consider whether this need for flexibility will affect the design, operation, and maintenance of the plant.	Yes	The need for flexible operation of the H_2 plant is already incorporated into its design, operation and maintenance planning. The CO_2 plant design has been developed to accommodate flexible operation of the plant and appropriate additional controls will be incorporated into operational management controls where where such flexibility in operation could potentially lead to changes in: • the efficiency of operation; • emissions and associated environmental impacts; • potential incident risks.
	You should identify flexible operating scenarios where environmental performance could be affected, or where additional emissions are expected.	Yes	Flexible operation has been factored into the design, and the anticipated operational scenarios have been identified and reviewed, with design measures and operational controls put in place so as to minimise potential environmental and resource efficiency implications. Plant monitoring and control systems, along with trained operational staff will be used to manage flexible operation and identify and minimise the risk of any potential environmental impacts. Modelling of CO_2 venting scenarios has been undertaken to assess potential human health and occupational exposure risk during venting. The CO_2 plant design has used the modelling output data to ensure that there are no significant on or offsite risks. Details of the CO_2 venting scenarios and associated modelling are presented in Section 7.1 and Appendix H of the main technical supporting document.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	You should describe measures you would take to minimise the environmental impact of these scenarios, which could result in, for example: • reduced CO_2 capture rates • reduced energy efficiency • increased emissions to air, venting and flaring • increased effluent or wastes produced • increased risk of accidents in non-steady state conditions	Yes	As above
3.2 – Reliability and availability	You will need to identify equipment and systems that are critical in avoiding emissions. You will need to design, operate, and maintain these to make sure they are reliable and available, including providing installed back-up equipment, where necessary.	Yes	Environmentally critical plant has been identified during the design process for the CO_2 plant. This plant will be highlighted in the site pre-planned inspection and maintenance system, managed under then IMS. Inspection and maintenance tasks will be scheduled in accordance with designer / manufacturer recommendations with condition monitoring being undertaken where appropriate to inform the inspection frequency. The site will keep key spares to minimise unplanned plant down time. The identification of environmentally critical plant within the site systems will this be undertaken as part of the final plant design and development of the operational philosophy and inspection / maintenance procedures which will be in place prior to commencement of operation.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	You should implement a risk-based other than normal operating conditions (OTNOC) management plan, which identifies potential scenarios, mitigation measures, monitoring and periodic assessment.	Yes	The plant incorporates a plc based control system which is linked to an integrated control system which allows control of the plant from the on-site control room and also from the offsite remote main control room. The plant includes monitoring of key process parameters to ensure that it operates to within its design parameters with data trending and system alarms set up to give warning of the potential for potential OTNOC scenarios such that appropriate actions can be taken to correct the plant operations. The site Integrated Management System includes aspects to minimise the risk of OTNOC occurring which includes: • Identification of critical equipment; • Scheduled Inspection and Maintenance of critical plant (as well as other plant); and • Control system testing. Following OTNOC events (should they occur), these would be investigated, and corrective actions implemented where appropriate in line with the requirements of the IMS.
3.3 – Overall CO_2 capture efficiency	You should design plant to maximise the carbon capture efficiency. As a minimum, you should achieve an overall CO_2 capture rate of at least 95%, although this may vary depending on the operation of the plant. You can base this on average performance over an extended period.	Yes	The proposed CO_2 recovery plant is intended to recover up a proportion of the CO_2 present in the gases currently vented from the SMR. It is not intended to act as a full CO_2 capture system.
	You should consider how you would comply with future requirements for increased CO_2 capture efficiency by making your plant decarbonisation ready.	Yes	The currently proposed CO_2 recovery and liquefaction plant will not prevent BOC from installing additional CO_2 capture capacity at a later date, should it be required.
	You should plan to allow for space and technical retrofit within the design for additional carbon capture plant.	Yes	Should additional carbon capture plant be required, BOC would seek to locate this on an adjacent plot on the North Tees Site, subject to landlord agreement. There is currently a number of such plots available.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	You should aim to minimise any carbon-containing compounds that will be emitted to the environment in downstream uses, such as combustion.		This has been incorporated into the plant design with CO_2 levels having been reduced in the PSA tail gas returned to the SMR for combustion.
3.4 – Process CO_2 capture from hydrogen product	You should select the solvent, process design and operating conditions that maximise energy efficiency, capture performance, and minimise the waste and effluent treatment required. Where you have considered various options, you should provide the reasoning behind this to demonstrate that your chosen option uses overall BAT.	Yes	As part of the development of the CO_2 plant project, BOC investigated a number of technology options including: • A PSA CO_2 adsorption unit to treat the syngas generated from the SMR before separation of the $H_{2;}$ • A PSA CO_2 adsorption unit to treat the H_2 PSA tailgas after the separation of the $H_{2;}$ • A CO_2 wash adsorption unit to treat the syngas generated from the SMR before separation of the $H_{2;}$ • A flue gas CO_2 wash adsorption unit to treat the flue gas from the SMR prior to release to atmosphere. Technical and financial evaluation of these techniques was undertaken along with consideration of the environmental risks and CO_2 removal achievable prior to selection of the proposed technology. The detailed design of the CO_2 plant has included consideration of optimisation of energy and process efficiency, as well as minimisation of environmental risks and impacts. The selection of the amine adsorption solution and the design of the associated system has included consideration of the performance of the material for the duty required, the potential for degradation, and minimisation of environmental risk.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
3.5 – CO_2 capture for steam methane reforming	You will need to justify the best overall approach when designing the plant, considering all environmental impacts. When optimising for environmental performance, you should consider: • selecting appropriate solvents • emissions to air of solvent and associated degradation products • energy requirements • effluents and wastes • cooling requirements • pump and fan noise • flue gas pre-treatment • treated flue gas dispersion	Yes	In addition to the above, Effluent and waste production during operation will be minimised. Cooling systems have been designed to match the process heat demand needs (i.e. not oversized) and to minimise water use and the potential for plume formation. Mechanically assisted air-cooled evaporative cooling towers have been selected as providing the optimum balance between cooling water availability, energy use and cooling efficiency. The plant has been designed to meet a pre-specified noise limit and to avoid offsite impacts.
	You should take account of any differences between the flue gases considered in the PCC guidance and the flue gases from the SMR reformer furnace.	N/A	N/A applies to existing H_2 plant only.
3.6 – CO_2 capture from residual gas from hydrogen purification	You should consider how to capture CO_2 produced by the combustion of residual gas, which results when hydrogen is purified.	N/A	Applies to existing H2 plant only. CO_2 separation is upstream of H_2 PSA units.
	You should aim to remove this CO_2 to maximise the overall carbon capture efficiency and to make sure you achieve at least 95%.	N/A	N/A The proposed CO_2 recovery plant is intended to recover a proportion of the CO_2 present in the gases currently vented from the SMR and to sell these into industry for use. It is not intended to act as a full CO_2 capture system.
3.7 – Energy efficiency, process efficiency, cooling	You should choose your hydrogen production process and design your plant to maximise: • energy efficiency (minimise the energy needed to produce each tonne of hydrogen) • process efficiency (minimise the raw materials, such as methane and water, needed to produce each tonne of hydrogen)	Yes	See Section 9 of the main technical supporting document for details of the energy efficiency measures introduced by the addition of the CO_2 plant.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	You must explain how you plan to achieve these efficiencies. This should take into account all of the chemical and physical processes within the installation boundary needed to produce hydrogen and capture carbon. Main energy users will include: • air separation unit (ASU) – for oxygen supply to ATR and POX • hydrogen compressors • CO_2 compressors • hydrogen and CO_2 purification • solvent recovery system • pumping or fan systems		The H2 plant is existing and gas been in operation for over 20 years. The addition of the CO_2 recovery plant has been subject to a thorough design process which has included a detailed review and optimisation of the process and energy efficiency. See Section 9 of the main technical supporting document for details of the energy efficiency and heat integration measures introduced by the addition of the CO_2 plant.
	You should consider: • electrical power needs and whether you will import or generate on site • high pressure steam need and availability • maximising any residual waste heat recovery • cooling needs • cooling type and medium		

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	You should also consider heat integration optimisation, for example, heat recovery at: - higher temperatures from compression systems including the ASU, CO_2 and hydrogen compression for power generation or drives - medium temperatures for solvent recovery - lower temperatures for boiler feed pre-heat. You should reference the BREF documents: - Industrial Cooling Systems - Energy Efficiency		
	You must consider heat recovery from the heat generated by the air compression system and whether you can use it within the rest of the hydrogen production process to maximise energy efficiency. We expect you to explore all opportunities for waste heat recovery as the ASU will be considered part of the installation.	N/A	As above.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
3.8 – Oxygen production	You should take the following into account when designing the oxygen production plant and optimise to show you are using BAT: • overall energy consumption depends on the design of the ASU and its air compressor • energy required will be a balance between oxygen purity, oxygen pressure needed to supply the hydrogen production process and energy needed to purify the hydrogen • higher oxygen purity will increase the energy required for oxygen production, but reduce the amount needed for hydrogen purification to remove residual argon and nitrogen • co-production of argon and nitrogen can be used for export or on site • heat energy needed to dry and purify the compressed air • options to increase the compressor exit temperature to improve options for heat recovery should be explored, balanced with compressor design and higher power requirement. • safe and reliable operation of both the ASU and hydrogen production plant where heat integration is used • high availability of oxygen supply and backup supply or liquid storage is important to avoid potential environmental impacts of emergency or frequent shutdown and start-up of the plant	N/A	N/A – Oxygen is not produced within the CO_2 plant.
3.9 – Water supply	You should: • minimise the amount of water you use • segregate, treat and reuse water where possible • choose a cooling method that takes account of the temperature impact on process performance, energy efficiency and environmental impact on the receiving medium	Yes	The design has considered minimisation of water use. Cooling systems have been designed to align with the process requirements and with due consideration of the water effluent generated.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
3.10 – Water treatment	You should decide how much water to treat and how to treat it before it is: • reused • released to surface water or sewage undertaker • disposed of	Yes	There is no opportunity for recovery of the trace pollutants present within the effluent generated, and no ability for them to be re-used in the process. Treatment of wastewater from the CO_2 plant will be limited to testing, and if necessary, neutralisation of those effluent streams which contain potential pollutants. No other effluent treatment is provided on site. There is no integrated wastewater treatment plant on-site. All uncontaminated or low risk process water discharges are discharged directly into the North Tees Site Drainage system. Details of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are detailed in Section 7.2 of the main technical supporting document. Appendix F presents a Surface Water Pollution Risk Assessment which includes an assessment of compliance with BAT AEL's and published emissions benchmarks, along with an assessment of potential environmental impacts, including consideration of local nutrient neutrality in the Tees Estuary. This assessment has demonstrated that the emissions to water from the LIC plant will comply with relevant BAT-AEL's and will not lead to any significant water quality impacts.
	You should identify how much contaminant, such as methanol and ammonia, needs to be removed and design the treatment process accordingly.	Yes	As Above.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	You should identify any emissions to air or wastes that may result from the water treatment process, for example, emission of CO_2 from deaeration of boiler feed water.	Yes	The H_2 plant includes boiler feedwater de-aeration, and the site includes CO_2 emissions from this process within the overall site CO_2 reporting. There is no water treatment associated with the CO_2 plant.
	You should use the following references to choose the most appropriate treatments: • BREF and BATC for common waste water and waste gas treatment/management systems in the chemical sector • BREF and BATC for refining of mineral oil and gas	Yes	See Appendix A, B and C of this document.
	For discharges to water, you should refer to the guidance ‘Surface water pollution: risk assessment for your environmental permit’.	Yes	Details of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are detailed in Section 7.2 of the main technical supporting document. Appendix F presents a Surface Water Pollution Risk Assessment which includes an assessment of compliance with BAT AEL’s and published emissions benchmarks, along with an assessment of potential environmental impacts, including consideration of local nutrient neutrality in the Tees Estuary. This assessment has been undertaken in accordance with the guidance ‘Surface water pollution: risk assessment for your environmental permit’.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
3.11 – Feed gas quality and treatment	You will need to take account of the possible range of gas composition so that you can design your processes to minimise the overall environmental impact, including substances such as: • sulphur (S), typically as H2S • nitrogen (N2) • CO_2 • Mercury • other hydrocarbons	N/A	N/A applies to existing H_2 plant only.
	You will need to design your gas treatment and downstream processes in order to: • minimise solid wastes (for example, catalyst) for recycling or disposal • minimise sulphur dioxide (SO_2) emissions to air where feed gas is combusted. • maximise overall process reaction and energy efficiency • minimise emissions to air associated with the removal of nitrogen or other inerts	N/A	N/A applies to existing H_2 plant only.
	You should consider removing sulphur compounds by hydrogenation and using catalyst adsorbent to avoid SO_2 emissions from combustion and catalyst poisoning.	N/A	N/A applies to existing H_2 plant only.
	You should consider removing other hydrocarbons by pre-reforming to avoid carbon deposition on catalysts.	N/A	N/A applies to existing H_2 plant only.
	You should consider the impact a pre-reforming step will have on the downstream reforming stage for an SMR. You may be able to optimise the energy efficiency and minimise NOx emissions to air due to reduced gas fired reformer furnace duty. You will need to consider the impact on steam balance for the plant.	N/A	N/A applies to existing H_2 plant only.
	You should remove mercury to avoid catalyst poisoning and other downstream contamination.	N/A	N/A applies to existing H_2 plant only.
	Any CO_2 in the feed gas will be removed along with the CO_2 produced in the process. You should include this in the overall CO_2 balance and capture efficiency monitoring and reporting.	Yes	This will be considered in the overall CO_2 balance and capture efficiency monitoring and reporting.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
3.12 – Reforming and CO shift	You should convert methane to hydrogen, CO, and CO_2 in the reforming stage, while minimising unreacted methane.	N/A	N/A applies to existing H_2 plant only. CO Shift is part of the existing H_2 plant to optimise conversion of CO to CO_2.
	You should optimise CO conversion to CO_2 considering the overall CO_2 capture requirement and the impact on downstream processing stages to meet the hydrogen product specification.		
3.13 - Reforming	You should select, design, and operate the reformer reaction in order to: • reduce the risk of carbon deposition on catalyst, which would result in reduced reaction efficiency • minimise catalyst change frequency and the need for recycling or waste disposal	N/A	N/A applies to existing H_2 plant only.
3.14 – CO shift	You should select, design and operate CO shift reaction in order to: • maximise energy efficiency through, for example, heat integration with the overall hydrogen production and CO_2 capture processes • minimise the duration of start-up operations and associated emissions to air from flaring • minimise the production of wastes for recycling or disposal	N/A	N/A applies to existing H_2 plant only. Energy efficiency and heat integration between the H_2 and CO_2 plant has been incorporated in the design. See Appendix A - Table A - Section 2.7.1. and Section 9 of the main technical supporting document.
	You should consider a single step CO shift process rather than a more conventional high temperature or low temperature shift process, with isothermal conditions achieved through reactor cooling with recovery of heat.	N/A	N/A applies to existing H_2 plant only.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
3.15 – Catalyst selection	When you choose which catalysts to use, you should consider the overall environmental performance, including, for example: • any required pre-treatment to avoid poisoning, to minimise waste and associated treatment • preventing any dust emissions, where applicable • the ability to recover or recycle the solids or metals from the spent catalyst waste handling spent catalyst for environmentally safe recovery, recycling or disposal	N/A	N/A applies to existing H_2 plant only.
3.16 Hydrogen product	You should take account of hydrogen purification requirements. These will depend on: • the hydrogen product quality specification • impurities in the hydrogen following reforming, CO shift and CO_2 capture steps	N/A	N/A applies to existing H_2 plant only.
	You should consider pressure swing adsorption (PSA) to remove impurities from the hydrogen.	N/A	PSA is applied in the existing H_2 plant.
	You should consider the impact on overall energy efficiency and the need for further treatment of hydrogen purification off-gas streams.	N/A	N/A applies to existing H_2 plant only.
	You should design the overall process to minimise the power required for compression to achieve the pressure required by the user. See section 3.7 energy efficiency, process efficiency, cooling.	N/A	N/A applies to existing H_2 plant only. Energy efficiency and heat integration between the H_2 and CO_2 plant has been incorporated in the design. See Appendix A - Table A - Section 2.7.1. and Section 9 of the main technical supporting document.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
3.17 – CO_2 product	You should design the process to meet the required CO_2 quality specification, temperature and pressure as required for transport to permanent geological storage. You should design the overall process to minimise the power required for compression to achieve the pressure required by the user. You should maximise recovery of waste heat from compression. See section 3.7 energy efficiency, process efficiency, cooling.	Yes	The process has been designed to meet the required CO_2 quality specification, temperature and pressure as required by the end users. The CO_2 plant is intended to recover CO_2 for use in industry e.g. food & drink etc.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
4.0 – Emissions to air	You should eliminate, minimise, or reduce any emissions to air that could cause pollution.	Yes	There are no routine emissions to air from the CO_2 plant other than nitrogen venting associated with plant inertisation. The only emissions to air under normal operating conditions are the SMR flue gas from the H_2 plant The only changes to the normal emissions profile at the installation will be a slight increase in the emissions of NOx from the Steam Methane Reformer (SMR) as a result of the reduction in the CO_2 content within the PSA tail gas returned to the SMR burner. This is a minor change and will not require any change in the existing SMR emissions limits for NOx, or lead to any significant offsite impacts. See Section 8.1.1 of the main technical supporting document. Under other than normal operating conditions (OTNOC), there are a number of venting systems on the CO_2 plant that could be used to ensure safe operation / shutdown of the plant – these would vent CO_2 to atmosphere and would operate very infrequently – no emission benchmark values would be applied to such venting. Details of these vents are presented in in Section 7.1 of the main technical supporting document Modelling of CO_2 vents has been undertaken to assess potential human health and occupational exposure risk during venting. The CO_2 plant design has used modelling output data to ensure that there are no significant on or offsite risks. Details of the CO_2 venting scenarios and associated modelling are presented in Section 8.1.2 and Appendix H of the main technical supporting document.
	You should make sure that your process emissions can comply with all ELVs which are required under the relevant BATC.	Yes	See Appendix C of this document. All emissions to air will comply with relevant BAT-AEL’s.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	You should carry out a risk assessment, including detailed air quality modelling, to assess the impact of these emissions.	Yes	As Above.
4.1 – Combustion processes	You should maximise energy efficiency and heat integration, so you minimise the need for combustion processes, resultant CO_2 and other combustion products.	Yes	Energy and heat integration has been applied to the plant design – See Appendix A – Table A - Section 2.7.1. and Section 9 of the main technical supporting document.
	You should maximise the capture of CO_2 from combustion processes, taking account of the overall carbon capture requirement.	Yes	The proposed CO_2 recovery plant is intended to recover a proportion of the CO_2 present in the gases currently vented from the SMR. It is not intended to act as a full CO_2 capture system.
	You must identify and minimise the continuous and periodic emissions of combustion products to air.	Yes	Emissions monitoring from the SMR is undertaken using a CEMS system in compliance with the exiting Environmental Permit requirements. The addition of the CO_2 plant will not significantly alter the nature of the emissions.
	You should consider NOx abatement techniques where the combustion of hydrogen-rich gas with the potential for higher flame temperatures will increase thermal NOx formation, including: • burner design • flue gas recirculation • heat exchange with fuel or air	Yes	The SMR combustion system includes Low NOx burners, and can achieve NO_X emission levels that will comply with applicable BAT-AEL's. The potential implications of reduced CO_2 content within the PSA tail gas returned to the SMR for combustion has been assessed within Section 8.1.1 of the main technical supporting document.
	You should consider whether abatement of any of these emissions is required to comply with relevant BAT AELs or local air quality standards, for example, for NOx. Where relevant, you should consider the following abatement techniques: • selective catalytic reduction (SCR) • selective non-catalytic reduction (SNCR)	N/A	Such abatement techniques are not required to achieve compliance with the BAT-AEL's.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	You should consider: • the overall impact of using residual gas from the hydrogen purification process as a supplementary fuel for fired equipment to balance overall heat requirements, while considering the impact of the additional emissions of combustion products to air • for SMR, the requirement for post-combustion carbon capture for the reformer furnace emissions to air and any pre-treatment of combustion gases needed see the PCC guidance • for ATR, whether the relatively smaller additional heat need can be supplied by combustion of hydrogen-rich residual gas or combustion of hydrogen product • for POX, the process is usually energy-balanced or produces excess heat and so combustion processes may not be needed • the impact on emissions to air due to variability in fuel gas composition or any need to switch between fuel gas sources, for example, at start-up when residual PSA gas for fuel is not available and some feed gas may need to be combusted	Yes	The existing H_2 plant is already designed to operate using PSA tail gas returned to the SMR to support combustion. The addition of the CO_2 plant is intended to reduce overall CO_2 emission to air from the process and recover CO_2 for re-use in industry. This change also will improve the overall H_2 production energy efficiency.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	You should design combustion processes to comply with required emissions limit values (ELVs) from the existing sources of statutorily applicable emission limits and BAT AELs, including the following: • Medium Combustion Plant Directive • Industrial Emissions Directive Chapter III Annex V ELVs • BAT AELs identified in the Large combustion plant BREF and BATC • Refining of Mineral Oil and Gas • Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers • Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector	Yes	The plant has been designed to comply with the relevant BAT-AEL's: • MCP – N/A • IED Annex V - N/A • LCP – N/A • Refining BREF – N/A • LVIC – Applicable – see Appendix A of this document. • CWW – Applicable – See Appendix B of this document. • WGC – Not Yet Applicable – See Appendix C of this document.
	You should consider the: • type of combustion equipment • fuels proposed to be combusted • net rated thermal inputs • BAT for control of emissions • conclusions of an environmental risk assessment, considering the dispersion of pollutants into air and the sensitivity of the relevant receptors	Yes	As Above.
4.3 – Flaring and venting	You must design and operate your plant to minimise the need for continuous or intermittent flaring or venting of gases, whether for operational or safety reasons, including: • methane or refinery fuel gas • hydrogen • CO_2	N/A	There is no flaring at the installation. Venting from the existing H_2 plant is not considered in this assessment. There may be venting of CO_2 from the CO_2 Plant.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	You must minimise emissions under start-up, shutdown, and abnormal operations.	Yes	The CO_2 plant is intended to operate continuously, and hence the frequency of emissions during start-up and shutdown will be minimised. When required, start up and shut down durations will be minimised where possible to minimise emissions. Abnormal venting of CO_2 will be minimised where possible through: • Effective plant maintenance to avoid unplanned shutdowns; and • Effective plant management to match operation of the CO_2 plant to the H_2 plant operations and the demand for CO_2 product.
	You should quantify and assess harm from other routine venting and purging requirements, identifying any pollutants that are expected to be present, including, for example: • CO_2 • hydrogen • CO • methane • ammonia vapour • methanol vapour	Yes	Under other than normal operating conditions (OTNOC), there are a number of venting systems on the CO_2 plant that could be used to ensure safe operation / shutdown of the plant – these would vent CO_2 to atmosphere and would operate very infrequently – no emission benchmark values would be applied to such venting. Details of these vents are presented in Section 7.1 of the main technical supporting document. Modelling of the SMR was undertaken as part of the original EPR / PPC application and has been reviewed in Section 8.1.1 of the main technical supporting document. Modelling of CO_2 vents has been undertaken to assess potential human health and occupational exposure risk during venting. The CO_2 plant design has used modelling output data to ensure that there are no significant on or offsite risks. Details of the CO_2 venting scenarios and associated modelling are presented in Section 8.1.2 and Appendix H of the main technical supporting document.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	Requirements for intermittent venting may include, for example: • CO2 vented in abnormal conditions, such as when the downstream transportation and storage system is not available, or if the CO2 does not meet the export specification • venting needed as part of purging equipment for maintenance activities	Yes	As above.
5.0 – Emissions to water	You must identify and eliminate, minimise, recycle or treat any emissions to water that could cause pollution.	yes	Details of the water emissions to the North Tees Drainage system for eventual discharge to the Tees Estuary are detailed in Section 7.2 of the main technical supporting document. Appendix F presents a Surface Water Pollution Risk Assessment which includes an assessment of compliance with BAT AEL's and published emissions benchmarks, along with an assessment of potential environmental impacts, including consideration of local nutrient neutrality in the Tees Estuary. This assessment was undertaken in accordance with the guidance 'Surface water pollution: risk assessment for your environmental permit'.
	You should carry out a risk assessment, including detailed modelling, where appropriate, to assess the impact of these emissions. For discharges to water, you should refer to the guidance Surface water pollution: risk assessment for your environmental permit.		
	You should identify continuous and periodic effluent streams from the process and determine whether effluent treatment is required.	Yes	All Continuous and periodic effluent streams have been included in the above assessment.
6.0 - Waste	You must eliminate or minimise wastes and treat, where appropriate.	Yes	The plant has been designed and will operate to minimise waste arisings where possible.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
6.1 - Liquid wastes	You should consider how to deal with the following wastes that may be generated- Liquid wastes such as: • demineralised water production reject stream • amine solvent – for example, from bleed or feed replacement • dehydration solvent – for example, in case of tri-ethylene glycol dehydration • amine reclaimer residue	Yes	All waste arisings from the CO_2 plant will be handled and disposed of in line with the existing site waste management protocols. Wastes generated on site are segregated and appropriate offsite disposal options are selected with due consideration of the waste hierarchy in the selection of the disposal route. All legally required data including waste transfer notes etc. are retained. There will be limited wastes arising from the process operation of the CO_2 recovery and liquefaction plant, other than periodic / infrequent replacement of the amine solution used within the adsorption column, the use of which will be minimised through effective control and operation of the process and monitoring of process parameters to minimise the degradation of the amine solution. Other waste arisings will be linked to routine maintenance.
6.2 – Solid wastes	You should consider how to deal with the following wastes that may be generated- Solid wastes such as: • depleted catalyst material – hydrogenation, reforming, CO shift • spent adsorbent materials – gas treatment, dehydration, hydrogen purification • solids from amine filtration • soot (POX process)	Yes	As above

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
7.0 – Monitoring	You must also carry out monitoring to show that resources are being used efficiently. This includes: • energy and resource efficiency • carbon capture efficiency • verifying that the CO_2 product is suitable for safe transport and storage • hydrogen product quality • verifying (when applicable) compliance with low carbon hydrogen standards	Yes	The site has continuous monitoring of natural gas usage at the site (which is the primary thermal input to the site and uses this to provide continuous online feedback on the energy efficiency of the plant. Frequent monitoring of electrical usage is also undertaken and fed into the calculation of overall plant efficiency. Energy efficiency performance and the progress with improvement projects is regularly reported into the company systems, and reviewed on site on a monthly basis. Calculation and reporting of CO_2 equivalent emissions data is also undertaken in line with UK ETS requirements. Monitoring key parameters to assess CO_2 recovery efficiency will be implemented prior to commencement of CO_2 export. H_2 product quality is continuously monitored for CO content to ensure it remains within the required specification for the end user. Monitoring of CO_2 product quality will be implemented to ensure it remains within the required specification of the end user. The specific monitoring requirements will be determined prior to commencement of CO_2 export.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	Your permit application should include a monitoring plan for both a commissioning phase and routine operation.	Yes	The H_2 plant is operational and has existing monitoring requirements within the Environmental Permit. There will be no change in the emissions to air and associated monitoring. Additional water emission monitoring requirements associated with the CO_2 Plant are detailed in Section 11 of the main technical supporting document. A commissioning plan for the CO_2 plant will be developed prior to commencement of commissioning and will include consideration of any monitoring required to confirm process performance and emissions.
	During the commissioning phase, you will need to assess monitoring results and optimise the operation of the process. You will need to report on your commissioning phase monitoring results, your assessment of them and any changes you want to make to the operation.	Yes	Key Plant performance data and emissions monitoring will be undertaken during the commissioning of the CO_2 Plant and will be used to inform any plant adjustments / performance fine tuning.
	It's likely you will need to do more extensive monitoring during the commissioning phase than during routine operation. As these production techniques for hydrogen with CCS are emerging techniques, you will need to develop monitoring methods and standards. You should include proposals for this in your permit application.	Yes	A commissioning plan for the CO_2 plant will be developed and agreed with the regulator prior to commencement of commissioning and will include consideration of any monitoring required to confirm process performance and emissions.
	You must also show that you are managing the process to prevent (or minimise) the formation of solvent degradation products.	Yes	The amine selected for CO_2 recovery is understood to experience minimal degradation, with predicted lifespan of up to 5 years. Monitoring of the amine will be undertaken periodically in line with the supplier's guidance, and the condition of the amine will then be used to inform ongoing operation with the existing amine, or to identify the need for amine replacement or regeneration. The plant will be operated in line with the manufacturers and designers guidance to minimise amine degradation.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	Where degradation products are formed (and may be released), you must reduce these and any solvent emissions to the appropriate level. This process control monitoring will also be part of the permit conditions.	Yes	See above The amine system is a closed system with no route of emission to the environment.
7.1 – Monitoring point source emissions to air	You should provide a monitoring plan for monitoring emissions to air, based on expected pollutants such as: • ammonia • amine compounds • SO_2 • NOx • CO • Methane • hydrogen You should do this using appropriate methods and measuring techniques.	Yes	There are no routine emissions to air from the CO_2 plant other than nitrogen venting associated with plant inertisation. CO_2 plant emissions would solely comprise CO_2 venting under OTNOC situations, or when the liquefaction plant is offline, and it is not intended that these would be sampled or analysed. Emissions to air from the H_2 plant steam methane reformer will continue to be monitored using CEMS in line with the extant Permit requirements. The CEMS will comply with the appropriate testing and analysis standards.
	Emissions of methane and hydrogen should be eliminated or minimised due to their global warming potential.	Yes	Emissions of methane and hydrogen from the point emission sources will be minimised through effective combustion in the SMR.
	Your monitoring should consider, for example: • NO_x and CO emissions from combustion • SO_2 emissions from combustion where the fuel source contains sulphur • ammonia emissions where SCR or SNCR is used • amine or amine degradation products and other volatile solvent emissions, where relevant • methane and hydrogen ‘slip’ from any combustion processes • any other sources of methane or hydrogen emissions	Yes	The existing CEMS monitoring system provides continuous monitoring of combustion emissions (NOX / CO) and also monitors for methane slip. SO_2 is not assessed as the primary feedstock is natural gas. Ammonia is not assessed as SCR / SNCR is not used. Amine and amine degradation products will be within a sealed system and will not vent to atmosphere.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
7.2 – Monitoring emissions to water	You must monitor emissions to water based on expected impurities (for example, ammonia, amine compounds, methanol, CO_2) using appropriate methods and measuring techniques. You should use monitoring standards for discharges to water following: • BATC for common waste water and waste gas treatment/management system in the chemical sector • BATC for the refining of mineral oil and gas	Yes	Additional water emission monitoring requirements associated with the CO_2 Plant are detailed in Section 11 of the main technical supporting document and have been selected to align with potential pollutant species that could credibly be present in the discharge from the process activities. All emissions monitoring will be MCERTS compliant.
7.3 – Monitoring standards	The person who carries out your monitoring must be competent and work to recognised standards such as the Environment Agency's monitoring certification scheme (MCERTS).	Yes	All monitoring undertaken in relation to demonstrating compliance with the emission limits defined in the Environmental Permit will be undertaken in compliance with MCERTS.
7.4 – Monitoring CO_2 capture performance	You should clearly identify how you will monitor the CO_2 capture performance (CO_2 capture rate and CO_2 quality) of the plant. You will need to include: • CO_2 equivalent mass balance • CO_2 equivalent in feed gas • total capture efficiency (CO_2 equivalent captured as a mass percentage of CO_2 equivalent in feed gas) • CO_2 equivalent released to the environment • CO_2 quality	Will comply before commencement of operation	The detailed design of the CO_2 plant is still underway, and as part of this full mass balances and energy requirement calculations are being prepared. Prior to commencement of operation BOC will put in place via its IMS: • Monitoring of key parameters to allow the CO_2 capture performance to be assessed; • Set key performance targets for the CO_2 plant; • Development of a data recording, calculation and reporting processes to assess the capture efficiency and the CO_2 emissions as CO_2 equivalent . It is expected that the data recording, handing and reporting processes will be integrated with the existing site wide processes.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
7.5 - Monitoring process performance	You should identify the main requirements for monitoring process operations where these ultimately impact on environmental performance, including, for example, for the CO_2 capture system: - amine system performance, including monitoring of amine solvent quality such as amine concentration - pH and presence of degradation or corrosion products - amine temperatures - amine and wash water circulation rates - rich and lean amine CO_2 loading - stripper reboiler steam rates	Will comply before commencement of operation	The detailed design of the CO_2 plant is still underway, and as part of this the control and operating procedures for the CO_2 plant are still under development. The plant has been designed to ensure that all key process parameters required to ensure the effective and efficient operation of the plant have appropriate monitoring systems in place e.g. process temperatures, flowrates, pressures, product quality, etc. In addition to this additional monitoring requirements will be developed as part of the pre-planned maintenance programme for the site to ensure that required periodic monitoring of process condition is undertaken e.g. amine condition, All such monitoring will be undertaken in line with the manufacturers and designers guidance.
	You should monitor energy efficiency in the hydrogen production and CO_2 capture processes by measuring feed and product gas flows and electrical power consumption to calculate overall energy consumption.	Yes	The existing H_2 plant has a target Specific Energy Consumption which is assessed as an overall thermal efficiency target which is currently set at around 69% and is linked to the quantity of H2 produced. The H_2 plant has continuous monitoring of natural gas usage (which is the primary thermal input) and uses this to provide continuous online feedback on the energy efficiency of the plant. Monitoring of electrical usage is also undertaken and fed into the calculation of overall plant efficiency.
	You should monitor the quality of the hydrogen product to ensure it is fit for purpose.	Yes	H_2 product quality is continuously monitored for CO content to ensure it remains within the required specification for the end user.
	Requirements for process performance monitoring, either online or offline, will also be a condition of the permit.	Yes	Process performance monitoring as outlined above is undertaken continuously and data is reported online via the plant control systems.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
8 – Unplanned emissions and accidents	You should propose a leak detection and repair (LDAR) programme that is appropriate for the fluids and their composition. This should use industry best practice to manage releases, including from joints, flanges, seals and glands.	Yes	Leak detection and repair is incorporated into the existing H_2 plant pre-planned inspection and maintenance programme and daily routines. This will be extended to include the CO_2 plant. Identified leaks or weeps are logged into a fugitive releases report and then prioritised for repair dependant on the scale of the losses occurring.
	You should include how you will use LDAR to eliminate or reduce fugitive emissions of methane and hydrogen due to their global warming potential.		

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
	Your hazard assessment and mitigation for the plant must consider the risks of accidental releases to the environment. This should also consider the actual composition of the liquids, gases and vapours that could be released from the plant after an extended period of operation.	Yes	The design of the CO_2 plant has included detailed safety and risk assessments including : HAZID, HAZOP, LOPA etc. These assessments have been undertaken to identify credible risks associated with the operation of the plant (including consideration of potential amine degradation products) and to inform the design to effectively minimise and control such risks. These processes have also been used to identify required management controls and procedures which have then been implemented through the IMS. Where potential for accidental releases of materials have been identified e.g. unplanned CO_2 venting, the potential impact on the environment has been assessed through dispersion modelling. The amine selected for CO_2 recovery is understood to experience minimal degradation, with predicted lifespan of up to 5 years. Monitoring of the amine will be undertaken periodically in line with the supplier’s guidance, and the condition of the amine will then be used to inform ongoing operation with the existing amine, or to identify the need for amine replacement or regeneration. The amine system is a sealed system, and so no emissions to the environment are expected.

Guidance Section No.	Requirement	Operating to Guidance Requirement	Demonstration of BAT Compliance
9 – Noise and odour	You need to consider sources that have high potential for noise and vibration. In particular, CO_2 and hydrogen compression, pumping and fan noise could be significant additional sources. Once you've identified the main sources and transmission pathways, you should consider using common noise and vibration abatement techniques and mitigation at source	Yes	Details of potential noise sources and impacts are detailed in Section 8.3 of the main technical supporting document. Appendix G2 presents details of the noise control concept for the design of the LIC plant. The design has included defined noise limits for all equipment and has been designed to achieve <85dB at 1m from the process area. Noise risk during operations will be managed through the IMS and potential sources of noise will be included in the pre-planned inspection and maintenance plans for the site. Appendix G4 presents a screening noise impact assessment. Potential offsite noise impacts have been assessed at both residential and ecological receptors, and no significant impacts are predicted. No detailed noise management plant is therefore considered to be required.
	Handling, storing and using some amines may result in odour emissions, so you should always use best practice containment methods. Where there is increased risk that odour from activities will cause pollution beyond the site boundary, you will need to send an odour management plan with your permit application.	N/A	The CO_2 plant does not generally handle particularly odorous materials. The amine proposed for CO_2 recovery will be used within a sealed system which will be subject to an appropriate pre-planned inspection and maintenance programme. Any refiling / regeneration activities will be undertaken subject to specific controls and where possible using sealed systems (e.g. with back venting into the system), hence minimising the potential for any odour emission. Offsite odour emissions and impacts at nearby sensitive receptors are not anticipated. Hence an Odour Management Plan is not required.

Making Sustainability Happen