Immingham Green Energy Terminal
Green Hydrogen Production Facility

EPR/VP3425SV/A001

Environmental Permit Application

Appendix D4 – Best Available Techniques to Industrial Cooling Systems

Environmental Permitting (England and Wales) Regulations 2016

Applicant: Air Products (BR) Ltd

May 2024

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Table of contents

1 Introduction

1.1. PURPOSE OF THE REPORT

1.1.1 This document has been prepared by AECOM Limited (‘AECOM’) on behalf of Air Products (BR) Limited (‘APBRL’), referred to as ‘the Operator’ or ‘AP’, in support of an Environmental Permit application for the proposed Green Hydrogen (H_2) Production Facility (‘proposed installation’) which forms part of the wider Immingham Green Energy Terminal (‘IGET’) Nationally Significant Infrastructure Project (NSIP) being developed by Associated British Ports (‘ABP’) on the eastern side of the Port of Immingham, situated in northeast Lincolnshire on the south bank of the Humber Estuary.

1.1.2 The purpose of this report is to demonstrate that the proposed installation will be designed and operated in accordance with indicative Best Available Techniques (BAT) for cooling. The report should be read in conjunction with other supporting application documents.

1.1.3 AECOM has prepared this BAT assessment using concept engineering information related to the initial design parameters of the proposed installation, available information about the local environment and the existing standards and guidelines presented in published guidance, including:

- European Commission Reference Document on the application of Best Available Techniques to Industrial Cooling Systems

1.1.4 The main Supporting Statement provides an overall view of the Permit variation application being made for the proposed installation. In addition to this BAT assessment for cooling, additional BAT assessments have been prepared for emissions (Appendix D1), energy efficiency (Appendix D2), and process and technology (Appendix D3), recognising that the overall integration of these aspects will determine BAT for the proposed installation.

1.2. PROPOSED INSTALLATION DESCRIPTION

1.2.1 The proposed installation comprises the development of a green H_2 production facility which includes infrastructure for the offloading and transfer of green ammonia (NH_3) from ships to ammonia storage facilities, the main H_2 production facility and vehicle and trailer H_2 refuelling facilities.

1.2.2 The proposed installation will be located in North East Lincolnshire on the south bank of the Humber Estuary on the eastern side of the Port of Immingham. The installation location will be approximately centred on National Grid Reference (NGR) E520783 N415271.

1.2.3 The environmental permit application is therefore for an H_2 production facility which will comprise the following within the installation boundary:

- NH3 ship offloading infrastructure to facilitate the receipt of NH3 for H2 production. The offloading infrastructure will be located on a new jetty being constructed by Associated British Ports (ABP). Only the offloading infrastructure is incorporated in the application and the jetty itself remains outside the installation boundary.

- NH3 transfer pipeline which links the ship offloading infrastructure with the NH3 storage tanks located on the east site.
- East site which comprises:
  - (a) a NH_3 storage tank and related plant including an NH_3 tank flare stack and oil-off gas compression system to liquefy the generated boil-off gas during offloading from Ship and static boil-off from Ammonia Tank.
  - (b) H_2 production facility comprising up to three H_2 production units including associated flue gas and flare stacks.
  - (c) Power distribution buildings for NH_3 and H_2 production plant.
  - (d) Instrumentation buildings for NH_3 and H_2 processes.
  - (e) Analyser shelters for the H_2 production plant.
  - (f) Pipe-racks, pipelines, pipes, utilities and other infrastructure associated with both NH_3 and H_2 equipment.
  - (g) Welfare facility.
- West site which comprises:
  - (a) H_2 production facility comprising up to three H_2 production units including associated flue gas and flare stacks.
  - (b) Up to four liquefier units.
  - (c) H_2 storage tanks.
  - (d) H_2 trailer filling stations.
  - (e) H_2 vent stack and associated process equipment.
  - (f) H_2 vehicle and trailer filling stations.
  - (g) H_2 compressors and associated process equipment.
  - (h) Control room and workshop building.
  - (i) Security and visitor building.
  - (j) Contractor building.
  - (k) Warehouse.
  - (l) Driver administration building.
  - (m) Safe haven building.
  - (n) Electrical substation and metering station.
  - (o) Power distribution buildings.
  - (p) Process instrumentation buildings.
  - (q) Analyser buildings.
  - (r) Process and utility plant including cooling towers and pumps, fire water tank, instrument air equipment, pipe racks, pipelines, pipes, cable racks, utilities and other infrastructure nitrogen generation package (HPN) with LIN Tank and LIN Vaporizers and steam generation package.
- Pipeline corridor for underground pipelines, pipes, cables and other conducting media for the transfer of NH_3, H_2, nitrogen (N_2) and utilities, with cathodic protection against saline corrosion.

2 Best Available Techniques

2.1. DEFINITION OF BEST AVAILABLE TECHNIQUES

2.1.1 The Industrial Emissions Directive (2010/75/EU) defines BAT as "*the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and where that is not practicable, generally reduce emission and the impact on the environment as a whole*".

2.1.2 The Directive continues to provide further definition as follows:

- "available techniques" are those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the cost and advantages, whether or not the techniques are used or produced inside the United Kingdom, as long as they are reasonably accessible to the Operator.

- "best techniques" are the most effective in achieving a high general level of protection of the environment as a whole.

- "techniques" are both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

2.1.3 BAT may be demonstrated by either:

- Compliance with the sector-level, indicative BAT performance described guidance such as Sector Guidance Notes provided by the Environment Agency or in the European Commission 'Reference Documents on BAT' (BREFs) or BAT conclusions; or

- By conducting an installation-specific, options appraisal of candidate techniques.

2.1.4 The indicative BAT provided in the European BREF/BAT Conclusion documents is based on an analysis of the costs and typical benefits for typical, or representative, plants within that sector. When assessing the applicability of the sectoral, indicative BAT standards at the installation level, departures may be justified on the grounds of the technical characteristics of the installation concerned, its geographical location and the local environment.

2.2. BAT FOR THE INSTALLATION

2.2.1 The development of the H_2 production plant from concept to full commercial scale must proceed alongside the emerging BAT regulatory positions, so there is confidence that the project meets indicative BAT before it proceeds with Front-End Engineering Design (FEED) and to drive the vendor procurement processes, whilst maintaining the best protection for the environment as a whole.

2.2.2 At this stage of project development, the Jetty and Pipelines, Ammonia storage tank and associated utilities are on east site, FEED is complete for other part of the installation, and we have therefore applied an approach to the derivation of BAT which is driven by:

- The technology licensors requiring commercial confidentiality of their process cycle and catalysis;
- To allow the FEED process to progress without limiting options for later technology optimisations;
- To determine indicative BAT and BAT Achievable Emission Levels (BAT-AELs) for the plant which are consentable, taking into consideration the environmental sensitivities and conditions at the site.

2.2.3 The techniques described in this report and the associated BAT assessments are therefore based on the currently anticipated approaches to optimising H_2 production and its associated emissions management requirements.

2.2.4 A number of BAT reference documents were confirmed applicable during pre-application discussions with the Environment Agency to cover the process and technology related to hydrogen production at Immingham Green Energy Terminal. This section provides an overview of each relevant guidance document, followed by the BAT conclusions in tabulated form in the subsequent sections.

BRef For Industrial Cooling Systems

2.2.5 BRef Document for Industrial Cooling Systems is the appropriate BAT for the cooling system within the proposed installation. BAT conclusions are presented, and approaches justified in section 3 below.

2.3. CONCLUSIONS

2.3.1 On the basis of the assessment against the required BAT Conclusions for process and Technology, as shown in Sections 3 and 4, it is considered that the proposed installation will be designed and operated in compliance with and in accordance with BAT.

3 BAT Conclusions for Cooling

Table 3.1 BAT Assessment Against BRef for Industrial Cooling Systems

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
1	**BAT 1 Reduction of energy consumption** It is BAT in the design phase of a cooling system: • To reduce resistance to water and airflow • To apply high efficiency/low energy equipment • To reduce the amount of energy demanding equipment (Annex XI.8.1) • To apply optimised cooling water treatment in once-through systems and wet cooling towers to keep surfaces clean and avoid scaling, fouling and corrosion. For each individual case a combination of the above-mentioned factors should lead to the lowest attainable energy consumption to operate a cooling system. Concerning BAT a number of techniques/approaches have been identified. In an integrated approach to cooling an industrial process, both the direct and indirect use of energy are taken into account. In terms of the overall energy efficiency of an installation, the use of a once-through systems is BAT, in particular for processes requiring large cooling capacities (e.g. > 10 MWth). In the case of rivers and/or estuaries once-through can be acceptable if also: • extension of heat plume in the surface water leaves passage for fish migration;	The following techniques will be used to reduce energy consumption: • Modulation of air/ water flow • Optimised water treatment and pipe surface treatment • Apply pumping heads and fans with reduced energy consumption • Regular maintenance The Operator will be using an evaporative cooling tower as the cooling water system as the air-cooled system would increase the site-wide power consumption by ~4MW (as shown through simulations of both scenarios). See cooling description in Section 3.2 Process Overview of the Supporting Statement.	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	• cooling water intake is designed aiming at reduced fish entrainment; • heat load does not interfere with other users of receiving surface water. For power stations, if once-through is not possible, natural draught wet cooling towers are most energy-efficient than other cooling configurations, but application can be restricted because of the visual impact of their overall height.		
2	**BAT 2 Reduction of water requirements** For new systems the following statements can be made: • In the light of the overall energy balance, cooling with water is most efficient; • For new installations a site should be selected for the availability of sufficient quantities of (surface) water in the case of large cooling water demand; • The cooling demand should be reduced by optimising heat reuse; • For new installations a site should be selected for the availability of an adequate receiving water, particularly in case of large cooling water discharges; • Where water availability is limited, a technology should be chosen that enables different modes of operation requiring less water for achieving the required cooling capacity at all times; • In all cases recirculating cooling is an option, but this needs careful balancing with other factors, such as the required water conditioning and a lower overall Energy efficiency.	Evaporative cooling, using recirculated cooling water systems is the method used for employing water to remove process waste heat, rejecting that waste heat into the environment. Water supply will be from a non-potable thus protecting groundwater and potable supplies. Water is consumed by the cooling water system in two ways: • Evaporation (approx. 70-80% of water consumed) • Discharge (20 - 30% of water consumed) Water is required to be discharged to avoid a build-up of pollutants / solids etc from water treatment chemicals in the water. The peak demand for water at Phase 3 will be 177 m^3/hr and the techniques used at the installation for reducing water requirements will include: • Optimisation of heat reuse to reduce the need of cooling • Using a water recirculation system • Optimization of cycles of concentration • Installation of a water treatment package during Phase 1 to facilitate reuse of water.	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	For existing water cooling systems, increasing heat reuse and improving operation of the system can reduce the required amount of cooling water. In the case of rivers with limited availability of surface water, a change from a once-through system to a recirculating cooling systems is a technological option and may be considered BAT. For power stations with large cooling capacities, this is generally considered as a cost-intensive exercise requiring a new construction. Space requirements must be taken into account.	During design stages, the operator is also reviewing cooling techniques with cooling water system specialists to optimise the final package installed. See cooling description in Section 3.2 Process Overview of the Supporting Statement.	
3	**BAT 3 Reduction of entrainment of organisms** The adaptation of water intake devices to lower the entrainment of fish and other organisms is highly complex and site-specific. Changes to an existing water intake are possible but costly. From the applied or tested fish protection or repulsive technologies, no particular techniques can yet be identified as BAT. The local situation will determine which fish protection or repulsive technique will be BAT. Some general applied strategies in design and position of the intake can be considered as BAT, but these are particularly valid for new systems. On the application of sieves it should be noted that costs of disposal of the resulting organic waste collected from the sieves can be considerable.	Entrainment of organisms only applies to once-through cooling systems or cooling systems with intakes of surface water.	N/A
4	**BAT 4 Reduction of emissions to water** **approach to reduce heat emissions** Whether heat emissions into the surface water will have an environmental impact strongly depends on the local conditions. Such site conditions have been described, but do not lead to a conclusion on BAT in general terms. Where, in practice, limits to heat discharge were applicable, the solution was to change from once-through technology to open recirculating cooling (open wet cooling tower). From the available	To limit heat discharge, the system will be an open recirculating cooling system instead on once through. Blowdown from the cooling water system will be routed to the waste water treatment package and from non-potable water quality produced will be reused within the facility and reject stream will be routed to Anglian Water for further treatment.	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	information, and considering all possible aspects, care must be taken in concluding that this can be qualified as BAT. It would need to balance the penalty increase in overall energy efficiency of applying a wet cooling tower (Chapter 3.2) against the effect of reduced environmental impact of reduced heat discharge. In a fully integrated assessment at the level of a river catchment, this could for example include the raised overall efficiency levels of other processes using the same, but now colder, water source, which becomes available because there is no longer a large warm water discharge into it. Where the measures generally aim at reducing the ΔT of the discharged cooling water, a few conclusions on BAT can be drawn. Pre-cooling (Annex XII) has been applied for large power plants where the specific situation requires this, e.g. to avoid raised temperature of the intake water. Discharges will have to be limited with reference to the constraints of the requirements of Directive 78/659/EEC for fresh water sources. The criteria are summarised in Table 3.6. Reference is made to a provision in Article 11 of this directive regarding derogation of the requirements in certain circumstances		
	approach to reduce chemical emissions to water Measures should be taken in the design phase of wet cooling system using the following order of approach: • identify process conditions (pressure, T, corrosiveness of substance), • identify chemical characteristics of cooling water source, • select the appropriate material for heat exchanger combining both process conditions and cooling water characteristics,	The following design and maintenance techniques for reduction of chemical emissions to water will be used at the facility: • monitoring the corrosive properties within the process and cooling water to optimise the additive selection and reduce use of hazardous chemicals where possible. • Design of the cooling system to avoid stagnant zones to reduce fouling and corrosion • Control water velocity to reduce deposition (fouling) in condensers and heat exchangers	

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	• select the appropriate material for other parts of the cooling system, • identify operational requirements of the cooling system, • select feasible cooling water treatment (chemical composition) using less hazardous chemicals or chemicals that have lower potential for impact on the environment (Section 3.4.5, Annex VI and VIII) • apply the biocide selection scheme (Chapter 3, Figure 3.2) and • optimise dosage regime by monitoring of cooling water and systems conditions. This approach intends to reduce the need for cooling water treatment in the first place. For existing systems technological changes or changes to the equipment are difficult and generally cost-intensive. Focus should be on the operation of the systems using monitoring linked to optimized dosage. A few examples of techniques with good performances have been identified. They are generally applicable for certain categories of systems; they are considered cost effective and do not need large changes to the cooling installation. After reducing the sensitivity of the cooling system to fouling and corrosion, treatment may still be needed to maintain an efficient heat exchange. Selecting cooling water additives less harmful to the aquatic environment and to applying them in the most efficient way is then the next step. With respect to the selection of chemicals, it has been concluded that a ranking of treatments and the chemicals of which they are composed is difficult if not impossible to carry out in a general way and would be unlikely to lead to BAT conclusions. Due to the large variation in conditions and treatments only a site-by-site assessment will lead to the appropriate solution. Chapter 4 130 Industrial Cooling	• Use debris filters to protect the heat exchangers where clogging is a risk • Monitoring and control of cooling water chemistry to reduce additive application • Use of dedicated chemical dosing program for treatment of the cooling water system. The selected chemicals will be less hazardous and will have lower impact on the environment. Open recirculation cooling water system is employed, thus reject stream form the system will be routed to Anglian Water for further treatment which avoids any potential impact on the environment.	

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	Systems Such an assessment and its constituent parts could represent an approach that can be considered BAT.		
5	**BAT 5 Reduction of emissions to air** Comparatively, air emissions from cooling towers have not been given much attention, except for the effects of plume formation. From some reported data it is concluded that levels are generally low but that these emissions should not be neglected. Lowering concentration levels in the circulating cooling water will obviously affect the potential emission of substances in the plume. Some general recommendations can be made which have a BAT-character.	Techniques to be used at the installation for reductions of emissions to air include: • Ensure plume emissions are at a sufficient height and with a minimum discharge air velocity at the tower outlet to avoid plumes reaching ground level; • Use of less hazardous material • Designing and positioning tower outlet to avoid intake of air through air conditioning systems and affecting air quality. • Reduce drift loss by applying drift eliminators	Yes
6	**BAT 6 Reduction of noise emissions** Noise emissions have local impact. Noise emissions of cooling installations are part of the total noise emissions from the site. A number of primary and secondary measures have been identified that can be applied to reduce noise emissions where necessary. The primary measures change the sound power level of the source, where the secondary measures reduce the emitted noise level. The secondary measures in particular will lead to pressure loss, which has to be compensated by extra energy input, which reduces overall energy efficiency of the cooling system. The ultimate choice for a noise abatement technique will be an individual matter, as will the resulting associated performance level. The following measures and minimum reduction levels are considered as BAT.	The design of the cooling system is subject to further detailed design and based on the noise assessment, consideration will be given to: • Selection of low noise fans; • Optimising the sizing of the fan coolers; • Using of anti-vibration supports and interconnections for the equipment. • Employing additional screening or bunding.	Yes
7	**BAT 7 Reduction of risk of leakage** To reduce the risk of leakage, attention must be paid to the design of the heat exchanger, the hazardousness of the process	To reduce the risk of leakage, the installation will: • Material selection will be based on the fluid in the exchangers.	Yes

BAT No.	BATC Requirements	Demonstration of BAT	Operating to BAT?
	substances and the cooling configuration. The following general measures to reduce the occurrence of leakages can be applied: • select material for equipment of wet cooling systems according to the applied water quality. • operate the system according to its design, • if cooling water treatment is needed, select the right cooling water treatment programme, • monitor leakage in cooling water discharge in recirculating wet cooling systems by analysing the blowdown.	• Avoid small cracks by limiting the change in temperature over the heat exchanger. Exchanger performance is monitored. • Reduce erosion by managing the temperature of metal on the cooling water side. • Constantly monitor blowdown. • Dedicated cooling water chemical dosing program to maintain water quality. See cooling description in Section 3.2 Process Overview of the Supporting Statement.	
8	**BAT 8 Reduction of biological risk** To reduce the biological risk due to cooling systems operation, it is important to control temperature, maintain the system on a regular basis and avoid scale and corrosion. All measures are more or less within the good maintenance practice that would apply to a recirculating wet cooling system in general. The more critical moments are start-up periods, where systems' operation is not optimal, and standstill for repair or maintenance. For new towers consideration must be given to design and position with respect to surrounding sensitive objects, such as hospitals, schools and accommodation for elderly people.	To reduce biological risk as a wet recirculating cooling system, the installation will demonstrate good maintenance practices and take the following primary approaches: • Reduce light energy reaching the cooling water to reduce algae formation • Avoid stagnant zones(design) and apply optimized chemical treatment to reduce biological growth • A combination of mechanical and chemical cleaning after outbreak • Periodic monitoring of pathogens in the cooling systems to control the pathogens • Maintain an up to date legionella risk assessment and ensure defined preventive maintenance and other tasks are by scheduling them in the maintenance system To reduce the risk of wet cooling towers, the operators will wear a half-face respirator with N95 particulate filters/P2 cartridge for operations around the cooling tower where that are likely to be exposed to droplets or aerosols See cooling description in Section 3.2 Process Overview of the Supporting Statement.	Yes