ABBVIE IRELAND NL.BV BIO-CHEMICAL FACILITY, CO. SLIGO – ASSESSMENT OF COMPLIANCE WITH REFERENCE DOCUMENT ON THE APPLICATION OF BEST AVAILABLE TECHNIQUES TO INDUSTRIAL COOLING SYSTEMS, DECEMBER 2001

The full and complete BAT Conclusion Document is available at the EIPPC Bureau website: http://eippcb.jrc.ec.europa.eu/reference/

Conclusions on BAT	Applicability Assessment (describe how the technique applies or not to your installation)	State whether it is in place or state schedule for implementation
4.2.1 Integrated heat management		
4.2.1.1 Industrial cooling = Heat management		
Cooling of industrial processes can be considered as heat management and is part of the total energy management within a plant. The amount and level of heat to be dissipated requires a certain level of cooling systems performance. This performance level will in turn affect the system configuration, design and operation and consequently the cooling systems' environmental performance (**direct impact).** Reversibly, the cooling performance will also affect the overall efficiency of the industrial process (**indirect impact).** Both impacts, direct and indirect, need to be balanced, taking into account all variables. Every change in the cooling system has to be considered against the consequences it may have for this balance. **BAT for all installations** is an integrated approach to reduce the environmental impact of industrial cooling systems **maintaining the balance between both the direct and indirect impacts**. In other words, the effect of an emission reduction has to be balanced against the potential change in the overall energy efficiency. There is currently no minimum ratio in terms of the environmental benefits and the possible loss in overall energy efficiency that can be used as a benchmark to arrive at techniques that can be considered BAT. Nevertheless, this concept	Applicable – New and existing cooling systems. The existing facility has been designed to minimise any heat loss or wastage of heat from the processes. The new suite has similarly been designed to high heat efficiency standards (BSEN 378-1 for design requirements). There are 2 no. cooling towers at the existing facility as well as 3 no. water cooled (cooling tower) and 3 no. air cooled chillers. Both sets are used for HVAC and Process (moulding machines) cooling.	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.

can be used to compare alternatives **(Chapter 3.2 and Annex II).**	The new cooling systems will consist of 3 no. cooling towers and 3 no. new HVAC water cooled chiller – air conditioning using air to water heat exchangers. The new cooling towers will also be used to provide cooling for the Lyo and misc. process users, rather than using chillers, which therefore reduces the energy requirement of the cooling system. Both the existing water-cooled chillers and the new chillers will extract heat to the cooling towers and will operate using duty/duty/standby system Open cooling towers have been selected for the new suite as they offer an efficient and reliable form of cooling with minimal impact on the environment. Open cooling towers (closed loop) are also in place at the existing facility. The heat differential between the new chillers and the new cooling towers will be up to 8 degrees C (highest cooling load). Heat recovery is not currently proposed as the actual operational heat load will typically be significantly lower.	

	The cooling system is designed for anticipated maximum loads including the climate. Whilst the heat differential between the chillers and the cooling towers cannot be recovered, the cooling towers will not typically result in a significant heat dump due to the small temp differential. Heat extracted to the cooling towers from the new HVAC system will be surplus heat only as the HVAC system has been designed with its own internal heat recovery. The heated water in the HVAC system after cooling is used to pre-heat the incoming air, as required, and the remaining heat in the water stream will be cooled in the cooling towers with a very small heat differential and minimal heat dumping A heat pump is also installed at the existing facility to recover the majority of the waste heat from the water cooling system before it goes to the cooling towers. The recovered heat is used pre-heat the Low Pressure Hot water (LPHW) boilers for the HVAC system.	

	Heat recovery is not currently possible on the air-cooled chillers. However, the 3 no. air cooled chillers are small in size and will have a heat differential of c.8 degrees (climate dependant) only. Heating and cooling pipes are (and will be at the new suite) insulated to prevent losses throughout the system and to improve efficiency. The heat loss is balanced against the requirement for cooling at the facility. Heat loss will be minimised and is sufficient to maintain processes at standardised temperatures.	
4.2.1.2 Reduction of the level of heat discharge by optimization of internal/external heat reuse		
A preventive approach should start with the industrial process requiring heat dissipation and aim to reduce the need for heat discharge in the first place. In fact, discharge of heat is wasting energy and as such not BAT. Reuse of heat within the process should always be a first step in the evaluation of cooling needs. Process-integrated energy measures are outside the scope of this document, but reference is made to other BAT Reference Documents drafted in the framework of IPPC describing options for energy measures. In **a greenfield** situation, assessment of the required heat capacity can only be BAT if it is the outcome of **maximum use of the internal and external available and applicable options** for reuse of excess heat.	Applicable – New and existing cooling systems. The new suite has been designed to ensure minimal excess heat generation and as such the only loss of heat at the new suite is via the new cooling towers which is up to 8 deg C. As noted above, reuse of waste heat is an integral part of the design of the new suite.	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once

In **an existing installation**, **optimizing internal and external reuse** and reducing the amount and level of heat to be discharged must also precede any change to the potential capacity of the applied cooling system. Increasing the efficiency of an existing cooling system by **improving systems operation** must be evaluated against an increase of efficiency by technological measures through retrofit or technological change. In general, and for large existing cooling systems, the improvement of the systems operation is considered to be more cost effective than the application of new or improved technology and can therefore be regarded as BAT.	The existing facility is also designed to optimise the use of heat and recover heat where practical. The technology selected will not result is significant heat dumping. The heat differential for the existing air-cooled chillers is c.8 deg C (climate dependant – may be < 1 deg C in winter months) whilst the heat differential for the existing cooling towers is designed to be c. 5 deg C. Heat reuse is currently being considered as part of the future design of the facility and changes to the heat efficiency will be set out in the facility's EMS and will be reported in the AERs following commencement of the IE licence. The facility is accredited to 14001 and 50001.	constructed and operational.
4.2.1.3 Cooling system and process requirements		
The selection of a cooling configuration should be based on a comparison between the different feasible alternatives within all requirements of the process. Process requirements are for example control of chemical reactions, reliability of process performance and maintenance of required safety levels. The aim is to minimise the indirect impact of the selected alternative. For each alternative the environmental performances can be best compared if expressed in direct and indirect use of energy (kW_e) per unit of energy discharged (kW_{th}). Another way to	Applicable – New and existing cooling systems. Facility has been designed to ensure minimal excess heat generation.	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of

compare configurations is to express the change in direct energy use (kW_e) of the cooling system and the change in production level of the process in tonnes, both per unit of energy discharged (kW_{th}).

A change in cooling technology to reduce the environmental impact can only be considered BAT if the efficiency of cooling is maintained at the same level or, even better, at an increased level.

Table 4.1: Examples of process requirements and BAT

Process characteristics	Criteria	Primary BAT approach	Remark	Reference
Level of dissipated heat high (> 60°C)	Reduce use of water and chemicals and improve overall energy efficiency	(Pre-) cooling with dry air	Energy efficiency and size of cooling system are limiting factors	Section 1.1/1.3
Level of dissipated heat medium (25-60°C)	Improve overall energy efficiency	Not evident	Site-specific	Section 1.1/1.3
Level of dissipated heat low (<25°C)	Improve overall energy efficiency	Water cooling	Site selection	Section 1.1/1.3
Low and medium heat level and capacity	Optimum overall energy efficiency with water saving and visible plume reduction	Wet and hybrid cooling system	Dry cooling less suitable due to required space and loss of overall energy efficiency	Section 1.4
Hazardous substances to be cooled involving high environmental risk	Reduction of risk of leakage	Indirect cooling system	Accept an increase in approach	Section 1.4 and Annex VI

<u>High heat dissipation</u>
Cooling of the exhaust air from the new LPHW boilers (part of the HVAC system) will be in place prior to emission to air. As such, condensing boilers will be in use at the new facility with recovery of the heat for pre-heating of the boiler water. Condensing boilers are also used with heat pump for pre-heating the boiler water at the existing facility.

Clean steam in the flash-pot and boiler blowdown will be cooled with domestic water prior to being discharged to the low strength wastewater system; however, the amount of water required is small and the amount of heat lost is not significant and not viable for recovery.

Following steaming of the solution prep vessels process air will be used to cool the vessels.

Hot WFI cooling is undertaken by heat exchangers using a 2-stage process: a domestic water-based heat exchanger and a tower water-based heat exchanger.

new bio-chemical suite.
These will comply with BAT once constructed and operational.

	<u>Low heat dissipation</u> - New cooling systems (i.e. HVAC units, chillers, process cooling) will use water cooling via recirculating cooling towers in maximise efficiency. - Existing cooling systems will use both air and water cooling. Air cooling has been selected where level of dissipated heat low and the use of air cooling chillers is more cost effective. Energy efficiency measures for the HVAC and process systems are outlined in the Energy Efficiency BREF assessment. No hazardous substances to be cooled.	
4.2.1.4 Cooling system and site requirements		
The site-imposed limits apply particularly to new installations, where a cooling system must still be selected.	Applicable - New and existing cooling systems.	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once

Table 4.2: Examples of site characteristics and BAT

Characteristics of site	Criteria	Primary BAT approach	Remarks	Reference
Climate	Required design temperature	Assess variation in wet and dry bulb T	With high dry bulb T dry air cooling generally has lower Energy efficiency	Section 1.4.3
Space	Restricted surface on-site	(Pre-assembled) Roof type constructions	Limits to size and weight of the cooling system	Section 1.4.2
Surface water availability	Restricted availability	Recirculating systems	Wet, dry or hybrid feasible	Section 2.3 and 3.3
Sensitivity of receiving water body for thermal loads	Meet capacity to accommodate thermal load	- Optimise level of heat reuse - Use recirculating systems - Site selection (new cooling system)		Section 1.1
Restricted availability of groundwater	Minimisation of groundwater use	Air cooling if no adequate alternative water source is available	Accept energy penalty	Section 3.3
Coastal area	Large capacity > 10 MW_{th}	Once-through systems	Avoid mixing of local thermal plume near intake point, e.g. by deep water extraction below mixing zone using temperature stratification	Section 1.2.1 / Section 3.2 /Annex XI.3
Specific site requirements	In case of obligation forplume reduction and reduced tower height	Apply hybrid cooling system	Accept energy penalty	Ch.2

Climate: Irish climate suitable for cooling

Space: No issue

Water availability: Cooling water is available at the site – from mains.

Sensitivity of receiving waterbody: Not applicable – wastewater to Irish Water mains.

Availability of groundwater: Not applicable to cooling systems.

Coastal area: Not applicable

Site specific requirements: Not applicable

constructed and operational.

4.2.2 Application of BAT in industrial cooling systems		
For **new cooling installations** it is BAT to start identifying reduction measures in the design phase, applying equipment with low energy requiring requirement and by choosing the appropriate material for equipment in contact with the process substance and/or the cooling water. In this sense the following quotation is exemplary: "in practice… attention to design, layout and maintenance of the cooling water system has a relatively low priority compared to the environmental consequences of a poorly designed and/or operated cooling water system. Since little attention is paid to design factors, treatments often have to make up for bad design, and therefore need to be chosen in such a way that they minimize risks of fouling. Few changes of this attitude are to be expected as long as there is a low level of awareness of the long-term costs of operating and maintaining poorly designed CWS" [tm005, Van Donk and Jenner, 1996]. If dry air cooling systems are the preferred option, measures are primarily related to reduction of direct energy consumption and noise emissions and the optimization of size with respect to the required cooling surface. For **existing installations,** technological measures can be BAT under certain circumstances. Generally, a change in technology is cost-intensive where overall efficiency must be maintained. Cost evaluation should then compare investment costs of the change versus the change in operational costs and validate the reduction effect versus other environmental consequences. For example, it would need a comparison between the environmental effect of recirculating the cooling water - requiring the application of biocidal water treatment - against a once-through system without biocides, but a large heat emission to the aquatic environment. In the case of pre-assembled off-the-peg cooling towers, a change in technology seems feasible both technically and economically. No comparable data have been submitted that can support this, but supplier experience is that it is relatively easy to change small size cooling towers, for example, from a closed recirculating wet to a closed recirculating hybrid or wet/dry configuration. This would not need major process modifications or construction work. For large custom-designed towers that are erected on-site, technological changes are not easy to make. A different technology generally means a completely new cooling tower.	Applicable – New and existing cooling systems. The facility has been designed to minimise any heat loss or wastage of heat from the processes. New cooling systems consist of cooling towers using air cooling methods. Minimal heat loss as water is at ambient temperature only. Distribution lines are (and will be for the new suite) insulated to prevent losses of heat from the system.	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.

For existing wet cooling systems, where the focus is largely on environmental measures to reduce water use and to emissions of chemicals to the surface water, BAT has not so much technological but rather an operational character. Monitoring, operation and maintenance are the key issues here.		
4.3 Reduction of energy consumption		
4.3.1 General		
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; • 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.	Applicable – New and existing cooling systems. The existing facility has been designed to minimise any heat loss or wastage of heat from the processes. The new suite has similarly been designed to high heat efficiency standards (BSEN 378-1 for design requirements). All equipment for the bio-chemical suite is new and specified to reduce energy consumption for heating and cooling. Pipes, ducts, etc sized to allow ease of flow. Heating and cooling pipes are (and will be for the new suite) insulated to prevent losses throughout the system and to improve efficiency. Cooling towers (new and existing) are closed systems with water recirculated between the chillers	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.

	and the cooling towers. Chemical treatment of cooling tower water is in place to prevent scaling/corrosion/fouling.	
4.3.2 Identified reduction techniques within the BAT-approach		
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). **Table 4.3: BAT for increasing overall energy efficiency**	Applicable – New and existing cooling systems. High efficiency equipment has been selected.	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.

Relevance	Criterion	Primary BAT approach	Remarks	Reference
Large cooling capacity	Overall energy efficiency	Select site for once-through option	See text above table	Section 3.2
All systems	Overall energy efficiency	Apply option for variable operation	Identify required cooling range	Section 1.4
All systems	Variable operation	Modulation of air/ water flow	Avoid instability cavitation in system (corrosion and erosion)	
All wet systems	Clean circuit/ exchanger surfaces	Optimised water treatment and pipe surface treatment	Requires adequate monitoring	Section 3.4
Once-through systems	Maintain cooling efficiency	Avoid recirculation of warm water plume in rivers and minimise it in estuaries and on marine sites		Annex XII
All cooling towers	Reduce specific energy consumption	Apply pumping heads and fans with reduced energy consumption		

Large cooling capacity not applicable.

Cooling range is 6 - 8 degrees C for new cooling towers and 4 – 6 degrees C on existing towers

Corrosion or pipelines managed through use of dosing chemicals.

Recirculation to surface water not applicable.

Cooling towers (new and existing) use variable speed pumps and variable speed drives on fans to reduce energy use.

4.4 Reduction of water requirements

4.4.1 General

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;	Applicable – New and existing cooling systems.	In place at the existing facility where practical.

• 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. 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.	Cooling with air cooled water is the only form of industrial cooling chosen for the new suite (this does not include the cryogenic freezers). Water cooling is also employed at the existing facility (air cooled chillers are also used but only for low cooling with a small heat differential). Cooling water will be from the Irish Water mains. IW have confirmed adequate supply. Both the proposed and existing cooling systems utilise heat recovery where practical as outlined above.	New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.
4.4.2 Identified reduction techniques within the BAT-approach		
Table 4.4: BAT for reduction of water requirements	Applicable – New and existing cooling systems. HVAC systems for the new suite use high efficiency design with cool air supplied and heated locally at the required units, rather than supplying warm air which requires subsequent water cooling. HVAC systems for the existing facility also use high efficiency design in GMP areas with a mix of fresh air and return air being	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.

Relevance	Criterion	Primary BAT approach	Remarks	Ref.
All wet cooling systems	Reduction of need for cooling	Optimisation of heat reuse		Ch.1
	Reduction of use of limited sources	Use of groundwater is not BAT	Site-specific in particular for existing systems	Ch.2
	Reduction of water use	Apply recirculating systems	Different demand on water conditioning	Ch.2/3.3
	Reduction of water use, where obligation for plume reduction and reduced tower height	Apply hybrid cooling system	Accept energy penalty	Ch.2.6/ 3.3.1.2
	Where water (make-up water) is not available during (part of) process period or very limited (drought-stricken areas)	Apply dry cooling	Accept energy penalty	Section 3.2 and 3.3 Annex XII.6
All recirculating wet and wet/dry cooling systems	Reduction of water use	Optimization of cycles of concentration	Increased demand on conditioning of water, such as use of softened make-up water	Section 3.2 and section XI

supplied as per requirements, this is heated or cooled locally as required depending on room conditions, all is controlled thermostatically on the building management system

Some office spaces and portacabins have spilt air conditioning units

Mains water supply not groundwater – no issue with limited sources.

Water reused in cooling towers. Discharge to low strength wastewater (discharge to sewer) is based on conductivity of the water cycling and is controlled by the cooling requirement.

Plume reduction not required.

If make up water is not available for a short period of time the chillers and the HVAC units will automatically shut down to prevent overheating. The lyo (cooling tower water user) in the production building will also shut down however production can continue for the preliminary

	production stages. Dry cooling is not possible. In the existing facility, if make up water is not available for a short period of time the chillers and cooling towers will shut down, HVAC will continue to run with non-temperature controlled water until manually turned off. Cool rooms / IT rooms / Electrical rooms use air cooled units. These would therefore be unaffected by water supply. Cooling tower water is recirculated and maintained through automated dosing. Cooling tower water is discharged to sewer when the build-up of solids is such that it is not viable to treat the water any further.	
4.5 Reduction of entrainment of organisms		
4.5.1 General		
The adaptation of water intake devices to lower the entrainment of fish and other organisms is highly complex and site-specific. 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.	Not Applicable – surface water not used for cooling systems	N/A

<table>
<tr><th colspan="3">4.5.2 Identified reduction techniques within the BAT-approach</th></tr>
<tr><td>Table 4.5: BAT for reduction of entrainment
<table>
<tr><th>Relevance</th><th>Criterion</th><th>Primary BAT approach</th><th>Remarks</th><th>Ref.</th></tr>
<tr><td rowspan="2">All once-through systems or cooling systems with intakes of surface water</td><td>Appropriate position and design of intake and selection of protection technique</td><td>Analysis of the biotope in surface water source</td><td>Also critical areas, such as spawning grounds, migration areas and fish nurseries</td><td>Section 3.3.3 and Annex XII.3.3</td></tr>
<tr><td>Construction of intake channels</td><td>Optimise water velocities in intake channels to limit sedimentation; watch for seasonal occurrence of macrofouling</td><td></td><td>Section 3.3.3</td></tr>
</table>
</td><td>Not Applicable – surface water not used for cooling systems

Ducts and piping sized to minimise pressure drop.</td><td>N/A</td></tr>
<tr><th colspan="3">4.6 Reduction of emissions to water</th></tr>
<tr><th colspan="3">4.6.1 General BAT approach to reduce heat emissions</th></tr>
<tr><td>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 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 delta-T 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.</td><td>Not applicable – cooling tower blowdown discharges to sewer not surface water.

The process wastewater including cooling tower blowdown will be allowed to cool to 35 degrees C prior to being discharged to the sewer.</td><td>N/A</td></tr>
</table>

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.		
4.6.2 General BAT approach to reduce chemical emissions to water		
Referring to the statement that 80% of the environmental impact is decided on the design table, 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, • 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. 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. A site-specific approach should be taken. The BREF includes a tool that can assist in a first ranking of selected chemicals and of an approach to assess biocides, linking the requirements	Applicable – New and existing cooling systems. Cooling tower blowdown discharges to sewer not surface water. Cooling tower blowdown will be combined with process wastewater prior to discharge. Ducts have been designed to reduce pressure drops. Chemical dosing of cooling tower water applied using automated system. Water make up known (from Irish Water). Chiller systems and piping– heat exchanger material compatible with the requirements of the process and the water inputs. The operational requirements of the new cooling system were included as part of the design spec for the new facility.	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.

of the cooling system to requirements of the receiving aquatic ecosystem (Annex VIII). The approach aims at minimising the impact of cooling water additives and, in particular, biocides.	Cooling tower water treatment will include biocide with a H400+ classification. Engineering solutions including high flow velocities, design to reduce stagnant zones, and use of corrosion resistant materials will be employed. Dosing regimen will be automated in accordance with monitoring rather than shock dosing. (new and existing). Quality of the cooling water is monitored continuously, and a monitoring system is used to control the dosing system. There will be minimal levels of contaminants in the wastewater stream from the cooling towers. This wastewater will combine with the process wastewater and will discharge to the Irish Water sewer for offsite treatment in accordance with the parameters of the IE licence.	
4.6.3 Identified reduction techniques within the BAT-approach		
4.6.3.1 Prevention by design and maintenance		
Table 4.6: BAT for reduction of emissions to water by design and maintenance techniques	Applicable – New and existing cooling systems.	In place at the existing facility where practical.

Relevance	Criterion	Primary BAT approach	Remarks	Reference
All wet cooling systems	Apply less corrosion-sensitive material	Analysis of corrosiveness of process substance as well as of cooling water to select the right material		Ch.3.4
	Reduction of fouling and corrosion	Design cooling system to avoid stagnant zones		Annex XI.3.3.2.1
Shell&tube heat exchanger	Design to facilitate cleaning	Cooling water flow inside tube and heavy fouling medium on tube side	Depending on design, process T and pressure	Annex III.1
Condensers of power plants	Reduce corrosion-sensitiveness	Application of Ti in condensers using seawater or brackish water		Annex XII
	Reduce corrosion-sensitiveness	Application of low corrosion alloys (Stainless Steel with high pitting index or Copper Nickel)	Change to low corrosion alloys can affect formation of pathogens	Annex XII.5.1
	Mechanical cleaning	Use of automated cleaning systems with foam balls or brushes	In addition mechanical cleaning and high water pressure may be necessary	Annex XII.5.1

Cooling tower blowdown discharges to sewer not surface water.

Wet Cooling Systems

Cooling tower blowdown will be combined with process wastewater prior to discharge.

Cooling towers, pipes, ducts, chillers – use less corrosion sensitive materials in the new systems. Stagnant zones reduced via design of the pipelines and ducts. Existing systems pre-date current owners and design is not known. However, routine assessments are carried out on existing piping network to ensure no dead legs.

Shell & tube Heat Exchangers

Used for GMP areas using WFI. These are designed to be easily cleanable. Cooling tower water for cooling is on the tube side with the WFI inside the tube.

Condensers of power plants

Not applicable

New cooling towers and cooling systems proposed as part of new bio-chemical suite.
These will comply with BAT once constructed and operational.

Condensers and heat exchangers	Reduce deposition (fouling) in condensers	Water velocity > 1.8 m/s for new equipment and 1.5 m/s in case of tube bundle retrofit	Depending on corrosion sensitivity of material, water quality and surface treatment	Annex XII.5.1
	Reduce deposition (fouling) in heat exchangers	Water velocity > 0.8 m/s	Depending on corrosion sensitivity of material, water quality and surface treatment	Annex XII.3.2
	Avoid clogging	Use debris filters to protect the heat exchangers where clogging is a risk		Annex XII

<u>Condensers and heat exchangers</u>
New chillers will use condensers and evaporators. Fouling will be reduced by selecting chiller units which are designed with tube sizes and velocities to prevent either fouling or erosion of the tubes. This will not be selected on the basis of velocity alone but will be based on best practice with consideration of the risk of erosion as well as the efficiency of the boiler.

The existing system is checked for fouling and undergoes preventative maintenance at least yearly.

Velocity of the water through the tubes in the new condensers will be >1.8m/s. Existing systems pre-date current owners and design is not known.

Heat exchangers will also be used to cool the hot WFI. This includes both domestic water and cooling tower water-based heat exchangers. The velocity of the cooling water through the exchangers will be >0.8m/s.

Once-through cooling system	Reduce corrosion-sensitiveness	Apply carbon steel in cooling water systems if corrosion allowance can be met	Not for brackish water	Annex IV.1
	Reduce corrosion-sensitiveness	Apply reinforced glass fibre plastics, coated reinforced concrete or coated carbon steel in case of underground conduits		Annex IV.2
	Reduce corrosion-sensitiveness	Apply Ti for tubes of shell&tube heat exchanger in highly corrosive environment orhigh quality stainless steel with similar performance	Ti not in reducing environment, optimised biofouling control may be necessary	Annex IV.2
Open wet cooling towers	Reduce fouling in salt water condition	Apply fill that is open low fouling with high load support		Annex IV.4
	Avoid hazardous substances due to anti-fouling treatment	CCA treatment of wooden parts or TBTO containing paints is <u>not BAT</u>		Section 3.4 Annex IV.4
Natural draught wet cooling towers	Reduce anti-fouling treatment	Apply fill under consideration of local water quality (e.g. high solid content, scale)		Annex XII.8.3

Heat exchangers are also used at the existing facility for the domestic hot water. Existing systems pre-date current owners and design is not known.

Debris filters (strainers) on water piping systems and filters on air distribution systems.

<u>Once through Cooling System</u>
Not applicable

<u>Open wet cooling systems</u>
Sea water is not being used for the cooling tower make up – not applicable.

No wooden parts – not applicable.

<u>Natural draught cooling towers</u>
Not applicable

<table>
<tr><th colspan="3">4.6.3.2 Control by optimised cooling water treatment</th></tr>
<tr>
<td>
Table 4.7: BAT for reduction of emissions to water by optimised cooling water treatment
<table>
<tr><th>Relevance</th><th>Criterion</th><th>Primary BAT approach</th><th>Remarks</th><th>Reference</th></tr>
<tr><td rowspan="2">All wet systems</td><td>Reduce additive application</td><td>Monitoring and control of cooling water chemistry</td><td></td><td>Section 3.4 and Annex XI.7.3</td></tr>
<tr><td>Use of less hazardous chemicals</td><td>It is <u>not BAT</u> to use
• chromium compounds
• mercury compounds
• organometallic compounds (e.g. organotin compounds)
• mercaptobenzothiazole
• shock treatment with biocidal substances other than chlorine, bromine, ozone and H_2O_2</td><td></td><td>Section 3.4 Annex VI</td></tr>
<tr><td>Once-through cooling system and open wet cooling towers</td><td>Target biocide dosage</td><td>To monitor macrofouling for optimising biocide dosage</td><td></td><td>Annex XI.3.3.1.1</td></tr>
</table>
</td>
<td>Applicable – New and existing cooling systems.

Cooling tower blowdown discharges to sewer not surface water.

Cooling tower blowdown will be combined with process wastewater prior to discharge.

Continuous monitoring of cooling water and automated dosing.

No use of the hazardous chemicals listed other than biocide – however, no heavy dosing (continuous dosing only).

Biocide, inhibitor, and bio-detergent dosage for cooling towers via fully automated system.</td>
<td>In place at the existing facility where practical.

New cooling towers and cooling systems proposed as part of new bio-chemical suite.
These will comply with BAT once constructed and operational.</td>
</tr>
</table>

Once-through cooling system	Limit application of biocides	With sea water temperature below 10-12°C no use of biocides	In some areas winter treatment may be needed (harbours)	Annex V
	Reduction of FO emission	Use of variation of residence times and water velocities with an associated FO or FRO-level of 0.1 mg/l at the outlet	Not applicable for condensers	Ch.3.4 Annex XI.3.3.2
	Emissions of free (residual) oxidant	FO or FRO ≤ 0.2 mg/l at the outlet for continuous chlorination of sea water	Daily (24h) average value	Annex XI.3.3.2
	Emissions of free (residual) oxidant	FO or FRO ≤ 0.2 mg/l at the outlet for intermittent and shock chlorination of sea water	Daily (24h) average value	Annex XI.3.3.2
	Emissions of free (residual) oxidant	FO or FRO ≤ 0.5 mg/l at the outlet for intermittent and shock chlorination of sea water	Hourly average value within one day used for process control requirements	Annex XI.3.3.2
	Reduce amount of OX-forming compounds in fresh water	Continuous chlorinating in fresh water is <u>not BAT</u>		Ch.3.4 Annex XII

<u>Once through Cooling System</u>

Not applicable

Relevance	Criterion	Primary BAT approach	Remarks	Reference
Open wet cooling towers	Reduce amount of hypochlorite	Operate at $7 \leq pH \leq 9$ of the cooling water		Annex XI
	Reduce amount of biocide and reduce blowdown	Application of side-stream biofiltration is BAT		Annex XI.3.1.1
	Reduce emission of fast hydrolyzing biocides	Close blowdown temporarily after dosage		Section 3.4
	Application of ozone	Treatment levels of ≤ 0.1 mg O_3/l	Assessment of total cost against the application of other biocides	Annex XI.3.4.1

<u>Open Wet Cooling Towers</u>

Periodic dosing with hypochlorite. Automated monitoring chemical dosing will be in place for the new towers which will include monitoring of pH. pH will be maintained between 7-9 and will be dependent on the composition of the water supply.

Existing towers also undergo dosing and pH will be maintained as per water treatment vendors recommendation.

Side-stream filtration will be used for the new cooling tower water.

Blow down on new and old systems occurs via an automated system based on continual monitoring of the water stream.

Blow down valve is closed temporarily during dosing in accordance with BAT.

No ozone application.

4.7 Reduction of emissions to air		
4.7.1 General approach		
To reduce the potential emission of substances in the plume.	Applicable – There will be no significant contamination of the cooling tower water with unusual chemicals or foreign substances.	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.
4.7.2 Identified reduction techniques within the BAT-approach		
Table 4.8: BAT for reduction of emissions to air	Applicable – New and existing cooling systems. Tower height sufficient for plume not to reach ground. Tower located to minimise recirculation. No plume suppression techniques required. No asbestos pipelines used in new systems. No known asbestos issues at existing facility.	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.

Relevance	Criterion	Primary BAT approach	Remarks	Reference
All wet cooling towers	Avoid plume reaching ground level	Plume emission at sufficient height and with a minimum discharge air velocity at the tower outlet		Chapter 3.5.3
	Avoid plume formation	Application of hybrid technique or other plume suppressing techniques such as reheating of air	Need local assessment (urban areas, traffic)	Chapter 3.5.3
All wet cooling towers	Use of less hazardous material	Use of asbestos, or wood preserved with CCA (or similar) or TBTO is <u>not BAT</u>		Chapter 3.8.3
	Avoid affecting indoor air quality	Design and positioning of tower outlet to avoid risk of air intake by air conditioning systems	Is expected to be less important for large natural draught CT with considerable height	Section 3.5
All wet cooling towers	Reduction of drift loss	Apply drift eliminators with a loss <0.01% of total recirculating flow	Low resistance to airflow to be maintained	Section 3.5 and XI.5.1

Located away from buildings to prevent intake and impact on indoor air quality.

Drift eliminations will be in place for the new systems. Drift will be reduced to 0.005%

Drift eliminators are in place on existing cooling towers however specifications on the reduction levels is not documented. Would be similar to the new cooling towers as similar structure.

4.8 Reduction of noise emissions

4.8.1 General

To reduce noise emissions from cooling systems	Applicable – New and existing cooling systems. A noise model was provided with IED licence submission. This demonstrates noise emissions	In place at the existing facility. New cooling towers and cooling systems proposed as part of new bio-chemical

<table>
<tr><td></td><td>from the proposed site are compliant with relevant limits.</td><td>suite. These will comply with BAT once constructed and operational.</td></tr>
<tr><td colspan="3">4.8.2 Identified reduction techniques within the BAT-approach</td></tr>
<tr><td>Table 4.9: BAT for the reduction of noise emissions
<table>
<tr><th>Cooling system</th><th>Criterion</th><th>Primary BAT approach</th><th>Associated reduction levels</th><th>Ref.</th></tr>
<tr><td rowspan="2">Natural draught cooling towers</td><td>Reduce noise of cascading water at air inlet</td><td>Different techniques available</td><td>≥ 5 dB(A)</td><td>Section 3.6</td></tr>
<tr><td>Reduce noise emission around tower base</td><td>E.g application of earth barrier or noise attenuating wall</td><td>< 10 dB(A)</td><td>Section 3.6</td></tr>
<tr><td rowspan="4">Mechanical draught cooling towers</td><td rowspan="2">Reduction of fan noise</td><td rowspan="2">Apply low noise fan with characteristics, e.g.:
- larger diameter fans;
- Reduced tip speed (≤ 40 m/s)</td><td rowspan="2">< 5 dB(A)</td><td>Section 3.6</td></tr>
<tr><td>Section 3.6</td></tr>
<tr><td>Optimised diffuser design</td><td>Sufficient height or installation of sound attenuators</td><td>Variable</td><td>Section 3.6</td></tr>
<tr><td>Noise reduction</td><td>Apply attenuation measures to inlet and outlet</td><td>≥ 15 dB(A)</td><td>Section 3.6</td></tr>
</table>
</td><td>Applicable – New and existing cooling systems.

<u>Natural draught towers</u>
Not applicable.

<u>Mechanical draught towers</u>

Low noise fans – large diameter fans.

Single attenuation on fan inlet to reduce noise.

Existing cooling towers (2No.) are served by 2No. propeller fans on top of each unit and these are low noise large diameter fans.</td><td>In Place at existing facility.

New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.</td></tr>
<tr><td colspan="3">4.9 Reduction of risk of leakage</td></tr>
<tr><td colspan="3">4.9.1 General approach</td></tr>
<tr><td>To reduce the risk of leakage, attention must be paid to the design of the heat exchanger, the hazardousness of the process 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;</td><td>Applicable – New and existing cooling systems.</td><td>In place at the existing facility.</td></tr>
</table>

• 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.	Materials selected to prevent corrosion leading to leakages. Heating and cooling systems will be operated in accordance with the design. Cooling tower water will be continuously monitored, and treatment will be applied via automated system. Flow transmitter will be installed on the make-up water inflow. This will monitor the required water intake and will therefore indicate whether there is a leak.	New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.
4.9.2 Identified reduction techniques within the BAT-approach		
Table 4.10: BAT to reduce the risk of leakage		

Relevance[1]	Criterion	Primary BAT approach	Remarks	Reference
All heat exchangers	Avoid small cracks	ΔT over heat exchanger of ≤ 50°C	Technical solution for higher ΔT on case-by-case basis	Annex III
Shell&tube heat exchanger	Operate within design limits	Monitor process operation		Annex III.1
	Strength of tube/tube plate construction	Apply welding technology	Welding not always applicable	Annex III.3
Equipment	Reduce corrosion	T of metal on cooling water side < 60°C	Temp. affects inhibition of corrosion	Annex IV.1
Once-through cooling systems	VCI score of 5-8	Direct system $P_{cooling\ water} > P_{process}$ and monitoring	Immediate measures in case of leakage	Annex VII
	VCI score of 5-8	Direct system $P_{cooling\ water} = P_{process}$ and automatic analytical monitoring	Immediate measures in case of leakage	Annex VII
	VCI score of ≥ 9	Direct system $P_{cooling\ water} > P_{process}$ and automatic analytical monitoring	Immediate measures in case of leakage	Annex VII
	VCI score of ≥ 9	Direct system with heat exchanger of highly anticorrosive material/ automatic analytical monitoring	Automatic measures in case of leakage	Annex VII
	VCI score of ≥ 9	Change technology - indirect cooling - recirculating cooling - air cooling		Annex VII
	Cooling of dangerous substances	Always monitoring of cooling water		Annex VII
	Apply preventive maintenance	Inspection by means of eddy current	Other non-destructive inspection techniques are available	
Recirculating cooling systems	Cooling of dangerous substances	Constant monitoring of blowdown		

1) Table not applicable for condensers

Applicable – New and existing cooling systems.

Heat Exchangers
Heat reduction will not exceed delta 50 degrees C in any one exchanger.

Shell & Tube
Monitoring of process operation via temperature, pressure, and flow monitoring. Appropriate alarms will be in place should there be any major deviation.

All equipment will be welded in accordance with vendor procedures.

Equipment
Cooling water significantly below 60 degrees C.

Once Through Cooling Systems
Not applicable

Recirculating cooling systems
Cooling tower water treatment will include biocide with a H400+ classification. No data available on MSDS for bio-accumulation potential so VCI score of 8.

In place at the existing facility where practical.

New cooling towers and cooling systems proposed as part of new bio-chemical suite.
These will comply with BAT once constructed and operational.

	Automated monitoring provided in accordance with BAT for VCI score of 8. Cooling tower water will be continuously monitored, and treatment will be applied via an automated system. Preventative maintenance will be undertaken as recommended by manufacturer. Continuous monitoring system will open the valve for blowdown when required. The flow rate is also monitored.	
4.10 Reduction of biological risk		
4.10.1 General approach		
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.	Applicable – New and existing cooling systems. Temperature monitored continuously. Scale and corrosion managed using automated dosing system. Automated monitoring remains in place even if water is static (existing and proposed).	In place at the existing facility where practical. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.

	One cell taken out at a time for maintenance depending on the level of maintenance needed. The AbbVie Ballytivnan site is located to the north of Sligo town however there are no schools, hospitals, or accommodation for elderly people along the boundary. There are residential properties to the west and south. The new cooling towers have been situated away from the boundary of the site in the north part of the site and will not impact on sensitive receptors.	
4.10.2 Identified reduction techniques within the BAT-approach		
Table 4.11: BAT to reduce biological growth	Applicable – New and existing cooling systems. No reduction in light energy available (open cooling towers). Continuous biocide dosing as well as constant flow and best practice cleaning regime will be in place to prevent algae formation. Stagnant zones reduced in design (cooling systems for new suite), and maintenance is per cell. Existing systems pre-date current owners and design is not known.	In place at the existing facility. New cooling towers and cooling systems proposed as part of new bio-chemical suite. These will comply with BAT once constructed and operational.

Cooling system	Criterion	Primary BAT approach	Remarks	Reference
All wet recirculating cooling systems	Reduce algae formation	Reduce light energy reaching the cooling water		Section 3.7.3
	Reduce biological growth	Avoid stagnant zones (design) and apply optimized chemical treatment		
	Cleaning after outbreak	A combination of mechanical and chemical cleaning		Section 3.7.3
	Control of pathogens	Periodic monitoring of pathogens in the cooling systems		Section 3.7.3
Open wet cooling towers	Reduce risk of infection	Operators should wear nose and mouth protection (P3-mask) when entering a wet cooling tower	If spraying equipment is on or when high-pressure cleaning	Section 3.7.3

Cleaning following algae outbreak will be as per vendor recommendation.

Mains water – pathogens not applicable. The site has a legionella risk assessment and monitoring regime complying to:

1.1 HSE document L8 – 'Legionnaires' disease - The control of legionella bacteria in water systems' Approved Code of Practice and guidance on regulations (L8) Fourth Edition 2013.

1.2 National Guidelines for the Control of Legionellosis in Ireland, 2009

Access to cooling towers controlled under SOP including the use of PPE.