Amazon Data Services Ireland Limited

Industrial Cooling Systems BAT Reference Document

Attachment-4-7-4

Prepared by AWN Consulting

Licence Application Ref: LA009940

Conclusions on BAT from the ICS BAT Reference Document (extracts)
The full and complete ICS BAT reference document (December 2001) is available at the EIPPC Bureau website: http://eippcb.jrc.ec.europa.eu/reference/.

SCOPE OF BEST AVAILABLE TECHNIQUES (BAT)

The following industrial cooling systems or configurations are covered in this BREF document:

- Once-through cooling systems (with or without cooling tower)
- Open recirculating cooling systems (wet cooling towers)
- Closed circuit cooling systems
  - air-cooled cooling systems
- Closed circuit wet cooling systems
- Combined wet/dry (hybrid) cooling systems
  - open hybrid cooling towers
  - closed circuit hybrid tower

The particular processes and activities at the installation that come within the scope of the conclusions on BAT from the ICS reference document (BREF) are:

- Air Cooling via Air Handling Units (AHUs) are located at each data hall and typically operate on Free Cooling Code (air cooling) with Evaporative Cooling (wet cooling) mode used during peak ambient temperatures.
- Office air conditioning is provided by a Variable Refrigerant Flow (VRF) system which is not covered under the scope of this document as this uses refrigerant rather than air and/or water cooling.

Conclusions on BAT	Applicability assessment and description of the technique.	Schedule for implementation
Integrated Heat Management:		
BAT 1. 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	**Applicable** - Cooling is required for each data hall within the data storage facility and is provided via free air cooling during normal operations. Evaporative cooling mode is only used during peak ambient temperatures i.e. in other than normal operations. During evaporative cooling mode, there is not a	In place

considered BAT. Nevertheless, this concept can be used to compare alternatives (Chapter 3.2 and Annex II).	significant discharge as this water will be consumed in the evaporative process. The data servers are the best available technology and some heat generation is unavoidable due to the nature of the technology. Alternative technologies are considered on an ongoing basis by the Operator as a part of each of its designs based on many factors including technical feasibility, environmental impact, efficiency, security, reliability and cost. ADSIL is committed to continually assessing and improving this technology particularly with respect to minimising power consumption and reducing heat losses.	
BAT 2. Reduction of the level of heat discharge by optimization of internal/external heat reuse. 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. 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.	**Applicable** - The waste heat from the data storage facilities is removed continually by motorised fans in the AHU system. The cooling systems include Air Handling Units (AHUs) to utilise outdoor air to cool the space. Additional cooling to this is provided by evaporative means. Waste heat from the office spaces of Building X and Y is re-used within the development as part of the fresh air ventilation system. Energy efficient Heat Recovery Units recover the waste heat and use it to pre-heat the incoming air thereby reducing the overall energy consumption of the heating system within the Building X and Y office spaces.	In place

	Energy efficiency measures have been implemented as outlined in the BREF assessment for Energy Efficiency.	
BAT 3. Cooling system and process requirements: a) 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. See table 4.1' *Examples of process requirements and BAT'*. b) Hazardous process substances, which involve a high environmental risk to the aquatic environment in case of leakage, should be cooled by means of indirect cooling systems to prevent an uncontrollable situation. c) 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.	**Applicable –** The facility has been designed to ensure minimal waste heat is produced. The selection of the cooling system has taken into account process requirements. Free (dry) air cooling is suitable for the data storage facilities during normal conditions and cooling towers are not required. Evaporative cooling is only undertaken when ambient external conditions are too high and where the use of outside air is no longer achievable without some form of additional cooling from the evaporative process No hazardous substances are required to be cooled. An efficient cooling system has been designed.	In place
BAT 4. Cooling system and site requirements: For temperature-sensitive processes it is BAT to select the site with the required availability of cooling water. See table 4.2 *Examples of site characteristics and BAT*. **Table 4.2: Examples of site characteristics and BAT**	**Applicable**. Climate: Wet and dry bulb variation has been considered; the Irish climate is suitable. Space: The building and cooling system has been designed concurrently. There is sufficient space to access and maintain units. Surface water availability: Not required. There is sufficient mains water available provided by Irish Water.	In place

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

Sensitivity of receiving waterbody: No direct discharge of wastewater to waterbodies.

Groundwater availability: Not required. There is sufficient water available provided by Irish Water.

Coastal area: Not applicable. No direct discharge of wastewater to coastal water.

Site specific requirements: Not applicable.

Application of BAT in industrial cooling systems:

BAT 5. 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.	**Applicable -** The cooling system employed for the data halls has been designed with low energy usage in mind. The direct energy consumption in the server rooms is monitored and minimised by: the use of efficient equipment (AHUs), and the use of BMS (Building Management System) controls to minimise running speed at all times. Appropriate material(s) have been considered and designed in for the	In place

	equipment in contact with the cooling water.	
BAT 6. 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 existing wet cooling systems where focus is largely on measures to reduce water use and emissions of chemicals to surface water BAT is operational rather than technological.	**Applicable** – this is a relatively new installation, however, measures to reduce water use in the evaporative cooling systems are ongoing. The recirculation of cooling water is one aspect being considered.	In place and ongoing
Reduction of energy consumption		
BAT 7. 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.	**Applicable -** The direct energy consumption in the data storage facilities is minimised by the use of efficient equipment (i.e. AHUs), and the use of BMS (Building Management System) controls to minimise running speed at all times. Water pipes, air ducts, etc are designed to be of a size to reduce resistance to water and airflow. Dead legs in the system are reduced where possible, and removed as part of ongoing maintenance. Heating and cooling pipes are insulated to prevent losses throughout the system and to improve efficiency; or where this is currently not the case, ADSIL is working towards getting these installed where required. Appropriate material has been designed for the equipment in contact with the warm air and cooling water. Ducts are galvanised steel. Evaporative cooling water pipes are PVC and copper.	In place

BAT 8.

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*.

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		

Applicable - The process requirements have been identified; high efficiency equipment is selected to provide the most efficient cooling to the required temperature range.

The data halls are cooled used using outside air cooling during normal operations. This system is standard for data storage facilities due to the Irish climate.

The cooling system is monitored for temperature, pressure, humidity and flow rates and controlled by an electronic BMS. The system monitors conditions and responds to reduce fan speeds to maintain the operating point at the minimum necessary to meet the data storage room environmental conditions.

Additional cooling is provided by evaporative means, utilizing water as cooling media. There is no requirement for chemical water treatment as the water is typically evaporated during the process. Unused water is re-circulated within the AHUs for re-use during the cooling cycle. At the end of the cooling cycle water from the AHUs are drained down to stormwater. A UV steriliser is employed to ensure the water remains clear of biological growth. The conductivity probe and UV system are controlled by the BMS.

Evaporative cooling is only used during peak ambient temperatures.

In place

	There are no once-through water-based systems. There is no discharge directly into a surface water body. The AHUs have high efficiency electrically commutated (EC) fans equipped with Variable Speed Drives (VSD) which are responsible for adjusting the exhaust fan speed based on the measured pressure differentials. The system is monitored and controlled by the BMS which monitors conditions and responds to reduce fan speeds and pump speed to maintain the operating point at the minimum necessary to meet the data storage room environmental conditions. The EPMS will alarm in the event of a supply fan failure, evaporative cooling pump failure, main power loss, failure of supply air temperature sensors, low supply air temperature, high supply air temperature, UV light failure, AHU sump too high, AHU sump level too low, AHU leak detection, etc. The AHU unit controllers are equipped with default failsafe modes in the event that an input from the BMS Area Controller is lost or fails to send valid setpoints/values. The AHU unit controller shall generate an alarm on any loss of input signal from the EPMS.	
Reduction of water requirements		
BAT 9. **For new systems the following statements can be made:** • cooling with water is most efficient with respect to overall energy balance;	**Applicable -** The site is not considered to have a large cooling demand. The facility will not consume water during normal operations, when air cooling has been	In place

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• For new installations a site should be selected for availability of sufficient (surface) water and adequate receiving water in case of large cooling demand;

• Cooling demand should be reduced by optimising heat re-use;

• Where water is limited a technology should be chosen that enables different modes of operation requiring less water for required cooling capacity;

• In all cases recirculated cooling in an option.

See table 4.4 BAT for reduction of water requirements.

<table>
<tr><th>Relevance</th><th>Criterion</th><th>Primary BAT approach</th><th>Remarks</th><th>Ref.</th></tr>
<tr><td rowspan="5">All wet cooling systems</td><td>Reduction of need for cooling</td><td>Optimisation of heat reuse</td><td></td><td>Ch.1</td></tr>
<tr><td>Reduction of use of limited sources</td><td>Use of groundwater is not BAT</td><td>Site-specific in particular for existing systems</td><td>Ch.2</td></tr>
<tr><td>Reduction of water use</td><td>Apply recirculating systems</td><td>Different demand on water conditioning</td><td>Ch.2/3.3</td></tr>
<tr><td>Reduction of water use, where obligation for plume reduction and reduced tower height</td><td>Apply hybrid cooling system</td><td>Accept energy penalty</td><td>Ch.2.6/ 3.3.1.2</td></tr>
<tr><td>Where water (make-up water) is not available during (part of) process period or very limited (drought-stricken areas)</td><td>Apply dry cooling</td><td>Accept energy penalty</td><td>Section 3.2 and 3.3 Annex XII.6</td></tr>
<tr><td>All recirculating wet and wet/dry cooling systems</td><td>Reduction of water use</td><td>Optimization of cycles of concentration</td><td>Increased demand on conditioning of water, such as use of softened make-up water</td><td>Section 3.2 and section XI</td></tr>
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determined to be sufficient to meet the cooling requirements for the server rooms.

AHUs require humidified water input when they operate in evaporative cooling mode. Humidified water is required for the data halls during elevated temperatures when operating in evaporative cooling mode. This system is optimised through the use of temperature sensors and the BMS.

Humidified water is supplied from the mains and stored in humidified water tanks at each of the data storage facilities. Irish Water have been consulted prior to submission of each planning application to ensure that there is adequate supply for all data storage facilities on the site.

Evaporative cooling pipework is distributed to each AHU corridor with each route / pipework capable of supplying the required volume of water for all units in that corridor. This maximises water use efficiency.

Water in the evaporative cooling system is predominately used up (i.e. evaporated) in the process. Unused water will be recirculated during the cooling cycle and reused until the conductivity of the water reaches 1500 µS/cm (or after 7 days as is required to prevent legionella growth).

Dry cooling (air cooling) is the primary cooling method.
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<td>BAT 10. Reduction of entrainment of organisms.</td>
<td>Not applicable – surface water not used.</td>
<td>N/A</td>
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For once through systems or systems with intakes of surface water, BAT is analysis of biotope in surface water source and optimisation of water velocities in intake channels to limit sedimentation.		
BAT 11. Identified reduction techniques within the BAT-approach. Analysis of the biotope in surface water source, Optimise water velocities in intake channels to limit sedimentation; watch for seasonal occurrence of macrofouling. see table 4.5 *BAT for reduction of entrainment.*	**Not applicable** – surface water is not used.	N/A
Reduction of emissions to water		
BAT 12. General BAT approach to reduce heat emissions 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.	**Not applicable** - There is no discharge of heated water from the cooling system into a surface water body.	N/A
BAT 13. General BAT approach to reduce chemical emissions to water. 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. Such an assessment and its constituent parts could represent an approach that can be considered BAT.	**Applicable** - The selection of water treatment (UV sterilisation) is appropriate for the facility. No water treatment chemicals are required.	In place
BAT 14. 80% of environmental impact is decided on design table, measures should be taken in the design of wet cooling system using the following order of approach: • Identify process conditions (P, T, corrosiveness); • Identify chemical characteristics of cooling water sources; • select appropriate material for heat exchanger for both process and cooling water characteristics;	**Applicable** - The data storage facilities have a number of AHUs that require water input when they operate in evaporative cooling mode). These systems have been designed to maximise the use of dry cooling (air cooling) with water cooling used only during the warm summer months.	In place

• select appropriate materials for other parts of the cooling system; • Identify operational requirements of the cooling system; • Select feasible cooling water treatment using less hazardous chemicals or lower potential for environmental impact; • apply biocide selection scheme; • optimise dosage regime by monitoring of cooling water and systems conditions;	The evaporative cooling system has been designed to ensure it is as efficient as possible. The evaporative cooling water is supplied from the mains network. Appropriate material has been designed in for the equipment in contact with the humidified water. Evaporative cooling water pipes are PVC and copper. The operational requirements of the cooling system have been established to ensure energy efficiency. There is no requirement for water treatment (e.g. with biocide) as the water is typically evaporated during the process. A UV sterilisation system is also employed. Cleaning of the closed systems with a hydrogen peroxide solution will only be undertaken in the event that Legionella has been detected. The use of the evaporative cooling mode and water consumption is minimised by the use of efficient equipment (AHUs), and the use of BMS controls to minimise running speed at all times.	
Identified reduction techniques within the BAT-approach		
BAT 15. Prevention by design & maintenance See table 4.6 BAT for reduction of emissions to water by design and maintenance techniques	**Applicable** - There is no proposed emission of process water. The cooling systems will require water only when operating in evaporative cooling mode.	In place

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

The evaporative cooling water is supplied from the mains network.

Evaporative cooling pipework is distributed to each AHU corridor with each route / pipework capable of supplying the required volume of chilled water for all units in that corridor. This maximises water use efficiency.

Water pipes are designed to be of a size to reduce resistance. Dead legs in the system are currently being addressed and ADSIL are working to remove them.

Appropriate material has been designed in for the equipment in contact with the cooling water. Evaporative cooling water pipes are PVC and copper.

Pipework pressure tests are carried out during system install to determine if there is a leak in the system.

Cleaning of the closed systems with a hydrogen peroxide solution will only be undertaken in the event that Legionella has been detected.

Site maintenance and housekeeping systems are in place for the installation and relevant plant is included within a preventative maintenance schedule. This is managed by an Enterprise Asset Management System which is administered by a dedicated Asset Management Team. The EAM system records plant and equipment at each ADSIL site – each item is individually logged in the EAM system along with the PM requirements and frequency of

<table>
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<tr><td rowspan="3">Condensers and heat exchangers</td><td>Reduce deposition (fouling) in condensers</td><td>Water velocity > 1.8 m/s for new equipment and 1.5 m/s in case of tube bundle retrofit</td><td>Depending on corrosion sensitivity of material, water quality and surface treatment</td><td>Annex XII.5.1</td></tr>
<tr><td>Reduce deposition (fouling) in heat exchangers</td><td>Water velocity > 0.8 m/s</td><td>Depending on corrosion sensitivity of material, water quality and surface treatment</td><td>Annex XII.3.2</td></tr>
<tr><td>Avoid clogging</td><td>Use debris filters to protect the heat exchangers where clogging is a risk</td><td></td><td>Annex XII</td></tr>
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<td>maintenance required – an automatic update is sent to DCEO in advance when maintenance is due.</td>
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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

BAT 16. Control by optimised cooling water treatment See table 4.7 *BAT for reduction of emissions to water by optimised cooling water treatment*	**Applicable** - There is no proposed emission of cooling water during normal operation. The evaporative cooling water is supplied from the mains network.	In place

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<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>
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<td>There is no requirement for water treatment (e.g. with biocide) as the water is typically evaporated during the process. A UV sterilisation system is employed.

Cleaning of the closed systems with a hydrogen peroxide solution will only be undertaken in the event that Legionella has been detected.

There are no hazardous chemical additions to the water supply.</td>
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<tr><td colspan="3">Reduction of emissions to air</td></tr>
<tr>
<td>BAT 17. Identified reduction techniques within the BAT-approach

See table 4.8. BAT for reduction of emissions to air

Identified reduction techniques within the BAT approach for all wet cooling towers:

i) Avoid plume reaching ground level
ii) Avoid plume formation
iii) Use of less hazardous material
iv) Avoid affecting indoor air quality
v) Reduction of drift loss</td>
<td>Not Applicable - Wet cooling towers are not used; there is no plume generated.</td>
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<tr><td colspan="3">Reduction of noise emissions</td></tr>
<tr>
<td>BAT 18. Identified reduction techniques within the BAT-approach

See table 4.9 BAT for reduction of noise emissions

Identified reduction techniques within the BAT approach for natural draught cooling towers:

i) reduce noise of cascading water at inlet:</td>
<td>Not applicable - The facility does not use natural draught cooling towers.</td>
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ii) reduce noise emission around tower base Identified reduction techniques within the BAT approach for mechanical draught cooling towers: iii) reduction of fan noise iv) optimised diffuser design No Standard commercial cooling tower utilised - low noise v) noise reduction		
BAT to reduce the risk of leakage		
BAT 19. Identified reduction techniques within the BAT-approach 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. See table 4.10 BAT to reduce the risk of leakage. The following general measures to reduce the occurrence of leakages can be applied: i) select material for equipment of wet cooling systems according to applied water quality ii) operate the system according to its design iii) if cooling water treatment is needed, select the right cooling water treatment programme; iv) monitor leakage in cooling water discharge in recirculating wet cooling systems by analysing the blowdown	**Applicable** – Water flow in the evaporative cooling system has been designed in accordance with best practice to minimise the risk of leaks. There are no hazardous process substances. Pipework pressure tests are carried out during system install to determine if there is a leak in the system. Materials for the construction of the cooling system are selected to prevent corrosion leading to leakages. The cooling system is operated in accordance with the design. Leak detection systems are installed in the units and these are connected to the BMS.	In place
Reduction of biological risk		
BAT 20. Identified reduction techniques within the BAT approach See table 4.11 *BAT to reduce biological growth* Identified reduction techniques within the BAT approach for all wet recirculating cooling systems:	**Not applicable** – Water is provided by the public main and no biological growth is anticipated. Cleaning following any algae outbreak will be as per vendor recommendation.	In place

i) reduce algae formation ii) reduce biological growth iii) cleaning after outbreak iv) control of pathogens Identified reduction techniques within the BAT approach for all open wet cooling towers: v) reduce risk of infection	Cleaning of the closed systems with a hydrogen peroxide solution will only be undertaken in the event that Legionella has been detected.	