19 Application Guidelines

1. Introduction

The satisfactory performance of cooling equipment is dependent on correct selection and proper attention to overall system design, installation, water care and maintenance. The purpose of this document is to highlight the major points, which should be considered when designing a system with BAC evaporative cooling equipment.

2. Safety

Adequate precautions, appropriate for the installation and location of these products, should be taken to safeguard the public from possible injury and the equipment and the premises from damage. Operation, maintenance and repair of this equipment should be undertaken only by personnel qualified to do so. Proper care, procedures and tools must be used in handling, lifting, installing, operating, maintaining, and repairing this equipment to prevent personal injury and/or property damage.

3. Thermal duty

The selection of a particular model is based on a thermal duty and the wet bulb temperature. Thermal ratings are based on the wet bulb temperature of the air entering the equipment and do not take into account any recirculation of warm and humid discharge air, which may occur under certain weather and wind conditions. Verification of ratings assumes a test according to a recognised test standard and the application of tolerances as recorded during the test and applied to the test results.

4. Operating Conditions

	Open Cooling Towers		Closed Circuit Cooling Towers		Evaporative Condensers	
	Counterflow	Crossflow	Counterflow	Combined flow	Counterflow	Combined flow
Design Pressure std. coil (bar)	NA	NA	10	10	22	22
Design Pressure high press. coil (kPa)	NA	NA	NA	NA	28	28
Spray Pressure, max. at inlet (kPa)	50	NA	14	14	14	14
Fill Spacing std. (mm) (1)	14	19	NA	19	NA	19
Inlet temperature, max. (°C) (2)	55	50	80	60	120	120
Inlet temperarure CPVC. max. (°C)	65	58	NA	NA	NA	NA
Inlet temperature, PP, max. (°C) (3)	80	NA	NA	NA	NA	NA
Outlet temperature, min. (°C)	5	5	10	10	-20	-20
Make-Up Pressure mechanical valve (kPa) (4)	100-500	100-500	100-500	100-500	100-500	100-500

(1) BACount® (PVC or CPVC) fill has spacing of 14 mm and is generally used on all counterflow cooling towers. For specific cooling tower lines, consult your BAC Balticare Representative.
(2) For pultruded material of construction and FRP, maximum inlet temperature is 60°C.
(3) High temperature 80°C application requires special high temperature execution of tower.
(4) It must be ensured that adequate make up water supply is available for proper operation of the equipment within the supply pressure range suitable for the make up valve. Alternative valve selections are available for such cases.

5. Fluid Compatibility

The fluid to be cooled must be compatible with the coil material. Fluids not compatible with coil materials can lead to corrosion and tube failure. Certain fluids may require occasional pressure cleaning or mechanical cleaning of the inside of coil tubes. In such cases the coil must be designed to provide this capability.

6. Open-Closed System

The standard galvanised steel serpentine and coils (prime surface) are carbon steel, hot-dip galvanised on the outside only, and are intended for application on closed, pressurised systems which are not open to the atmosphere. Stainless steel coils or cleanable coil units (with tubes hot-dip galvanized inside and out) are available to cool corrosive fluids or water and ethylene/propylene glycol solutions in systems open to the atmosphere.

7. Code Requirement for Evaporative Condensers

All evaporative condenser coils supplied from Europe, including desuperheater coils, are certified according to the European Pressure Equipment Directive. Since November 1999 this Pressure Equipment Directive has been adopted by the national legislation of all EU and EFTA member states. The PED specifies the design, manufacturing, quality and documentation requirements for pressure vessels and replaces previous national code requirements. BAC evaporative condenser coils fall under Category IV of the PED reglementation and require a CE Declaration of Conformity which is supplied by BAC at time of shipment.

Standard PED Coil design (hot-dip galvanised)
All BAC evaporative condenser coils, including bare serpentine coils, split circuit coils, extended surface coils and desuperheater coils are designed as standard for a maximum operating pressure of 23 bar (minimum -1 bar). Design temperatures are minimum: -20°C and maximum +120°C. All standard PED coils are pneumatically tested at 34 bar after fabrication.

Optional High pressure PED coil design (hot dip galvanised)
For specific refrigerants or applications requiring higher operating pressures (> 23 bar), the high pressure coil option is available for all hot-dip galvanised condenser coil types (see above under standard PED coil design). The high pressure coils are designed for a maximum operating pressure of 28 bar (min. -1 bar) and are pneumatically tested at 40 bar. Design temperatures are minimum -20°C and maximum +120°C.

Optional Stainless Steel PED coil design
Bare serpentine coils only (with or without split) are available in stainless steel AISI 304 or AISI 316 execution. All stainless steel coils are designed for a maximum operating pressure of 23 bar (min. -1 bar) and are pneumatically tested at 34 bar. Design temperature limits are minimum -20°C and maximum +120°C.

8. Construction Materials Compatibility

Cooling Towers Fill Packing
The heat transfer surface is of the film type and compatible with water found in most cooling tower applications. For cooling applications, where the water is contaminated by solids of large size, oil or grease or organic contaminants, alternative heat transfer surfaces with larger spacing must be considered.

Closed Circuit Cooling Towers and Condenser Coils
The standard coil is all prime surface continuous serpentine steel tubing. It is designed for low pressure drop with sloping tubes for free drainage. The coil is encased in a steel framework and the entire assembly is hot dip galvanised after fabrication. Fluids circulated through the inside of the coils must be compatible with the coil construction material, i.e.

- black steel, for std. hot dip galvanised coils
- stainless steel AISI 304L or 316L (option)
- galvanised steel for cleanable coil option (not available for all coil product lines)

Standard coils may contain certain contaminants, such as carbon iron oxide or welding particles. The interior condition of the coil including humid air must be considered, when using halocarbon (or HFC) refrigerants and sensitive system components, such as electronic expansion devices or semi-hermetic compressors.
The installer must take the necessary precautions on site, including complete clean up and evacuation and the installation of filter/dryers to safeguard the operation of these components in conjunction with the condenser coils. It is not uncommon that in the first year of operation filter cartridges have to be replaced more frequently.

9. Vibration Cutout Switches

Vibration cut-out switches are recommended on all axial fan installations. Vibration cut-out switches are designed to interrupt power to the fan motor and/or provide an alarm to the operator in the event of excessive vibration. Both electronic and mechanical vibration cut-out switches are available.

10. Water Quality

Evaporative cooling is accomplished by the evaporation of a small portion of water. As water evaporates, the dissolved solids originally present in the water remain in the system. The concentration of dissolved solids increases rapidly and can reach unacceptable levels. In addition, airborne impurities and biological contaminants are often introduced into the recirculating water, since the evaporative cooler is washing the air.
If impurities and contaminants are not effectively controlled, they can cause scaling, corrosion, sludge or biological fouling, which reduce heat transfer efficiency and increase system operating costs. For optimal heat transfer efficiency and maximum equipment life, the quality of the make-up and recirculating water should be maintained within the limitations listed below.

Make-Up Water
Make-up water to the evaporative unit should have minimum 30 ppm hardness as $CaCO_3$. BAC discourages the use of fully softenend water as make-up to BAC equipment.
Where softening is required,a blend with the raw water supply is imperative to give a recommended residual hardness in the make-up of 30-70 mg/l as $CaCO_3$. This will counter the corrosive tendency of fully softened water, assist the effectiveness of most modern corrosion and scale inhibitors and reduce the use of inhibitors in order to protect the environment.
Maintaining a minimum hardness in the make-up water offsets the corrosive properties of totally softened water and reduces the reliance on corrosion inhibitors to protect the system.

Circulating Water Quality (Cycles of Concentration)
The quality of the recirculating water is related to the make-up water by the cycles of concentration.
For example: If a given make-up water had 45 ppm of Chlorides, it would be possible to run the system at 150 / 45 equals 3,33 cycles of concentration without exceeding the 150 ppm of Chlorides allowed for a galvanised steel/Zinc Aluminium or Baltiplus unit. Note that this calculation process needs to be repeated for all of the Guideline parameters (Sulphates, Alkalinity, etc), and the lowest resultant Cycles of Concentration used.

Circulated Water Quality Guidelines for Baltiplus Protection

	Baltiplus Protection
pH	6.5 to 9.0
pH during initial passivation	below 8.2
Total hardness (as $CaCO_3$)	50 to 600 mg/l
Total alkalinity (as $CaCO_3$)	500 mg/l max.
Total dissolved solids	1500 mg/l max.
Conductivity	2400 µS/cm
Chlorides	250 mg/l max.
Sulfates*	250 mg/l max.*
Total suspended solids	25 mg/l max.
Chlorination (as free chlorine): continuous	1 mg/l max.
Chlorination (as free chlorine): batch dosing for cleaning & disinfection	5-15 mg/l max. for 6 hours max. 25 mg/l max. for 2 hours max. 50 mg/l max. for 1 hour max.

Circulated Water Quality Guidelines for Baltibond Hybrid Coating

	Baltibond® and SST 304
pH	6.5 to 9.2
pH during initial passivation	below 8.2 (for units with HDG coil only)
Total hardness (as $CaCO_3$)	50 to 750 mg/l
Total alkalinity (as $CaCO_3$)	600 mg/l max.
Total dissolved solids	2050 mg/l max.
Conductivity	3300 µS/cm
Chlorides	300 mg/l max.
Sulfates*	350 mg/l max.*
Total suspended solids	25 mg/l max.
Chlorination (as free chlorine): continuous	1.5 mg/l max.
Chlorination (as free chlorine): batch dosing for cleaning & disinfection	5-15 mg/l max. for 6 hours max. 25 mg/l max. for 2 hours max. 50 mg/l max. for 1 hour max.

Circulated Water Quality Guidelines for Pultruded Composite

	Pultruded Composite
pH	6.5 to 9.5
pH during initial passivation	not applicable
Total hardness (as $CaCO_3$)	750 mg/l max.
Total alkalinity (as $CaCO_3$)	600 mg/l max.
Total dissolved solids	2500 mg/l max.
Conductivity	4000 µS/cm
Chlorides	750 mg/l max.
Sulfates*	750 mg/l max.*
Total suspended solids	25 mg/l max.
Chlorination (as free chlorine): continuous	2 mg/l max.
Chlorination (as free chlorine): batch dosing for cleaning & disinfection	5-15 mg/l max. for 6 hours max. 25 mg/l max. for 2 hours max. 50 mg/l max. for 1 hour max.

Circulated Water Quality Guidelines for Stainless Steel

	SST 304 and SST 316 with HDG coil	SST 316 (with SST 316 coil)
pH	6.5 to 9.2	6.5 to 9.5
pH during initial passivation	below 8.2 (for units with HDG coil)	not applicable
Total hardness (as $CaCO_3$)	50 to 750 mg/l	750 mg/l max.
Total alkalinity (as $CaCO_3$)	600 mg/l max.	600 mg/l max.
Total dissolved solids	2050 mg/l max.	2500 mg/l max.
Conductivity	3300 µS/cm	4000 µS/cm
Chlorides	300 mg/l max.	750 mg/l max.
Sulfates*	350 mg/l max.*	750 mg/l max.*
Total suspended solids	25 mg/l max.	25 mg/l max.
Chlorination (as free chlorine): continuous	1.5 mg/l max.	2 mg/l max.
Chlorination (as free chlorine): batch dosing for cleaning & disinfection	5-15 mg/l max. for 6 hours max. 25 mg/l max. for 2 hours max. 50 mg/l max. for 1 hour max.	5-15 mg/l max. for 6 hours max. 25 mg/l max. for 2 hours max. 50 mg/l max. for 1 hour max.

** Higher concentrations of sulfates allowed provided the sum of chlorides + sulfates parameters does not exceed 500 mg/l for Baltiplus, 650 mg/l for Baltibond/SST 304 and 1500 mg/l for SST 316/Pultruded*

Note: For Ozone water treatment applications, stainless Steel 316 execution is required.

Blow Down

To prevent an excessive build-up of impurities in the recirculating water, a small amount of water must be bled from the recirculating water. In many localities, this constant bleed and replacement with fresh make-up water will keep the concentration of impurities in the system at an acceptable level.

The **bleed rate** will depend on the cycles of concentration required to maintain recirculating water quality and the **evaporation rate**.

After the cycles of concentration have been determined, the bleed rate can be calculated using the following equation:

$$B = E / (N - 1)$$

Where:
B = bleed rate in l/s;
E = evaporation rate in l/s;
N = number of cycles of concentration.

The maximum evaporation rate can be determined by one of the following methods:

- Method n° 1: The evaporation rate is approximately 1,8 litres per 1000 kcal of heat rejection.
- Method n° 2: The evaporation rate is approximately 1,8 litres per 4180 kJ of heat rejection.
- Method n° 3: evaporation rate = water flow rate (l/s) x range (°C) x 0,0018
- Method n° 4: evaporation rate = total heat rejection kW / 2322 = l/s

Examples:

Method n° 2: At a flow rate of 10 l/s and a cooling range of 10 °C the evaporation rate is 0,18 l/s (10 l/s x 10 °C x 0,0018 = 0,18 l/s)

Method n° 4: Duty calculates to 418kW, therefore the evaporation rate is 0.18 l/s (418 / 2322 = 0,18 l/s)

Note: The calculation method described above should not be used to determine the water consumption of evaporative cooling equipment. Next to heat load and water quality the water consumption depends on climatic conditions, the capacity control strategy and the equipment configuration. Water consumption calculations are therefore complex and should not be based on the maximum evaporation rate, which occurs at dry ambient conditions. The above mentioned calculation methods are only suitable for the purpose of sizing a proper blow down.

Total Water Make-Up Rate

Water make-up rate = evaporation rate + bleed rate + drift loss

The evaporation and bleed rates are calculated as above. Provided the equipment is correctly fitted with well maintained high efficiency drift eliminators (as per standard Baltimore Aircoil supply), the drift loss can be considered as insignificant when compared with the evaporation and bleed rates.
Note that if other system components require adherence to more stringent recirculating water quality guidelines, the more stringent guidelines must be followed.

Water Treatment

The above guidelines do not themselves guarantee portection of the cooling system. The water treatment program must be able to achieve control of corrosion, scaling, microbiological growth and fouling with the BAC equipment and the cooling system it serves. The water treatment regime must also comply with the specific local requirement in term of legionella control. The final choice of the water treatmen program and its follow-up remain the sole and entire responsibility of the water treatment company or the equipment owner.

The water treatment guidelines below should be followed:

- Water treatment chemicals or non-chemical systems need to be compatible with the materials of construction used in the cooling system including the evaporative cooling equipment itself.
- In case of chemical water treatment, chemicals should be added to the recirculating water by an automatic feed system. This will prevent localised high concentrations of chemicals, which may cause corrosion. Preferably the water treatment chemicals should be fed into the cooling system at the discharge of the recirculation pump. The chemicals should not be fed in concentrated form, nor batch fed directly into the cold water sump of the evaporative cooling equipment.
- BAC specifically discourages acid dosing as means of scale controls (unless under certain strict circumstances for open circuit cooling towers with very large volume and remote sump, or constructed from stainless steel.

- A competent water treatment company should be consulted for the specific water treatment programme to be applied. Next to the supply of dosing and control equipment and chemicals, the programme should include regular monthly monitoring of the circulating and make up water quality.
- If it is proposed to operate a treament program outside the BAC Water Quality Control Guidelines, the BAC factory warranty may be invalidatd if the water quality is persistently outside the control guidelines, unless specific prior written BAC approvel (some parameters may be exceeded under certain strict circumstances).

Passivation

When new systems are first commissioned, special measures should be taken to ensure that galvanized steel surfaces are properly passivated to provide maximum protection from corrosion. Passivation is the formation of a protective, passive, oxide layer on galvanized steel surfaces. To ensure the galvanized steel surfaces are passivated, the pH of circulating water should be kept between 7.0 and 8.2 and calcium hardness between 100 and 300 ppm (as $CaCO_3$) for four to eight weeks after start-up, or until new zinc surfaces turn dull gray in color. If white deposits form on galvanized steel surfaces after the pH is returned to normal service levels, it may be necessary to repeat the passivation process.
Note: Stainless steel units and units protected by the Baltibond Hybrid Coating, without galvanized coil, do not require passivation.

In case you can't keep the pH below 8.2, a secondary approach is to conduct a chemical passivation using inorganic phosphate or film-forming passivation agents. COnsult your water treatment specialist for specific recommendation.

11. Control of Biological Contamination and Water Treatment

The growth of algae, slimes and other micro-organisms, if uncontrolled, will reduce heat transfer efficiency and may contribute to the growth of potentially harmful micro-organisms, such as Legionella, in the recirculating water. Accordingly a treatment programme specifically designed to address biological control should be initiated when the system is first filled with water and administered on a regular base thereafter in accordance with any regulations (national, regional) that may exist or in accordance with accepted codes of good practice, such as EUROVENT 9 - 5 & 6.

It is strongly recommended to monitor the bacteriological contamination of the recirculating water on a regular base (for example TAB test with dip slides on a weekly base) and record all results. (TAB = Total Aerobic Bacteria)

In addition to the control of biological contamination, which must be done at all times, it may be necessary to install a water treatment regime to prevent the formation of scale or corrosion. To ensure recognition of any risk and the implementation of protective measures, it is recommended to conduct a risk analysis by a specialised risk assessor. It is also recommended to develop an operations plan for the cooling system.

Algae

Algae are plants, which, like all plants, require sunlight and nutrients to grow. In evaporative cooling equipment algae are aesthetically undesirable and may promote other microbial growth. However, unless the algae interfere with the thermal performance of the unit, e.g. by blocking fill or plugging nozzles, it is of itself relatively benign. A biologically active system is one with an active slime layer and high plank tonic bacteria count. Such a system is at risk for poor thermal performance, microbial influenced corrosion, and pathogens.

Algae growth, combined with high total bacteria count , can be a warning sign of a biologically active system. Algae growth combined with low Total Bacteria Count (TBC) is NOT a warning sign for a biologically active system. Consistently low total bacteria counts are a sign of a biologically INACTIVE system regardless of the presence or absence of algae.

Algae growth may be particularly noticeable during the spring and summer. As previously noted, algae requires sunlight to grow; therefore, open cooling systems and systems that receive direct sunlight are more prone to algae growth. Blown-in dirt and nutrients also promote algae growth.

The use of filtration systems to relieve the system of blown-in and precipitated solids can reduce the area for algae to thrive. Effective filtration will not remove existing algae but should prevent future blooms.

12. Location

Each cooling tower, evaporative cooler or condenser should be located and positioned to prevent the introduction of the discharge air and the associated drift, which may contain contaminants, such as Legionella, into the ventilation systems or open windows of buildings. To yield full thermal performance, equipment location must be chosen in a way that there is unimpeded supply of air to the entire air intake surface. In addition access to all maintenance and inspection points must be safeguarded. Located in enclosures or close to adjoining building walls, the top of the equipment must be level with or higher than the top of the adjacent walls in order to reduce the possibility of recirculating warm and humid discharge air back to the air intake(s).

To accomplish this, in some cases the equipment needs to be installed elevated or equipped with discharge hoods or ductwork. In case of elevated locations (more than 300 mm above surface), it is necessary to equip counterflow forced draft equipment with a solid bottom panel, to provide protection from moving parts and ensure that the air is drawn horizontally into the cooling tower and not from the bottom (bottom air entry can be considered but requires reduction of nominal fan speed to avoid fan motor overload).

For indoor locations with forced draught centrifugal fan equipment it is common practice to apply ductwork to air entry and discharge. Such ductwork must be designed for even air distribution and minimum pressure drop and access doors must be foreseen to allow access to the interior of the duct and from there to the equipment itself. In some cases the equipment room may be used as an intake plenum, in which case only discharge ductwork is needed. In such cases measures need be taken to prevent erratic air distribution when switching fans and/or cells, for example by the sue of positive closure discharge dampers.

13. Piping

General
Piping should be sized and installed in accordance with rules of good practice. Dead legs and stagnant water conditions in the piping should be avoided. If more than one inlet connection is required, balancing valves should be installed to properly balance the flow to each inlet. Depending on the design of the hydraulic circuit, it may also be necessary to install balancing valves at the suction connections of the towers. The use of shut off valves is dictated by the necessity to (automatically or manually) isolate cells or towers for capacity control or servicing. If the equipment is installed on vibration rails, compensators must be installed in the connecting piping.

Open Cooling Towers
Piping must be sized and installed in accordance with good piping practice. All piping should be supported by pipe hangers or other supports, not by the unit. On open systems, in order to prevent basin overflow at shutdown and to ensure satisfactory pump operation at start-up, all heat exchangers and as much piping as possible should be installed below the operating level of the cooling tower.

Some units may require flow balancing valves (supplied by others) at the hot water and coil inlets to balance the flow to individual inlets and cells. External shutoff valves (supplied by others) may also be required if the system design necessitates the isolation of individual cells.
When multiple cells are used on a common system equalizing lines should be installed between the cold water basins to ensure balanced water level in all cells. It is good engineering practice to valve the inlet and outlet of each tower separately for servicing. The shut-off valves can be used, if necessary, to adjust any minor unbalanced condition in water flow to or from the units.

Although equalizing lines can be used to balance water levels between multi-cell closed circuit cooling towers, the spray water for each cell must be treated separately, and a separate make-up must be provided for each cell. Note that a common remote sump for multi-cell installations can simplify make-up and water treatment. See the appropriate Operating and Maintenance Instruction Manual for more information on water treatment.
Since the sump capacity of any cooling tower is limited, it can only accumulate a certain amount of water draining from the system into the tower, when the circulating water pump stops. Therefore install all heat exchangers and as much tower piping as possible below the operating level of the tower. The BAC Balticare Representative can advise the available sump capacity for system drainage for a given model and operating conditions.

When multiple cooling towers are used on a common system, install equalising lines between the sumps of the towers to ensure a balanced water level. Standard equalising lines are designed for a maximum water level differential (between sumps) of 25 mm and an equalising flow of 15% of the circulating water flow for the largest tower in the system based on the cooling towers being located in close proximity to each other. The connecting pipework (by others) should maintain the same diameter along their length for proper operation. If hydraulical isolation of individual cells is desired a shut off valve in the equalising piping is needed.

Closed Circuit Cooling Towers
Fluid piping should allow flexibility for expansion and contraction between component parts of the system. All fluid piping should be supported separately from the equipment by pipe hangers or supports. In a completely closed system, an expansion tank should be installed for purging air from the system and to allow for fluid expansion.

A vacuum breaker or air vent at the high point and a drain at the low point should be installed in the piping system to permit complete drainage of coils.

For Refrigerent Piping
Piping should be adequately sized according to standard refrigeration practice and arranged to allow flexibility for

expansion and contraction between component parts of the system. Suitably sized equalising lines must be installed between the condenser and high pressure receiver to prevent gas binding and refrigerant backup in the condenser. Service valves should be installed so that the component parts may be easily serviced.

On multiple evaporative condenser installations, evaporative condensers in parallel with shell-and-tube condensers, or single condensers with multiple coils, refrigerant outlet connections must be trapped into the main liquid refrigerant header. The height of the trapped liquid legs must be sufficient to balance the effect of the unequal coil pressures without backing up liquid refrigerant into the condensing coil. This type of liquid line piping permits independent operation of any one of the parallel circuits without manually closing inlet and outlet valves.

Although equalising lines can be used to balance water levels between multi-cell evaporative condensers, the spray water for each cell must be treated separately, and a separate make-up must be provided for each cell. Note that a common remote sump for multi-cell installations can simplify make-up and water treatment. See the appropriate Operating and Maintenance Instruction Manual for more information on water treatment.

Weld Byproduct Cleaning
The installation and manufacturing processes commonly used for field assembly of steel-piped systems may leave weld byproducts inside coils and connecting piping (especially in refrigeration systems). It is common practice to install filters and/or strainers that remove contaminants during initial system operation. Shortly after system startup, the filters and/or strainers should be cleaned or replaced.

For installations with high pressure float valves, ensure that liquid piping from condenser outlet to valve(s) is sized for low refrigerant velocity (0,5 m/s) so that valve operation is not disturbed by flash gas and that an equalising line is properly installed. For systems with thermosyphon oil cooling ensure adequate equalising and sufficient height difference between condenser(s) and receiver.

Standard condenser coils are manufactured from black steel and hot dip galvanised after fabrication and may contain certain contaminants, such as carbon, iron oxyde or welding particles. The interior condition of the coil, including humid air must be considered, when using halocarbon (or HFC) refrigerants and sensitive system components, such as electronic expansion devices or semi hermetic compressors. The installer must take the necessary precautions on site to safeguard the operation of these components in conjunction with the condenser coils.

14. Capacity Control

General
Most cooling systems are subject to substantial changes in heat load and ambient temperature conditions during the operating season. The capacity of evaporative cooling equipment varies greatly as the wet bulb temperature changes. To prevent freezing inside the equipment at subfreezing ambient conditions and/or when a reasonably constant temperature of the cooling water is desired, some form of capacity control is required. The preferred control method is to reduce the airflow through the equipment to adapt to heat load and ambient conditions. It is not recommended to modulate the water (fluid) flow for capacity control reasons. Regardless the type of capacity control chosen, it is necessary to start the circulating pump first and the fan motor(s) thereafter. At the same time prolonged operation of circulating pump(s) only without fan(s) running should be avoided during subfreezing conditions.

Fan Cycling
Fan cycling is the simplest method of capacity control, suitable for multiple cell installations. The number of control steps available for fan cycling is generally determined by the number of fan motors, however on certain models two fan motors must be cycled simultaneously to prevent erratic air distribution. Consult your BAC Balticare Representative for more details. The more steps for fan cycling are available the better the control of the cooling water temperature is. Rapid on-off cycling can cause the fan motor to overheat. It is recommended that controls be set to allow a maximum of 6 on-off starts per hour. The number of steps of capacity control can be increased using the Baltiguard® Fan System*, the independent fan motor* option, or two-speed fan motors in conjunction with fan cycling. These options provide substantial energy savings when compared to simple fan cycling.
** Only available for some BAC-products*

On ammonia systems, most evaporators are fed by high pressure or low pressure float valves or float switches which are less sensitive to variations in head pressure. On this type of system, fan cycling of the evaporative condenser will usually provide satisfactory capacity control on the high side of the system, where the evaporative condenser may have several fan motors which can be cycled in steps.

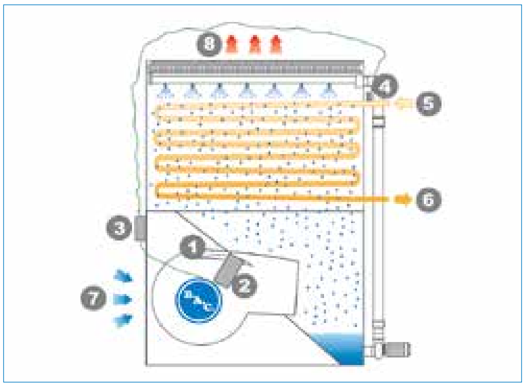
Halocarbon systems generally utilize evaporators controlled by thermal expansion valves. A reasonably constant pressure differential across the thermal expansion valve is required for its proper operation. Therefore, this type of system requires a closer degree of evaporative condenser capacity control than can be obtained with fan.

Note for Closed Circuit Cooling Towers and Evaporative Condensers: Spray water pump cycling should not be used for capacity control. This method of control often results in short cycling of the pump motor as capacity changes substantially with pump cycling. In addition, alternate wetting and drying of the coil promotes scaling of the heat exchanger coil surface.

Multi-Speed Drives

The number of steps available for fan cycling can be increased by using multi-speed drives. These can either be accomplished by the installation of multi-speed motors (Dahlander/Two speed separate windings) or the Baltiguard® Drive system.

At half of the nominal fan speed (Dahlander/two speed, separate windings) the nominal capacity of the tower will be appr. 60%; at 2/3 of nominal fan speed (Baltiguard®) the nominal capacity of the tower will be appr. 70%. When switching from high to low speed a time interval of min. 15 s must be foreseen, before the low speed drive can be activated to allow the fan(s) to slow down.



Evaporative Condenser with Modulating Fan Discharge Dampers (Single Coil Circuit Unit)
1. Modulating Fan Discharge Damper; 2. Fan Damper Actuator; 3. Terminal Box; 4. Sensing Element; 5. Vapour In; 6. Liquid Out; 7. Inlet Air; 8. Air Discharge

Modulating Capacity Control

Modulating capacity control is recommended when a closer control of the cooling water temperature or condensing pressure is desired and in particular if free cooling at sub-freezing ambient conditions is anticipated. Modulating capacity control can be accomplished with modulating fan discharge dampers (only for centrifugal fan models). Fan discharge dampers vary the airflow to match tower capacity to system heat load and ambient condition. The damper motors switch to low speed and shut off the fan motor(s) when the dampers reach minimum position.
Modulating dampers also affect a reduction in fan motor kW which is approximately proportional to the reduction in air flow as the dampers move toward the closed position. Modulating discharge dampers are also available on centrifugal fan condensers.

♦ **Single Coil Circuit Units**

Damper control is recommended for any system using evaporators controlled by thermal expansion valves. On a single circuit condenser, a condensing pressure sensing element is located in the compressor discharge line or in the receiver (see Figure aside). The pressure controller is electrically connected to the damper motor, and when the condensing pressure changes, a signal is sent to the damper motors to reposition the dampers and provide more or less airflow as required.

♦ **Multiple Coil Circuit Units**

On multiple circuit condensers where it is necessary to control condensing pressures for two or more circuits, a spray water temperature sensing controller, located in the pan, is substituted for the condensing pressures on the multiple condenser circuits. Even with a very light load on one circuit, the condensing temperature in that circuit can not fall below the spray water temperature.
Note: This system will not provide control if the pan is drained for dry condenser operation in winter.

Alternatively to modulating fan dampers variable speed control devices can be installed. In such cases steps must be taken to avoid operating at or near the fan's "critical speed". Consult with the BAC representative or BAC Balticare of any application utilising variable speed control to determine whether any critical speed may be encountered and whether the anticipated fan motor selection is suitable for this application. Fan motors must be equipped with PTC Thermistors for these applications to facilitate protection against motor overheating. Where isolation rails are used in conjunction with variable fan speed controls, the isolation springing should be high deflection, and the minimum continuous running fan speed limited to avoid resonant frequencies with the springing.

Modulating capacity control is the best way to closely control cooling water temperatures, however even with modulating control some variation of the cooling water temperature or condensing pressure will occur, in particular at light heat load or start-up conditions. In applications with open or closed circuit cooling towers where such variations cannot be tolerated (start-up of absorption chiller) an additional bypass to stabilise temperatures must be foreseen.

Variable Frequency Drives

Installations which are to be controlled by Variable Frequency Drives (VFD) require the use of an inverter duty motor as designed IEC 34.1, which recognizes the increased stresses placed on motors by these drive systems. Inverter duty motors must be furnished on VFD applications in order to maintain the motor warranty. Fan motors must be furnished with thermal protection (either PTC sensors or coil thermostats normally open, or normally closed). The motor protection consists of temperature sensitive cutout devices embedded in the motor windings (minimum 3 per motor).

The minimum fan motor speed during normal operation should not be below 30% of the speed indicated on the motor nameplate. This corresponds with 15 Hz for a 50 Hz supply and 18 Hz for a 60 Hz supply.
When the fan speed is to be changed from the factory-set speed, including through the use of a variable speed control device, steps must be taken to avoid operating at or near fan speeds that cause a resonance with the unit or its supporting structure. At start-up, the variable frequency drive should be cycled slowly between zero and full speed and any speeds that cause a noticeable resonance in the unit should be "locked out" by the variable speed drive.

15. Dry Operation (Coil Products only)

During winter operation, when the load may be reduced and the ambient temperature is far below the design conditions, the equipment may be operated dry, i.e., without recirculated water flow. This reduces the capacity of the unit to more nearly match the reduced load.

Dry operation of an evaporative product is intended to be a seasonal process. Water pump cycling should not be used for capacity control. Capacity changes greatly with and without spray water, so that this method of control often results in short cycling of the recirculating pump. In addition, alternate wetting and drying of the coil promotes formation of scale on the condensing surface.

Evaporative cooling products should not be operated dry in sub-freezing ambient temperatures while the recirculated water is stored in the pan of the unit. The flow of cold air through the unit may freeze the water, even if electric heaters or steam coils have been provided for freeze protection. These heaters are designated to prevent freezing only when the pumps and fan are idle. Furthermore, air turbulence created by the fans will blow water throughout the interior of the unit, and cause icing on the cold surfaces. It is recommended that the equipment be completely drained of water when dry operation is desired.

16. Winter Safety

General
When a unit is shut down in freezing weather, the basin water must be protected by draining to an indoor auxiliary remote sump tank or by providing supplementary heat to the cold water basin. Supplementary heat can be provided by electric immersion heaters or in some cases, hot water, steam coils, or steam injectors. All exposed water piping, make-up lines, and spray pumps (if applicable) that do not drain at shutdown should be traced with electric heater tape and insulated. When dry operation is planned for low ambient conditions, centrifugal fan units should be supplied with oversized fan motors to prevent motor overload when the spray water is not operating. For remote sump applications, the spray water pump must be selected for the required flow at a total head which includes the vertical lift, pipe friction (in supply and suction lines) plus the required pressure at the inlet header of the water distribution system (14 kPa). A valve should always be installed in the discharge line from the pump to permit adjusting flow to the unit requirement. Inlet water pressure should be measured by a pressure gauge installed in the water supply riser at the spray water inlet, and adjusted to the specified inlet pressure.

Unless the system is shut down and drained during winter, measures must be taken to protect the system from freezing during the winter, during operation and standstill. Freeze protection during operation is achieved by selecting an adequate method of capacity control. For reasonably constant loads and cooling water or condensing temperatures above 15°C step control is usually adequate. For variable loads, in particular when combined with free cooling modulating controls are recommended.

When the equipment is shut down in freezing weather the sump water must be protected. This can be accomplished by the installation of electrical sump heaters. The standard electric heaters are sized to maintain +4°C sump water when the ambient temperature drops to - 18°C.

All sump heaters have six power terminals and one earth terminal. Heaters with six terminals can be wired in Star for 400 Volt; 3 phase supply; or in Delta for 230 Volt, 3 phase supply. All heaters can alternatively be used with a 230 Volt single-phase supply, if the terminals are wired in parallel. Sump heaters need to be sized to maintain a sump water temperature of 4°C at an applicable ambient temperature (for example: - 18°C). They are installed together with a heater thermostat and a low level cut out switch to prevent heater operation, when the sump is drained.

Draining the sump water into a separate tank installed in an area protected from freezing, is an alternative to auxiliary heating of the integral sump. Remote sump sizing must include the water draining from external piping, the tower water distribution system, water suspended in the fill pack or coil and sump as well as water needed to prevent vortexing inside the remote sump.

In addition to the sump all exposed water piping, pumps and make up lines, including mechanical or electrical valves that do not drain at shutdown should be traced with electrical heater tape and insulated.

Coil Protection for Closed Circuit Cooling Towers, Dry Coolers and Dry Coolers with Adiabatic Pre-Cooling
At below freezing ambient conditions, the unit can experience heat loss even without the recirculating spray water pump and fans in operation. Without a heat load on the circulating fluid, coil freezing can occur even at full flow. Protective means are readily available to avoid potential freeze problems. Where the system will permit, the best protection against coil freeze-up is the use of an industrially inhibited anti-freeze solution.
When this is not possible, the system must be designed to meet both of the following conditions:

- Maintain minimum recommended flow through the coil at all times.
- Maintain a heat load on the circulating fluid so that the temperature of the fluid leaving the coil will not be below 7ºC.

If the process load is extremely light, or if the process is periodically shut off entirely, then an auxiliary heat load must be applied to the circulating fluid when below freezing ambient temperatures exist to prevent damage to the coil. Refer to the Heat Loss Data for the auxiliary heat load requirement. The amount of auxiliary heat necessary to prevent coil freezing can be further reduced by the use of a positive closure damper hood and insulation.
Draining the coil is not recommended as a normal method of freeze protection. However, draining is acceptable as an emergency method of freeze protection. Frequent draining can promote corrosion inside the coil tubes. If the coil is not protected by an industrially inhibited anti-freeze solution, an automatic drain valve and air vent is recommended to drain the coil if flow stops or fluid temperature drops below 7ºC when the ambient temperature is below freezing. Note that cold water basin heaters will not provide freeze protection for the coil.

The coil of dry coolers can never drain completely. If a minimum heat load can not be guaranteed on the dry coil during the winter period, then the use of an anti-freeze solution is the only available protection against coil freezing.

Draining of the coil(s) is not recommended as a normal method of freeze protection unless the coil(s) are constructed from stainless steel or are of the cleanable type. For standard hot dip galvanised coils draining is acceptable as an emergency method of freeze protection. For this purpose an automatic drain valve and air vent needs to be installed to drain the coil(s) if flow stops or the fluid temperature drops below 10°C when the ambient temperature is below freezing.

17. Plume and Plume Abatement

At the air discharge water droplets can be formed by condensation of warm humid discharge air by contact with the colder ambient air upon leaving the equipment. This type of condensation is the visible plume that often can be seen rising above evaporative cooling equipment during the winter season. The water vapour caused by condensation contains droplets of pure water and is harmless. In some instances visible plumes are considered as a hinder, in which case measures must be taken to minimise or eliminate the occurrence of plume. Consult the BAC Balticare Representative for such requests.

18. Electrical Wiring and Controls

Wiring to electrical components should be via suitable weatherproof cable glands. Unused electrical entries should be plugged with a weatherproof plug.
Where motors are supplied with PTC Thermistors they should be incorporated into the control circuit as means of motor overheat protection. Also the use of anti condensing heaters is strongly recommended.

19. Starting of Fan Motors

Fan motors up to 5,5 kW nameplate rating can normally be started direct on line (DOL). Above these ratings the motor should be started using star delta starter and not DOL. DOL starting requires high starting currents and imposes a large starting torque on the fan drives. Alternatively a soft starter or a variable speed frequency drive may be used instead of star delta starting, according to the project requirements. In all cases, precautions should be incorporated into the control circuitry to protect against motor overloading.

20. Sound

BAC provides sound data as sound pressure levels in 5 directions, in 1,5 m and 15 m from the equipment as well as overall sound power levels. Data are available for equipment with and without sound attenuation and should be the base of any acoustical specification and guarantee for outdoor locations. For indoor locations it is preferable to specify partial sound power levels for the air intake and discharge areas. For sound pressure specifications relating to indoor locations, consult the BAC Balticare Representative.

21. Maintenance

Regular maintenance in accordance with the appropriate BAC Operating and Maintenance instructions and with prevailing local regulations and Codes is essential for the efficient and safe operation of a cooling tower, evaporative cooler or condenser. A programme of regular maintenance and inspections needs to be set up, executed and documented. For proper execution of maintenance and inspections and depending on site conditions ladders, safety cages, stairways, access platforms with handrails and toe-boards must be installed as appropriate for the safety and convenience of authorised service and maintenance personnel. (See also Chapter 17: The Value of Maintaining Evaporative Cooling Equipment.)

22. Safety information

For safe operation of unshielded equipment exposed to wind speeds above 120 km/h installed at a height above 30 m from the ground, contact your local BAC Balticare Representative. For safe operation of equipment installed in moderate and high hazard areas contact your local BAC Balticare Representative.