EUROVENT 9/5

RECOMMENDED CODE OF PRACTICE TO KEEP YOUR COOLING SYSTEM EFFICIENT AND SAFE

EUROVENT • CECOMAF

EUROVENT 9/5 - 2000

Guidelines for the Preventention of
Uncontrolled Bacteriological Contamination,
including Legionella Pheumophila, in Cooling
Towers and Evaporative Condensers.

This code of practice has been developed by Eurovent/Cecomaf WG 9.
The major European manufacturers of evaporative cooling equipment are associated in the EUROVENT / CECOMAF working group 9 “Cooling Towers”. The working group focuses on the environmental importance of efficient and safe heat rejection systems for which evaporative cooling technology provides effective solutions.
The group has prepared this code of practise on how to keep evaporative cooling systems safe accordingly. It is based on the status of knowledge avaiable at the time of issue.

EUROVENT 9/5 - 2002

Guidelines for the Prevention of
Uncontrolled Bacteriological Contamination,
including Legionella Pneumophila,
in Cooling Towers and Evaporative Condensers

This code of practice has been developed by Eurovent/Cecomaf WG 9.
The major European manufacturers of evaporative cooling equipment are associated in the Eurovent/Cecomaf Working Group 9 “Cooling Towers”. The Working Group focuses on the environmental importance of efficient and safe heat rejection systems for which evaporative cooling technology provides effective solutions.
The Group has prepared this code of practice on how to keep evaporative cooling systems safe. It is based on the status of knowledge available at the time of issue.

AREA,
Air Conditioning & Refrigeration European Association,
supports and recommends these guidelines.

CONTENTS

1. **INTRODUCTION**

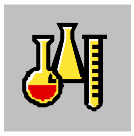
2. **MAINTAINING SYSTEM EFFICIENCY**

   2.1 Evaporation and Blow-down

   2.2 Maintenance and Cleanliness
   - a) Scale formation
   - b) Corrosion
   - c) Biocidal control
   - d) Fouling

   2.3 Recirculating Water Quality

3. **THE FACTS ABOUT LEGIONNAIRES' DISEASE**



   3.1 Chain of Events

   3.2 Conditions That Enhance Multiplication of Legionella

   3.3 Aerosols

4. **MAINTAINING EQUIPMENT SAFETY**

   4.1 Selection of Evaporative Cooling Equipment

   4.2 General System Requirements

   4.3 Mechanical Maintenance Programme

   4.4 Water Quality Control Parameters

   4.5 Water Quality Monitoring Procedures

   4.6 Personal Safety

   4.7 Monitoring & Record Keeping

5. **ANNEXE 1 : SUMMARY OF GENERAL AND WATER QUALITY REQUIREMENTS**

   ANNEXE 2 : TYPICAL CONTENTS OF COOLING SYSTEM LOGBOOK

1. INTRODUCTION

Cooling towers and evaporative condensers are efficient and cost effective means of removing heat from air conditioning, refrigeration and industrial process cooling systems. They have been in use for more than half a century. They are compact, quiet, consume little energy and save more than 95% of the water in circulation. They are simple to operate and maintain and, with the use of this Code of Practice, system efficiency and safety are assured.

Evaporative cooling is based on a natural principle. In an open circuit cooling tower the water to be cooled is distributed over a fill pack whilst air is blown or drawn through the packing. A small quantity of the water evaporates and this causes the remainder of the water to be cooled. The cooled water falls into the sump of the tower and the heat extracted from the water is carried out in the leaving air stream.

Evaporative condensers or closed circuit evaporative cooling towers have a heat exchanger or coil within the tower instead of a fill pack. Water is distributed over the heat exchange coil and heat is extracted from the refrigerant or primary fluid circulating through the coil by the same evaporative process.

Evaporative cooling combines high thermal efficiency and cost effectiveness by achieving low cooling temperatures with minimum energy and water usage. Low cooling temperatures are essential for many processes to achieve high system efficiency. These processes consume less energy and in this regard evaporative cooling contributes to preserving natural resources and the environment.

The purpose of this Code of Practice is to detail the actions needed to maintain this thermal efficiency and to prevent the growth of potentially harmful micro-organisms, including Legionella.

PRINCIPLES OF OPERATION

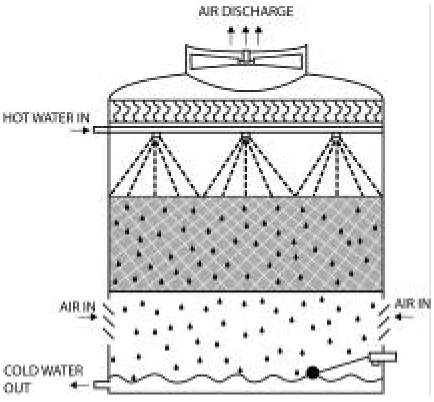


Fig 1: Induced Draught

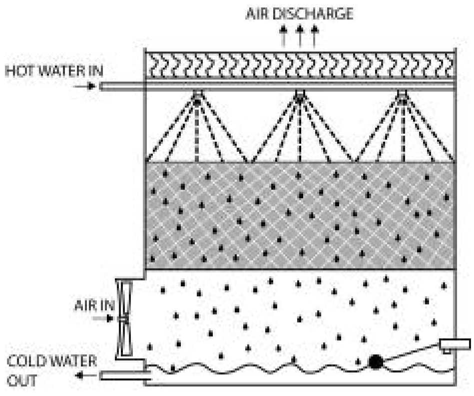


Fig 2: Forced Draught

Open Circuit Cooling Tower (Figs 1 & 2)
Water from the heat source enters an inlet connection and is distributed over the fill pack through a spray distribution arrangement. Simultaneously, ambient air is induced or forced through the tower, causing a small portion of the water to evaporate. This evaporation removes heat from the remaining water. The cooled water falls into the tower sump from where it is returned to the heat source. It is open circuit as the water to be cooled is in contact with the atmosphere.

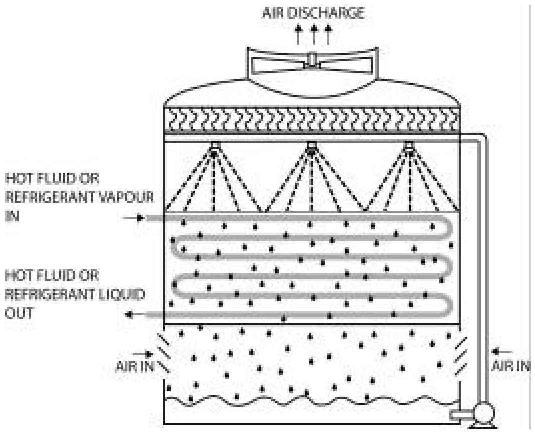


Fig 3: Induced Draught

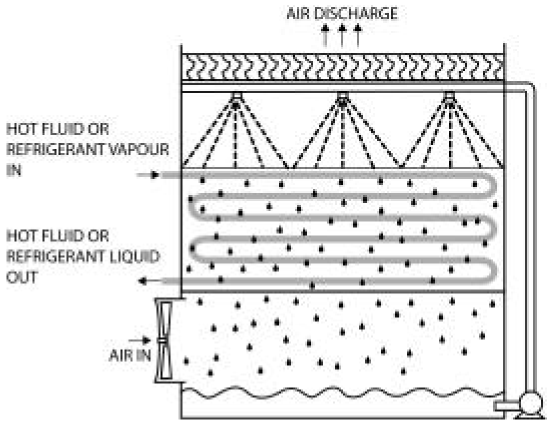


Fig 4: Forced Draught

Closed Circuit Cooling Tower or Evaporative Condenser (Figs 3 & 4)

The fluid to be cooled is circulated inside the tubes of the heat exchange coil. A secondary system distributes water over the tubes of the coil. Simultaneously air is forced or drawn through the coil causing a portion of the secondary water to evaporate. This evaporation removes heat from the fluid inside the coil. The secondary water falls to the sump from where it is pumped over the coil again. This is called closed circuit as the fluid to be cooled is in a sealed loop and does not come into contact with the atmosphere.

An evaporative condenser operates on the same principle except there is a phase change as the refrigerant vapour is condensed to a liquid in the heat exchange coil.

2. MAINTAINING SYSTEM EFFICIENCY

Maintaining the design system efficiency is of vital importance both to the thermal and environmental performance of your evaporative cooling system. At its design efficiency the cooling system will not only assure optimal operation of the cooling process, but will use minimum resources in terms of water and energy. In addition, the system will operate safely as uncontrolled bacteriological contamination will be prevented.

The key requirements for maintaining system efficiency are adequate control of the recirculating water quality and a programme of maintenance to keep the equipment clean and in good condition.

2.1 EVAPORATION AND BLOW-DOWN

In evaporative cooling equipment the cooling is accomplished by evaporating a small portion of the recirculating water as it flows through the unit. When this water evaporates, the impurities originally present in the water remain. Unless a small amount of water is drained from the system, known as blow-down, the concentration of dissolved solids will increase rapidly and lead to scale formation or corrosion or both. Also, since water is being lost from the system through evaporation and blow-down, this water needs to be replenished.

The total amount of replenishment, known as make-up, is defined as:

Make-up = evaporation loss + blow-down

The evaporation loss depends mainly on how much heat rejection is being achieved and, to a lesser extent, on the relative humidity of the incoming air. A general formula is 0,44 litres of water evaporation per 1000 kJoule of heat rejection.

The amount of blow-down is determined by the design cycles of concentration for the system. These cycles of concentration depend on the quality of the make-up water and the design guidelines for the quality of the recirculating water. Depending on the materials of construction of the system the water quality guidelines may differ and the system designer or manufacturer's instructions must be adhered to in this regard.

Cycles of concentration are the ratio of the dissolved solids concentration in the recirculating water compared to the dissolved solids concentration in the make-up water. Once the design cycles of concentration have been defined, the blow-down rate can be calculated:

$$Blow-down = \frac{Evaporation\ Loss}{Cycles\ of\ Concentration - 1}$$

As a general rule it is recommended that the design cycles of concentration are between 2 and 4. Above 4 the water savings through smaller amounts of blow-down become less and less significant.
Very high cycles of concentration usually go hand in hand with a high operating risk, as any loss of control quickly leads to undesirable scaling or corrosion within the system.

2.2 RECIRCULATING WATER QUALITY

In addition to impurities present in the make-up water, any airborne impurities or biological matter are carried into the tower and drawn into the recirculating water. Over and above the necessity to continuously bleed off a small quantity of water, a water treatment programme specifically designed to address scale, corrosion and biological control should be initiated when the system is first installed and maintained on a continuous basis thereafter. Moreover there must be an ongoing programme of monitoring in place to ensure that the water treatment system is maintaining the water quality within the control guidelines; A typical programme is described in Sections 4.4 & 4.5.

The incoming make-up water will normally have a tendency to be either corrosive or scale forming and this will also be influenced by the water temperature and the cycles of concentration. Either tendency is detrimental to your cooling system and steps must be taken to prevent both corrosion and scale formation.

a) ***Scale Formation***

Excessive scaling on the heat transfer surfaces within a cooling tower or evaporative condenser greatly reduces heat transfer efficiency. This can result in higher cooling temperatures than design and eventually system down-time. Scale formation always causes higher energy consumption, and this applies all year round regardless of the load on the system. Whilst scale itself is not considered as a nutrient for bacteriological growth, heavy scale formation provides a breeding haven for micro-organisms and can therefore add to the risk of bacteriological contamination.

Depending on the main supply water and system operation, scale formation can be prevented by the correct combination of softening of the make-up water, control of bleed-off and dosing of scale inhibitor chemicals. Physical methods for controlling scale such as electro-magnetic techniques are available but need to be carefully evaluated on a case-by-case basis.

Scale formation is independent of the materials of construction of the system components. Scale can form on protected steel, stainless steel or organic materials. Whilst stainless steel or organics may be more forgiving when it comes to removing the scale, it needs to be a clear objective to avoid scale formation in the first place.

b) ***Corrosion***

Premature or rapid corrosion is detrimental to the cooling system components and may shorten equipment life considerably. Corrosion by-products, such as iron oxides, can furthermore encourage bacteriological growth. For these reasons corrosion within your cooling system should be prevented at all times. To achieve this the recirculating water quality must be kept within the limits specified by the supplier of system components and, in many cases, the dosing of a chemical corrosion inhibitor is recommended.

Note: Due to advances in chemical blending most water treatment chemical suppliers offer a corrosion and scale inhibitor as a single chemical.

c) ***Biocidal Control***

Proper operation, blow-down and chemical water treatment for scale and corrosion are not a guarantee of controlling bacteriological growth in your cooling system. Therefore specific attention must be given to the matter of bacteriological control. Not only can bacteriological growth reduce heat transfer efficiency by formation of slimes or biofilms but, more importantly, proliferation of bacteria can sufficiently contaminate the recirculating water that it becomes a potential health hazard. Amongst the harmful bacteria the most important in this context is Legionella Pneumophila which, in uncontrolled conditions, could result in cases of Legionnaire's Disease.

There is a wide range of chemical biocides, both of the oxidising and non-oxidising type, which are effective in controlling bacteriological levels including Legionella. In addition there are other non-chemical methods of biocidal control such as ozone, ultra-violet light and copper and silver ions. A water treatment specialist should advise you on the best biocidal treatment for your cooling system.

d) ***Fouling***

Fouling of heat exchange surfaces due to dirt, sludge and slimes in the system will not only affect thermal performance but may also encourage the growth of bacteria. Therefore steps must be taken to avoid a build up of dirt and debris within the cooling tower and the rest of the system. If this should occur, they must be removed.

For systems with dirty water or where significant amounts of airborne dirt and debris are carried into the system, filtration of the recirculating water may be needed. Usually this is side stream type where a portion of the water is drawn from the sump of the cooling tower, filtered and then returned to the system.

Sometimes silt and sludge can be controlled with chemical biodispersants, which are either dosed separately or blended with a chemical biocide.

2.3 MAINTENANCE AND CLEANLINESS

In order to ensure maximum thermal efficiency and safety of the system, a structured programme of mechanical maintenance and keeping the equipment clean is required.

The maintenance of the equipment should be in accordance with the recommendations of the manufacturer or the system supplier. A typical maintenance programme is outlined in Section 4.3.

The cleanliness of your cooling system will depend on its location, contamination from the atmosphere and type of cooling process as well as the effectiveness of your water treatment and maintenance programmes. From time to time it will be necessary to inspect and clean your system as described in Section 4.5.

In cases of excessive biological contamination as indicated by persistently high aerobic bacteria counts, disinfection of the cooling system is needed. You should consult a competent water treatment company for advice. Refer to Section 4.5 for more information on disinfection.

Good maintenance and cleanliness are vitally important to the safety of your cooling system – no well-maintained and clean cooling tower has ever been the cause of Legionnaires' Disease.

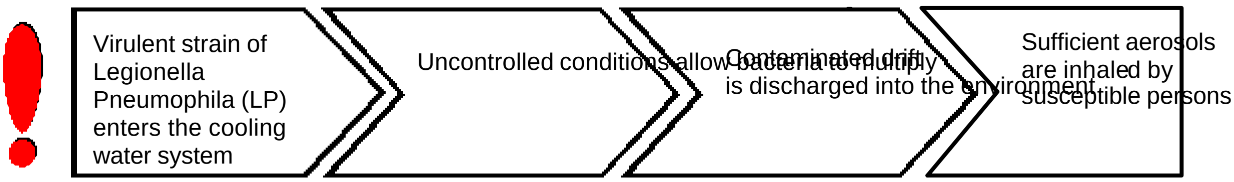
3. THE FACTS ABOUT LEGIONNAIRES' DISEASE

Legionnaires' Disease is an uncommon but serious form of pneumonia. It affects only a small percentage of people who are susceptible to an infection of this kind. It can only be contracted by inhaling contaminated aerosols. It cannot be contracted by drinking contaminated water.

Legionella, the bacteria, which causes the disease, is commonly found in surface water such as ponds and rivers. It is likely to exist in low concentration in most water systems. In such concentrations the bacteria is harmless and only some species of the bacteria can become harmful to humans. It requires an improbable and avoidable chain of events to cause people to be infected with Legionella bacteria from cooling towers or evaporative condensers.

3.1 CHAIN OF EVENTS

An outbreak of Legionnaires' Disease associated with a cooling tower or evaporative condenser requires a 'Chain of Events' with ALL EVENTS in the chain LINKED together and occurring in sequence.



To effectively prevent the risk of Legionnaires' Disease, it is necessary to break this chain of events at any link. There are three chain links, which can be broken by good design and correct operation of the cooling system:

- prevent conditions that encourage multiplication of bacteria
- minimise drift or aerosol effect in the discharge air stream
- reduce chances of inhalation by people through equipment location and/ or personal protection.

The measures mentioned above are not equally effective in terms of prevention. By far the most important measure is to prevent uncontrolled conditions that allow the bacteria to multiply.

3.2 CONDITIONS THAT ENHANCE MULTIPLICATION OF LEGIONELLA

If a virulent strain of Legionella enters the cooling system, a number of factors dictate whether multiplication can occur. To become harmful Legionella bacteria, particularly the species which affect humans, must proliferate in an uncontrolled manner in the recirculating water. Typically concentrations of total aerobic bacteria up to 10^4 cfu/ml mean the system is under control but concentrations of more than 10^5 cfu/ml require immediate corrective actions to reduce the bacterial level. Within the total aerobic bacteria count the level of legionella bacteria can be separately tested and this should be below 10^3 cfu/l

The following conditions can lead to high concentrations of legionella:

- Temperature
  Below 20°C the bacteria do not multiply (but will still survive); above 60°C they do not survive. The maximum growth rate is at a temperature of 37°C. While it is desirable to maintain low cooling water temperatures year round, it is not always possible to avoid temperature conditions which encourage growth.

- Nutrients
  For growth to occur nutrients for Legionella multiplication must exist in the cooling system. Typical nutrients are sediments, sludge, corrosion debris and materials, such as untreated wood and natural rubber, which support microbiological growth. Such materials should not be used within the cooling system. Algae, slimes and fungi also provide nutrients for Legionella multiplication. Scale by itself is not a nutrient, but can provide a haven for the bacteria to grow. Unless specified otherwise by local or national regulations it is recommended to maintain the total aerobic bacterial count (cfu/ml at 30°C) below $10^{5.}$ during system operation. Refer to Section 4.5 – Water Quality Monitoring Procedures.

- <u>Havens for Legionella bacteria</u>
  Biofilms, slimes and scale can provide a haven for the growth of Legionella. Regular inspection and, if required, cleaning and disinfection are needed to minimise these within the cooling system. The system and associated components need to be designed such that inspections and cleaning operations can be carried out.

3.3 AEROSOLS

Evaporative cooling by its design involves close contact between water and air and droplets of water become entrained in the airstream. However not all of the water entrained in the air is potentially harmful. Plume from cooling towers and evaporative condensers is often mistakenly considered as environmental pollution. Plume occurs when warm air discharging from the cooling tower condenses upon contact with colder ambient air. However this is pure water vapour and does not contain bacteria.

On the other hand water droplets that are entrained in the air stream and carried outside the equipment as drift loss could be harmful if they are contaminated with Legionella bacteria.

To reduce drift and thus aerosols in the vicinity, all evaporative cooling equipment needs to have well designed drift eliminators covering the full discharge area. The higher the efficiency of the drift eliminators the smaller the water loss in the form of aerosols. Note however that even the best drift eliminators do not eliminate aerosols entirely.

Whilst the efficient reduction of drift loss may help to reduce any risk, it cannot be viewed as a “stand alone“ preventive measure.

Despite this, it is important to install drift eliminators with high efficiency. The eliminators should be accessible for regular inspections and readily removable for cleaning or replacement.

4. MAINTAINING EQUIPMENT SAFETY

The key to making your cooling system safe and efficient is to prevent uncontrolled multiplication and dispersion of bacteria. To achieve this, a total approach is needed, including :

- Correct selection, location and installation of the cooling system components
- Implementation and operation of an appropriate water treatment programme to maintain the water quality within control parameters
- Set up and execution of a preventive maintenance programme
- Proper monitoring and record keeping of the system operation and recirculating water quality

4.1 SELECTION OF EVAPORATIVE COOLING EQUIPMENT

The cooling tower or evaporative condenser should be designed such that it is easy to maintain and keep clean. Materials of construction should have good corrosion resistance. For steel components galvanising is considered as a minimum requirement. High efficiency drift eliminators should always be fitted and older towers with either nil or inefficient drift elimination need to be retrofitted with modern eliminators.

Cooling towers should be located as far away as possible from occupied areas, open windows or air intakes to buildings. The design of the cooling tower should allow easy access for inspection and maintenance.

It is imperative that the manufacturer or system installer provides comprehensive operating and maintenance instructions for the equipment in the cooling system.

4.2 GENERAL SYSTEM REQUIREMENTS

It is recommended to draw up a risk analysis and operating plan for the cooling system in order to assess the consequences that may arise from contamination with Legionella and how to avoid the risk.

The operating plan and a user logbook, in which all relevant actions, test results and events are noted, must be available before system start-up

***Table 1* : General System Requirements**

Type of requirement	Time of activity
Cooling system risk analysis to assess the risk of Legionnaires' Disease.	Before system start-up (*)
Operating plan including water treatment and maintenance to avoid the risk.	Before system start-up
Installation of suitable biocide treatment with automatic or continuous dosing.	Before system start-up & maintained continuously thereafter
Installation of a water treatment system to control scale and corrosion as necessary depending on the supply water quality.	Before system start-up & maintained continuously thereafter
Logbook to record service & maintenance activities.	Before system start-up and updated regularly (weekly or monthly)

Note: (*) Risk analysis is recommended; however it is becoming compulsory in certain European countries. Check national or regional regulations.

A water treatment programme specifically designed to address scale, corrosion and biocidal control of the recirculating water must be implemented when the cooling system is first operated and continuously maintained thereafter.

As described in Section 2 this needs to include the following elements to keep the heat exchange surfaces clean and prevent the multiplication of potentially harmful bacteria:
- Maintain adequate blow-down at all times
- Prevent scale formation and corrosion
- Apply an effective biocide treatment
- Avoid fouling within the cooling system.

4.3 MECHANICAL MAINTENANCE PROGRAMME

A specific maintenance programme needs to be established and then monitored to ensure that the required actions are taken. This means that maintenance tasks are properly scheduled, carried out and records kept. The procedures outlined below will help you to establish this programme for your cooling tower or evaporative condenser.

***Table 2* : Typical Mechanical Maintenance Schedule**

Description of Service	**Start–Up (see Note 1)**	**Monthly**	**Every six months**	**Shut- Down**	**Annually**
Inspect general condition of the system	X			X	X
Inspect heat transfer section(s) for fouling	X		X		
Inspect water distribution	X		X		
Inspect drift eliminators for cleanliness and proper installation	X		X		
Inspect sump	X		X		
Check and adjust sump water level and make-up	X		X		
Check chemical feed equipment	X	X			
Check proper functioning of blow-down	X	X			
Check operation of sump heaters (if applicable)	X		X		
Clean sump strainer	X		X		
Drain sump & piping				X	

- Refer to manufacturer's instructions for detailed description of maintenance procedures.
  Note 1: Initial start-up and after seasonal shut-down period.

Description of Service Procedures

Inspect general condition of the system

The inspection should focus on the following areas:
- Damage to protective finishes (if applicable)
- Signs of corrosion
- Evidence of scaling
- Accumulation of dirt and debris
- Presence of biofilms

Listed below are the actions to be taken if any of the above are found during inspection:

- Damage to protective finishes	
a) Small damage (scratches, pin holes, small blisters):	Repair, following instructions of the manufacturer.
b) Large areas of damage	Consult manufacturer for repair recommendations. Check the water treatment programme and records. Make analysis of recirculating water quality and compare against recommended control guidelines.
- Signs of corrosion	The same procedure as above
- Evidence of scale	Hardness of recirculating water is too high. This could be the result of: - inadequate blow-down - malfunction of softener or water treatment In case of local or soft scale formation; try mechanical removal. If there is significant scale formation throughout the equipment, chemical cleaning is needed. Contact the manufacturer or competent water treatment company for recommendations.
- Accumulation of dirt and debris:	Clean out dirt and debris. If necessary system should be drained and filled with fresh water. At start up apply biocide shock treatment.
- Presence of biofilms:	If there is evidence of biofilms, the system, including piping, should be drained, flushed and cleaned of slimes, algae and other organic contamination. Refill with clean water and apply initial biocide shock treatment. Check pH value and ongoing biocide treatment.

Note:
The quality of the recirculating water varies continuously during the operation of the equipment. A water sample taken at one moment in time may differ from a water sample taken at another. For this reason it is necessary to maintain a historical record of water samples taken at regular intervals. Diagnosis of a problem based on a single water analysis is usually not possible.

Inspect heat transfer section(s) for fouling

Minor fouling can usually be removed chemically or by temporary changes to the water treatment programme. Contact your water treatment supplier for advice. Major fouling requires cleaning and flushing, replenishment with fresh water and a review of the effectiveness of the water treatment.

Note:
A proper biocide treatment programme reduces the need for cleaning and disinfection actions. Regular checking of the total aerobic bacteria count and maintaining it within the recommended levels are the key to prevent fouling.

Inspect water distribution

The water distribution system should be free of dirt and debris. All nozzles, troughs etc. need to be in place and clean. In case of contamination, clean the water distribution system as per the manufacturer's instructions. Replace damaged or missing nozzles, as well as any nozzles which cannot be cleaned.

Inspect drift eliminators

Drift eliminators must be clear of debris and any foreign matter. Remove any dirt or obstructions. Damaged or inefficient eliminators need to be replaced. Ensure eliminators fit tightly with no gaps as per the manufacturer's instructions.

Inspect sump

The cleanliness of the sump is a good guide to the overall condition of the cooling system. In the case of larger sumps (usually concrete) regular cleaning and flushing may not be practical. If not already done take water samples and check the aerobic bacteria count. If this is above the recommended level, apply biocide shock treatment or temporarily adjust biocide treatment until required values are maintained.

Check and adjust sump water level and make-up

Set sump water level in accordance with the manufacturer's recommendation. Check functional operation of the make-up system and adjust settings as per the manufacturer's requirements. Replace any worn or damaged components in the water level control and make-up assemblies.

Check chemical feed equipment

Check that the chemical feed equipment has power and that it is functioning normally. It is recommended that a more detailed check is carried out on a regular basis by your water treatment service provider.

Check proper functioning of blow-down

In the case of continuous blow-down with a metering valve in the bleed line, ensure that the valve is unobstructed and that blow-down water can drain freely. Measure the blow-down flow rate by recording the time needed to fill a given volume.

For automatic blow-down using conductivity control, ensure that the conductivity probe is clean and that the blow-down solenoid valve is operational. Unless you have a specific set point adjustment procedure, your water treatment company should check and adjust set points.

Check operation of sump heaters

Sump heaters must only operate in the winter to prevent the sump water from freezing. Under no circumstances should sump heaters operate at other times as they could potentially heat the water to temperature levels, which are favourable for bacteriological growth. Ensure the heater thermostat is properly set and clean. Also ensure that heater control and safety devices, such as low-level cut-out switches, are operational and properly incorporated into the control circuit.

Clean sump strainer

Remove the strainer from the sump. Clean mechanically or with a high pressure hose. Replace if damaged or corroded. Re-install as per the manufacturer's instructions.

Drain sump & piping

During a prolonged shutdown it is recommended to drain the sump and the associated piping. Ensure the drain remains open, so rain water or melting snow can drain from the sump. Also ensure that all piping exposed to freezing conditions is drained; if not this piping has to be insulated and heat-traced. Piping that will not be drained should be valved off to avoid contact with the atmosphere. Shut off the make-up water supply.

4.4 WATER QUALITY CONTROL PARAMETERS

The table below indicates typical recommended control parameters and their required values to control biological growth and scale formation. Maximum values for rates of corrosion should be stipulated by the system designer and verified by the water treatment specialist.

***Table 3* : Water Quality Control Parameters**

Type of Parameter	Required Face Value
TAB in recirculating water	Not exceeding 10^5 cfu/ml (*) (***)
LP (when measured)	Not exceeding 10^4 cfu/l (**) (***)
pH of recirculating water	between 7 and 9
Hardness of recirculating water	< 50°F < 28°D < 500 mg/l as $CaCO_3$
Other parameters, such as chlorides, sulphates and conductivity	As per system specification or water treatment specialist recommendations.

Note : (*) TAB (Total Aerobic Bacteria) expressed in cfu/ml: Colony Forming Units per millilitre
(**) LP (Legionella Pneumophila) expressed in cfu/l: Colony Forming Units per litre
(***) refer to Table 5 for recommended actions

Some local or national regulations may require other TAB and LP concentration control levels. *ALWAYS* observe local or national regulations.

4.5 WATER QUALITY MONITORING PROCEDURES

Table 4 lists water quality monitoring procedures and their recommended frequency

***Table 4* : Typical Water Quality Monitoring Schedule**

Control Activity	Time of Execution
Check operation of water treatment system	Initial start-up & after seasonal shut-down period. Thereafter monthly.
Check stock of chemicals	Initial start-up & after seasonal shut-down period. Thereafter weekly.
Monitor TAB concentration	Weekly
Monitor recirculating water quality against Control Parameters	Monthly
Visual inspection for algae, biofilm formation	Every 6 months (see text)
Check LP concentration	If TAB remains high (see Table 5) after corrective action (see text). If LP contamination is suspected.
System cleaning & disinfection	Prior to start-up, annually, after a shut-down longer than one month. If TAB is above 10^5 cfu/ml. If LP concentration is above 10^4 cfu/l. If excessive growth of organic material is noticed.

Check operation of water treatment system

It is imperative that proper water treatment is in operation at start-up and continuously operated and maintained thereafter. If you are using a water treatment company they must be responsible for commissioning the dosing and control equipment at start-up and thereafter making monthly service visits to check the operation of the system and the recirculating water quality against the control guidelines.

If you are not using an outside water treatment company then the responsible person(s) at your site must carry out the same commissioning, operation and monitoring tasks to maintain the water treatment system in good order and control the water quality.

Check stocks of chemicals

It is important not to run out of chemicals and arrangements should be made with your supplier or water treatment company to replenish stocks of chemicals well before they are exhausted.

Monitor Total Aerobic Bacteria (TAB) concentration

The simplest method to measure bacteriological levels in water is the use of dip slides. Refer to the instructions of the supplier. Follow the correct procedures for taking a sample of the recirculating water. You will need a suitable incubator to store the dip slides to be sure of getting an accurate result.

For evaporative cooling equipment the following control levels should be observed.

***Table 5* : TAB Concentration Corrective Action Levels**

TAB concentration in cfu/ml	Recommended Action
Below 10^4	No action required
Between 10^4 and 10^5	Repeat test and if high TAB concentration is confirmed increase biocide treatment. If high TAB persists carry out LP test. If LP concentration at 10^4 cfu/l or above is confirmed, clean and disinfect the system. Repeat test every two weeks until LP concentration remains below 10^3 cfu/l.
Above 10^5	Immediate cleaning and disinfection is required.

(*) Some local or national regulations may require other TAB concentration control levels. *ALWAYS* observe local or national regulations.

Monitor recirculating water quality against Control Parameters

a) *Check make-up water quality*

Take a sample of the make-up water to the cooling tower. Mark sample and record the date. Usually 1 litre of sample water is sufficient. The analysis must be made within a few days after the sample has been taken. As a minimum the following parameters need to be checked:

- pH
- total hardness
- alkalinity
- chlorides
- sulphates
- conductivity

Compare the analysis with previous records or, in the case of a first sample at start-up, with the water data used to choose the water treatment system. If results deviate from design data or previous data, it is recommended to analyse three more samples taken in successive weeks. Based on the results, find the cause of varying make-up water quality with the assistance of a water treatment specialist and adjust the water treatment programme accordingly.

Note :
Where the make-up water quality is variable, it is recommended to install a conductivity controlled blow-down system. In addition more care needs to be taken in monitoring the chemical water treatment. Consult a competent water treatment company for advice.

b) *Check circulating water quality against guidelines*

Follow the same procedure as the make-up water except for the location of sample taking. Usually the sump is the best place to take circulating water samples. Make sure the sample is not taken in an area influenced by any make-up water or chemical dosage. Do not take samples shortly after cleaning and/or refilling operations – allow minimum 3 days of operation under significant load before a sample is taken. Other locations such as the blow-down line can also be considered for sample taking.
In the case of installations with filtration do not use backflush water from the filter for sample taking.

Compare the results with the water quality control parameters for your system. If any of the given limits are exceeded significantly, immediate action is required. In many cases an increase of the blow-down will provide a satisfactory solution. It is however recommended to consult a reputable water treatment specialist. Where the limits are slightly exceeded, compare results with previous records and look for trends. If these show increased or persistent deviations, adjustments to the water treatment programme may be needed. It is recommended to temporarily increase the sample taking to one sample per week for three weeks. If these samples are within limits, no action is required. If not adjustment to the water treatment programme is needed.

Visual inspection for algae, biofilm formation

If the recommended maximum levels for TAB concentration are not exceeded and corrective action (if required) is taken in good time, it is unlikely that biofilms will develop within the system. Nevertheless it is recommended to visually inspect the system for biofilm every six months. Since a visual inspection of ALL system internals is generally not possible, it is sufficient to inspect the "critical" areas, i.e. these areas where biofilms are likely to develop first. The top and bottom of the fill pack, drift eliminators and sumps, as well as areas where the water may be stagnant during shut-down, are the most "critical" areas. If biofilm formation is noted, it is necessary to clean and disinfect the system (see below). It is also recommended to conduct a functional check of the biocide treatment, as the formation of biofilm may be a result of system malfunction.

Check LP concentration

Unless specified by local regulations, it is not normally necessary to test for LP concentration in the recirculating water. However there are a number of situations when the concentration of LP should be verified. The need for LP testing occurs if :

- LP contamination is suspected
- If the TAB concentration remains above 10^4 cfu/ml after corrective action.

Depending on the results of the LP test, the actions listed in Table 6 will apply.

Testing for LP is a specialist procedure and samples must be sent to an accredited laboratory. It takes several days to get test results.

Table 6 : Concentration Corrective Action Levels

LP concentration in cfu/l	Recommended Action
Below 10^3 (*)	No action required
Between 10^3 and 10^4 (*)	Repeat LP test and simultaneously conduct TAB test. If LP concentration is confirmed and TAB above limit, clean and disinfect system. If LP concentration is confirmed and TAB below limit, repeat test every two weeks until LP concentration is below 10^3. (In order to achieve this, adjustment of biocide treatment may be necessary).
Above 10^4 (*)	Immediate cleaning and disinfection is required.

(*) Some local or national regulations may require other LP concentration control levels. *ALWAYS* observe local or national regulations.

System Cleaning and Disinfection

a) *Cleaning*

It is important that your cooling system be cleaned prior to initial start-up or before being put back into service after a prolonged shut-down.
It is also recommended that your cooling system be drained and cleaned annually. In heavily industrialised areas or if the recirculating water is contaminated this may be needed more often. Where high aerobic bacteria count is suspected or is a re-occurring problem the system should be disinfected as described below *PRIOR* to the cleaning operation.

Once the system is drained an inspection of all the internal surfaces will indicate the extent of physical cleaning needed. All silt, sludge and debris should be removed from the sump. Where the fill pack is heavily fouled or contaminated it should also be cleaned or replaced. The water distribution system and drift eliminators should be thoroughly cleaned and inspected for damage or missing parts.

Sound attenuators or other accessories that show signs of contamination will also require cleaning.

After cleaning, the system should be flushed thoroughly and re-filled with fresh water. Before putting the equipment back into service the appropriate start-up level of treatment chemicals especially biocidal treatment must be added.

b) *Disinfection*

As described earlier disinfection of your cooling system is needed in the event of high TAB and LP concentrations as shown in Tables 4, 5 and 6 and prior to cleaning a cooling tower or evaporative condenser with suspected or known high bacteriological levels.

Some local or national guidance also recommends disinfection prior to initial start-up, after a prolonged shut-down, after each routine cleaning operation or when significant alterations have been made to the cooling system.

Disinfection must be carried out in accordance with a proper procedure and take into account the safety of the cleaning and disinfection staff.

Typically disinfection is achieved using sodium hypochlorite solution to maintain a residual value of 5 – 15 mg/l of the free chlorine and circulate his around the system for up to 6 hours. Higher free chlorine levels for a shorter period are possible but you should consult a water treatment specialist or the supplier(s) of the cooling system components for advice.

Excessive levels of chlorine must be avoided as this can quickly lead to corrosion and damage your system.

Chlorinated water should be de-chlorinated before draining and after disinfection the system must be thoroughly flushed through with clean water.

4.6 SAFETY

To trigger any risk of Legionnaires' Disease, a contaminated aerosol is necessary. To be able to inhale deeply into the lungs, the size of the contaminated water droplets in the aerosol must be 5µ or smaller. Some precautions can be taken to minimise the risk of inhaling such droplets.

- System design
  The evaporative cooling equipment should be positioned such that it is away from occupied areas or where drift cannot enter directly into the windows or air intakes of buildings in the vicinity of the installation. The prevailing wind direction should be taken into account wherever possible.

- Personal Protection
  Maintenance or cleaning personnel working on equipment that may be contaminated should wear half face respirator masks of P3 or equivalent type.

  This precaution is needed:
  - if stagnant or contaminated water has not been drained off
  - if adjacent cells are still operating
  - when cleaning with a high pressure jet.
  - if a high LP concentration has been measured.

PERSONAL SAFETY

The health and safety of both your employees and other people not connected with the work activity but who are in the vicinity of the installation, must be protected. You should ensure that personnel working on the cooling water system have taken the following precautions:

- Fans, pumps, heaters etc. are electrically isolated before commencing any inspection or maintenance work.

- Normal protective clothing is adequate for all internal inspection and cleaning operations. However, note requirement for half face respirator masks when working on equipment that may be contaminated.

4.7 MONITORING AND RECORD KEEPING

In order to be able to monitor the efficient and safe operation of your cooling system all maintenance and water quality monitoring actions should be recorded in a cooling system logbook.

If a specialist maintenance contractor or water treatment company is servicing your cooling system, copies of their visit reports and service actions should also be reviewed carefully and filed in the logbook.

As a minimum the following records should be kept:
- Commissioning and initial start-up reports.
- Monthly, six monthly and annual mechanical maintenance actions.
- Seasonal shut-down and start-up actions.
- Monthly and annual water quality monitoring actions.
- Monthly water treatment service reports.
- Weekly TAB test result.
- Cleaning and disinfection actions.
- Cooling system problems and corrective action taken.

The Code of Practice has described how you can ensure that your evaporative cooling system will operate efficiently and safely without risk of bacteriological contamination that could lead to cases of Legionnaires' Disease.

If you need more specific information you should consult the manufacturer of your evaporative cooling equipment, your water treatment service provider or the local authority in your area responsible for environmental health.

5. ANNEXES

ANNEXE 1 : SUMMARY OF GENERAL AND WATER QUALITY REQUIREMENTS

Table 1 : General System Requirements

Type of requirement	Time of activity
Cooling system risk analysis to assess the risk of Legionnaires' Disease.	Before system start-up (*)
Operating plan including water treatment and maintenance to avoid the risk.	Before system start-up
Installation of suitable biocide treatment with automatic or continuous dosing.	Before system start-up & maintained continuously thereafter
Installation of a water treatment system to control scale and corrosion as necessary depending on the supply water quality.	Before system start-up & maintained continuously thereafter
Logbook to record service & maintenance activities.	Before system start-up and updated regularly (weekly or monthly)

Note: (*) Risk analysis is recommended; however it is becoming compulsory in certain European countries. Check national or regional regulations.

Table 2 : Water Quality Control Parameters

Type of Parameter	Required Face Value
TAB in recirculating water	Not exceeding 10^5 cfu/ml (*) (***)
LP (when measured)	Not exceeding 10^4 cfu/l (**) (***)
pH of recirculating water	between 7 and 9
Hardness of recirculating water	< 50°F < 28°D < 500 mg/l as $CaCO_3$
Other parameters, such as chlorides, sulphates and conductivity	As per system specification or water treatment specialist recommendations.

Note : (*) TAB (Total Aerobic Count) expressed in cfu/ml: Colony Forming Units per millilitre

(**) LP (Legionella Pneumophila) expressed in cfu/l: Colony Forming Units per litre

(***) refer to Table 5 for corrective action

Some local or national regulations may require other TAB and LP concentration control levels. *ALWAYS* observe local or national regulations.

Table 3 : Maintenance and Servicing

Activity	**Time of Execution**
Maintenance of cooling tower or evaporative condenser.	As per manufacturer's instructions.
Maintenance of water treatment system.	By water treatment specialist or as per supplier's instructions.
System cleaning & disinfection	Prior to start-up, annually, after a shutdown longer than one month. If TAB is above 10^5 cfu/ml. If LP concentration is above 10^4 cfu/l. If excessive growth of organic material is noticed.

Table 4 : Monitoring Activities

Monitoring Activity	**Time of Execution**
Monitor TAB (*) concentration.	Weekly
Monitor recirculating water quality against Control Parameters.	Monthly
Visual inspection for algae, biofilm formation.	Every 6 months
Check LP concentration (**)	If TAB remains high (see Table 5) after corrective action. If LP contamination is suspected.

Note : (*) TAB : (Total Aerobic Bacteria) expressed in cfu/ml
(**) LP concentration expressed in cfu/l.
Refer to Table 5 for recommended actions.

Table 5 : TAB Concentration Corrective Action Levels

TAB concentration in cfu/ml	**Recommended Action**
Below 10^4	No action required
Between 10^4 and 10^5	Repeat test and if high TAB concentration is confirmed increase biocide treatment. If high TAB persists carry out LP test. If LP concentration at 10^4 cfu/l or above is confirmed, clean and disinfect the system. Repeat test every two weeks until LP concentration remains below 10^3 cfu/l.
Above 10^5	Immediate cleaning and disinfection is required.

ANNEXE 2 : TYPICAL CONTENTS OF COOLING SYSTEM LOGBOOK

Section 1 : Owner Information

- Name and address of plant owner.
- Responsible plant manager/engineer
- System operator(s)
- Person(s) in charge of maintenance

Section 2 : System Components

- Supplier/type of cooling tower or evaporative condenser, serial number, cooling system reference number
- Supplier/type of biocide treatment, description and reference numbers of components/chemicals
- Supplier/type of water treatment, description and reference numbers of components/chemicals
- Supplier/type of auxiliary equipment [pump(s), heat exchanger(s), filter(s), other] and serial numbers of components
- Suppliers' technical data sheets and/or catalogues.
- Operating limits (temperatures / pressure / water quality etc.)

Section 3 : Subcontractors / Service Providers

- Full address and contact details of subcontractors/service providers and names of people admitted to site.

Section 4 : Risk Analysis

- Cooling system risk analysis, if available.

Section 5 : 0perating and Maintenance Plan

- Operating plan (description of cooling system and water treatment, control sequence, shut-down periods etc.)
- Mechanical maintenance schedule (see Attachment A)
- Suppliers' operating and maintenance literature.

Section 6 : Data Logging and Record Keeping

- TAB testing and results (see Attachment B)
- Water quality monitoring and results (see Attachment C)
- Event record keeping (see Attachment D)

Section 7 : Safety

- Location of cooling tower(s) (if not already in risk analysis)
- Personal safety instructions for mechanical maintenance.
- Personal safety instructions for water treatment system.
- Safety data sheets for all chemicals.
- Personal safety instructions for auxiliary components.

Section 8 : Reports

- Insert all relevant reports (commissioning reports, certificates, training records etc.).

ATTACHMENT A : TYPICAL RECOMMENDED MAINTENANCE SCHEDULE FOR COOLING TOWERS AND EVAPORATIVE CONDENSERS

Description of Service	Start–Up or after Shut-down	Weekly	Monthly	Every Six Months	Annually
Inspect general condition of unit					
Check debris from unit					
Inspect sump – clean & flush if required					
Clean sump strainer					
Check & adjust sump water level and make-up					
Inspect heat transfer section(s) for fouling					
Inspect water distribution					
Check drift eliminators					
Check water quality against guidelines					
Check chemical feed equipment					
Check & adjust bleed rate					
Check pan heaters and accessories					
Drain sump and piping					
Inspect protective finishes					
Check fans for rotation without obstruction					
Check fan & pump motors for proper rotation					
Check unit for unusual noise/vibration					
Check motor(s) voltage and current					
Lubricate fan shaft bearings					
Check & service fan drive system					

ATTACHMENT B : TAB TESTING AND RESULTS

Week	Date Sample Taken	TAB Concentration cfu/ml	Remarks	Signature of Tester
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				
52				

ATTACHMENT C : TYPICAL WATER QUALITY MONITORING CHECKS

A. Make-up Water

Parameter	Control value	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
pH													
Total hardness													
Alkalinity													
Chlorides													
Sulphates													
Conductivity													
Remarks													
Signature													

B. Recirculating Water

Parameter	Control Value	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
pH													
Total hardness													
Alkalinity													
Chlorides													
Sulphates													
Conductivity													
Remarks													
Signature													

ATTACHMENT D : EVENT RECORD KEEPING

Type of Event (Inspection/Maintenance/ Cleaning/Disinfection)	Date of Event	Remarks	Signature

NATIONAL ASSOCIATIONS

BELGIUM
AGORIA
80 bd Reyerslaan,
1030 BRUSSELS
www.agoria.be

●

FINLAND
FREA
P.O. Box 318
0081 HELSINKI

●

FRANCE
UNICLIMA
92038 PARIS LA DEFENSE CEDEX
www.uniclima.org

●

GERMANY
FV ALT im VDMA-
Postfach 71 08 64
60498 FRANKFURT AM MAIN
www.vdma.de

●

GREAT BRITAIN
FETA (HEVAC and BRA)
Henley Road, Medmenham
MARLOW BUCKS SL7 2ER
www.feta.co.uk

●

ITALY
ANIMA
Via Battistotti Sassi 11/B
20133 MILANO
www.anima-it.com

●

NETHERLANDS
NKI
Postbus 190
2700 AD ZOETERMEER
www.nvkl.nl

●

NORWAY
NVEF
Postboks 7174 Majorstua
0307 OSLO
www.nvef.no

●

SPAIN
AFEC
Francisco Silvela 69-1°C
28028 MADRID
www.afec.es

●

SWEDEN
KTG
P.O. Box 5510
11485 STOCKHOLM
SWEDVENT
P.O. Box 175 37
11891 STOCKHOLM
www.svenskventilation.se

●

TURKEY
ISKID
Ruhi Bagdadi Sok No:1 , almumcu
80700 ISTANBUL
www.iskid.org.tr

Published by
EUROVENT / CECOMAF
Technical Secretariat
62 bd de Sébastopol
75003 PARIS
Tel. (33) 01 49 96 69 80
Fax (33) 01 49 96 45 10
info@eurovent-cecomaf.org
www.eurovent-cecomaf.org