

Cooling Tower Water Quality

Water Types



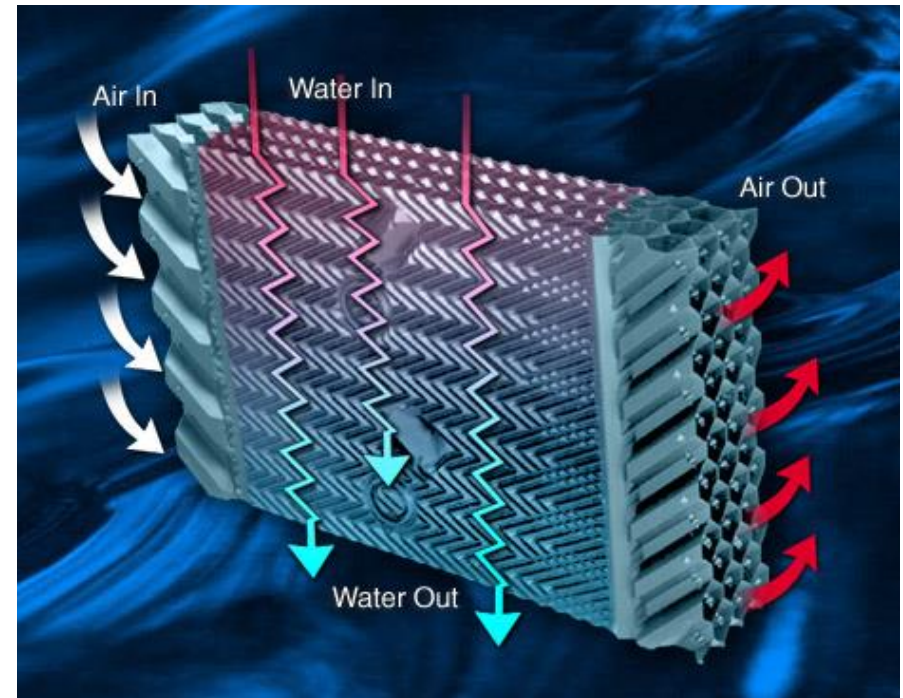
OR



Fill Comparisons

Film Fill

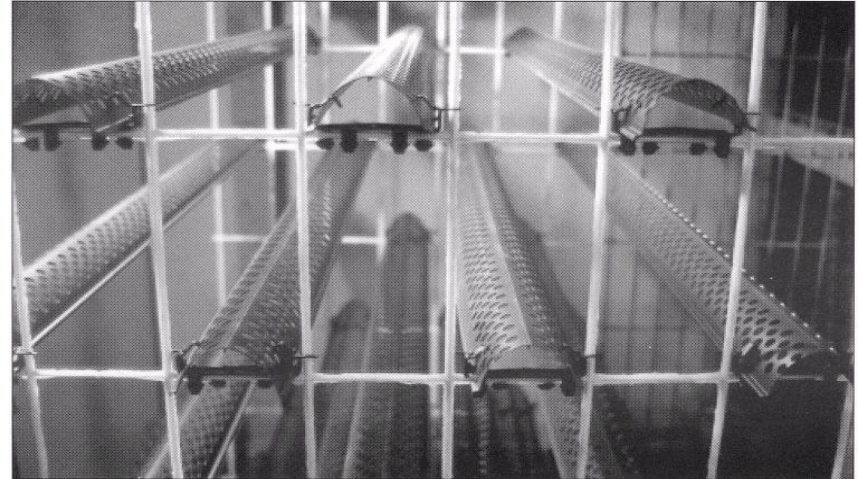
- Thermoformed PVC sheets
- Stretches water into a thin film on surface of PVC sheet
- Heat transfer takes place on surface of water film
- ***Much*** more surface available for cooling than splash fills
- Low tolerance to fouling or to uneven water distribution
- Allows for smaller tower
- Virtually all factory-assembled towers use film fill today



Water Types

Splash Fill

- Numerous material options and configurations depending on water quality and temperature
- **Less** surface available for cooling than film fills
- High tolerance to fouling or to uneven water distribution
- Results in much larger tower



Water Quality Guidelines

- Standard packaged towers are designed for clean, city water and no worse than moderate industrial environment

Water Quality Guidelines

- Certain water conditions, processes, or environments can cause problems
 - Careful tower and material selection and/or attention to water treatment may be required
 - Film fill may not be appropriate in all applications
 - Not just make-up water should be considered, surrounding environment and air quality can cause serious fouling issues
 - Examples
 - Reclaim make-up water (wastewater)
 - Ethanol plants in agricultural environment
 - Steel mill
 - Pulp and paper mill

Incorrect fill selection



Film fill cooling tower being used for effluent water cooling – water contains clay

Water Quality vs. Environmental Issues



Clogging caused by chipboard fibres in the air – not by actual circulating water

Splash Fill can be Clogged Too!



Splash grids clogged with paper fibres at a pulp and paper mill

Water Quality Guidelines

Normal Tower Operation

	<u>Galvanised Steel</u>	<u>Stainless Steel</u>
pH	6.5 to 8.0 for passivation period Higher pH allowed after passivation	5 to 11
Chlorides	300 ppm as Cl ⁻ maximum	900 ppm as Cl ⁻ maximum
Copper	0.1 ppm maximum	no limit
Temperature	51.7° C maximum for standard tower	
Langelier Saturation Index	0.0 to 1.0 recommended higher allowed if scale is controllable	
Silica	150 ppm as SiO ₂ maximum (scale formation)	
Chlorine	1 ppm free residual intermittent (shock), or 0.4 ppm continuous maximum Excess can attack sealants, accelerate corrosion, and embrittle PVC	

Dissolved Solids

Total Dissolved Solids

- Often measured using conductivity meter – may be used to control blowdown valve
- TDS to conductivity correlation depends on the minerals in the water – TDS value is approximately 60 to 70% of the conductivity in $\mu\text{S}/\text{cm}$

Caution in interpreting water analysis

- makeup vs. circulating water
- ions expressed as CaCO_3 or “as such”

Water Quality Guidelines

Drift Effects

- Glycols, biodispersants and antifoams may increase drift rate.
- When minimizing drift is vital, the circulating water shall have a surface tension of at least 65 dynes/cm and a total organic carbon (TOC) level below 25 ppm.
 - Reclaim or re-use waters may contain contaminants which increase drift rate either directly or by necessitating the use of treatment chemicals which increase drift rate.

Miscellaneous Solids and Nutrients

- Avoid water containing bacteria nutrients such as alcohols, nitrates, ammonia, fats, glycols, phosphates, and black liquor.
- Total organic carbon (TOC) should be less than 50 ppm in circulating water.
- Avoid fibrous, oily, greasy, fatty, or tarry materials which can plug fill.

Cycles of Concentration

Cycles of concentration

- Number of times the dissolved solids in a particular volume of water are concentrated through evaporation

$$\text{COC} = \frac{\text{Amount of chloride in the circulating water}}{\text{amount of chloride in the makeup water}}$$

- Regulated by adjusting the blowdown rate
 - To reduce cycles of concentration, the blowdown rate is increased.
 - Blowdown valves often use **conductivity** as the control parameter.

Blowdown

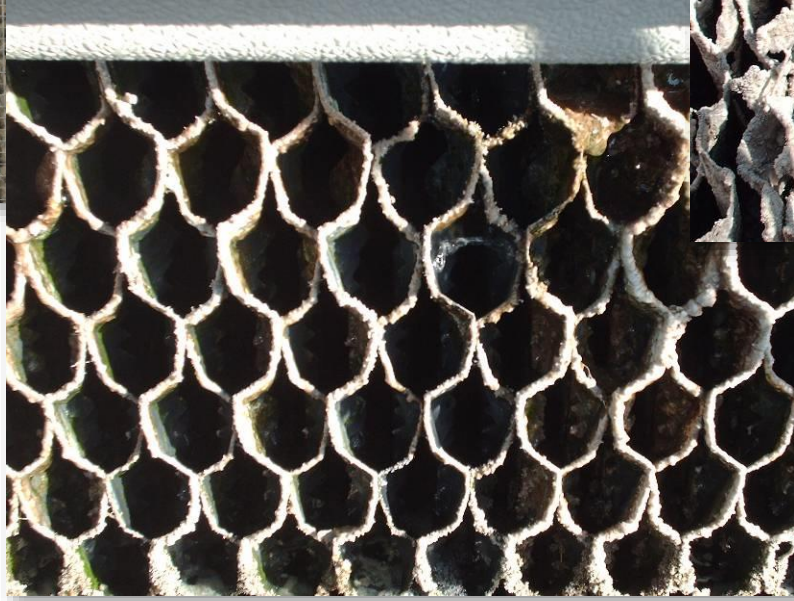
Evaporation, blowdown and makeup

- Evaporation = $(\Delta T \div 6) \times 0.01 \times \text{Flow (m}^3/\text{h)}$
 - 1% of flow for 6 degree C range
- Drift can be approximated at 0.001% of flow
 - Blowdown
 - Depends on cycles of concentration (COC)
 - $\text{Blowdown} + \text{Drift} = \text{Evaporation} \times \frac{1}{\text{COC}}$
 - Example: if Cycles = 5, Blowdown + Drift = $\frac{1}{4}$ Evaporation
 - Makeup
 - Equals Evaporation + Blowdown + Drift

Scale

- Formed from dissolved minerals precipitating out onto system surfaces. As water is evaporated in a cooling tower, the concentration of dissolved solids becomes greater until the solubility of a particular scale-causing mineral salt is exceeded.
- Calcium carbonate, calcium sulfate, calcium phosphate, silica, magnesium silicate, iron oxide.
- Affected by temperature, pH, high localised evaporation (crossflow towers).
- Prevention - Three basic methods:
 - Remove the water scaling ingredients from the water before use via softening, RO, etc.
 - Keep the scale-forming ingredients in solution via addition of acid or scale inhibitor chemical such as phosphonate or a specific polymer.
 - Some treatments alter the crystal structure formed by scaling minerals, allowing them to settle rather than adhere to surfaces. The sediment then can be removed by filtration.

Louvre Scale



Corrosion

Types of corrosion

- General – Total environment
- Pitting (localised)
- Under deposit
- Galvanic – Dissimilar metals
- Microbiologically induced (MIC)

Corrosion is accelerated by high temperature, surface deposits, biological activity, high chlorides, chemical upsets ...

Corrosion

Galvanised Steel corrosion factors:

- chlorides, temperature, pH, soft water, dissolved copper, sulphides.
 - (pH, calcium and alkalinity during first 8 weeks after startup is critical).
- Galvanized steel is sometimes ignored by water treatment companies when the cooling tower is the only galvanised component in the system.

Stainless steel corrosion factors:

- chlorides, low pH (especially hydrochloric acid), weld corrosion (sensitisation caused by carbide precipitation).

Passivation of Galvanised Steel

HMG (heavy mill galvanised)

- The zinc protects the base steel sheet by galvanic action.
 - For maximum life, proper water treatment is essential.
- Initially, the zinc coating must be allowed to develop a natural non-porous surface of “basic zinc carbonate”.
- This natural chemical barrier prevents further rapid corrosion of the zinc coating.
- The basic zinc carbonate barrier will form on HMG surfaces within eight weeks of tower operation under these water conditions:
 - neutral pH (6.5 - 8.0)
 - calcium hardness of 100 - 300 ppm (as CaCO₃)
 - alkalinity of 100 - 300 ppm (as CaCO₃)
- It is very important for the protective basic zinc carbonate barrier to form on galvanized surfaces to resist further corrosion.
- The initial operation of the cooling tower will *significantly* affect its service life.

White Rust

- Occurs when “passivation” is not completed
- Appears as a white, waxy or fluffy adherent deposit on surfaces.
- If it occurs unchecked, the galvanized steel coating will continue to corrode, eventually leading to an early failure.
- Is another form of zinc carbonate which has a different porous structure than the protective “basic zinc carbonate barrier”.
- Can form if your new cooling tower is operated with water of pH greater than 8.0 for an extended time period before the basic zinc carbonate barrier can form.
- Some types of film-forming inhibitor water treatments can promote the formation of white rust if used excessively.

White Rust



Biological Growth

Biocides

- To control bacteria growth which fouls the fill and contributes to corrosion

Oxidising

- Forms of chlorine, bromine, (or combination – BCDMH), ozone

Non-oxidising

- DBNPA (organic bromide)
- Quaternary ammonium salts
- Carbamates
- Sulphur compounds such as TCMTB
- Glutaraldehyde
- Tributyltin oxide

Deposits

- Deposit-forming solids can be introduced into the water by the makeup water, by the process being cooled, or by the surrounding environment.
- Increases fouling of fill and corrosion.
- Measured as Total Suspended Solids (TSS) in the circulating water. Loose correlation to turbidity (cloudiness):
 - TSS value is 100 to 150% of the turbidity value in NTU
- Iron content can cause staining (with appearance of red rust) and contribute to deposits buildup.

Legionella / Legionnaires Disease

- First discovered in 1976 in Philadelphia, USA at an American Legion Convention
- Appears in almost every ground and surface water
- Commonly found where there is stagnant water – cooling tower cold water basins, water heaters, shower fittings, etc.
- Infection results from inhaling airborne water droplets or mist containing viable *Legionella Pneumophila*
- Need to be small enough to pass deep into the lungs
- Most reported cases are in the 40-70 year age group
- Those at increased risk include smokers, and patients with cancer or acute respiratory illnesses
- Symptoms are fever, chills, headache and muscle pain

Legionella

Effective control measures

- Water treatment program
 - In place, being used, regular testing
- Tower cleanliness
- Drift eliminator effectiveness

Further information

- CTI WTP-148 Guideline (www.cti.org)
- UK HSE Guideline A Cop L8 is a useful resource in understanding control of legionella