JUBAIL CORROSION & MATERIAL ENGINEERING FORUM

Seawater Cooling Best Practices

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ABSTRACT

The paper reviews main operational challenges of Evaporative cooling systems using seawater as make-up

- Deposition and/or scaling,
- Micro/macro biological activity
- Potential corrosion, when using yellow alloys

As well as preventative chemistry and main monitoring areas

INTRODUCTION

Seawater is the answer to water scarcity, becoming a good option in coastal areas.

Once potential use problems on evaporative systems are minimized, through the right treatment programme, the use of seawater in evaporative cooling towers not only eliminates the need for freshwater, but by operating at higher cycles we can also reduce actual OpEx & CapEx costs

Evaporative cooling savings can be achieved through increasing the cycles of concentration, but options should be examined from an operational point of view.

Looking at seawater we'll find significant variability depending on:

- Sea currents,
- Temperatures, impurities coming from near harbors, rivers, or other bodies of water that can influence composition.
- In addition to airborne particulates

Even in one same area like Middle East and the Gulf, we can find significant differences on seawater composition:

Major components (expressed as ppm) in Middle East and Gulf seawater

Average TDS	~40000 – 45000		
Chlorides	21000 – 23000	Sodium	11,000 - 15000
Sulfates	3000 - 3300	Magnesium	1500 - 1700
Bicarbonates	130 - 160	Calcium	480 -540
Brome	67 - 75	Potassium	350 - 400
Fluor	1 – 2	Silica	0.5 - 6
Boron	4 - 6	pH	~ 7.9 - 8.2
Oil/HC	expected nil		

TYPICAL MATERIALS OF CONSTRUCTION

- Heat exchanger equipment, normally on titanium (optionally duplex stainless steel, cupro-nickel 90/10, aluminum brass, and admiralty brass)
- With piping, normally on fiberglass-reinforced plastic
- Cooling tower, plastic fill, drift eliminators, nozzles and tower enclosure: plastic
- Cooling tower structure and basin, coated concrete

Deposition
Factors that should be considered:

- Seawater source depth,
- sandpit dimensions (water-speed drop),
- Grid dimensions, and continuous mesh filters

Suspended sand and macro-organisms entering and attaching to different pieces of equipment within the system can increase pressure drop, reduce water flow, and impact condenser and heat-exchanger efficiency
Macro-organisms in the larvae state
can also infest the de-cooling network by settling on different surfaces and colonizing the area

Macrofouling

Defined as the attachment and growth of macro-organisms,

- reducing pipe cross-section within a pipe, water flow, and ultimately impacting on unit efficiency. Normally due to the settlement and growth of mussels, but other species may also contribute
- Typical seasonal profile based on the different life cycles
- Highest impact normally in spring and midsummer due to changes in water temperature.

Macrofouling can be a mix of various organisms, including:

- Mussels: Blue mussel, Mitylus edulis, Mytilus galloprovincialis Zebra mussel, Pacific clam, including other species.
- Other organisms: Banalus, Tube worm, Barnacles, Oysters, Crustacea, Congeria, hhydrozoa, sponges, etc.

Zebra Mussel or Dreissena Polimorpha

Blue mussel or Mitylus Edulis

Balanus

Tube Worm

MACROFOULING CONTROL

There are several techniques and methods that can be used to control or remediate macrofouling. These include:

- **Mechanical** on-line techniques such as screens, continuous filters, and strainers.

- **Physical** methods that normally implemented off-line:
  - Dewatering
  - Scraping
  - Thermal
  - Paints and coatings, distinguished by two groups:
    - Toxic coatings: typically prohibited
    - "Non-toxic" coatings: copper epoxy coatings, etc.

Chemical methods including:

Oxidizing biocides such as chlorine, chlorine dioxide, or activated bromide. But this biocides are detectable

- Normally produced on-site by electrochlorination.
- Attention should be payed to AOX formation if limited.
- The use of oxidants can be potentially Corrosive.
- Typical halogen-free residual at the effluent: 0.1-0.5 ppm,
- Requires consistent dosing of the oxidant

Non-oxidizing biocides,

- Do not interfere with the metabolism, not detected
- If used in conjunction with an halogen program, chlorination
- Should be stopped to avoid stopping water syphoning)
- New compounds do significantly reduce dosages and
- Environmental impact, improving biodegradability.

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Widely spread in the last 10 to 15 years, seawater impacts on on mass balance (reduced water vapor pressure and latent heat)

Depending on suspended solids side filtration advisable. Consider On-line condenser tube cleaning (e.g. Technos or Taprogge)

Macrofouling and algae growth along tower structures (such as columns, basin walls, tower fill, etc.) should be considered

Tower fill type (splash preferred), while equipment on Copper alloy may require of azoles to control corrosion

Tower basins should be on coated concrete to protect steel. Concrete coating must be carefully inspected on every shutdown

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Biomasses may form and interfere with heat transfer, and also generate localized anaerobic areas prone to sulfate-reducing bacteria (MIC). Not to forget Health risks associated with aerosols and Legionella pneumophila

Cycles of Concentration normally recommended: 1,2-1,3 mainly based on equipment manufacturers (warranty purposes), including controlled pH

Scale/deposition risk minimized with the use of organophosphates and dispersing polymers, and our experience demonstrates that at 1.5 cycles pH-control is unnecessary

And based on R&D at pilot plant level we have proved that cycles even higher than 2.0 can be achieved

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Cycles increased together to pH-free operation will:

- Further reduce water needs, thereby minimizing environmental impact.
- Eliminate the use of acid, resulting in safer plant operation.
- Reduce intake pumping costs.
- Better control biological growth by increasing residential times.

MONITORING FOR EFFICIENCY

Following is a list of the main parameters to monitor (by areas) in terms of water treatment results and program efficiency:

Intake:

Pipe-macrofouling:

- Larvae counts
- Mussel settlement witness (brick or concrete finishing)
- Suspended solids, turbidity
- Pump-basin water level trend at full load

Grid and continuous filters:

- Kilogram of debris shells rejected per week/month

Basket filters:

- Pressure drop
- Cleaning frequency

Key equipment:

- Corrosion coupons (if yellow alloys are in use)
- Heat exchangers: U-coefficient (or temperature approach)
- Condenser: Back pressure actual versus equilibrium
- Turbine oil cooler, temperature approach (typically plate type)
- Condensate conductivity (potential tube leakages)

Cooling tower:

- Actual cold water temperature versus design
- pH, if controlled (Stiff & Davis)
- Structure and main elements of periodical for algae
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Effluent:

- Free halogen residual at final effluent

OPTIMIZATION

Only when we are in control of a treatment program can we start To consider optimization.

Optimization should be based on defined KPIs for the entire scope of the project, assuring maximum equipment -efficiency at minimum maintenance -cost while complying with regulations.

Lastly, environmental impacts cannot be overlooked and can be reduced through two approaches: minimizing product use (e.g. switching to a pH-free treatment instead of pH-controlled), and improving chemical biodegradability (e.g. greener products).

CONCLUSION

Before designing any seawater treatment program, it is essential to know the system's hydraulics and mass balance; Pretreatment strategy at the water intake section; Average water quality and Variability, Materials of construction, and effluent regulations

Programme On evaporative systems should cover:

- macro- and microfouling control
- scale and/or deposition.
- corrosion control may also be needed (Cu-alloys)
- Correct dosing of chemicals, assuring quick homogenization, Including reliable dosing pumps For continuous dosing (properly Sized, blow down flowmeter controlled, and DCS monitored) For shot dosed products: time-programmed pump
- On-line controllers (Cl2-free at final seawater outlet and pH if the program includes acid dosing).