MARLEY

thermal science

Cooling Towers and Salt Water

What is Salt Water?

For cooling tower service, any circulating water with more than 750 parts per million chloride expressed as NaCl is generally considered as "salt water". However, the effects of chlorides will be much less severe at 750 ppm than they will at higher concentrations. Salt water may be from the open ocean, brackish (estuarine) or from brine wells. Since an open recirculating system concentrates the dissolved solids in the makeup water, a cooling tower may be exposed to salt water service even though the makeup contains less than 750 ppm NaCl.

If makeup for the cooling tower is from the open ocean, the hypothetical composition will be:

185 ppm	$Ca(HCO_3)_2$
1,200 ppm	$CaSO_4$
2,150 ppm	$MgSO_4$
3,250 ppm	$MgCl_2$
27,000 ppm	NaCl
500 ppm	KCl
100 ppm	KBr
Salinity	35,000 ppm
Total Alkalinity	15 ppm as $CaCO_3$
pH	About 8

How Does It Affect the Cooling Tower?

Materials—The primary effect of salt water is to increase the corrosion rate of metal in the cooling tower and the cooling system. It may cause fiber loosening on wood components which are alternately wet and dry. These effects can be overcome by proper selections of materials and coatings, as described on the next page.

Fouling—Fouling can be biological (slime or algae), inorganic (scale) or variable contamination (oil, debris, etc.). Suspended abrasive matter (sand) may be a problem and may increase corrosion and wear.

Thermal Performance—Salt has three basic effects upon water which affect thermal performance. It lowers the vapor pressure, reduces the specific heat, and increases the density of the solution. The first two tend to decrease thermal performance but the latter effect tends to increase it. However, the compensating effect of increased density is not sufficient to totally offset the effects of reduced specific heat and vapor pressure, so some loss of thermal performance results. The amount of loss is greater for higher salt concentrations and for more difficult cooling duties. For a circulating water with 55,000 ppm salinity, the anticipated loss of thermal performance of a typical mechanical draft cooling tower ranges from 2% to 4%, depending upon the difficulty of the cooling duty. The loss of thermal performance can be regained by adjusting several variables, such as: tower size, fan horsepower or circulating rate. SPX Cooling Technologies' Performance Section has rating systems which can determine the reduction in tower capacity for any degree of salinity and any thermal requirement, so accurate sizings are readily available for applications with salt water makeup.

How Does A Salt Water Cooling Tower Affect The Environment?

The primary concerns in a salt water cooling tower are drift and blowdown. For all practical purposes, the drift and blowdown will contain the same concentration of total dissolved solids as the circulating water. Methods are currently available for determining the total quantity of drift and the drift droplet size distribution. The actual drift rates from most modern cooling towers will range from .005 to .02% of the circulating rate. Drift rates below .005% are attainable with special attention to the eliminator designs and details. Even though low levels of drift are achievable, a salt water cooling tower should not be located close to sensitive equipment.

Blowdown from a salt water cooling tower will contain some multiple of the total dissolved mineral matter in the makeup, but in the case of sea water makeup, it would be unusual for the final concentration in the cooling tower to exceed two times that of the makeup. At the present time, there appears to be no major problem with the disposal of blowdown from salt water cooling towers, providing toxic materials have not been added to the circulating water. However, the subject of blowdown disposal is very complex and potential users of salt water cooling towers should check the authorities having jurisdiction.

What Precautions Can Be Taken?

Structure—Ordinarily made of FRP, wood, steel or concrete for fresh water. Because of the corrosiveness of salt water, a steel structure should be avoided. Pultruded FRP is inert to the effect of salt water, is very durable in salt water exposures and is the best choice for salt water cooling towers. California redwood or Pacific Coast Douglas fir, pressure treated with durable preservatives, also perform well in salt water service. There is no major difference in wood durability between a salt water cooling tower and one utilizing fresh water makeup except that the high concentration of dissolved solids may cause surface damage in areas which are alternately wet and dry. This effect is no different than that experienced in fresh water of very high alkalinity and/or very high total dissolved solids. Concrete should be made with Type II Portland cement for maximum resistance to sulfate attack and the mix should be rich, with a low water to cement ratio. The concrete should be dense and air entrained. A microsilica or metakaolin admixture is also beneficial. Rebar should be epoxy coated. Connectors and hardware in the structure should be resistant to salt water. Plastics and ceramics are inert to the effect of salt water and their use is desirable. Duplex stainless steel (e.g. 2205) or silicon bronze are the recommended alloys for bolting in the structure. Silicon bronze should not be used if the circulating water will be contaminated with sulfides or ammonia. Exposed portions of silicon bronze hardware need protection from falling droplets to avoid erosion-corrosion. Anchor plates or castings in the flooded sections of the tower should be of duplex stainless steel, red brass, or silicon bronze.

Casing and Louvers—FRP is the most commonly used material for these components. This material resists salt water very well. All joints in the casing, horizontal as well as vertical, should be sealed to avoid the buildup of salt deposits in the joints.

Fill and Eliminators—These may be made of wood or durable plastics. All of these perform very well in this application in salt water towers.

Fan Cylinders—These currently are most commonly made of FRP which is very durable in salt water exposures. Hardware in the fan cylinders should be stainless steel or silicon bronze.

Mechanical Equipment—Fan blades may be of FRP, fiberglass reinforced vinyl ester or coated aluminum. Geareducers, bearing housings and fan hubs may be made of cast iron provided they are protected with a heavy coating of epoxy enamel. Mechanical equipment supports and welded steel fan hubs should also be protected with a heavy coating of epoxy enamel. Drive shafts should be made with type 316 stainless steel or fiberglass and/or carbon-fiber composites. Fasteners in the mechanical equipment should be type 316 stainless steel also. Stainless steel resists salt water very well in areas which are highly aerated. It also polarizes readily so it causes little or no galvanic corrosion of less noble metals with which it is in contact in the plenum area.

Distribution System—Unprotected steel pipe should be avoided. PVC and FRP pipe perform well in salt water service. Steel and cast iron fittings in the distribution system should be coated with epoxy enamel or porcelain. The hardware used in the distribution system should be 316 stainless steel, duplex stainless steel, monel or silicon bronze. Silicon bronze should not be used in areas of high velocity.

Cold Water Basin—Generally made of concrete, FRP, or wood. Steel should be avoided. FRP material is inert to the effect of salt water and is very durable in salt water exposures Wood basins are not adversely affected by salt water. Concrete basins should be made with a rich mixture utilizing Type II Portland cement, should be dense and should utilize low water to cement ratios. Air entrainment is also beneficial.

Fouling—Algae and slime can be prevented by the prudent use of biocides. Chlorination is commonly used and is very effective in sea water towers since it releases bromine. Usually 1/2 ppm free residual chlorine is adequate for control. However, if marine animals are present, chlorination to as much as 3 ppm may be required and continuous addition for periods as long as 72 hours may be required. Alternating chlorination with nonoxidizing biocides may be required to maintain control. Scaling would be unusual in the cooling tower but may create heat transfer problems in exchangers. Generally, sea water may be concentrated to approximately 55,000 ppm salinity with no pH adjustment without serious scaling problems in the exchangers. Higher concentrations are possible but pH control by acid additions would probably be required. Two of the major users of sea water cooling towers operate to 55,000 ppm salinity as the upper limit and this procedure has been satisfactory.

Conclusion

Water cooling towers can be utilized where only salt water is available for makeup. With the proper selection of materials and coatings, long service life is achievable. Salt water, at the concentrations usually encountered, can be properly rated for thermal performance.

References

The following references contain additional information which may be useful in the design or operation of circulating systems utilizing salt water. For availability, contact the reference source.

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