PDHonline Course M131 (4 PDH)

HVAC Energy Conservation through Cooling Water Conditioning

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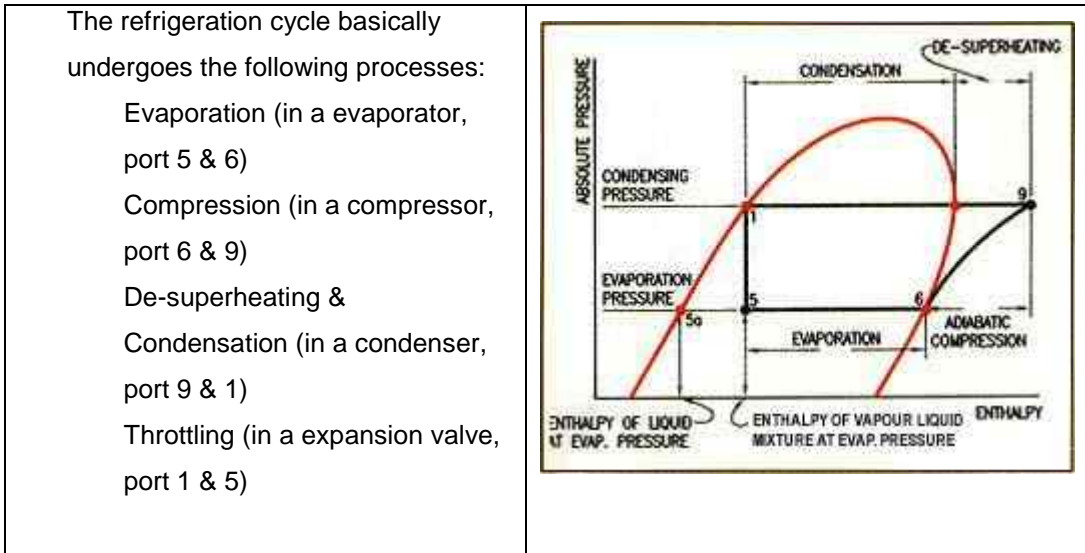
Course Content

In an endeavor to cut down input costs to meet challenges, energy conservation has become a prime consideration in water treatment. It is possible to cut energy bills by employing carefully selected water treatment and chemical additive application. Due to the soaring cost of energy, one must pay attention to all pockets of the system. The discussion in this paper is limited to the waterside problems causing energy losses in the central air-conditioning plants. The main reason for this loss is the limited understanding we have about the waterside problems and also, many a time, our poor attention and approach towards handling these problems.

This paper is aimed at air-conditioning engineers and energy auditors who are responsible for efficient operation and design of system. It is assumed that all the readers know the basic functioning of the air-conditioning system.

Only the waterside problems encountering the open and closed re-circulation cooling water systems are highlighted with brief discussion on how the energy is dissipated from these systems and how effective implementation and tight monitoring of the water treatment programs can conserve it.

Before we come to the discussion on waterside problems, let's first refresh fundamentals of basic refrigeration cycle and try to understand little about work and energy input to the air-conditioning chillers.

The majority of air conditioning systems are cooled by some type of refrigeration system, the most common being the vapor compression type. The basic cycle is shown in figure below:

The refrigeration cycle basically undergoes the following processes:

    Evaporation (in a evaporator, port 5 & 6)

    Compression (in a compressor, port 6 & 9)

    De-superheating & Condensation (in a condenser, port 9 & 1)

    Throttling (in a expansion valve, port 1 & 5)

Refrigerant flows through the system components alternating between the liquid and vapor phases.

- ✓ At point 1, hot liquid refrigerant at condensing pressure passes through the expansion valve where its pressure falls to evaporation pressure; point 5.

- ✓ Saturated refrigerant vapor leaves the evaporator and enters the compressor suction port at point 6 of the cycle and its pressure and temperature is increased by compression until the superheated discharge gas at a condensing pressure leaves the discharge port at point 9 of the cycle.

- ✓ The enthalpy difference between point 5 and 6 represents the heat absorbed by the refrigerant in the evaporator or is known as *"refrigeration effect".*

- ✓ The pressure differential between port 6 and 7 is "*the work or energy input for compression".* The heat of compression is absorbed by the refrigerant gas and is rejected by the condenser.

- ✓ Total heat rejected by the refrigeration system to the condenser cooling medium (point 9 & 1) = *Heat absorbed by the refrigerant in the evaporator (refrigeration effect) + heat equivalent of work input during compression*

- ✓ The coefficient of performance is the ratio of the refrigerant effect to the energy supplied to compressor.

Work Input to the air-conditioning Chiller

Work input to the chiller is defined by equation as under:

$$W \quad \alpha \, M, \partial P \text{ or } W \quad = k \, M \, \partial P$$

Where

W = Work input to compressor

M = Mass flow of refrigerant

∂P = Press difference between compressor suction and discharge pressures of the refrigerant

K = constant

From this formula, it is evident that if the ∂P is high, the work input will also be more, and therefore to minimize the work input, the ∂P will have to be maintained minimum.

Now we must know that the refrigerant pressure of the evaporator is a function of the refrigerant temperature and therefore minimum the temperature of the refrigerant at the compressor suction, minimum is the head pressure and less is the work input to the compressor.

It should be understood that, "hotter the refrigerant gas leaving the condenser, more is the electric power required to complete the compression cycle". Therefore it is necessary to maintain all the heat transfer areas clean to bring about perfect heat transfer across all the exchanger involved in the air-conditioning system. In other words, maximum heat transfer should be withdrawn from the refrigerant before it leaves the condenser.

VAPOUR COMPRESSION CHILLER PACKAGE

Commercial buildings and their HVAC systems vary widely in scale and complexity. There are basic elements in every case that are common. Most of the large air-conditioning plants utilize chilled water systems that use cooling tower re-circulating

system for heat rejection. The physical circuit and major component arrangement of such a system is shown below:
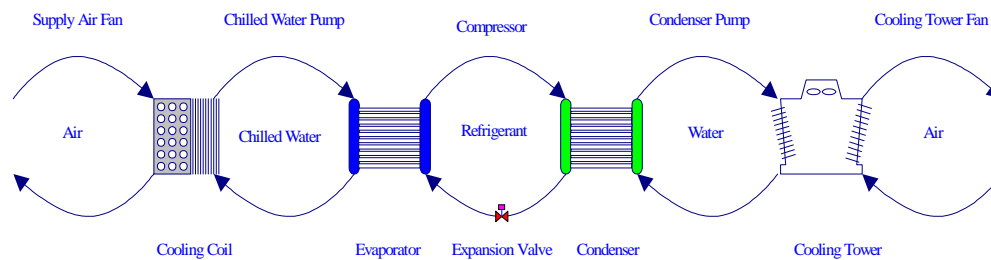
CHILLED WATER SYSTEM WITH WATER COOLED CONDENSER

The heart of the air-conditioning plant is the chiller package. The major elements of a chiller package include:

1. A refrigeration compressor (reciprocating, scroll, screw or centrifugal type),

2. Shell and tube heat exchanger (evaporator) for chilled water production

3. Shell and tube heat exchanger (condenser) for heat rejection in water cooled configuration

4. An expansion valve between condenser and the evaporator

The chiller compressors consume maximum energy be it a reciprocating, centrifugal or screw chiller. As the majority of the air-conditioning plants have the electric compression system, the emphasis in this paper is given to these systems though the nature of waterside problems encountering the air-conditioning system could be applied to the *"absorption systems"** as well. The open and closed circuits, in either of systems and sub-configurations is likely to be identical, if the other operating conditions and make-up water quality to be used in the system remains the same. However, the energy budgets and the losses of energy will vary in each type of system due to variance in operational efficiency and energy source utilized for each type of system.

(* The absorption systems use heat energy in form of steam, direct fuel firing or waste heat to achieve the refrigerant effect. Refer to a course titled 'overview of absorption systems' for more details)

POCKETS OF ENERGY DRAIN

Cooling Tower:

Cooling towers operate on a principle of evaporative cooling. Solids in the water are concentrated by the evaporative process. The cooling tower being open to atmosphere is prone to algae, fungi and microbial attack. The relatively warm water provides an ideal environment for microbial growth. Heavy growth of biomasses on the tower deck, accumulation of suspended matter in the distribution nozzles and tower fill etc disrupts the flow pattern and upsets the functioning of the entire system. The water containing turbidity, suspended impurities and air-borne contaminants (debris) further aggravate the situation. The result is poor heat rejection and low temperature drop across cooling tower.

The contaminants are transmitted throughout the circulating water system and get collected on the system's piping and heat exchanger tubes. The result is high hydraulic head pressure, high pump power and reduced heat transfer capacity

It may be noted that inefficient operation of cooling tower can lead to serious inefficiencies through out the plant processes and equipment, resulting in higher energy consumption and maintenance costs.

Condenser:

The condenser is prone to three types of problem:

1. ***Corrosion:*** The corrosion occurs primarily due to any of the following:

   - Dissolved oxygen in the system

   - Dissimilarity of the metal surfaces

   - Penetrating ions like chlorides and sulphates

   - Low pH and presence of various other impurities

   Depending on the type of corrosion, the condensers either meet with the pitting problems that eventuality leads to tube failures; and/or meet with problems like deposition of corrosion products on various localized areas, resulting in reduction of heat transfer across the heat exchangers. The dissolve oxygen in the system is the main cause for pitting attack.

2. **_Scale Formation:_** The prime causes of scale formation could be attributed to following:

- Re-circulating water having high TDS

- High alkalinity

- High levels of total hardness (calcium + Magnesium)

The scale build up inside the condenser tubes reduces the rate of heat transfer. In compression refrigeration system, scale translates into higher head pressures, hence an increase in power requirements and costs.

A research data indicates; a 1/8" of scale in a 100-ton refrigeration unit represents an increase of 22% in electrical energy compared to the same size unit free of scale. The table below provides a glimpse:

Scale Thickness (inches)	*Increase Energy Consumption (%age)*
1/32	*8.5*
1/16	*12.4*
1/8	*25*
1/4	*40*

3. **_Deposit formation_**

Presence of high levels of suspended impurities, turbidity, slime, microbes and other biomasses are transported through the circulating water to the condensers. These impurities accumulate fast on the low velocity areas such as: condenser sheet and with time accumulate in the condenser tubes. This not only cause reduction in heat transfer, but also lead to the under deposit corrosion and failure of the tubes due to holes in the weekend areas of tubes under the deposits.

Chiller Evaporator:

The chiller evaporator is a closed loop system. Scale is generally not a problem in the chilled water loop, as being closed to the atmosphere, evaporation of water or an

increase in concentration of circulating water never occurs. However due to possibilities of leakage of oxygen from atmosphere through valves, pipe joints, pump packing etc. corrosion remains the potential threat to this system. Also these systems are nevertheless free from the threat of slime formation and microbial attack causing heavy accumulation of deposits on the heat transfer surfaces ultimately bringing heavy energy and metal loss to the plant owners.

Un-controlled Blow down Cycles

In majority of the air-conditioning plants, the operators are instructed to carry out blow-down at the regular intervals and for a certain period. Such a practice of carrying out blow down is non-scientific as one doesn't know whether the blow down is really necessary to be carried out at that particular time and if it is necessary, it is not known as to what extent it should be carried out. Thus, without having the knowledge of the necessity and quantum of blow down, there are always chances that the operators may unnecessarily drain excessive water increasing the make-up water demand.

In contrast to this, many a times operators may carry out inadequate blow down, which consequently leaves the circulating water with high content of TDS and other scale forming salts which lead to the rapid scale formation on the heat transfer surfaces and add to the energy cost.

ENERGY MANAGEMENT

Most of the chillers available from various manufacturers are generally rated for the power consumption of about 0.60 to 0.9 kW per ton of refrigeration (TR). Also the other waterside components of the system such as pump motors, cooling tower fans and few others, consume approx 0.15 kW/ TR.

The cooling duty and power requirements of a compressor depend primarily on the evaporating and condensing temperatures. Compressor performance is usually presented by manufacturers as either graphs or tables of duty and power for range of evaporating and condensing temperatures. To have the fair understanding about the loss

of energy due to waterside problems, let's assume an average consumption of about 0.8 kW/ TR.

As most of the heat exchangers (condensers) are designed for the fouling factor of 0.0005 (0.15 mm thick scale on the heat transfer surface), the power consumption of 0.8 kW/ TR is assumed to be based on the above designed fouling factor.

Lets assume 300 tons plant rated at 0.8 kW/Ton of power consumption, then it should consume not more than

$$300 \text{ TR} \times 0.8 \text{ kW/ Ton} = 240 \text{ KW}$$

Suppose the plant operated for about 12 hours a day and for 150 days a year, then the total consumption should not exceed

$$240 \times 12 \times 150 = 4, 32, 000 \text{ kW/year}$$

Scale / Deposit

It has been found after years and years of experience by various experts and leading companies in the world that ordinary scale of $CaCO_3$, having thickness as low as 0.6mm, can bring energy loss of about 20% (0.6 mm thick scale represents fouling factor of 0.002)

If this scale/deposit instead of $CaCO_3$ is of an iron oxide, then the energy loss will be about 50% more, i.e. instead of 20% the loss will be in the order of 30%.

As discussed earlier, the cooling duty and power requirements of a compressor depend primarily on the evaporating and condensing temperatures. The condenser in particular due to warm water and in an open loop is susceptible to scale deposits that shall raise the condensing temperature of the system. Higher the condensing temperature, higher shall be the power drawn by the compressor and lower shall be the performance.

During normal operation, it may not be possible for the operators to understand the severity and magnitude of the problem. A routine O & M practices shall provide a clue of higher current drawn by the compressor and a drop in cooling range (differential of cooling water inlet and outlet temperature) across the condenser.

The actual audit and field work data undertaken on this plant showed the average current 454 amperes. The actual power taken by the compressor can be calculated from the current taken.

For a three phase low voltage supply:

Power*   = 1.73 x Volts x Amps /1000

In our example

Power   = 1.73 x 400 x 454 /1000

            ~ 314 KW

(* The power factor & efficiency is neglected for simplicity)

Thus we have an air-conditioning chiller plant of 300 Ton, which is practically consuming 314 KW as against 240 KW of its designed power consumption. This implies (314 – 240) = 74 KW additional power is consumed per hour of operation of plant.

As this plant is operated for 12 hrs a day and for 300 days a year, the excess power consumption is

            74 x 12 x 300   = 266,400 KWH/ yr

For an average price of $ 0.15 per KWH, the extra energy cost is $ 176,400 x 0.10 = $ 39960 per annum.

The other indirect costs are the poor performance, loss of efficient cooling, de-rating of chiller machine and cost of repairs and cleaning.

The above provides insight to one example. Million of dollars are being drained each year that can be saved and utilized for some other productive work. It is always possible to handle the waterside problems in a professional and efficient way.

There are various means and ways to treat the water. The treatment programs are to be designed and implemented on the case-to-case basis. This is mainly because of the great variance in the quality of water from one place to another.

To optimize chiller efficiency, the heat exchanging surfaces will have to be maintained clean, free from scale, deposits and other foulants. Such results should be attained at the least possible water treatment costs.

For example, in the above case, where an amount of $ 39960 is being drained off every year, could have been saved as against treatment costs of about $ 1/3rd which indicates that the net savings of $ 26640 is possible, if precisely monitored water treatment program is implemented.

WATER TREATMENT APPROACHES

Water treatment approaches vary greatly with the quality of water. It is seen that most of the HVAC installations rely on a simple water-softening plant irrespective of the make-up water quality. This is not a right approach.

The main reason for this could be attributed to the fact that usually the air-conditioning contracting companies are neither equipped with water treatment engineers nor are their design engineers trained in handling the treatment issues. Therefore first very step to an effective treatment program is to understand the waterside problems and making sure that the air-conditioning design engineers, the O & M personnel are trained to handle these issues.

Before any effective treatment for cooling towers and condensers can be decided upon it is necessary to consider the

1) the analysis of the cooling water to be used

2) the water temperature to and from the tower

3) the recirculation rate and

4) the rate of loss by evaporation.

As water is lost by evaporation the dissolved salts remain in the circulating water. The cooling water sump level is maintained by the make up supply, which introduces more solids. The concentration of TDS (Total dissolved solids) in the system will therefore

increase. The concentration factor is normally determined as the ratio of the TDS in the system water to the TDS in the make-up water. This factor is important in all evaporative cooling systems irrespective of the treatment used to restrict the TDS to a predetermined amount. Depending on the type of treatment, this factor will usually be within the range of 1 to 5. To restrict the build-up of dissolved solids and to keep the concentration factor constant it is necessary to 'purge' or 'bleed-off' water from the system to waste.

There are number and variety of treatment approaches available; each with its own applicability and specialized function. Few of common cost effective options are explained below:

1   Filtration

Say in a area, where make-up water is having high content of turbidity and suspended impurities, but less content of total hardness (Ca + Mg), then it would be more advisable to incorporate a filtration plant in the treatment facilities rather than relying on a softening plant.

Filtration system is composed of a sand filter or high efficiency cartridge filter. Two basic approaches are generally used:

1) *Full-flow filtration* continuously strains the entire system flow. For example, in a 100-ton system, the flow rate would be roughly 300 GPM. A filter would be selected to accommodate the entire 300 gal/min flow rate. In this case, the filter typically is installed after the cooling tower on the discharge side of the pump. While this is the preferred method of filtration, for higher flow systems, it may be cost prohibitive.

2) *Side-stream filtration* although popular, does not provide complete protection, but it can be effective. With side-stream filtration, a portion of the water is filtered continuously. These systems draw water from the sump, filter out sediment and return the filtered water to the tower, enabling the system to operate more efficiently with less water and chemicals. Side-stream filtration is particularly

helpful if your system is subject to dusty atmospheric conditions. For high flow systems, this method is cost-effective.

Properly sizing a side-stream filtration system is critical to obtain satisfactory filter performance. Many engineers size the system to continuously filter the cooling tower basin water at a rate equivalent to 5 to 10% of the total circulation flow rate. For example, if the total flows of a system is 1,200 GPM (a 400-ton system); a 120 gal/min side-stream system is specified.
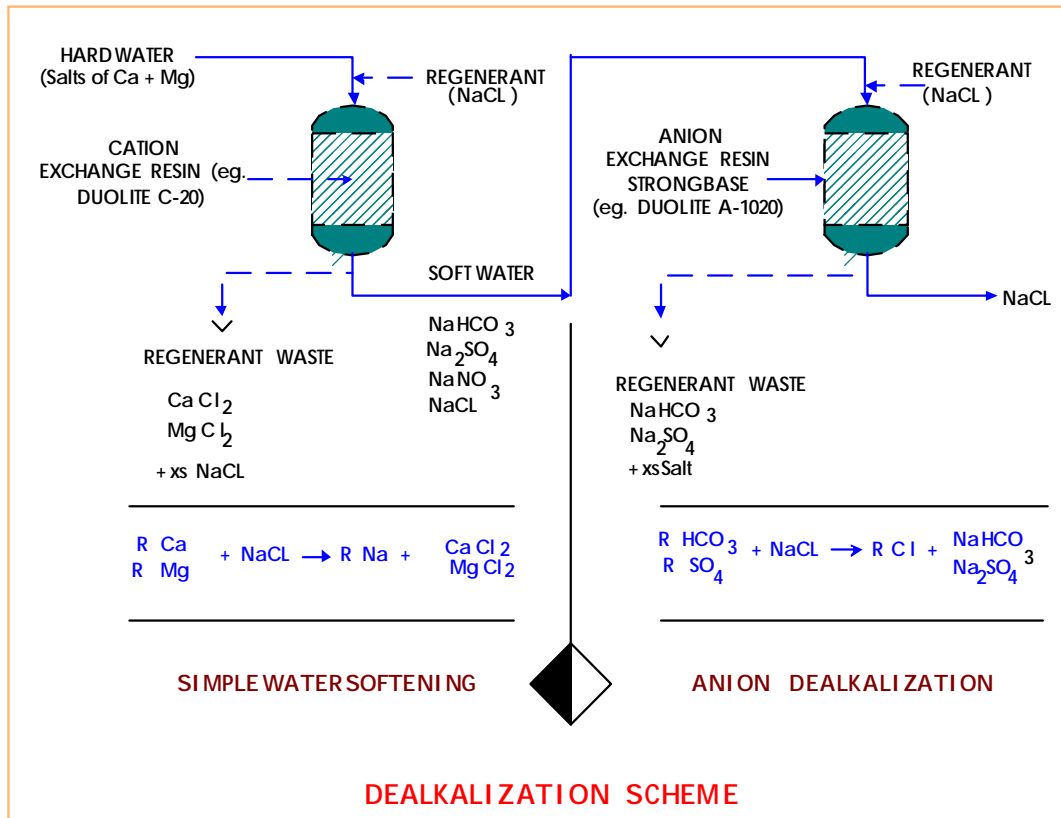
A more accurate approach is to calculate the system's total water volume and filter it once per hour.

The filter, coupled with the proper chemical control program, can significantly reduce or eliminate system fouling, microbial growth and the costly maintenance shutdowns. In many cases, system blow down can also be reduced. Operating cost reduction possibilities are obvious.

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2   De- Alkanizer

Suppose in the second area, where water is clean in appearance free from turbidity and suspended impurities, but having a high level of TDS, high level of total hardness and high level of bi-carbonate alkalinity (say TDS = 800 ppm, Total Alkalinity = 350 ppm, Total hardness = 350 ppm), then in such a situation, it would be more advisable to incorporate a de-alkalizer instead of a simple water softening plant, because the de-alkaliser will not only remove hardness, but also it will reduce the TDS by the value approximately equal to the bi-carbonate alkalinity.

HARD WATER
(Salts of Ca + Mg)   REGENERANT
(NaCL)

CATION
EXCHANGE RESIN (eg.
DUOLITE C-20)

ANION
EXCHANGE RESIN
STRONGBASE
(eg. DUOLITE A-1020)

REGENERANT
(NaCL)

SOFT WATER   NaCL

REGENERANT WASTE

$NaHCO_3$
Na_2SO_4
$NaNO_3$
$NaCL$

$Ca\,Cl_2$
$Mg\,Cl_2$

+ xs NaCL

REGENERANT WASTE
$NaHCO_3$
Na_2SO_4
+ xs Salt

$\begin{matrix} R & Ca \\ R & Mg \end{matrix}$ + NaCL $\rightarrow$ R Na + $\begin{matrix} Ca\,Cl_2 \\ Mg\,Cl_2 \end{matrix}$

$\begin{matrix} R & HCO_3 \\ R & SO_4 \end{matrix}$ + NaCL $\rightarrow$ R Cl + $\begin{matrix} NaHCO_3 \\ Na_2SO_4 \end{matrix}$

SIMPLE WATER SOFTENING   ANION DEALKALIZATION

DEALKALIZATION SCHEME

De-alkalizer will provide the following advantages:

1) By reducing TDS it will allow the system to operate at higher cycles of concentration thus reducing blow down cost by 53%.

   When ordinary water softener is used, the TDS remains unchanged because softening plant only removes hardness by replacing Ca + Mg with Na ions by following reactions:

   Ca $(HCO_3)_2$ + RNa_2 ---- 2 $NaHCO_3$ + R-Ca

   Mg $(HCO_3)_2$ + RNa_2 ---- 2 $NaHCO_3$ + R-Mg
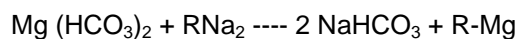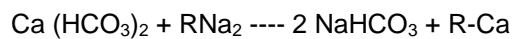
Thus the TDS of 800 ppm will remain around 800 at the outlet of softener, but when the De-alkaliser is used the TDS becomes 800 – 350 = 450 ppm

   In general, where proper water treatment practices are carried out, the TDS of the circulating water – in the open circuit is not allowed to exceed 2500 ppm so that the corrosion and scaling problems are kept under control. Therefore with this concept, when the make up water TDS is 800 ppm and maximum allowable TDS

in the circulating water is 2500 ppm, the system is not permitted to operate at more than **2500/800= 3.1** cycles of concentration, which means the total bleed (i.e. intentional blow down + drift losses) is to be maintained around 0.47% of the circulation rate as shown below:

$$B\% = \frac{E\%}{C-1}$$

$$B\% = \frac{1}{3.1 - 1.0}$$

$$= 0.47\%$$

Where E = % Evaporation, which is generally 1% of the circulating rate

B = % Blow down (drift + Intentional)

C= Allowable (maximum) cycles of concentration

If the De-alkalizer is used, the make up water TDS could be reduced to 450 ppm permitting the system to operate at

$$\frac{2500}{450} = 5.5 \text{ cycles of concentration}$$

The bleed demand shall be reduced to 0.22% of the circulating rate shown as under:

$$B\% = \frac{1}{5.5 - 1.0}$$

$$= 0.22\%$$

Thus a straight saving in blow down cost is 53%

$$= \frac{0.47 - 0.22}{0.47} \times 100$$

$$= 53\%$$

This will greatly increase water conservation, while decreasing those costs associated with both water supply and discharge to and from the cooling tower. One can imagine that the reduced water demand will bring savings in energy.

Thus, where we have assumed a system of 300 ton, the rate of circulation will be about 900 GPM and therefore the saving in blow down cost of 0.25% of circulating rate means a significant value as it works out to be around 18.42 m^3 in 12 hours or 2763 m^3 per 150 days of operation.

2)   Chances of corrosion due to the high electrical conductivity of the circulating water shall be minimized, as the de-alkalizer will reduce the electrical conductivity of the make up water.

3)   De-alkalizer will also reduce further chemical treatment costs.

However, with all these advantages of the de-alkaliser, the installation of de-alkalisers is a critical decision. This really is to be determined after thorough analysis of capital cost, operational cost, man power available for its operation and the actual benefits that can be realized from this equipment. A through life cycle analysis and payback analysis is recommended to decide its installation.

The de-mineralization (DM) plant and reverse osmosis are the expensive treatment approaches that can reduce the TDS to almost zero levels. The cost of operating & treatment with such systems is significantly high and are not recommended for the open re-circulation systems. The DM water may be used for cooling applications in closed loop environment, as the water loss is negligible.

CHEMICAL TREATMENT PROGRAM

Along with the permanent equipment facilities, the chemical dosing is integral part of the treatment process. The permanent facilities shall reduce the scale formation compound to certain levels while the regular chemical dosages keep the scale forming compounds in soluble form. Select proper corrosion and scale inhibitors for open cooling systems and monitor the program by proper lab and field testing. The portable field test kits are available for spot checking.

Corrosion prevention:

Particular treatment will depend on the materials and water properties. It is important to maintain the correct content of inhibitor in the water to avoid localized and intensified corrosion such as would occur if a large cathodic area were to be combined with a small anodic area.

- ✓ The chemical inhibitors for corrosion prevention are classified as anodic, cathodic or mixed.

    - The ***anodic type***, such as chromates and nitrates stop corrosion at the anode by forming an insulating and invisible film of anodic product. The other effective compounds are orthophosphates and silicates.

    - The ***cathodic inhibitors*** such as bicarbonates salts of magnesium, zinc and nickel, metal cations, polyphosphates reduce cathodic reaction by producing a visible coating on the metal and restricting the access of oxygen.

    - ***General:*** Soluble oils, other organics.

- ✓ ***In chilled water systems,*** where the circuit is closed, some measure of protection can be obtained by oxygen-scavenging chemicals such as sodium sulphite or tannin compounds and by raising the pH value of the water to 9 to 9.5 by the addition of caustic soda, which also reacts to neutralize occluded carbon dioxide.

- ✓ Another method is the ***'Cathodic protection'***

Cathodic protection is method of arresting corrosion between dissimilar metals by the production of a neutralizing electric current to oppose that produced by galvanic action.

Proprietary corrosion inhibiting chemicals such as sodium borate, sodium nitrite and sodium silicate are found to be effective.

Scale Prevention:

In the case of spray washers of continuous big systems, the concentration of dissolved solids in the recirculation water may be controlled by continuous bleed-off when the system is operating.

How do chemical scale inhibitors work?

- ✓ **Scale inhibitor chemicals** keep the scale forming materials in soluble form and do not allow deposit to form.
- ✓ **Scale conditioners** modify the crystal structure of scale, creating a bulky transportable sludge instead of hard deposit.

Common scale-control chemicals

- ✓ **Scale inhibitors:** Organic phosphates, polyphosphates polymer compounds
- ✓ **Scale conditioning compounds:** Lignin, tannins, polymeric compounds

Organic Growth Control:

Select proper biocides and add them at the desired intervals so that the biological and micro biological growth is controlled and the system is kept clean and free from fouling and deposit formation.

Install covers to block sunlight penetration. Reducing the amount of sunlight on tower surfaces can significantly reduce biological growth.

The treatment to minimize algae and slime growth consists of dosing the system with:

- ✓ Chlorine as sodium hypochlorite
- ✓ Proprietary algaecides, which are mainly amine preparations by others such as tributyltin oxide, although very effective for particularly obstinate cases of fouling, are slightly toxic

    ✓ Dosing with ozone

To counter the presence of organic matter and algae presence of 6/7 ppm of free chlorine is desired.

Where it is particularly necessary to keep concrete or plastics surfaces clean, then painting with chlorinated rubber paint not only discourages algae and slime growth but also provides a smoother surface to facilitate its easy removal.

Consider alternative water treatment options such as ozonation or ionization, to reduce water and chemical usage. Be careful to consider life cycle cost impact of such systems.

Acid Treatment

Consider using acid treatment such as sulfuric or ascorbic acid, where appropriate. When added to re-circulating water, acid can improve the efficiency of the water by controlling scale buildup created from mineral deposits. Acid treatment lowers the pH of the water, and is effective in converting a portion of the calcium bicarbonate, the primary cause of scale, into the more readily soluble forms.

Make sure that workers are fully trained in the proper handling of acids. With improper application it may attack system metal and cause severe metal attack. Improper flushing will leave metal surfaces in a highly reactive state, which makes them especially vulnerable to corrosion attack. It is recommended to use a timer and add acid at points where the flow of water is well mixed and reasonably rapid.

Also beware that lowering pH may mean you may have to add a corrosion inhibitor.

Chemical Feeders

Any chemical treatment program to be given should be uniform and consistent and therefore proper chemical feeding equipment should be installed so that the corrosion and scale inhibitors are fed on the continuous or monitored basis.

For small systems, generally a drip type feeder (capillary feeder) should be sufficient, where as for the medium and large size systems (over 100 ton) an electrically or electronically operated chemical feed pump should be installed.

The automated feed system should control blow down/bleed-off by conductivity and then add chemicals based on makeup water flow. These systems minimize water and chemical use while optimizing control against scale, corrosion and biological growth.

UNCONTROLLED BLOW DOWN CYCLES

To avoid inconsistencies of blow down cycles, it is advisable to install an automatic conductivity cum blow down controller. This equipment senses the conductivity (TDS) of the circulating water and whenever the value exceeds the pre-set value, a signal is given to the solenoid bleed valve installed in the bleed line, which is automatically actuated & the bleed takes place until the TDS is brought back to the desired (Pre-set) level.

Find out if conductivity is actually representative of your controlling parameter. Depending on the water supply, the equipment being cooled and the temperature differential across the tower, your governing parameters may be hardness, silica, total dissolved solids, algae or others. Once you determine the relationship between conductivity and your controlling parameter, set you blow down valve to keep that parameter constant.

Operational Benefit of Automatic Blow down

Install conductivity and flow meters on make-up and bleed-off lines. Meters that display total water being used as well as current rate of flow are most useful. *Check the ratio of conductivity of make-up water and the bleed off conductivity. Then check the ratio of bleed-off flow to make up flow. If both ratios are not about the same, check the tower for leaks or other unauthorized draw-off.* Read conductivity and flow meters regularly to quickly identify problems. Keep a log of make-up, bleed-off consumption, dissolved solid concentration, evaporation, cooling load, and concentration ratio.

COMMON CHEMICAL INHIBITORS

The common chemical inhibitors compounds are:

1. Chromates: These are generally used with zinc and poly-phosphates. When chromates are used alone, the level should be maintained otherwise it would

promote corrosion. Few countries/states do not permit the use of chromates because of its toxic nature.

2. Poly-Phosphates: These basically extend the solubility limit of Calcium. The main limitations of these are that in case pH increases beyond 7.3, these will be converted into ortho-compound, which will react with calcium and form the sludge.

3. Zinc: These provide film of zinc hydroxide. If pH = 6.5, maintenance is must. If pH > 6.5, zinc will go to the solution. If pH < 6.5, it will precipitate. It will tend to absorb the suspended particulates, which shall lead to higher turbidity.

4. Nitrates: These are anodic inhibitors. High level of sulphates and chlorides will affect its performance that leads to high turbidity.

5. Silicates: This cannot be used if pH is high (> 7) and hardness is over 250 ppm.

6. Sodium Meta Phosphate (SHMP): This is effective in a sense that it delays the solubility limit of calcium salts and therefore the scale formation is delayed. The disadvantage however is that it degenerates into ortho-compound and require pH to be controlled with in 6.5 to 7.4. It also acts as food for bio fouling. The latest developments are employing Amino Trimithylene Phosphonate Acid (ATMP) and Hydroxyl Ethylkedene di-Phosphonate Acid (HEDP) that does not have the limitations of SHMP.

Economics

Select your chemical treatment vendor with care. A simplest approach for HVAC system is to perform vendor evaluation on "cost to treat 1000 gallons makeup water" and highest "recommended system water cycle of concentration."

Course Summary

In today's world of expensive energy and replacement costs, it is more vital than ever, for heat exchange equipment to be kept free of insulating deposits. The four principal reasons for water treatment in HVAC systems is to (a) to limit corrosion, (b) to prevent the build-up of scale and sediment, and (c) to reduce the amount of bacteria, including Legionella, and other microorganisms and (d) to affect energy conservation.

Scale deposits and corrosion products on the tube surfaces reduce heat transfer efficiency and increases energy costs. These factors are important for another reason: they have a direct effect on equipment life.

The water-cooled air-conditioning systems consume large chunk of power. In absence of any water treatment or poorly managed treatment program, the threat of scale and deposit formation is severe. An effective water treatment program could contribute to saving good amount of dollars while offsetting the treatment costs.

Water conditioning thus is a very important aspect of energy conservation program.