CW CHEMICAL TREATMENT PRACTICES AT NTPC RAMAGUNDAM POWER STATION, EXPLORING ALTERNATIVES TO MEET NEW NORMS

Author: R Varadan,
AGM (Chem.) NTPC-Ramagundam,Telangana India
(Mail:rvaradan@ntpc.co.in, Ph: 7382009926)
Co-Author: Suresh Gundu,
Manager (chem.) NTPC-Ramagundam,Telangana,India
(mail:sureshgundu@ntpc.co.in, Ph: 9440682432)

ABSTRACT:

In a thermal power plant cooling water systems are key enablers of unit processes. Maximising cooling system performance serves to realize primary business goals such as efficient generation, energy and water conservation, capital asset preservation, environmental compliance and the protection of human health.

NTPC-Ramagundam is the pioneer in the implementation of CW treatment practices for the last twenty years with fulfilling all the system requirements and running the system most efficiently.

In this paper we have discussed on circumstances that caused introduction of CW chemical treatment at Ramagundam, and how the treatment formulations have been adopted to meet the specific requirements of the system over a period.

On the onset of new water consumption guidelines, we need to re explore the CW consumption optimisation options to face this challenge. We have explored what are the alternate options available and their feasibility with respect to system and cost.

CW CHEMICAL TREATMENT PRACTICES AT NTPC RAMAGUNDAM POWER STATION, EXPLORING ALTERNATIVES TO MEET NEW NORMS

TABLE OF CONTENTS

I.   INTRODUCTION:

Open evaporative recalculating cooling water systems share a common set of operating objectives. At the most basic level, the prevention of any unplanned loss in production, whether due to inadequate heat exchange or capital equipment failure is of paramount importance. Total production loss aside, the impairment of production operations must be avoided as well. With the basic requirements satisfied, the focus turns to optimizing the total cost of cooling operations over time without disrupting production, experiencing catastrophic loss, or compromising safety and with the greenest footprint possible.

Obtaining optimal results from open recalculating cooling systems requires careful management of the three inter-related dimensions of corrosion, deposition, and microbiological activity (Fig-01).
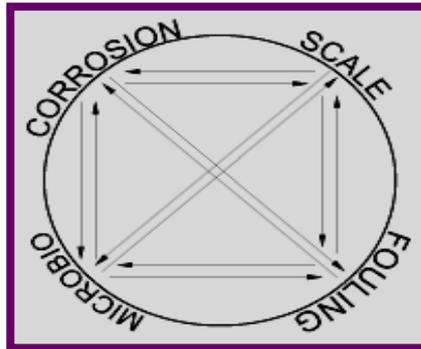

Fig-01:Dimentions of effective cooling water management

For several decades, this concept has been widely understood and practiced by knowledgeable water management professionals and operators of cooling systems themselves.

SCALING:
Scale is a dense coating of predominantly inorganic materials and results from super-saturation of water soluble minerals (Fig-03).Due to Inverse solubility (Fig-02) of predominant mineral substances like $CaCO_3$ leads scale formation results in condenser vacuum loss.

Factors Affecting Scale formation:
- Water Temperature
- Alkalinity or Acidity
- Concentration of scale forming materials in cooling water
- Physical Fouling
- Microbiological Characteristics of CW
- Flow rate of Cooling Water
- Operating Conditions of the Process

Effects of Scale:
- Scale forms an insulating barrier and restricts heat transfer thus decreasing cooling efficiency
- Flow restriction through tubes
- High operation cost
- Process down time costs money and loss in production
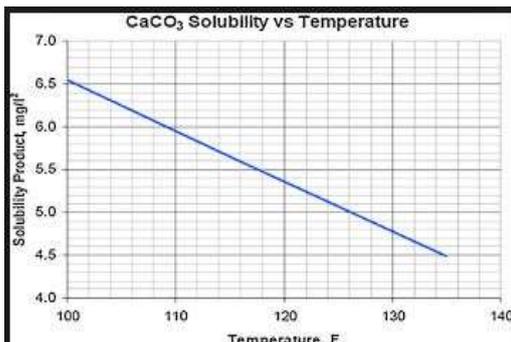- Unsafe process condition due to pressure, temperature etc.

Fig-02: Inverse solubility of CACO3   Fig-03: Scaling
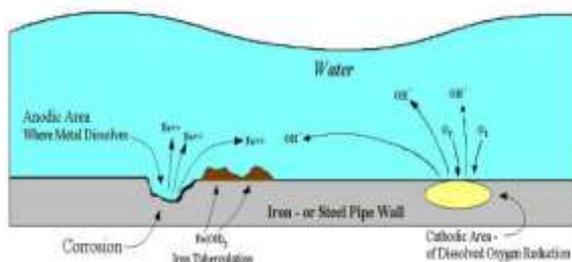
CORROSION & MICROBIOLOGICAL FOULING:

Fig-04: Corrosion cell

Fig-05: Corrosion

Poorly controlled steel corrosion results in the formation and accumulation of corrosion products. As they accumulate on heat exchange surfaces, these products can impede heat transfer, restrict cooling flow, constrain production, and increase energy consumption. As a result, production processes can be economically disadvantaged and the life span of capital assets becomes threatened. The application of inorganic phosphates for steel corrosion control requires the use of polymeric dispersants for the control of calcium carbonate, calcium phosphate or iron phosphate deposits. While polymers vary in their tolerance characteristics, their efficacy can be compromised by the release of soluble iron from an active corrosion site.

Deposits, regardless of whether they are the result of corrosion and/or mineral scales, facilitate microbiological fouling (Fig-06). Non-biological deposition provides sites that enhance the potential for colonization and growth of microorganisms. In turn, microbiological growth entraps more splendid solids or particulate matter, thereby accelerating the cycle of deposition. Microorganisms can cause microbiologically influenced corrosion (MIC) associated with bio films and the proliferation of anaerobic bacteria that prosper in the environments created under deposits. Organisms within biofilm (Fig-07) can deplete oxygen, block corrosion inhibitors from reaching fouled surfaces and concentrate corrosive products through metabolism. The result can be severe localized corrosion, as well as the premature loss of capital equipment. Deposits can lead to under-deposit or crevice corrosion, resulting in pitting-type corrosion. As the understanding and characterization of these inter-relationships has increased so to have the effective techniques for managing them, both chemically and operationally. In addition, new measurement technologies and automated process control for cooling water systems have advanced, bringing about a string of innovations for successfully managing one or more of these interrelationships.
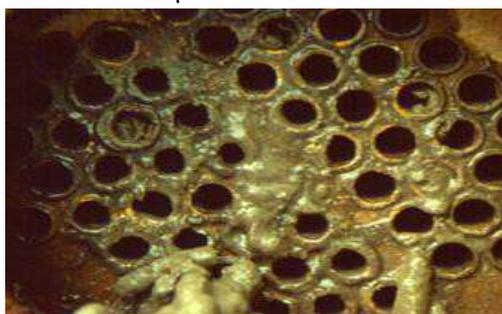

Fig-06: Microbiological Fouling
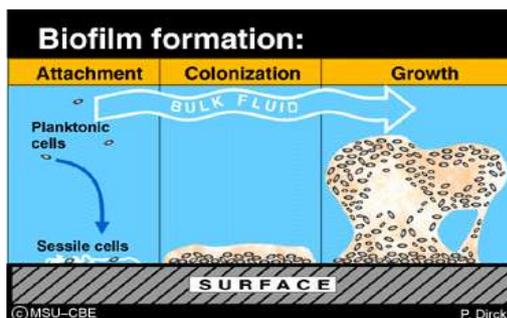
Fig-07; Biofilm formation

From water efficient stand point, you want to maximize cycles of concentration, this will minimize blow down water quantity and reduce makeup water demand. However this can only be done within the constraints of your makeup water and cooling water chemistry.

LANGELIER SATURATION INDEX:

Work by Professor **W.F. Langelier**, published in 1936, deals with the conditions at which a water is in equilibrium with calcium carbonate. An equation developed by Langelier makes it possible to predict the tendency of calcium carbonate either to precipitate or to dissolve under varying conditions. The equation expresses the relationship of pH, calcium, total alkalinity, dissolved

4

solids, and temperature as they relate to the solubility of calcium carbonate in waters with a pH of 6.5-9.5:

$$pHs = (pK_2 - pKs) + pCa^{2+} + pAlk$$

where: pHs is the pH at which water with a given calcium content and alkalinity is in equilibrium with calcium carbonate

K_2 = the second dissociation constant for carbonic acid

Ks = the solubility product constant for calcium carbonate

These terms are functions of temperature and total mineral content. Their values for any given condition can be computed from known thermodynamic constants. Both the calcium ion and the alkalinity terms are the negative logarithms of their respective concentrations. The calcium content is molar, while the alkalinity is an equivalent concentration. The calculation of the pHs has been simplified by the preparation of various monographs.

The difference between the actual pH (pHa) of a sample of water and the pHs , or pHa - pHs, is called the Langelier Saturation Index (LSI). This index is a qualitative indication of the tendency of calcium carbonate to deposit or dissolve. If the LSI is positive, calcium carbonate tends to deposit. If it is negative, calcium carbonate tends to dissolve. If it is zero, the water is at equilibrium.

The LSI measures only the directional tendency or driving force for calcium carbonate to precipitate or dissolve. It cannot be used as a quantitative measure. Two different waters, one of low hardness (corrosive) and the other of high hardness (scale-forming), can have the same Saturation Index.

The Stability Index developed by **Ryzner** makes it possible to distinguish between two such waters. This index is based on a study of actual operating results with waters having various Saturation Indexes.

Stability Index = 2(pHs) – pHa

Where waters have a Stability Index of 6.0 or less, scaling increases and the tendency to corrode decreases. Where the Stability Index exceeds 7.0, scaling may not occur at all. As the Stability Index rises above 7.5 or 8.0, the probability of corrosion increases. Use of the LSI together with the Stability Index contributes to more accurate prediction of the scaling or corrosive tendencies of water.

PSI- Pukorious stability index:

The PSI index is calculated in a manner similar to the Ryznar stability index. Puckorius uses an equilibrium pH rather than the actual system pH to account for the buffering effects

$$PSI = 2\ (pH_s) - pH_{eq}$$

Where:
- pH_s is the pH at saturation in calcite or calcium carbonate
- $pH_{eq} = 1.465\ x\ \log10[Alkalinity] + 4.54$
  $[Alkalinity] = [HCO_3^-] + 2\ [CO_3^{2-}] + [OH^-]$

TERMINOLOGY& SIGNIFICANCE:
Scale index value:

LSI	RSI	PSI	Condition without treatment
3.0	3.0	3.0	Extremely severe scaling
2.0	4.0	4.0	very severe scaling
1.0	5.0	5.0	severe scaling
0.5	5.5	5.5	Moderate scaling
0.2	5.8	5.8	Slightly scaling
0.0	6.0	6.0	Stable water
-0.2	6.5	6.5	Very Slightly scaling
-0.5	7.0	7.0	Dissolving
-1.0	8.0	8.0	Slightly scale dissolving
-2.0	9.0	9.0	Moderately scale dissolving
-3.0	10.0	10.0	strongly scale dissolving

Table-01: LSI- Langlier saturation index; **RSI-** Ryzner Stability index; **PSI-** Pukorious stability index

SCALE CONTROL:

There are three basic methods for preventing formation of calcium scale in cooling water system.
- Remove the calcium hardness or scaling minerals from the water prior to use.
- Keep scale-forming constituents in solution
- Allow the impurity to precipitate as a removable sludge rather than as a hard deposit.

THRESHOLD INHIBITORS:

Deposit control agents that inhibit precipitation at dosages far below the stoichiometric level required for sequestration or chelation are called "threshold inhibitors." These materials affect the kinetics of the nucleation and crystal growth of scale-forming salts, and permit super saturation without scale formation.

Threshold inhibitors function by an adsorption mechanism. As ion clusters in solution become oriented, metastable microcrystallites (highly oriented ion clusters) are formed. At the initial stage of precipitation, the micro crystallite can either continue to grow (forming a larger crystal with a well defined lattice) or dissolve. Threshold inhibitors prevent precipitation by adsorbing on the newly emerging crystal, blocking active growth sites. This inhibits further growth and favours' the dissolution reaction. The precipitate dissolves and releases the inhibitor, which is then free to repeat the process.

Threshold inhibitors delay or retard the rate of precipitation. Crystals eventually form, depending on the degree of super saturation and system retention time. After stable crystals appear, their continued growth is retarded by adsorption of inhibitor. The inhibitor blocks much of the crystal surface, causing distortions in the crystal lattice as growth continues. The distortions (defects in the crystal lattice) create internal stresses, making the crystal fragile. Tightly adherent scale deposits do not form, because crystals that form on surfaces in contact with flowing water cannot withstand the mechanical force exerted by the water. The adsorbed inhibitor also disperses particles, by virtue of its electrostatic charge, and prevents the formation of strongly bound agglomerates.

The most commonly used scale inhibitors are low molecular weight acrylate polymers and organophosphorus compounds (phosphonates). Both classes of materials function as threshold inhibitors; however, the polymeric materials are more effective dispersants. Selection of a scale control agent depends on the precipitating species and its degree of super saturation. The most

effective scale control programs use both a precipitation inhibitor and a dispersant. In some cases this can be achieved with a single component.

FOULING:

Fouling occurs when insoluble particulates suspended in recalculating water form deposits on a surface. Fouling mechanisms are dominated by particle-particle interactions that lead to the formation of agglomerates.

At low water velocities, particle settling occurs under the influence of gravity. Parameters that affect the rate of settling are particle size, relative liquid and particle densities, and liquid viscosity. The relationships of these variables are expressed by Stokes' Law. The most important factor affecting the settling rate is the size of the particle. Because of this, the control of fouling by preventing agglomeration is one of the most fundamental aspects of deposition control.

Foulants enter a cooling system with makeup water, airborne contamination, process leaks, and corrosion. Most potential foulants enter with makeup water as particulate matter, such as clay, silt, and iron oxides. Insoluble aluminum and iron hydroxides enter a system from makeup water pre-treatment operations. Some well waters contain high levels of soluble ferrous iron that is later oxidized to ferric iron by dissolved oxygen in the recirculating cooling water. Because it is very insoluble, the ferric iron precipitates. The steel corrosion process is also a source of ferrous iron and, consequently, contributes to fouling.

Settling occurs when the energy imparted by fluid velocity can no longer suspend the particle, due to agglomeration and growth. After particles have settled, the nature of the deposit depends on the strength of the attractive forces between the particles themselves (agglomerate strength) and between the particles and the surface they contact. If attractive forces between particles are strong and the particles are not highly hydrated, deposits are dense and well structured; if the forces are weak, the deposits are soft and pliable. Deposition continues as long as the shear strength of the deposit exceeds the shear stress of the flowing water.

MICROBIOL GROWTH

Cooling water systems, particularly open recirculating systems, provide a favorable environment for the growth of microorganisms. Microbial growth on wetted surfaces leads to the formation of bio films. If uncontrolled, such films cause fouling, which can adversely affect equipment performance, promote metal corrosion, and accelerate wood deterioration. These problems can be controlled through proper biomonitoring and application of appropriate cooling water antimicrobials

SUSPENDED MATTER

The amount of particulate entering a cooling system with the makeup water can be reduced by filtration and/or sedimentation processes. Particulate removal can also be accomplished by filtration of recirculating cooling water. These methods do not remove all of the suspended matter from the cooling water. The level of fouling experienced is influenced by the effectiveness of the particular removal scheme employed, the water velocities in the process equipment, the local conditions such as dusty environment and the cycles of concentration maintained in the cooling tower.

DISPERSANTS

Dispersants are materials that suspend particulate matter by adsorbing onto the surface of particles and imparting a high charge. Electrostatic repulsion between like-charged particles prevents agglomeration, which reduces particle growth. The presence of a dispersant at the surface of a particle also inhibits the bridging of particles by precipitates that form in the bulk water. The adsorption of the dispersant makes particles more hydrophilic and less likely to adhere to surfaces. Thus, dispersants affect both particle-to-particle and particle-to-surface interactions.

The most effective and widely used dispersants are low molecular weight anionic polymers. Dispersion technology has advanced to the point at which polymers are designed for specific classes of foulants or for a broad spectrum of materials. Acrylate-based polymers are widely used as dispersants. They have advanced from simple homopolymers of acrylic acid to more advanced copolymers and terpolymers. The performance characteristics of the acrylate polymers are a function of their molecular weight and structure, along with the types of monomeric units incorporated into the polymer backbone.

SURFACTANTS

Surface-active or wetting agents are used to prevent fouling by insoluble hydrocarbons. They function by emulsifying the hydrocarbon through the formation of microdroplets containing the surfactant. The hydrophobic (water-hating) portion of the surfactant is dissolved within the oil drop, while the hydrophilic (water-loving) portion is at the surface of the droplet. The electrostatic charge imparted by hydrophilic groups causes the droplets to repel each other, preventing coalescence.

Through a similar process, surfactants also assist in the removal of hydrocarbon-containing deposits.

II FORMULATION ADOPTED AT RSTPS (Ramagundam Super Thermal Power Station)

NTPC-Ramagundam started in the year 1985, having installed capacity of 2600MW (stage-I: 3X200MW; stage-II: 3X500MW &stage-III: 1X500MW) as on today.

Stage-I commissioned in the year -1986

Stage-II commissioned in the year -1992

Stage-III commissioned in the year -2002

In all the three stages, open evaporative recirculation type condenser cooling system is in operation.

Stage-I&II are supported with 2% of side stream filtration systems, where as stage-III is being operated without side stream filtration.

RSTPS is using makeup water from river Godavari (Yellampally) and the water characteristics are more or less same throughout the year and also over the years. The analysis data of CW-1, CW-2 and CW-3 & raw water (makeup) is given below.

CW system at RSTPS is given in Table-02.

Sl.No.	Description	CW-I	CW-II	CW-III
01	Metallurgy of condenser	Cu/Ni alloy	All ferrous	All ferrous
02	Side stream filtration availability	Rapid sand filters	Rapid sand filters	Not Available
03	pH reduction by Sulphuric acid	Not doing (Due to low COC)	In practice	In practice
04	Chlorine dioxide Dosing	Being done	Being done	Being done
05	Circulation Rate(m3/Sec)	25	50	16.67
06	Present COC Trend	1.5	3.0	3.0
07	Evaporation@2%(m3/Sec)	0.5	1	0.34
08	Blow down based on	3600	1800	600
09	Organophosphonate based Treatment	Being done	Being done	Being done

Table-02

Raw Water Analysis Data is given in table-03.

Sl.No.	Parameter	Raw Water	CW-I	CW-II	CW-III
01	pH	8.4	8.9	8.3	8.3
02	Cond us/m	43000.0	87000.0	135500.0	107000.0
03	Turb (NTU)	7.0	15.0	20.0	23.0
04	Calcium (kg/m3 as Ca Co3)	0.06	0.1	0.214	0.198
05	Magnesium (kg/m3 as Ca Co3)	0.081	0.125	0.266	0.252
06	Iron (kg/m3 as Fe)	8×10^{-5}	163×10^{-4}	303×10^{-4}	264×10^{-4}
07	P-Alkalinity (kg/m3 as Ca Co3)	0.004	0.026	0.006	0.006
08	M-Alkalinity(kg/m3 as Ca Co3)	0.170	0.325	0.203	0.162
09	Chloride(kg/m3 as Ca Co3)	0.046	0.115	0.149	0.114
10	Sulphate (kg/m3 as Ca Co3)	0.022	0.043	0.260	0.259
11	Silica (kg/m3)	0.017	0.040	0.049	0.045
12	Temp : (Kelvin)	303.5	306	308	308
13	TDS (kg/m3)	0.2545	0.518	0.825	0.662
14	TSS (kg/m3)	0.0105	0.013	0.023	0.021
15	Organic Matter (kg/m3)	0.0015	0.002	0.0018	0.0017
16	R.Chlorine (kg/m3)	-	0.0004	0.0005	0.0005
17	Sodium (kg/m3 as Ca Co3)	0.0875	0.160	0.227	0.180
18	Potassium (ppm as Ca Co3)	0.006	0.010	0.016	0.0135

Table-03

Treatment Formulation at RSTPS:

➢ Since commissioning of stage-I units (3x200MW) in the year 1986, there was no CW chemical treatment, except chlorination. The operating COC was around 1.5~2.0.

➢ From the year 1986 to 1992 during every overhaul condenser chemical cleaning was done even though COC 1.5 only. Significant condenser vacuum loss was there leading to less loading of turbine. By operating the system with low COC forced us to draw huge quantityofwater.The details are given in the table below (Table-04).

| Condenser vacuum loss (avg. in %)	No of chemical cleans (No's per Year)	Deposit Quantity (Tons/Year/Unit)
15 mm of Hg	01	5 to 6

Table-04

➢ At that time cooling water treatment practices are not in the practice in any of the power plants in India. In these circumstances, the station chemistry has taken up the challenge to start formulating the chemical which can best suits for cooling water nature (Table-05).

	Raw Water	CW-1
LSI	0.61	1.23 (scaling)
RSI	7.18	5.85 (scaling)

Table-05

➢ Station chemistry has taken up job of selection of suitable treatment program by analyzing through
i.Water chemistry,
ii.Water tendency,
iii.Environmental concerns,
iv.cost.

➢ Even though Scale inhibitors like **HEDP** (Hydroxyethylydene-1, 1-diphosphonate)(Fig-08), AMP (amino-tris-(methylene phosphonate)) are available into the market, and there are no expert suppliers to supply the formulation as per our requirements.
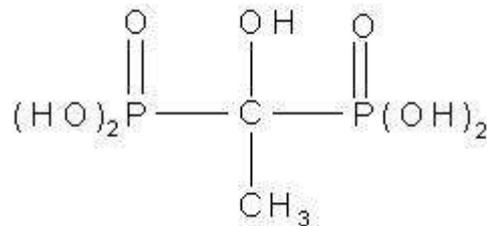
Fig-08: HEDP
(Phosphonates act as scale inhibitors by adsorbing onto specific crystal nuclei surfaces of insoluble salts, thus poisoning further crystal growth. They usually contain multiple phosphonate groups ($R-PO_3H_2$, R = organic chain) most commonly found in their deprotonated form, due to the particular pH range of operation)

➢ After several laboratory trials station chemistry come up with basic HEDP based calcium sequestration formulation with a calcium sequestration value of 150mg/gm.

➢ Started dosing the chemical, stabilisation took nearly two years and lot of COC fluctuation was there.

➢ **The reasons for fluctuations**: Initially only HEDP introduced with a calcium sequestration value of 150mg/gm, there was no corrosion inhibitor, though there is a slight reduction in scale formation but sudden increase of corrosion levels found in the system, then to counter the effect corrosion inhibitors in the form of Zinc (Iron) & Benzo tri azol (cupper) were introduced..Even though chlorine dosing is in practice, System experienced microbial growth on slight increase of COC.Then we have introduced shock dosing of chlorine.

➢ The system was observed through daily efficiency testings and inspection of periodic coupon test profile. Though the system was stabilized, mild scaling tendency was prevailed, then to improve this we increased the calcium sequestration levels from existing 150 mg/gm to 250mg/gm for effective scale inihibition.
Final formulation which is under implementation is given in Table-06.

S.No	Characteristic specification	Value	Dosage rate of formulation
1	Calcium sequestration value(kg/kg)	~0.25	0.0003 kg/m3
2	HEDP content	20 %min	
3	Zinc	1.0%min	
4	Benzo tri azole	1.0% min	
5	Total Phospate	17 %min	
6	Inorganic phosphate	0.5 %max	

Table-06

Later on the same formulation is being adopted for stage-II &III .As these condensers are made up of SS , sulphuric acid dosing is introduced to maintain PH(Acid treatment lowers the pH of the water and is effective in converting a portion of the alkalinity (bicarbonate and carbonate), a primary constituent of scale formation, into more readily soluble forms).

➢ Then one time chemical cleaning was done in all the units and after that over last two to three decades no condenser chemical cleaning was done.
➢ Appreciable deposit quantity was not there, little deposit in the top zone where it was blocked by floating plastic items of cooling tower was there.
➢ Screen were introduced in the Cooling water channel to trap these plastic items and it has drastically reduced now.
➢ Every opportunity condenser water box is being opened, physical debris if any are being removed. This has ensured that there is no condenser vacuum loss due to scaling.
➢ After success full implementation of the formulation in stage-I units, it get extended to the subsequently added stage-II&III units.
➢ At present the organophosphonate based treatment formulation is being dosed at all the three stages. And it can take care of scaling to maximum of 3 to 3.7 COC.
➢ At present with the exiting treatment practice, except CW-I, CW-II&III are being operated around 3 to 3.7 COC without any problem.
➢ In CW-I due to some systemic needs like water requirement for housekeeping, fire fighting and other miscellaneous uses are being fulfilled through continuous blow down, with this reason we are not able to maintain the system COC to the optimum level. Otherwise the system can be operated at its optimum level of COC at 3 to 3.7 very smoothly.

Since last twenty years this formulation is in implementation successfully. This formulation has been studied and lot of inputs are taken by various other NTPC power stations as well as state power stations for implementation.
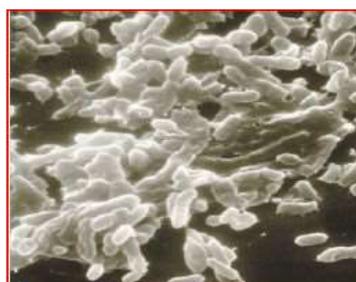
Advantages of operating the system COC@3.7:
-System can tolerate with upsets like high bleed off,

-System contains low chemical residues.

-System can tolerate with considerable changes in makeup water quality.

-Flexibility with respect to system monitoring.

-Flexible with respect to organic matter loading.

Chlorine dioxide dosing in all the three stages for effective control of Microbial Organism:
For effective Bacteriological control we have introduced (in the year 2013) chlorine dioxide dosing along with conventional chlorine dosing.
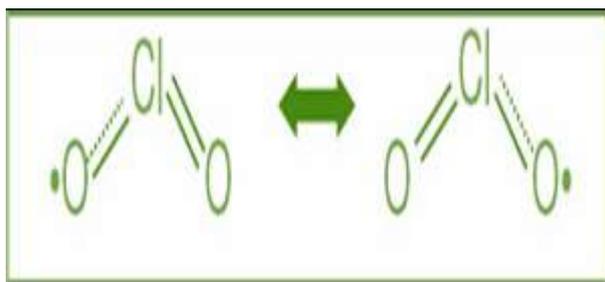
Fig-09: Chlorine di oxide Structure   **Fig-10:Microbial Organism**

Advantages of Chlorine dioxide:

> ➢ Powerful and highly effective oxidizer
>
> ➢ Not affected by pH because it is a dissolved gas
>
> ➢ Won't react with many organic contaminants - including ammonia compounds
>
> ➢ Excellent bio film removal - rapidly penetrates and oxidizes bio film
>
> ➢ Can destroy odors caused by microorganisms and organics
>
> ➢ Does not form disinfection by-products such as THM's and oxidized aromatics.

Regular ORP monitoring of all the stages are being carryout for effectiveness of chlorine dioxide and is maintained well above+500mv.

The microbial level assessment with respect to SRB (Sulphate reducing bacteria) &TVC (Total Viable count) are being monitored and the results found in the last Two years are given in table-07

		Stage-I	Stage-II	Stage-III
2014	**SRB** (CFU/ml)(limit:Nil)	Absent	Absent	Absent
	Microbiological population count(CFU/ml)(Limit<10000)	10^2 to 10^3	10^2	$<10^3$
2015	**SRB** (CFU/ml)	Absent	Absent	Absent
	Microbiological population count(CFU/ml)	10^2	10^2	$<10^3$

Table-07

III.RECENT DEVELOPMENTS IN STATUTORY NORMS

As per the new MOEF Notification released on 7th December 2015 by Government of India, water consumptions standards for thermal power plant are given in table-08.

Sl.No.	Industry	Parameter	Standard
5A	Thermal power plant(water consumption)	Water consumption	I.All plants with Once Through Cooling (OTC) shall install Cooling Tower (CT) and achieve specific water consumption up to maximum of **3.5 M³/MW hr** with in a period of two years from the date of publication of this Notification.
			II.All existing CT based plants reduce specific water consumption up to maximum of **3.5M³/MW hr** with in a period of two years from the date of publication of this Notification.
			III.New plants are to be installed after 1st January, 2017 shall have to meet specific water consumption up to maximum of **2.5M³/MW hr** and achieve zero waste water discharge.

Table-08

In order to fulfil the requirements of new norms we found potentiality in water conservation through increase of CW COC.

Water conservation scope, if we can switch from 3.7COC to 5COC:

Design Parameter	Stage-I	Stage-II	Stage-III
Circulation rate(m³/sec)	25	50	16.67
Evaporation loss @2% (m³/sec)	0.5	1	0.34

Table-09

Stage	Blow down (m³/sec)@COC-3.7	Blow down(m³/sec) @COC-5.0	Conservation of water (m³/sec) by switching to 5 COC
Stage-I	0.185	0.125	0.06
Stage-II	0.370	0.250	0.12
Stage-III	0.123	0.083	0.04
Total			0.22

Table-10

IV.EXPLORING ALTERNATIVES IN ORDER TO MEET THE NEW NORMS

In order to meet the new challenges in an economically viable shape, we need to explore alternatives in various dimensions like, alternate treatment chemicals, optimised dosing system, effective system monitoring etc.

Alternate Formulation:

Chemistry department of RSTPS has been taken up job for exploring the alternate formulation which can work even at the 5COC.

Laboratory scale experimentation has been taken up with all the supporting data and came up with following(table-11 to 14) formulation for implementation

S. No	Product Name	Phosphate (min)	Zinc as Zn (min)	High Stress Polymer (min)	Azole (min)
01	CORROSION INHIBITOR	40 %	5 %	10 %	5 %

Table-11

S. No	Product Name	PBTC(min)
02	SCALE INHIBITOR	50 %

Table-12

S. No	Product Name	Polymer (min)
03	SILICA DISPERSANT	50%

Table-13

S. No	Product Name	Polymer and Surface Active Agents (min)
04	BIO DISPERSANT	40%

Table-14

Recommended Dosage (table-15):

S. No	Product Name	Dosage in ppm
01	CORROSION INHIBITOR	10 ppm on blow down of cooling circuit
02	SCALE INHIBITOR	6 ppm on blow down of cooling circuit
03	SILICA DISPERSANT	3 ppm on blow down of cooling circuit
04	BIODISPERSANT	1 ppm on Hold up

Table-15

Dosing chemical specification details:

The proposed chemicals are to be non-chromate based nontoxic, non-hazardous. The proposed formulations are based on Zinc, inorganic phosphate, organophosphonate (only PBTC), Polymeric dispersant and bio dispersant.

a) Polymeric Dispersant, minimum 3ppm of Low Molecular weight based Co-Polymer or ter-polymer to keep silica and Calcium COC as close as possible. The difference between Calcium and Silica COC shall not exceed 0.5 at any point of time. Additional Silica dispersant, if required, shall be dosed along with dispersant or separately.

b) Polymeric Dispersant gives Minimum Calcium Inhibition of 90 % at pH of 8.0 and Calcium Hardness up to 400 ppm as CaCO3, Magnesium Hardness up to 400 ppm and 6 ppm ortho Phosphate, at proposed dose rate.

c) The total phosphate in the system should be maintained minimum of 5.0 ppm as PO4 out of which equivalent to 1.0 ppm shall be from PBTC only. Zinc should be minimum 0.5ppm as Zinc.

d) The chemicals shall not have any deleterious effect on any components of the CW system, including the packing materials of cooling towers.

Cost of the Formulation:

Due to specific quality of chemicals and strict system monitoring requirements, it is estimated that the cost of this formulation is almost four times more than that of existing formulation. At present per month for organophosphonate we are spending nearly Rs 5 lakhs per month.

Other important considerations for implementation of 5 COC:

1. It is highly sensitive when we operate at 5COC as calcium and silica will be above their solubility limits. Even minor changes in cycles, water quality, and chemical quality may result in notable damage. Hence monitoring and maintaining parameters is more critical for higher cycle's operation.

2. We have to have dose the supplementary chemical as detailed above, and rigours continuous real time monitoring is a must. Even if one day dosing of these chemicals not done properly , huge scaling will take place which cannot be removed unless we do chemical cleaning of condenser during overhaul. Severity and type of scale like this, requires a variety of chemicals for condenser cleaning which will be very costly as well as consume more time than Calcium carbonate scale removal. Corrosion may also occur leading to condenser leak. If we do not clean immediately till that time we have to lose efficiency and scaling will further increase.

3. Side stream filtration having 5% of circulation rate, designed with less than 20NTU turbidity is must to keep the circulation water turbidity and suspended solids within the limit.

4. Stringent blow down control practices with respect to optimum COC levels (i.e.5) to be followed otherwise huge chemical loss will takes place.

5. Consolidating the measurement of multiple parameters like corrosion, fouling & bio fouling monitor onto a single on-line platform and avoiding the acquisition and ongoing costs and complexities of multiple instruments creates a cost-effective means to implement the technology on a wide segment of recalculating cooling systems.

6. Bacteriological activity impact and Biocide sufficiency tests are to be taken up for 5 COC to re-establishing biocide effectiveness as well as dosing rates.

Effective monitoring of system parameters:

The efficient and safe operation of cooling water system involves a substantial amount of routine

monitoring of chemical parameters like pH, hardness, alkalinity, residuals of treatment chemicals, physical parameters like TSS, and microbiological phenomena like Total bacterial count, sulphate reducing bacteria, nitrifying bacteria. Requisite online real-time monitors with system integration will definitely improve the effectiveness.

Monitoring and Evaluation of Treatment Programme			
	Grab sample Parameters	Frequency	Online Parameters
01	pH	Daily	pH
02	Alkalinity	-do-	Conductivity
03	Calcium and Magnesium Hardness	-do-	Corrosion/Instant Corrosion meter
04	Chlorides	-do-	Scale and fouling monitor
05	Silica	-do-	Bio-fouling monitor
06	Turbidity	-do-	ORP monitor
07	Iron	-do-	Temperature
08	Residuals of Treatment Chemicals	-do-	Blow down rate
09	LSI &RSI	-do-	Make up rate
10	Residuals of Biocide	-do-	--
11	Total Bacterial count	weekly	--

V.CONCLUSION.

Water usage in power plants is and will be a critical issue, especially during water-scarce scenario. To meet the new norms will be definitely a challenging one. In most cases, water use in thermal power plants is dominated by cooling. If we consider all the above discussed points and with multi dimensional approach we can definitely meet the target without affecting the system efficiency.

VI.REFERENCES:

Energy.gov website
GE Water book
TP NACE2011Paper11387EN