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OZONE TECHNOLOGIES & SYSTEMS INDIA Pvt., Ltd.,
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OZONE
IN COOLING TOWER WATER MANAGEMENT

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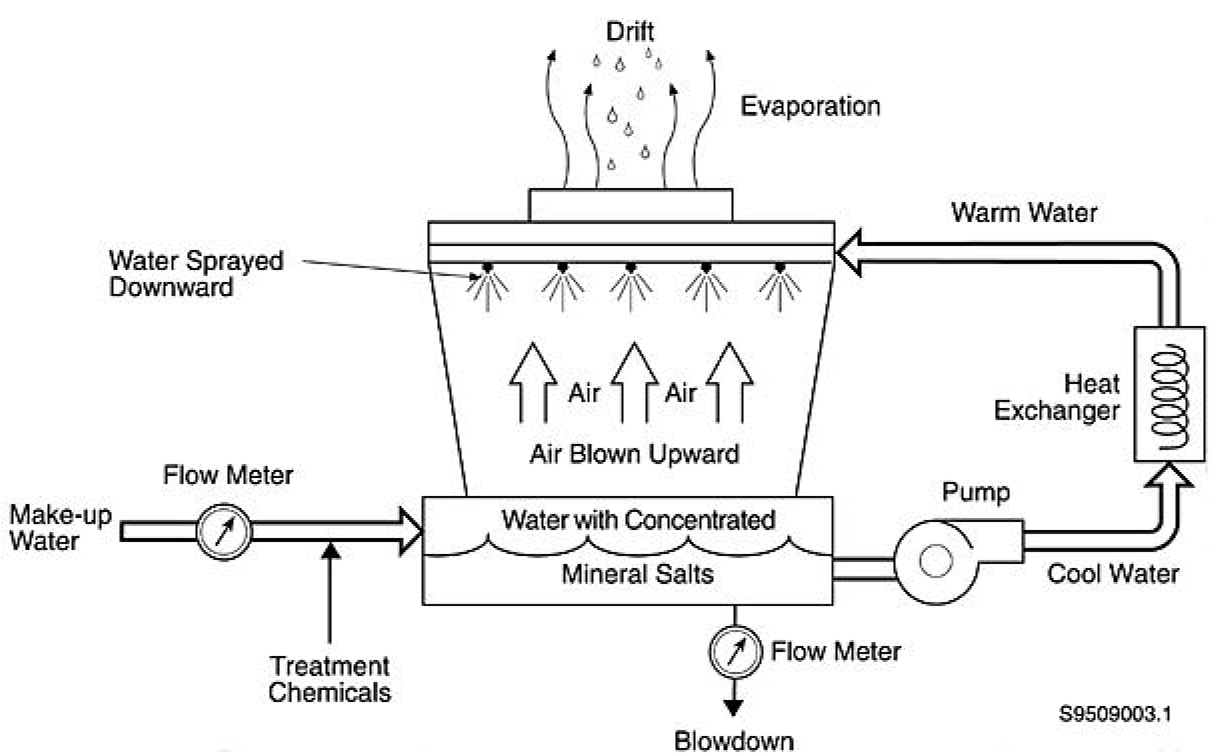
The Use of ozone in Cooling Tower water management is becoming popular nowadays .Ozone has been in use in water treatment and has been very well established. This is because the use of ozone in water treatment is quite simple and non –complicated. Use of ozone In cooling Tower requires adequate knowledge especially with respect to ozone Chemistry viz a viz cooling Tower water Chemistry. Ozone systems are designed to control scale formation, corrosion and organic growths. Simultaneously the system produces safe and non-toxic conditions within the Cooling Tower and the aerosol water passing from the system

A. Description of operation.:

There are many manufacturing plants, power generating systems and air conditioning installations, which require efficient cooling. Frequently, this cooling is achieved by using re-circulating water systems.

The typical system consists of a basin or sump from which the pump circulates the water through pipes to the other components, which are normally one or more heat exchangers, and a cooling tower, in which the warmed water is sprayed into an air stream. Cooling is achieved by the evaporation of the circulating water. The cooled water falls into the basin to complete the circuit and to obtain the most efficient utilization of water. Any make up water needed to replace water evaporated or bled from the system is added into the basin. The water evaporates as pure water, leaving behind - in the remainder of the water - any natural salts and impurities scrubbed from the cooling air stream.

A TYPICAL COOLING TOWER



B. Operating problems within the water circuit.:

1. Scale Formulation and Silt Accumulation

a. The Problems.

Scale formation and or silt accumulation reduces the efficiency and performance of the cooling system, by restricting heat transfer and interfering with water flow. The evaporation of pure water at the cooling tower increases the natural salts in the circulating water.

As this process continues, the natural Calcium alkaline hardness in the water will pass its solubility limit and scale formation will take place. The higher temperature at the heat transfer surfaces increases the rate of scale formation on these surfaces, there by reducing the efficiency and operating capacity of the unit.

Often scale formation is accompanied by the trapping of airborne debris, removed from the cooling air by the scrubbing action of the water as it is spraying through the tower. Such inclusion of corrosion product debris or a combination of these materials, is often held more tightly together by organic growths. The accumulation of debris in the absence of scaling results in silt creation.

CROSS SECTIONOF PIPE
SHOWING SCALE BUILD UP

b. *Existing methods of treatment.:*

It is necessary to bleed off in a controlled manner, some of the concentrated water, to limit scale forming and silting problems. In many cases the volume of bleed off needed to prevent scaling is excessive, and very precise control is required to achieve satisfactory results. This method is

normally impractical. An extension of this method is the addition of acids to the circulating water. Very precise application, missing and controls are needed to prevent severe damage to the system. There are also problems of safety arising from the need to store, handle and apply these acids. Target concentrations for either or a combination of the above may be calculated using the Langeliar Index approach.

But, as stated this technique is far from satisfactory because of the wide margins for error. These margins are further increased if there are variations in water composition. The above methods also impose uneconomic control requirements, especially in the higher output, smaller water capacity systems, which have come into use in recent times. Safer, less hazardous and more practical techniques are required.

2. Corrosion

***a. The problems**.:*

Corrosive attack on the metal surfaces reduces the life of the plant and requires repairs or complete replacement of the plant. Most waters are corrosive. These problems may be aggravated by absorption of acidic gases and other impurities from the cooling air. Many of the salts in solution in the water enhance corrosion, particularly Chlorides. Corrosion conditions may occur under scale, silt and / or organic growths. Corrosive product build up also interferes with heat transfer and water distribution. This may be amplified by inclusion of scale, silt, airborne material and or organic matter.

CROSS SECTION OF A PIPE THAT IS SUFFERING
FROM HEAVY
PITTING CAUSED BY CORROSION

***b. Existing methods of treatment**.:*

The control of Calcium Bicarbonate concentrations in the circulating water using the Langelier Index, as described by Dr. Wilfred L. Langelier, is an excellent method in theory. However, in practice it requires very precise controls to give the desired protection without causing scale formation. Attempts to widen are only partially successful and generally such methods have been superseded.

The use of various inhibitors such as Chromate, Zinc, Phosphates etc., have been successful, but the increasingly tighter controls on the discharge of toxic wastes into natural or piped disposal systems are limiting the use of these chemicals. The toxic water droplets or aerosols in the air exhausts from the tower have caused concern to health authorities. Pollution control regulations are increasingly preventing the use of these inhibitors. An improved and non-toxic corrosion protection method is clearly required.

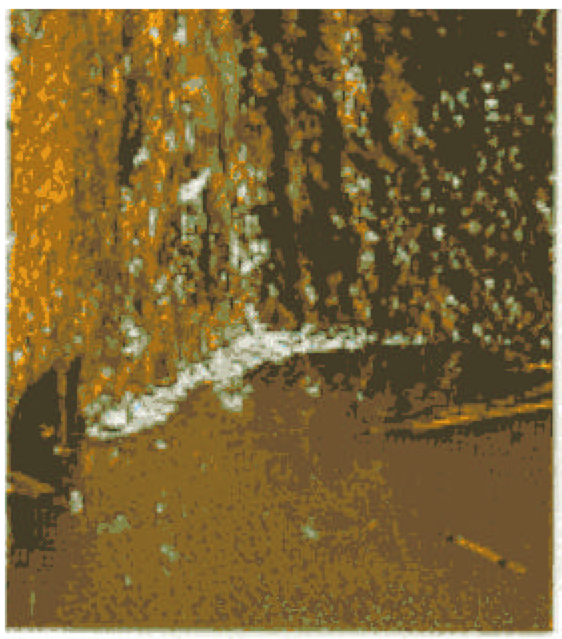
2. Organic Growths.:

a. The problems.

Organic contamination present in the water supply, and / or brought into the system by the flow of cooling air, provides the basis for very rapid growth of various forms of organic materials, such as slimes, algae etc. The conditions of temperature, aeration and sometimes, exposure to sunlight promote very vigorous growth.

Algae and slimes reduce heat transfer, interfere with water distribution and help bind more layers of scale and silt to adhere firmly to internal surfaces of the cooling system. This further aggravate heat transfer problems. Corrosion is frequently accelerated by the presence of organic matter.

Bacteria are another form of organic contamination. They rapidly multiply in the ideal growing conditions within the cooling water system. The presence of other organic materials within the system supplies the nutrient for the growth and multiplication of bacteria.



HEAVY FORMATION OF MICROBIOLOGICAL FOULING

Many forms of bacteria are dangerous and in recent years, special attention has been drawn to the virulent power of some strains of Legionella bacteria, especially on the elderly and those not enjoying the best of health. It is widely recognized that many deaths caused by Legionella have been attributed to other causes, such as pneumonia - due to diagnostic limitations.

Bacteria passes into the exhaust air from the tower in the fine water droplets, known as aerosols. These drift and are sucked in by air conditioning fresh air intakes or are directly inhaled by people, thus providing a source for the infection. Bacteria also escape from the system in the bleed off water and in the aerosols created when the system is washed out or maintenance is taking place.

b. Existing Methods of Treatment.:

A wide range of chemicals, such as Chlorine, Chlorine Dioxide as well as a multitude of organic chemicals have on algae and slimes, but with dangerously haphazard results on bacteria. The dosage and control is often in the hands of plant staff and usually is far from satisfactory. There are problems in the storing and handling of toxic Chlorine containing compounds. Also the discharge, either directly or as aerosols, of water containing some of these chemicals, is prohibited.

There is an urgent need for a vastly improved control method, which is not only effective, particularly against Legionella, but also safe, non-toxic and non-polluting.

II. OZONE method of corrosion control:

The Objectives:

The *OZONE* system is a process for the control of scale formation, corrosion and organic growths of all types in re-circulating water systems, such as condenser cooling water systems, industrial cooling systems etc. The equipment to control the process is also specified.

Ozone has a further deposition inhibiting property, which is well documented. In part this relies on the destruction of organic binding matter such as slimes, algae etc., which in many systems hold together precipitated Calcium Carbonate with airborne dust etc., to form heat transfer reducing scales and deposits. Ozone breaks down all these organic impurities to harmless by-products. Thus, Ozone eliminates all organic binder, which would otherwise aggregate insoluble matter.

De-scaling of fouled systems.: The same properties generally result in the de-scaling of fouled systems, by destroying the binding matter, and thereby, releasing the inorganic deposits from the surfaces.

A. Corrosion prevention.:

The properties of Ozone to passivate metal surfaces by means of a stabilized oxide layer on the metal surface is well documented. This effectively prevents corrosion and thus corrosion protection is far superior than using corrosion in controlling Calcium Carbonate.

This results in corrosion protection superior to that of the arithmetic addition of both methods.

III. The *OZONE system of Biocidal treatment.:*

Ozone destroys organic growths by breaking them down into simple by-products such as water and carbon dioxide with the release of oxygen. The removal of algae, slimes etc., is complete in the presence the specified level of ozone in the water system. Further, Ozone breaks down almost every organic contamination which could be expected to be found in a cooling system, removing the major source of sustenance for the growth, thereby having a twofold effect in growth control.

Control of organisms such as Legionella is significantly increased when ozone is supplied in correct quantities, so that only very low levels (if any) of infestation occur. The risks of exposure to Legionares disease in aerosol emissions from the cooling tower and the waste water from the cooling water system is considerably reduced.

Hazardous, scale preventing chemicals, corrosion inhibitors and organic growth retardant are not used in this process. Chemicals currently used in cooling systems such as Chromate, Zinc, Pentachlorophenols etc. are all highly toxic and their disposal into water courses or via public waste services is either forbidden or strictly limited. The presence of these materials in the aerosol form the tower is of considerable concern. The *Ozone system* produces no such dangerous toxic wastes.

IV. Monitoring and control equipment.:

Adequate ozone treatment results in the creation of a residual oxidation capacity in the water, which can be sensed by an appropriate electrode and measured by a *Redox* monitor in millivolts (mV). It has been amply documented that the required level of *Redox* potential to achieve control of scale formation, corrosion and organic growths is between 700 and 900 mV.
The Redox meter gives a continues reading of the oxidation potential. It is fitted with an alarm in case of system malfunction or heavy external infestation.

V. Recognition of superior treatment and control.:

In countries like Australia where the controls on quality of cooling tower water are as strict as that of drinking water , local Government authorities have agreed to waive certain regulations in towers with ozone treatment. Some of these regulations are :

1. The cooling water system be completely chemically cleaned out every three months.
3. The placing of fresh air intakes at least 20 meters away from the cooling tower. (in the case of existing installations where the air intakes are less than 20 meters from the cooling tower, the necessary work must be undertaken to achieve this separation. This would normally be an extremely costly alteration).

They have recognized that the use of ozone could be a solution to many of the perpetual problems often faced by a cooling Tower operator. NASA has been one of the earliest organization to recognize this fact and have conducted lots of trials and published lot of papers on this Technology. Today NASA have many of their cooling towers Ozonated.

Prevention of scale, silt and corrosion deposits of the system, allows the efficiency of the Ozone sterilization process to be enhanced, by virtue of the more complete access that Ozone has to all the surfaces and contents of the water system on a continuing basis.

The measurement of conductivity is achieved using a modified ohmmeter with an adjustable set point. When the conductivity reaches the set point, the control system operates a purpose built solenoid valve to bleed off a determined volume of water from the cooling system. The water is automatically replaced with make up water, containing only the natural level of Calcium Bicarbonate. On mixing with the concentrated water in the system, this results in the lowering of the calcium bicarbonate value in the circulating water. The bleed off water also removes suspended solids along with the circulating water .A dead band in the control action prevents overshoot and waste of water.

VI. SUMMARY

The passivation of the metal surfaces by Ozone, plus the threshold raising effect of Ozone through micro flocculation and scale inhibition, results in a remarkably effective scale prevention, corrosion inhibition and organic contamination control. This treatment does not require any toxic chemicals or harmful products in the aerosol or waste water from the cooling water system. Further, the bleed off from the system can normally be significantly reduced, with the resultant saving in water consumption. There is less need to washout the systems to limit Legionella bacteria and the level of Legionella control may allow regulating authorities to exempt the cooling water system, using fully controlled and monitored Ozone treatment, from regulations requiring extended distances between the fresh air intakes and the cooling towers.

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comparison of Ozone treatment vis-à-vis chemical treatment of cooling tower

Parameter	*Ideal*	*Ozone Treatment*	*Chemical Treatment*
TDS	With Ozone – 2000 ppm With chemicals – 1500 ppm	No increase other than due to evaporation	Besides evaporation, constant build up owing to addition of chemicals necessitating frequent bleeding and so, water loss
Chloride	Below 200 ppm	No increase other than due to evaporation	Besides evaporation, constant build up owing to addition of chemicals necessitating frequent bleeding and so, water loss
Scaling	Langlier: not above + 0.5 Rhiezner: not above 7.5	Easily maintainable. Scaling is reduced as the organic matrix for seeding is destroyed by Ozone	Heavy scale buildup in spite of chemicals, leading to frequent overhaul and wire scrubbing of condensor tubes.
De-scaling		Ozone destroys scale already formed by breaking the organic matrix	Questionable action
Heat transfer efficiency	No loss in efficiency	No loss in efficiency	Considerable loss owing to poor and erratic control
Corrosion	Langlier: not below - 0.5 Rhiezner: not below 6.5 Industry standard – 5 mpy	Easily maintainable. Ozone acts similar to Chromates used in earlier corrosion inhibitor process – passivates the metal surfaces	Difficult to maintain. Heavy doses of chemicals will be required, which upset other critical parameters drastically
Algae	Nil in water	Nil in water	Dependant on chemicals addition
Frothing	Nil	Nil. No organic sediments to cause froth.	Copious due to quaternary compounds used as biocides as well as other organic chemicals cause increased frothing and compromise heat transfer.
Bacterial count	Below 10000 cfu / ml	About 1000 cfu / ml	Erratic. Usually above 10^5. Often builds up above 10^7 cfu / ml.
Legionella	Nil	Nil	Very difficult to eradicate. Resistant to most chemicals and killed by chemicals too toxic to humans. Ironically, chemicals commonly used in tower maintenance promote growth of Legionella
Sludge	Minimal. Water clear	Water clear. High density sediments. Easily filterable.	Increased sludge. Low density sediments not easily filterable.