Chemical Process Utilities
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Lecture – 47
Control and Maintenance in Cooling Tower

Welcome to the control and maintenance aspect of cooling towers. In this particular lecture, we are going to discuss about the various aspects pertaining to the control measures of the cooling tower. Now, before we go into the detail, let us have a look at what we have discussed in the previous lecture. We discussed about the components and materials pertaining to the cooling tower and this we discussed about the drift eliminators.

We discussed about the water distribution profiling of cooling tower. Then we had a discussion about the cold-water basin which is an integral part of the cooling tower. Then different types of fans and fan drives. Apart from this, because the materials in the cooling tower play a very vital role.

So, we discussed about the material aspect in the manufacturing of cooling tower and then we discussed about the various application attributed to the cooling tower. Now, in this particular lecture we are going to discuss about the controls in cooling tower.

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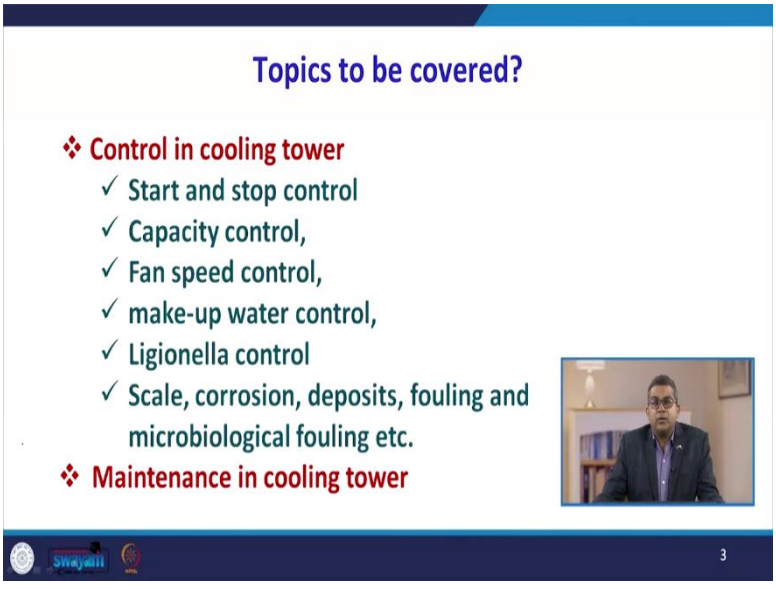

Because the controlling aspect in any kind of operation or any kind of equipment is quite essential. So, when we talk about the cooling tower and its importance then the control in the

cooling tower is equally important. So, in this particular lecture we are going to discuss about the start and stop control of cooling tower. Then how we can control the capacity of the cooling tower.

This will be, we will discuss. Then we will discuss about the speed concept of with respect to the control in the cooling tower. Then make up water control how we can make up because in the previous lectures we discussed about that, the makeup water plays a very vital role in the cooling tower efficiency. So, we will discuss that how to make up and how to control the makeup water.

Then we will discuss about the Ligionella control then scale and corrosion, deposit, fouling and microbiological fouling etcetera. Then lastly, we will discuss about the maintenance aspect in the cooling tower.

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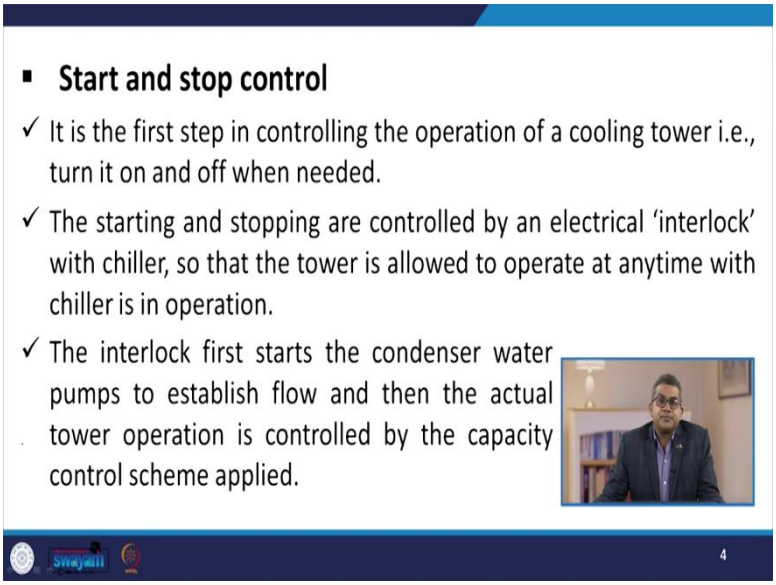

So, let us start with the start and stop control. Now, this is the first step in controlling the operation of cooling tower. That is turn it on or off when needed. Now this particular operation is quite important in the cooling tower because it ultimately starts any kind of operation and it also stops the any kind of cooling tower operation. So, the starting and stopping they are controlled by the electrical interlock with chiller.

So that the tower is allowed to operate at any time with the chiller is in operation. The interlock first starts the condenser water pump to establish the flow and then the actual tower operation is controlled by the capacity control scheme whatever applied to that particular cooling tower.

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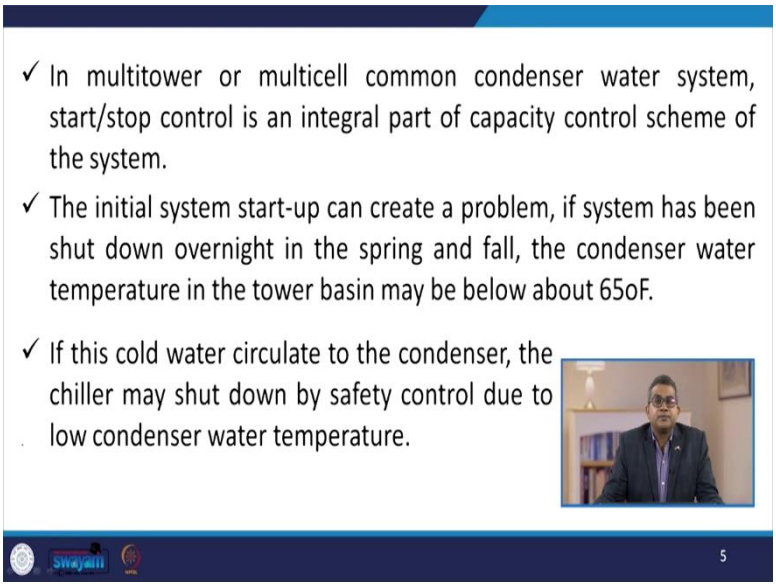

Now, in multi tower or multi-cell common condenser water system start stop control is an integral part of capacity control system of the cooling tower. Now the initial system is startup. This can create a problem if system has been shut down overnight in the spring and fall and the condenser water temperature in the tower basin may be below say, 65-degree Fahrenheit.

Now, if this particular cold water circulates to the condenser, the chiller may shut down by safety control due to low condenser water temperature. Now, in this case, chiller will not start until the condenser water temperature is increased above, say, 65-degree Fahrenheit. To prevent this modulating 3-way control valve should always be used with cooling tower system.

Now the control valve is open to bypass, thus on a startup all condenser water flow bypasses the tower and circulate through the condenser.

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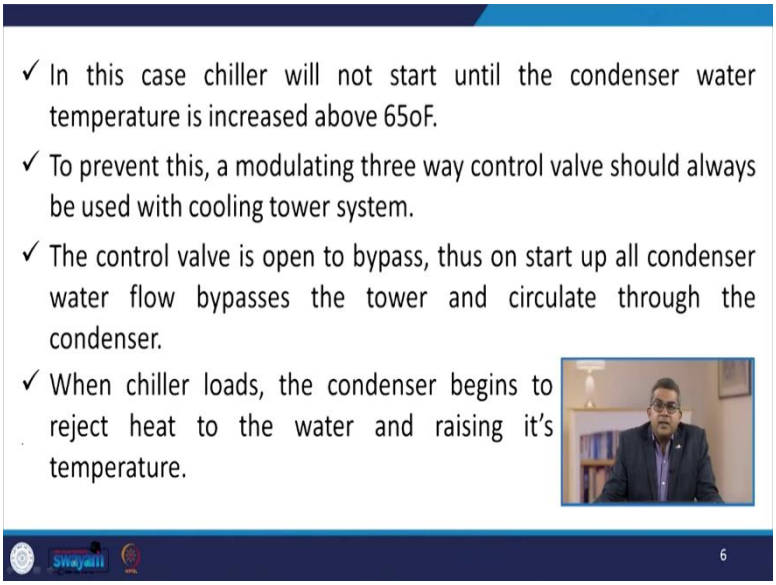

So, when chiller loads, the condenser begins to reject heat to the water and raising its temperature. So, this is the basic phenomena.

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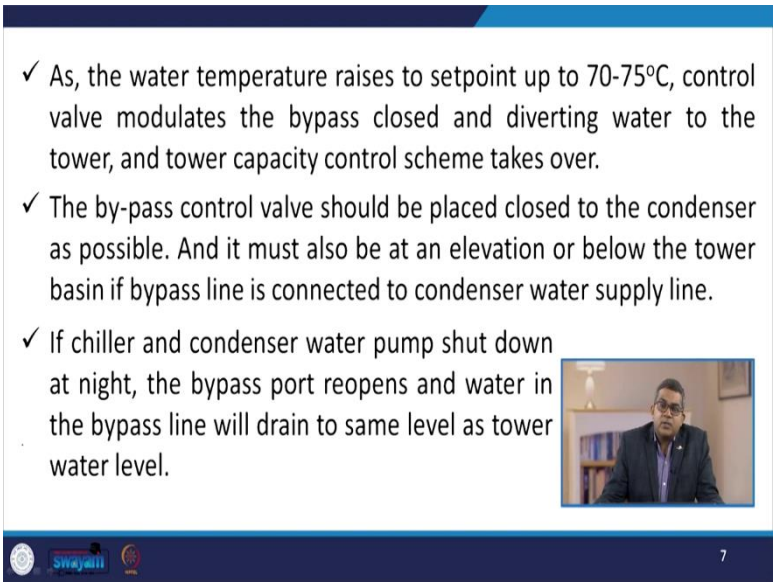

Now, as the water temperature raises, to a setpoint say up to say, 75 to 70 to 75 degree Celsius, control valve modulates, the bypass closed and diverting water to the tower and tower capacity control scheme takes over. The by-pass control valve should be placed close to the condenser as possible and it must also be at an elevation or below the tower basin if bypass line is connected to condenser water supply line.

Now sometimes, if chiller and condenser water pump shut down at night, the bypass port reopens and water in the bypass line will drain to same level as tower water level.

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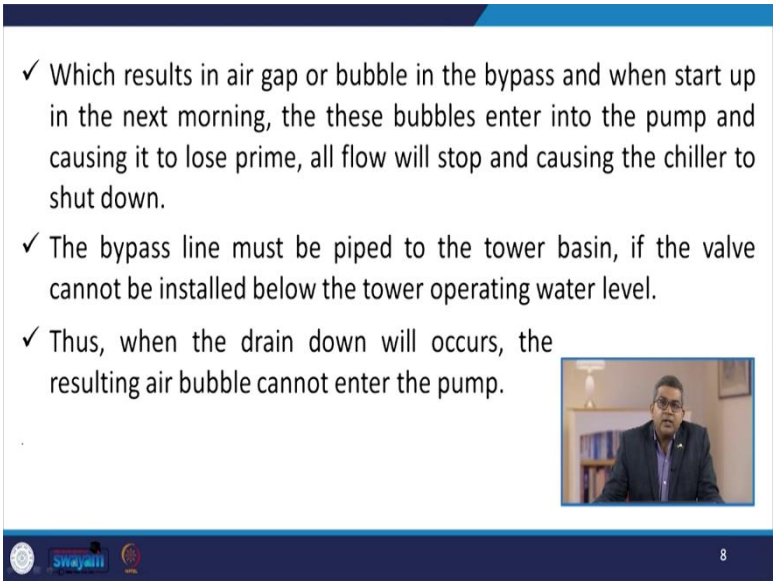

Now sometimes this results in air gap or bubble in the bypass and when start up in the next morning, these bubbles they may enter into the pump and causing to it to lose. Prime because these air bubbles create a problem and it may create a problem that the pump may lose its prime so, therefore, sometimes it may require the priming. Now all flow will stop and causing the chiller to shut down.

So, all these things are interlinked all together. So, the bypass line must be piped to the tower basin. Now, if valve cannot be installed below the tower operating water level, therefore, when the drain down will occur, the resulting air bubble cannot enter into the pump. So, the proper bypass valve installation it should be located or it should locate the valve close to the condenser.

The valve and all piping should be below the tower water operating level. The wall bypass should be piped directly to the condenser water supply. Now here you see that this figure shows the bypass valve installation that is a chiller piping.

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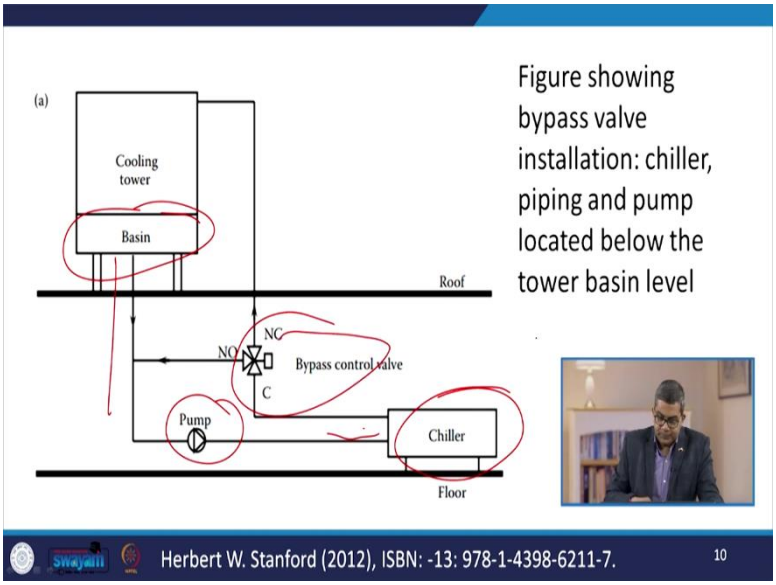

This is a chiller piping and pump located below the tower basin. Now here you see that this is the tower basin below the tower basin level and these are the bypass control valve.

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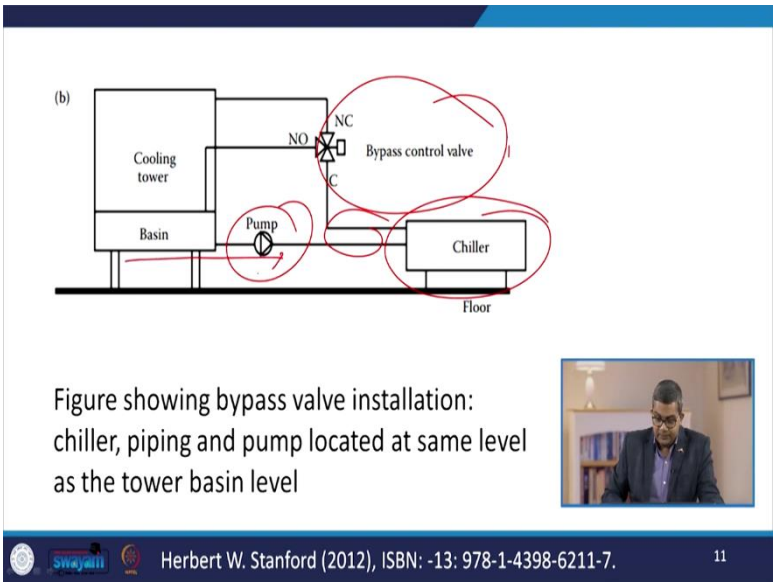

Similarly, this particular figure shows that the bypass valve installation, the chiller and chiller piping, this is the chiller piping and the pump. They are located at the same level of the tower basin.

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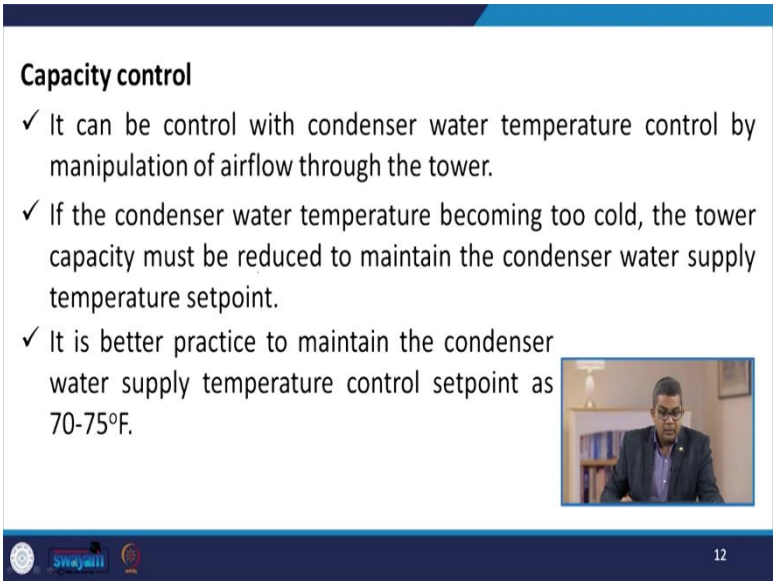

Now let us talk about the capacity control. Now the capacity can be controlled with condenser water temperature controlled by manipulation of air flow through the tower. Now, if the condenser water temperature becoming too cold, the tower capacity must be reduced to maintain the condenser water supply temperature set point. Now it is a better practice to maintain the condenser water supply temperature control set point as 70-to-75-degree Fahrenheit.

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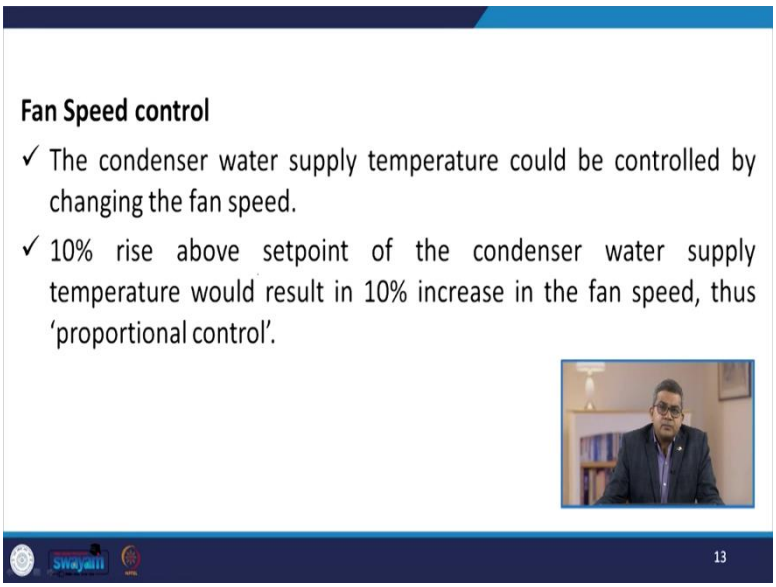

Now fan speed control. The condenser water supply temperature could be controlled by changing the fan speed. Now 10% rise above set point of the condenser water supply temperature would result in 10% increase in the fan, speed and therefore the proportional control.

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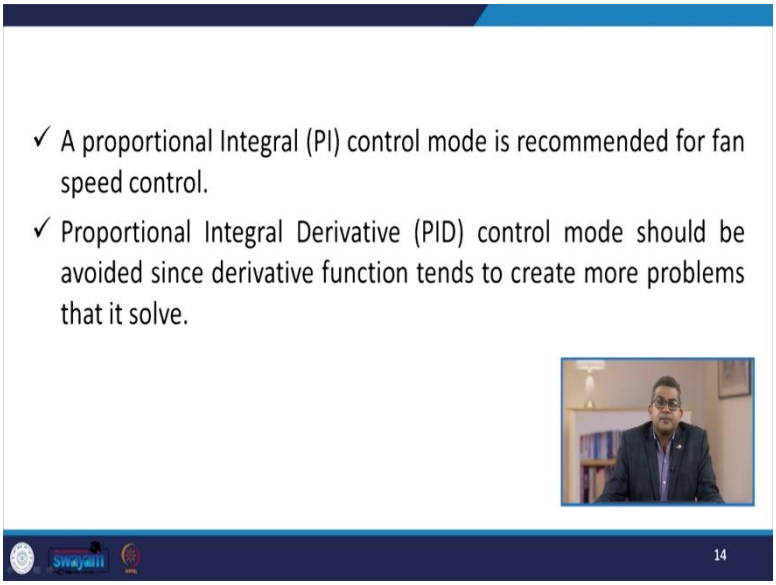

A proportional integral or sometimes referred, as PI control mode is recommended for fan speed control. The proportional integral derivative sometimes referred as PID. The PID control mode should be avoided, since derivative function tends to create more problem that it solves.

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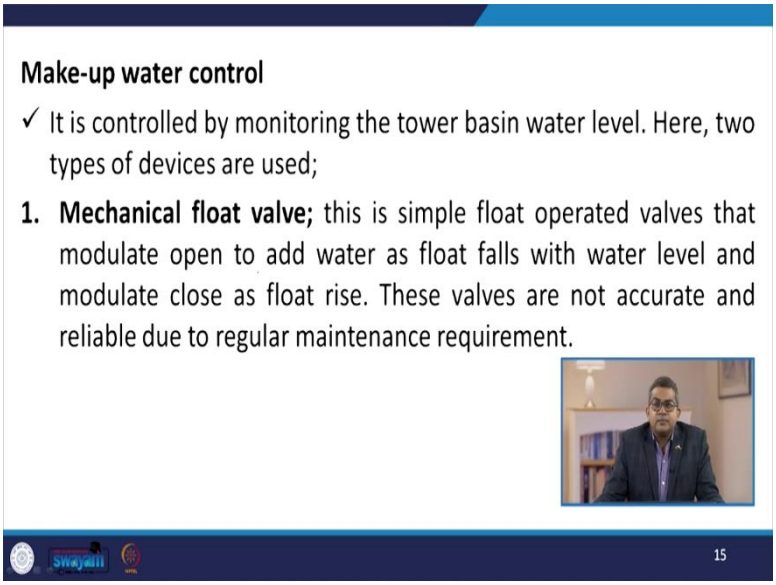

The Make-up water control: it is controlled by monitoring the tower base in water level. There are two types of devices being used. One is the mechanical float wall. Now this is the simple float operated valve that modulate open to add water as float falls with the water level and modulate close as float rise. Now these walls are not accurate and reliable due to the regular maintenance requirement.

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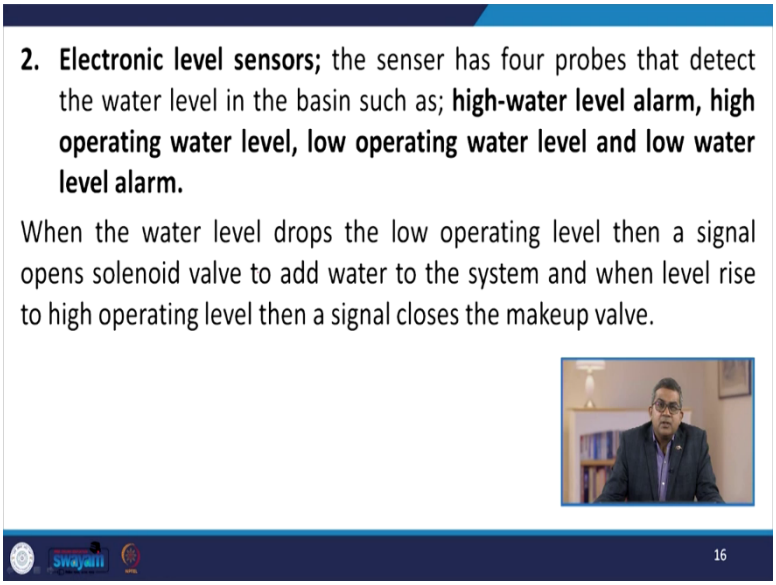

Now, second, is the electronic level sensors. The sensor has four probes that detect the water level in the basin, such as high-water level alarm, high operating water level, low operating water level and low water level alarm. So, when the water level drops the load operating level then a signal opens solenoid valve to add water to the system and when level rise is to high operating level then a signal closes to make up valve.

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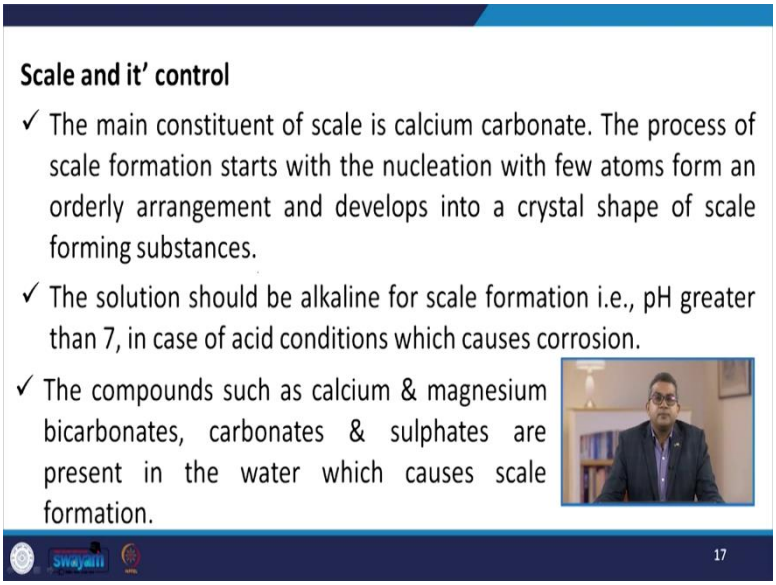

Now, scale and its control: scale is again very crucial aspect in cooling tower operation and that the main constituent of scale is calcium carbonate. The process of scale formation starts with the nucleation, with the few atoms form an orderly arrangement and develops into a crystal shape of a scale forming substances. The solution should be alkaline for scale formation that is a pH greater than 7 in case of acid conditions which causes corrosion.

The compound, such as calcium and magnesium, bicarbonates carbonate and sulfates. They are present in the water which causes scale formation.

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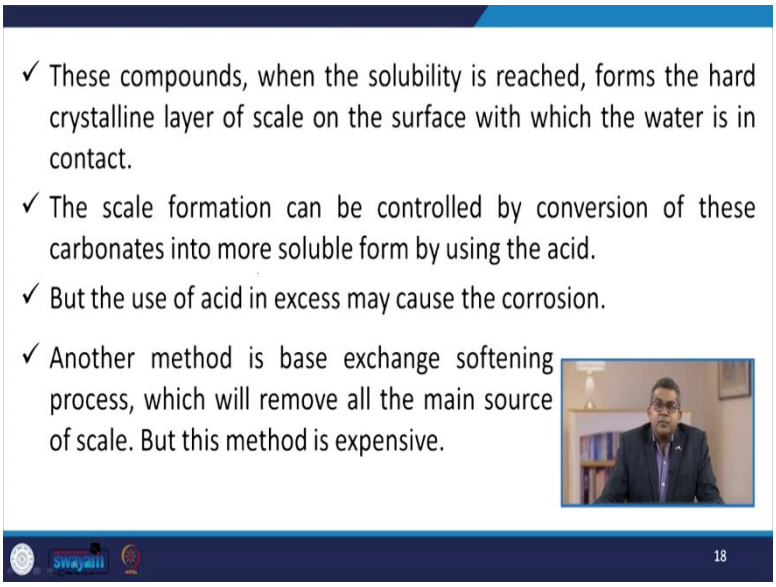

Now these compounds, when the solubility is reached from the hard crystalline layer of scale on the surface with which the water is in contact. Now the scale formation can be controlled by conversion of these bicarbonates or carbonates into more soluble form by using the acid. But the use of acid in excess may cause the corrosion and that is again a very difficult aspect.

Now another method is base exchange softening process which will remove all the main source of scale but this particular method is quite expensive. So, you need to look the cost factor of two.

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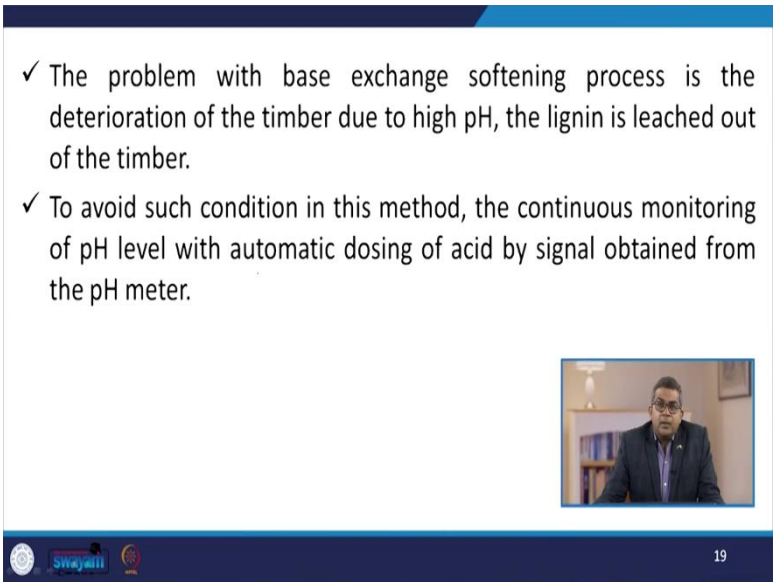

The problem with the base exchange softening process is the deterioration of the timber due to high pH the lignin is leached out of the timber now to avoid such condition in this particular method. The continuous monitoring of pH level, with automatic dose in dosing of the acid, by signal obtained from the pH meter. Now let us talk about the corrosion and its control. Now it is an electrolytic phenomenon in the same way as electrolytic cells, with an anode, a cathode and electrolytic solution.

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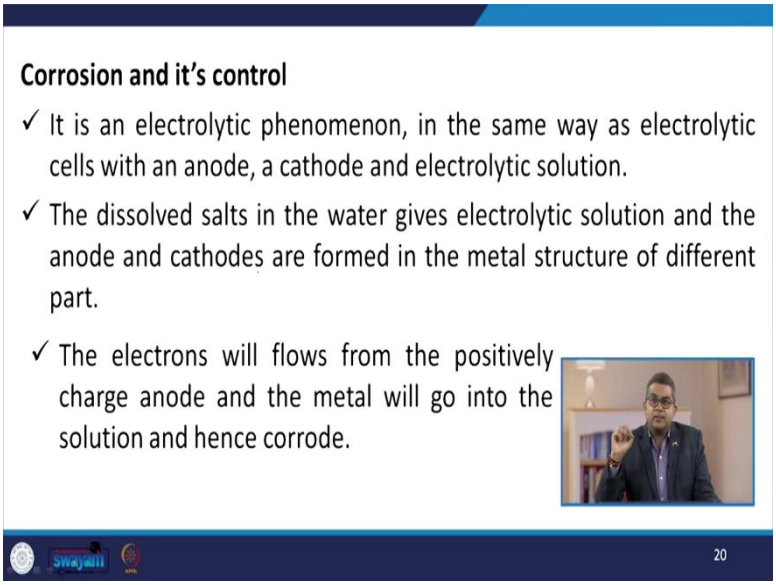

The dissolved salts in the water gives electrolytic solution and the anode and cathodes are formed in the metal structure of different part. The electron will flow the flow from the positively charged anode and the metal will go into the solution and therefore it may corrode.

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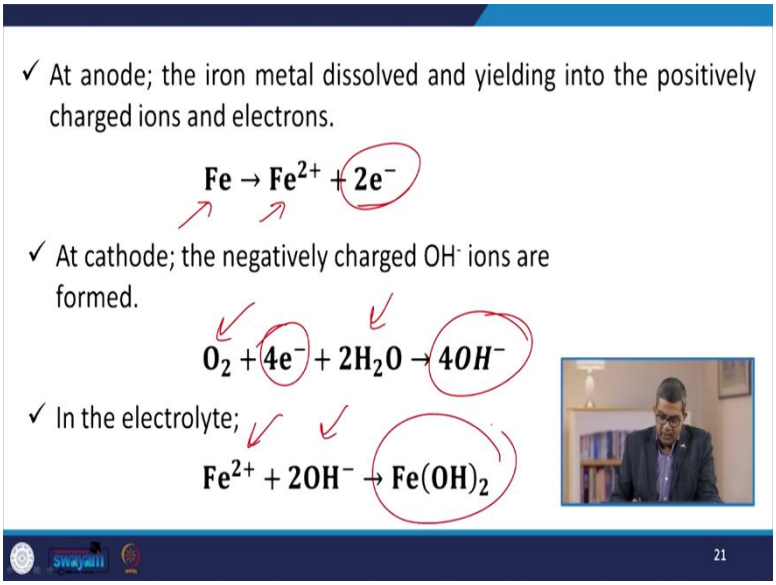

Now at anode the iron metal dissolves and yield into the positively charged ion and electrons like Fe, Fe 2 plus + 2 electrons. Now, at cathode that negatively charged OH minus ions are formed like O 2 + 4 electrons + twice H_2O and that is 4 OH minus. Now in the electrolyte Fe 2 plus + 2 OH minus they form Fe(OH) 2. Hold twice the corrosion can be avoided by blocking the electrolytic action by surface treatment of steel used in construction and by the close control of manufacturing process.

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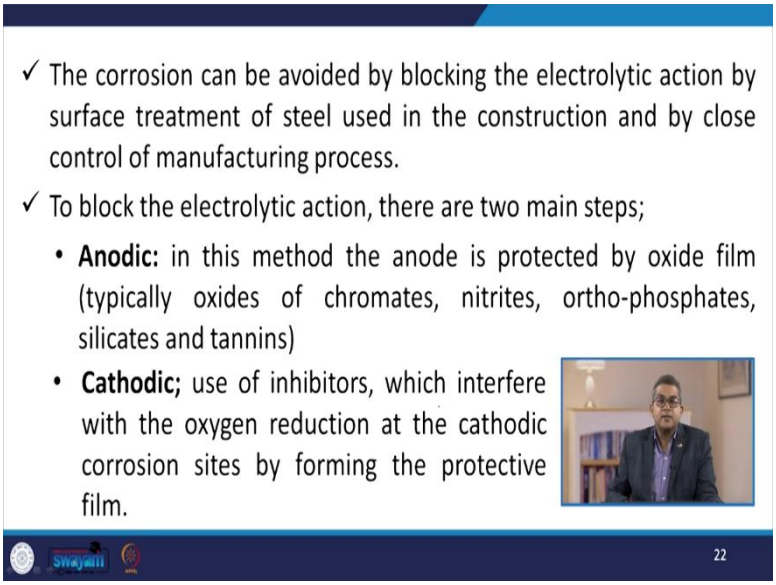

The corrosion can be avoided by blocking the electrolytic action by surface treatment of steel used in the construction and by close control of manufacturing process. Now to block the electrolytic action, there are two main steps. One is anodic, in this method. The anode is protected by oxide film and typically oxides of chromates, nitrates, orthophosphates, silicates and tannins.

The cathodic, use of inhibitors which interfere with the oxygen reduction at the cathodic corrosion sites by formation of protective film. So, a protective film is being formed so that this corrosion cannot take place.

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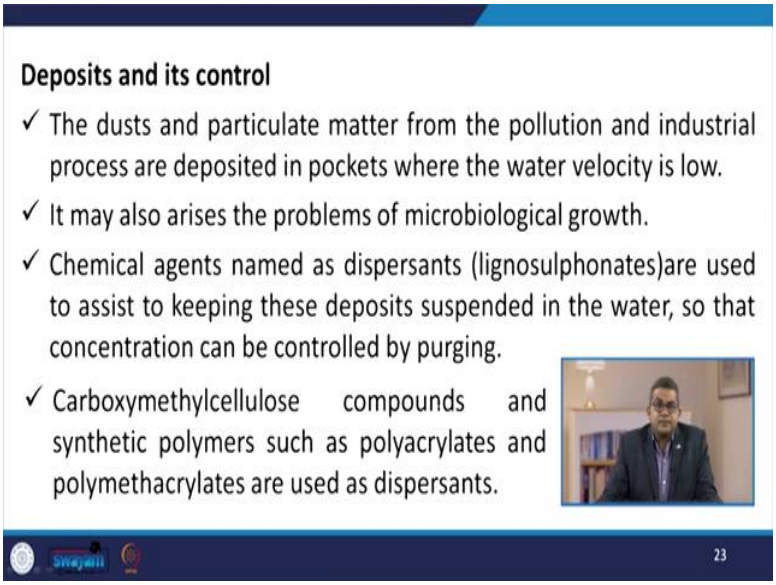

Now, let us talk about the deposits and its control. Sometimes dust and debris they may create a problem to the effective operation of cooling tower. So, the dust and particulate matter from the pollution and the industrial processes they are get deposited in pockets where the water velocity is very low. It may also arise is the problem of micro, microbiological growth and again it can create and for the growth of this microorganism may hamper the efficiency of cooling tower.

The chemical agent named as dispersant and sometimes it is referred as lignosulfonates. They are used to assist to keep these deposits suspended in the water so that the concentration can be controlled by purging now, carboxy methyl cellulose compounds and synthetic polymers such as polyacrylates and polymethyl methacrylates. They are used as dispersants.

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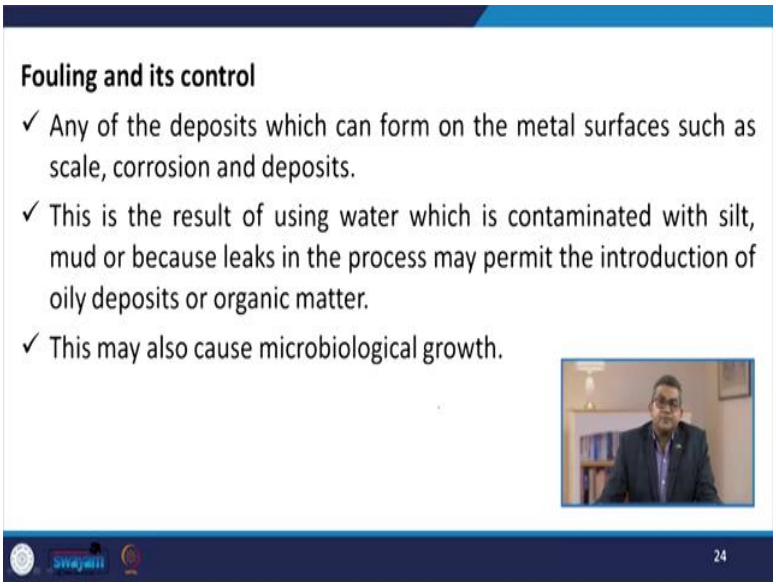

Fouling and its control: Any of the deposits which can form on the metal surfaces such as scale, corrosion and deposit. Now this is the result of using water which is contaminated with silt mud or because leaks in the process may permit. The introduction of oily deposits or organic matter, this may also cause microbiological growth.

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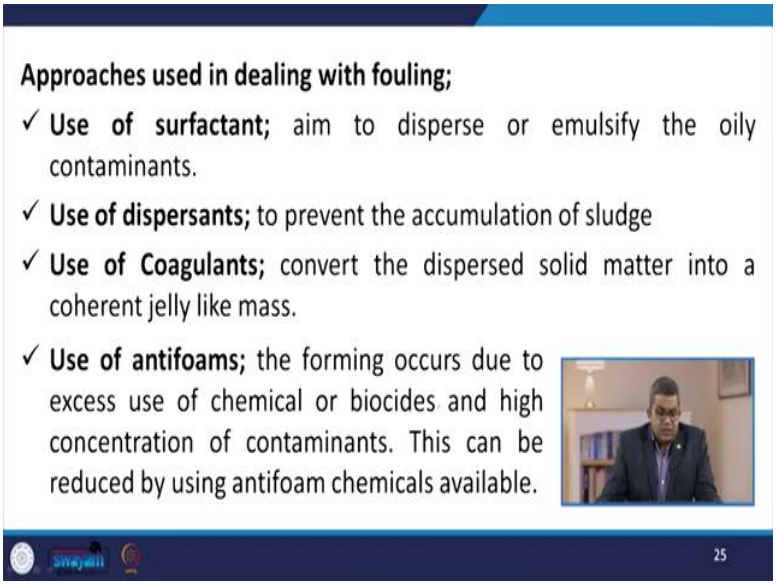

Now there are various approaches being used in dealing with the fouling. One is that one may use the surfactant. The aim of surfactant is to disperse or emulsify the oily contaminants. Another approach is the use of dispersant. This is to prevent the accumulation of different type of sludge then use of coagulants. This may convert the dispersed solid matter into a coherent jelly like mass.

Then use of antifoams the forming occurs due to excess use of chemicals or biocides and high concentration of contaminants. Now this can be reduced by using antifoam chemicals those are available very much.

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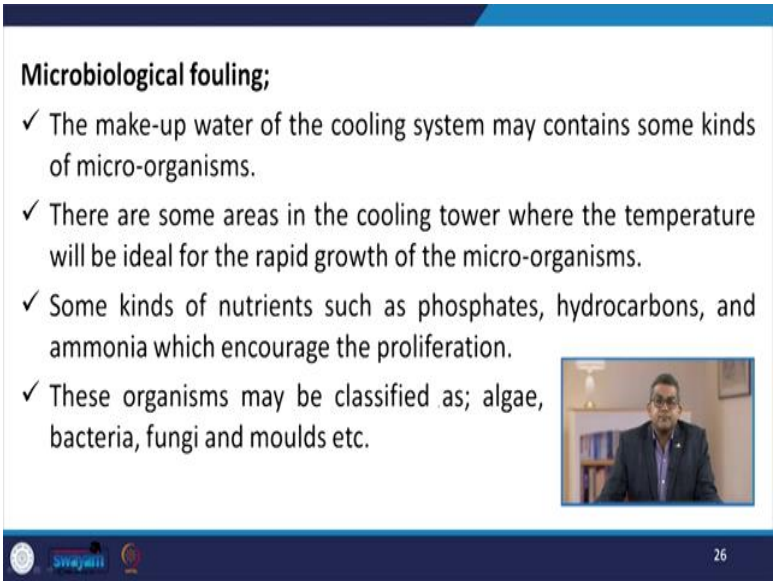

Let us talk about the microbiological fouling. The makeup water of the cooling system may contain some kind of micro-organism. Now there are some areas in the cooling tower where the temperature will be ideal for the rapid growth of micro-organism. Now some kind of nutrients, such as phosphates, hydrocarbons and ammonia which encourage the proliferation. Now these organisms may be classified like algae bacteria, fungi, molds, etcetera.

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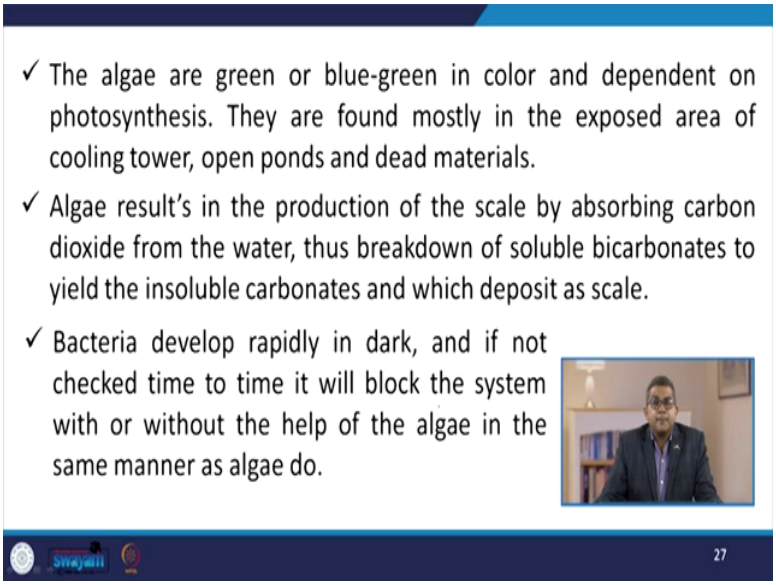

Now the algae are green or blue green in color and dependent on the photosynthesis. They are found mostly in the exposed area of cooling tower, open ponds and dead materials. Algae results in the production of the scale by absorbing carbon dioxide from the water, thus breakdown of soluble bicarbonates to yield the insoluble carbonates and which deposits as scale.

Bacteria develops rapidly in dark and if not checked time to time, it will block the system with or without the help of algae in the same manner as algae do.

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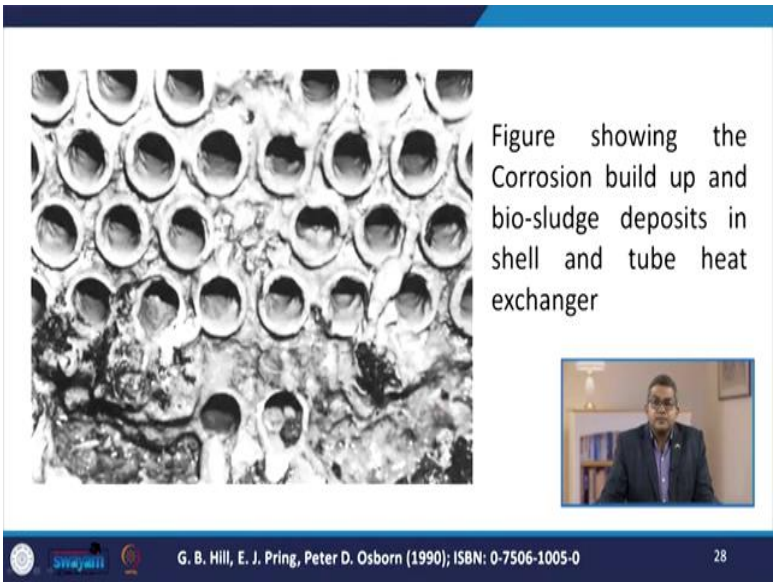

Now, here you see that the corrosion built up and bio sludge deposits in the shell and tube heat exchanger. You see that these dark now this is a very you - can say, alarming situation.

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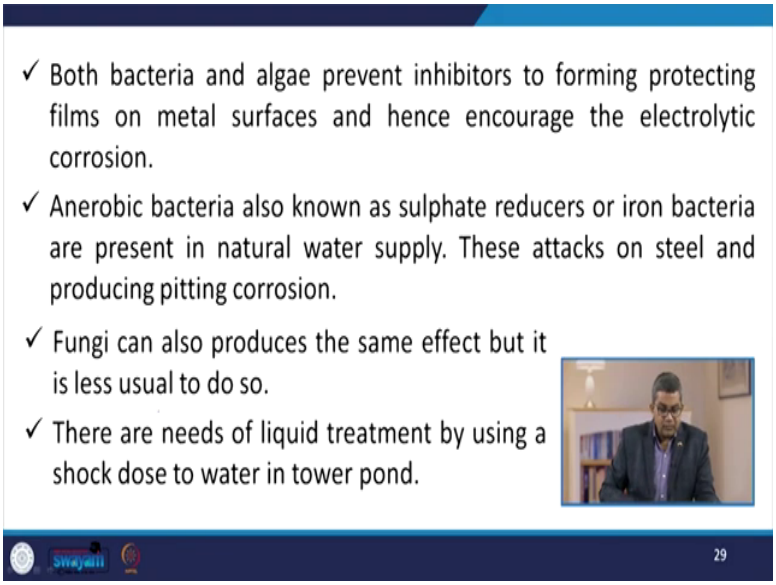

Now, the both bacteria and algae they prevent inhibitors to forming protecting film on metal surface and hence encourage the electrolytic corrosion. Anaerobic bacteria also known as sulphate reducers or iron bacteria. They are present in the natural water supply. Now these attacks on steel and producing pitting corrosion. Fungi can also produce the same effect but it is less usable to do so. There are need of liquid treatment by using a shock dose to water in tower pound.

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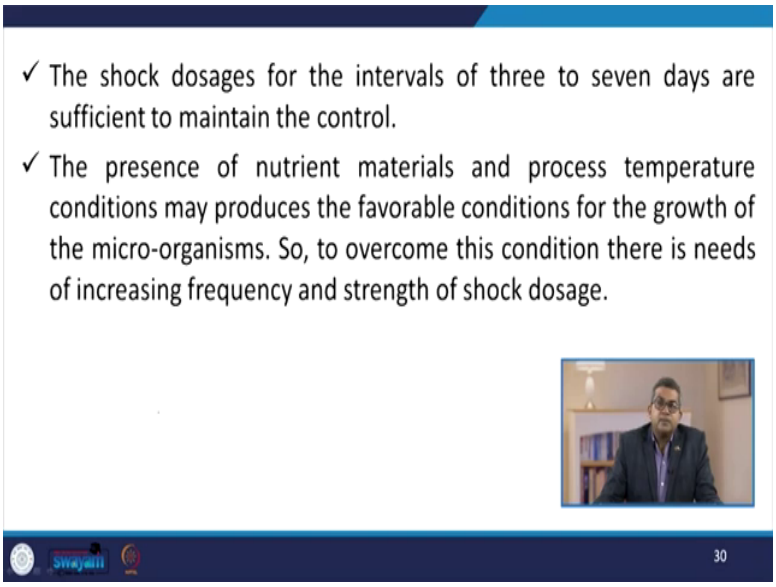

The shock doses for the interval of 3 or 7 days are sufficient to maintain the control. The presence of nutrient material and the process temperature condition. This may produce a favorable condition for the growth of microorganism. Therefore, to overcome this particular situation, there is a need of increasing the frequency and strength of shock doses.

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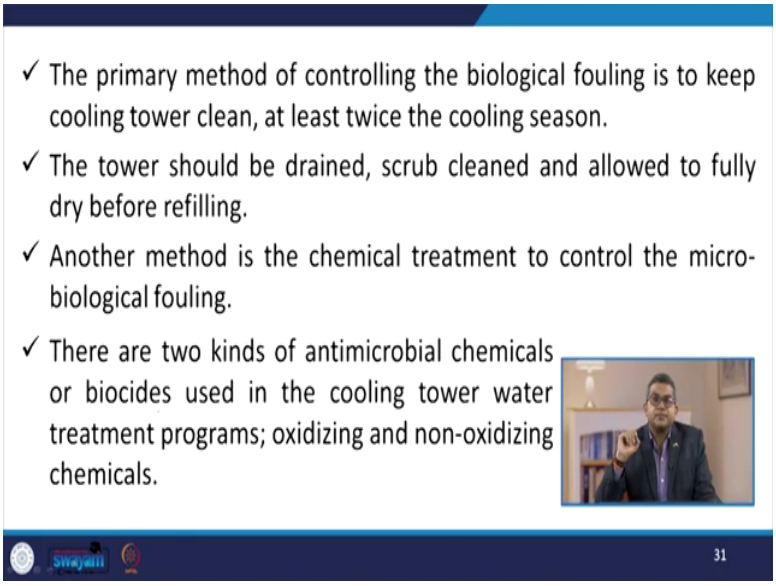

The primary method of controlling the biological fouling is to keep the cooling tower clean, at least twice the cooling season. The tower should be drained, scrubbed, clean and allowed to fully dry before refilling. Another method is the chemical treatment to control the microbiological fouling. There are two kinds of antimicrobial chemicals or biocides used in cooling tower water treatment.

One is oxidizing, another one is non oxidizing. Let us talk about the oxidizing chemicals. Now these includes the chlorine, bromine and ozone which accept the electron from the other chemical compounds.

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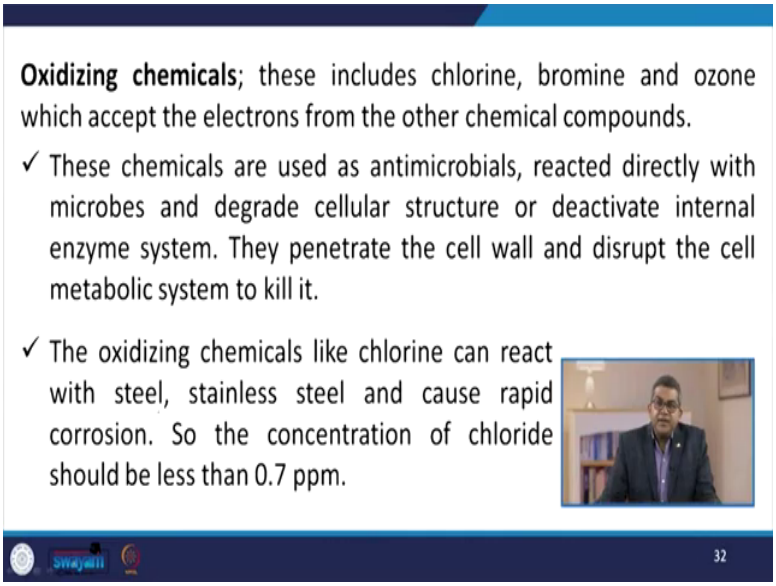

Now these chemicals are used as antimicrobial reacted directly with microbes and degrade cellular structure or deactivate internal enzyme system. They penetrate the cell wall and disrupt the cell metabolic system to kill it. The oxidizing chemicals like chlorine can react with steel, stainless steel and cause rapid corrosion. So, the concentration of chloride, it should be less than say 0.7 ppm or it should be very minimum.

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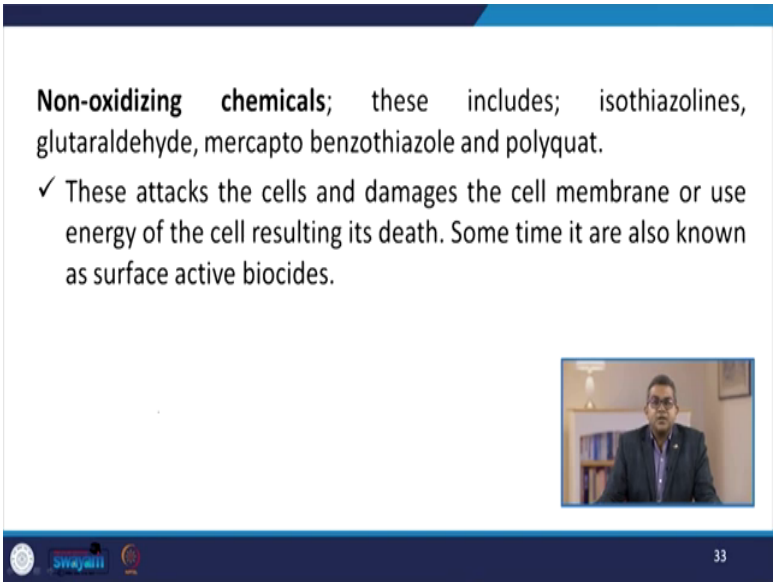

Non-Oxidizing chemical: Now, these chemicals include isothiolines glutara, aldehyde, mercapto, benzothiophjol and poliquid. Now these attacks the cells and damages the cell

membrane or use energy of the cell resulting its death. Sometimes it is also known as surface active biocides.

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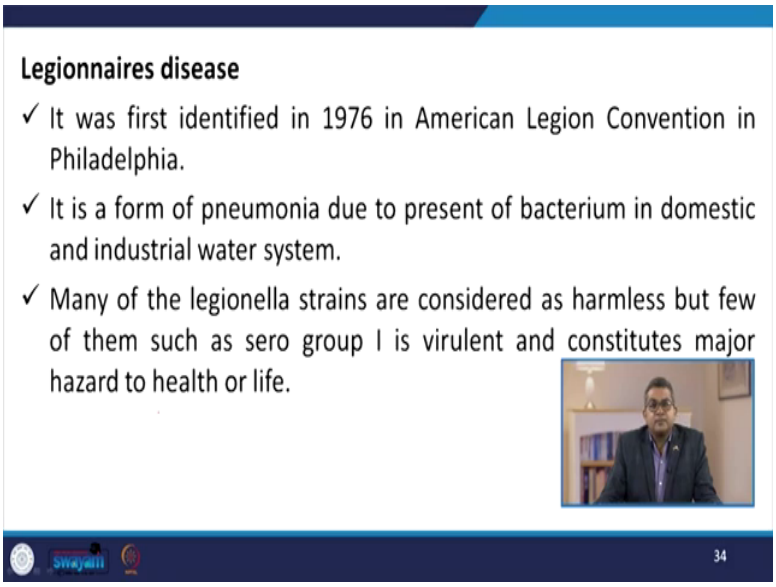

Now, let us talk about the legionnaires disease. Now it was first identified in 1976 in American Legion Convention in Philadelphia. It is a form of pneumonia due to the presence of bacterium in domestic and industrial water system. Many of these stains are considered as harmless but few of them, such as sero group, it is virulent and constitutes the major hazard to health or life.

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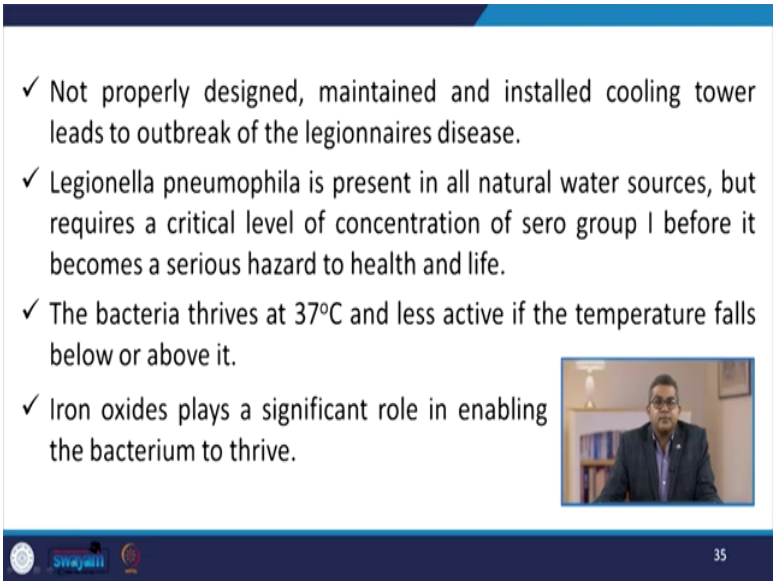

Not properly designed, maintained and installed. Cooling tower leads to outbreak of these diseases. Now this is present in all natural water sources but requires a critical level of concentration of sero group before it become a serious hazard to health and life. The bacteria

thrives at 37 degree Celsius and less active if temperature falls below or above it. Iron oxides play a significant role in enabling the bacterium to thrive.

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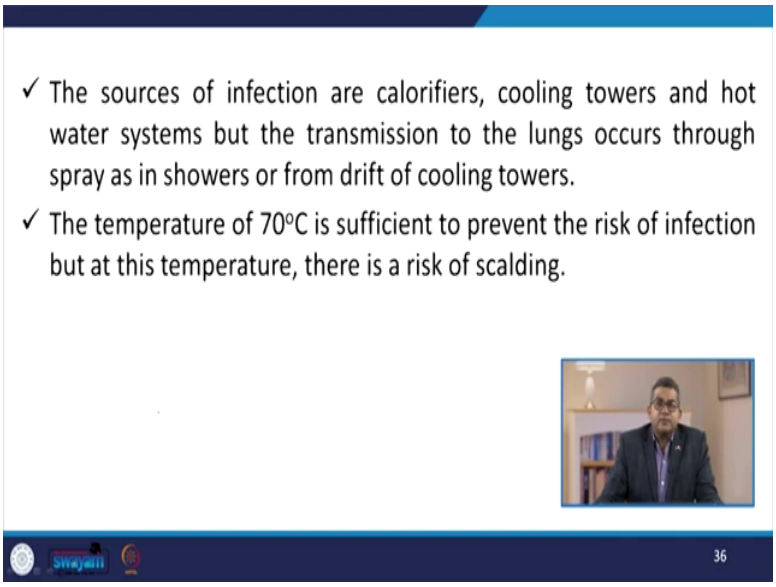

The source of infection are calorifiers, cooling towers, hot water system but the transmission of to the lungs occur through spray, as in the shower are in the form of drift of cooling tower. The temperature of 70 degree Celsius is sufficient to prevent the risk of infection but at this temperature there is a risk of scalding. Now reduction the risk of infection. Now how we can reduce the risk of infection and that is the concept of this particular sub heading.

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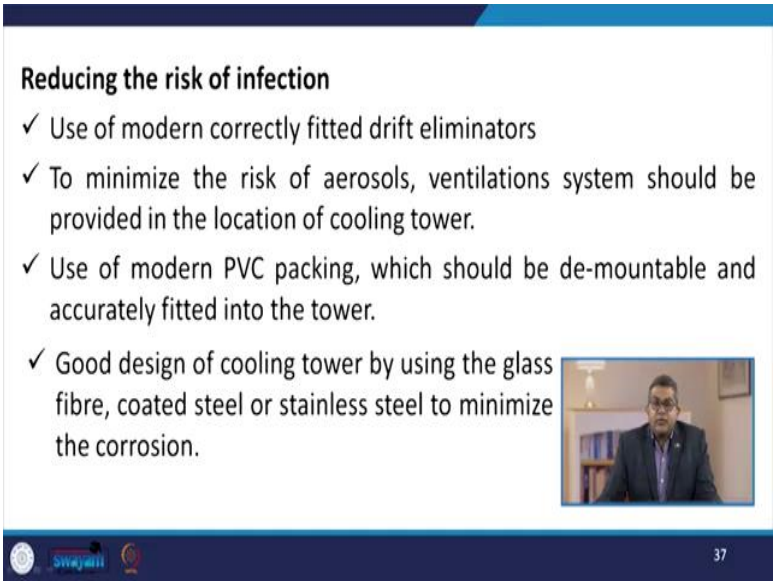

Use of modern, correctly fitted drift eliminators is the one way to minimize the risk of aerosol ventilation. System should be provided in the location of cooling tower use of modern PVC

packing which should be d mountable and accurately fitted into the tower. Good design of cooling tower by using the glass fiber coated steel or stainless steel to minimize the corrosion.

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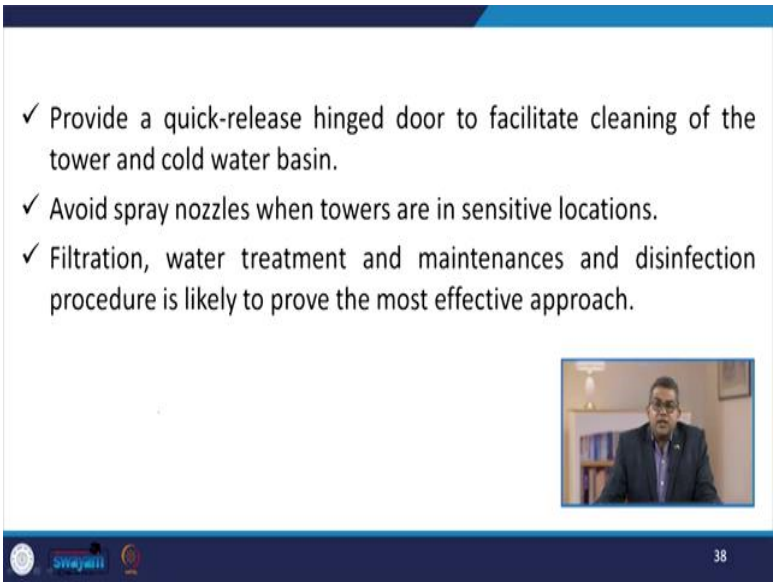

Provide a quick-release hinged door to facilitate the cleaning of tower and cold-water basin. Avoid any kind of spray nozzle when towers are in sensitive location, filtration water treatment and maintenances and disinfection process is likely to prove the most effective approach in this particular regard.

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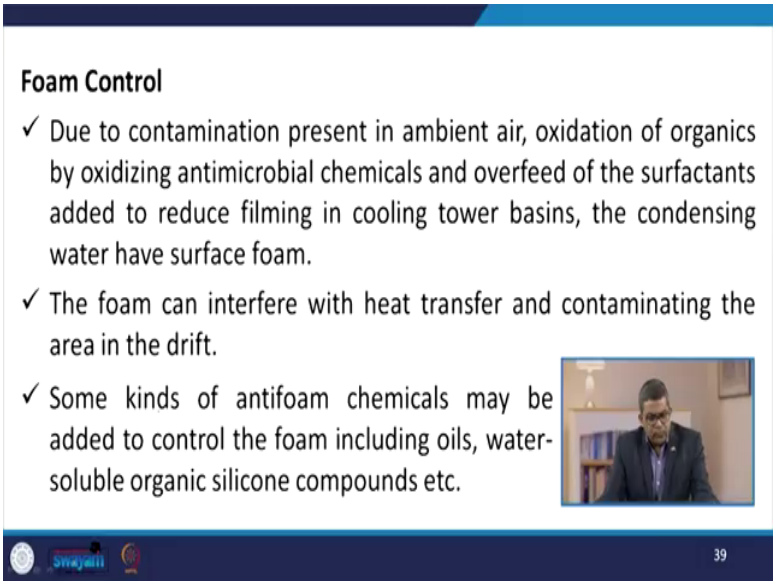

Let us talk about the foam control due to contamination present in the ambient air oxidation of organic by oxidizing and team microbial chemicals and over feed to the surfactant added to the reduced filming in cooling tower basin. The condensing water have surface foam. That depends on the surface energy of the condensing water. Now this foam can interfere with heat transfer

and contaminating the area in the drift. Some kind of antifoam chemicals may be added to control the foam this, including the oil, water-soluble organics silicon compounds, etcetera.

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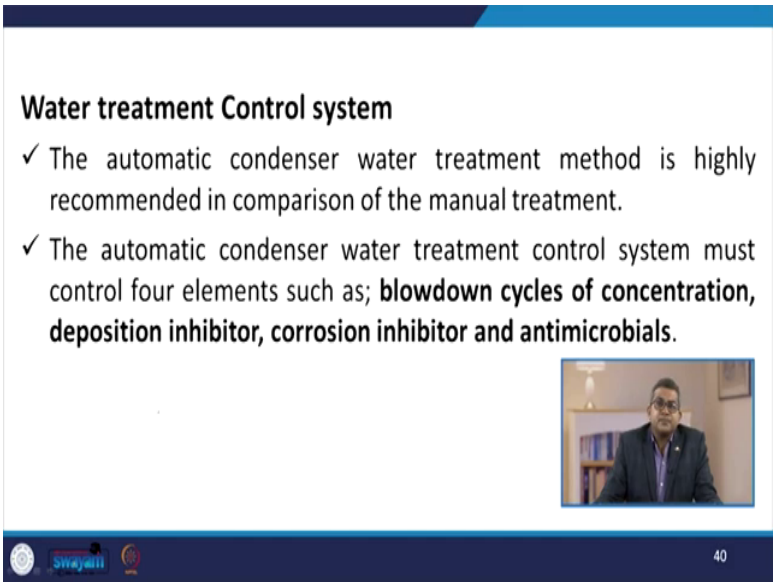

Now water treatment is again very crucial aspect in the cooling tower. So, let us talk about the water treatment control system. The automatic condenser water treatment method is highly recommended in comparison to the manual treatment. The automatic condenser water treatment control system must control four elements like blow down cycle of concentration, deposition inhibitors, corrosion inhibitors and antimicrobials.

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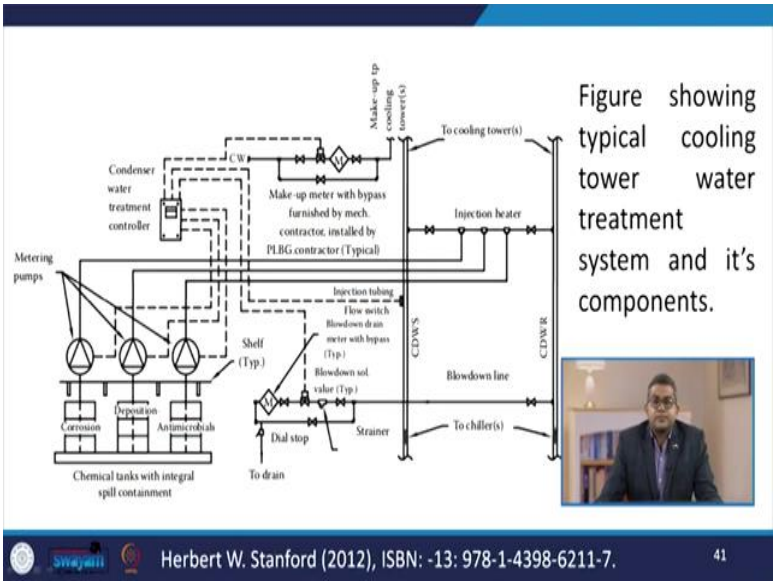

Now here you see the typical cooling tower water treatment system and its components. Here you see that this is the cooling tower lines, injection heaters, etcetera and there are various components are enlisted for the treatment of cooling water.

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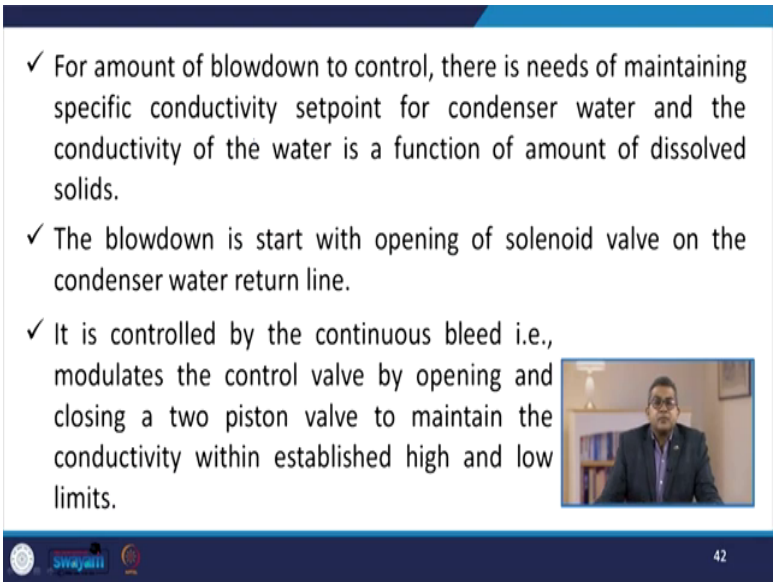

Now for amount of blow down to control, there is a need of maintaining specific conductivity set point for condenser water and the conductivity of the water is a function of amount of dissolved solids. The blow down is start with opening of a solenoid valve on the condenser water return line. Now it is controlled by the continuous bleed that is modulates the control wall by opening and closing a two-piston valve to maintain the conductivity within established, high and low limits.

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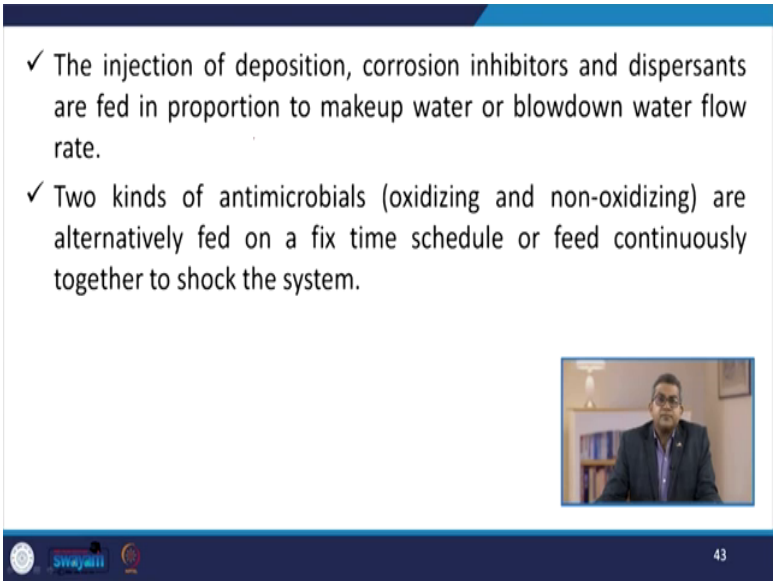

The injection of deposition, corrosion, inhibitors and dispersants. They are fed in proportion to make up water or blow down water flow rate. Two kinds of antimicrobial like oxidizing and non-oxidizing, they are, alternatively, fed on a fixed time schedule or feed continuously together to shock the system.

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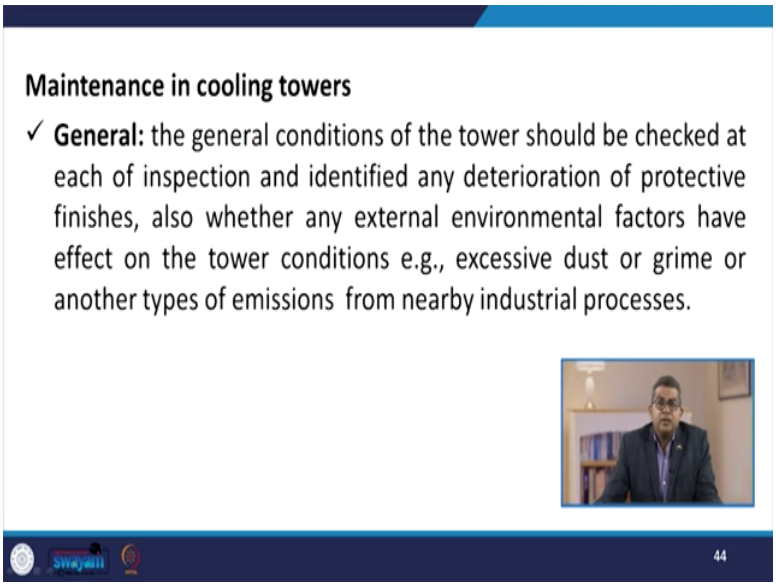

Let us talk about the maintenance in the cooling tower. One is the general maintenance. The general conditions of the tower should be checked at each of the inspection and identified any kind of deterioration of protective finishes, also, whether any external environmental factors have effect on the tower condition, sometimes like excessive dust or grimes or other another type of emissions from nearby industrial process.

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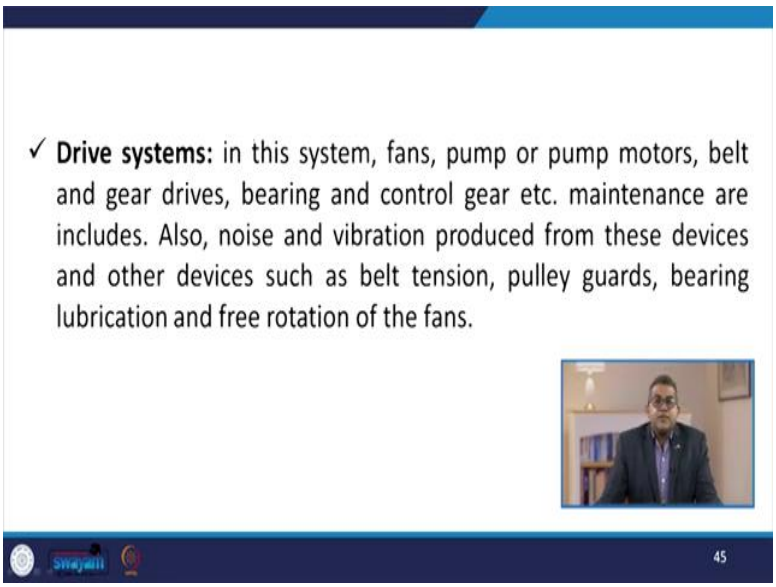

Drive systems, in this system, fan, pumps or pump motors, belt, gear drives bearing and control gears, etcetera. Maintenance are included also noise and vibration produced from these devices and other devices such as belt tension, pulley guards, bearing lubrication and free rotation of the fan.

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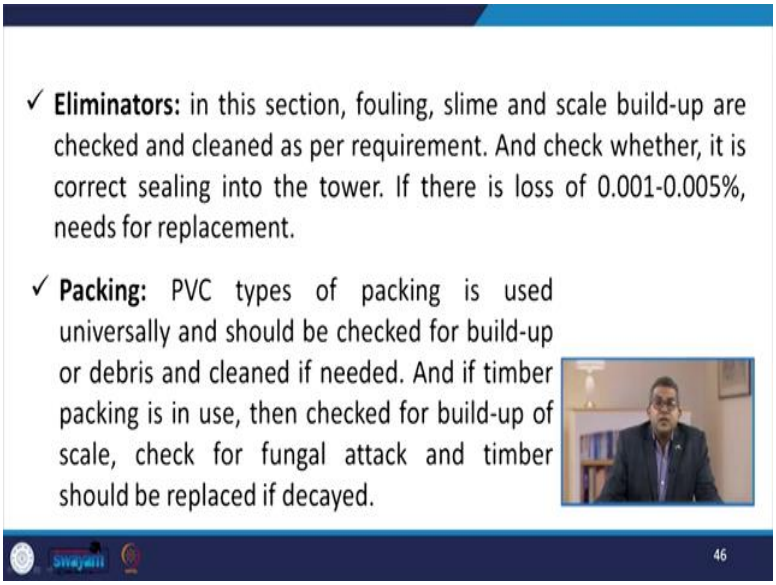

Eliminators, in this section, fouling slime and scale buildup are checked and cleaned as per the requirement and the check whether it is correct ceiling into the tower. If there is a loss of 0.001 to 0.005%need, there is a need for replacement packing. We discussed about packing and the packing plays a very vital role in any kind of cooling tower operation.

So, if you are using the PVC type then the PVC types of packing is more commonly used in the cooling tower or you can say it is being used universally and it should be checked for built up of any kind of debris and cleaned if needed. And if we are using the timber packing then they also need to be checked for build-up of scale check for any kind of fungal attack or fungal formation and these timber should be replaced if decayed.

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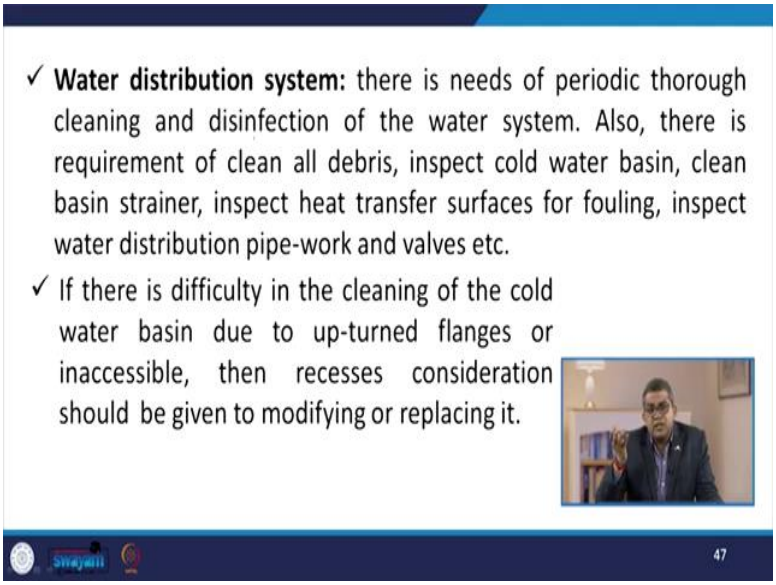

Then water distribution system. Now there is a need of periodic thorough cleaning and disinfection of the water system. Also, there is a requirement of clean all the debris, inspect cold water basin, clean basin strainer, inspect heat transfer, surfaces for fouling inspect water distribution pipe-work and valves. If there is a difficulty in the cleaning of cold-water basin, sometimes may be because of upturned flanges or inaccessibility then recess consideration should be given to modify or sometimes you may go for replacing it.

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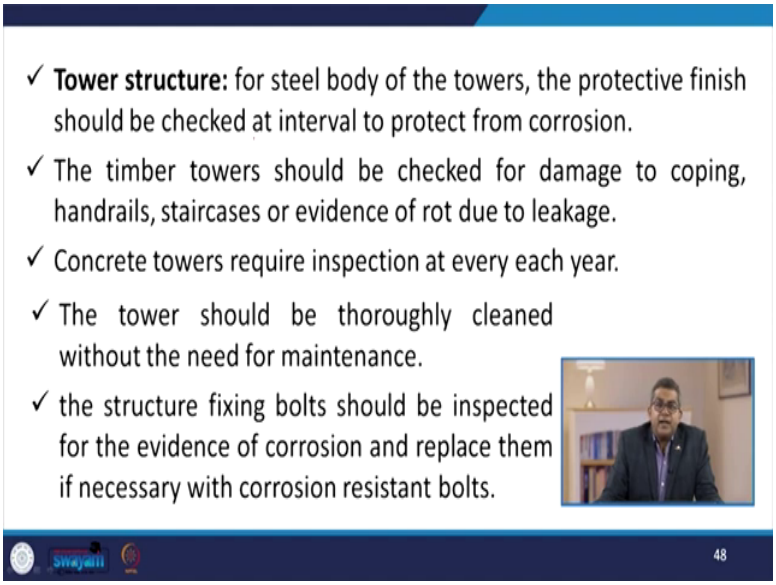

The tower structure, for a steel body of the tower, the protective finish should be checked at the regular interval to protect from corrosion. The timber tower should be checked or damaged of coping handrails, staircase or evidence of rot due to leakage. Concrete tower require inspection at every year. The tower should be thoroughly cleaned without the need of maintenance.

The structure fixing bolts should be inspected for the evidence of corrosion and replace them if necessary, with corrosion resistant bolts. So, in this particular lecture we have discussed about the various control aspects of cooling tower.

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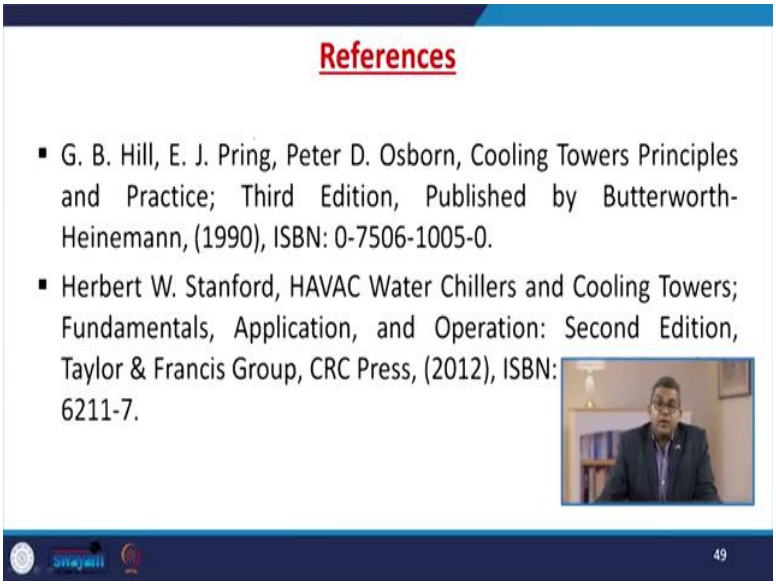

We discussed a lot because these control, these cooling tower requires a lot of things like cold water basin, different type of pump, walls, etcetera and they need to be checked frequently. So, we have discussed all the aspects which are essential for smooth functioning of cooling tower. For your convenience, we have listed couple of references you may go through if you require further reading. Thank you very much.