NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING
"Year of the consolidation of the Mar de Grau"

THERMAL DRIVING FORCE

MONOGRAPHIC WORK

"Design of a Water Treatment Station of a Natural Gas Fired Combined Cycle Thermal Power Plant"

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OVERVIEW

This document presents the "TECHNICAL AND ENGINEERING FOUNDATIONS of Water used in a Natural Gas-Fired Combined Cycle Thermal Power Plant. This document is part of the Course of THERMAL DRIVING FORCE (MN 153).

SUMMARY

This document presents the information regarding the water used in the Natural Gas-Fired Combined Cycle Plants. This document has been prepared by the working group and for academic use of the students.

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1. INTRODUCTION

Water treatment plants have the function of meeting local treatment needs through specific sanitation methods based on physical, chemical and biological principles (organic matter is mineralized and microorganisms are eliminated by competition or predation).

The improvement in the treatment processes and the efficiency of these is necessary and obligatory of these plants is the result of the overflow increase of the population and the agricultural and industrial activities, the latter requiring the implementation of wastewater treatment plants so that these can be returned to the environment with the least possible impact to the ecosystem in which it operates.

The level of water treatment required from the place of origin to the place of consumption depends on its use, from potable water for direct human consumption, to the feed water for thermal steam or combined cycle plants that require water with a higher degree of purity for a correct functioning of the equipment.

Even some power plants use a water purifier with certain operating measures such as the use of anaerobic digestion. In this way, the use of the resulting gases can satisfy local energy needs with the use of a cogenerator (use of the gases for energy production), so that the design of a plant must be evaluated and calculated according to variable parameters (Population, energy, supply, pipeline, industry, activities, location, among others).

In the following work, we describe the stages that are part of the water treatment process for use in thermal power plants.

2. OBJECTIVES AND SCOPE

2.1. Objectives

- Description of the mechanisms available for the treatment of water for consumption in Natural Gas-Fired Combined Cycle Thermal Power Plant.

- Calculation of the water quality needed to be used.

2.2. Scope

- Determination of the purge rate of the cauldron according to the rate of steam generation and water supply.

- Determination of maximum permissible concentration of mineral salts in water.

- Quality of drinking water outside the thermal power station and quality of the feed water inside the thermal power plant.

- pH of water.

- Water treatment program.

- Water Features for the condensing unit.

- Outline of equipment involved in the treatment of water within the thermal power plant.

CHAPTER III

Water supply in CCTs

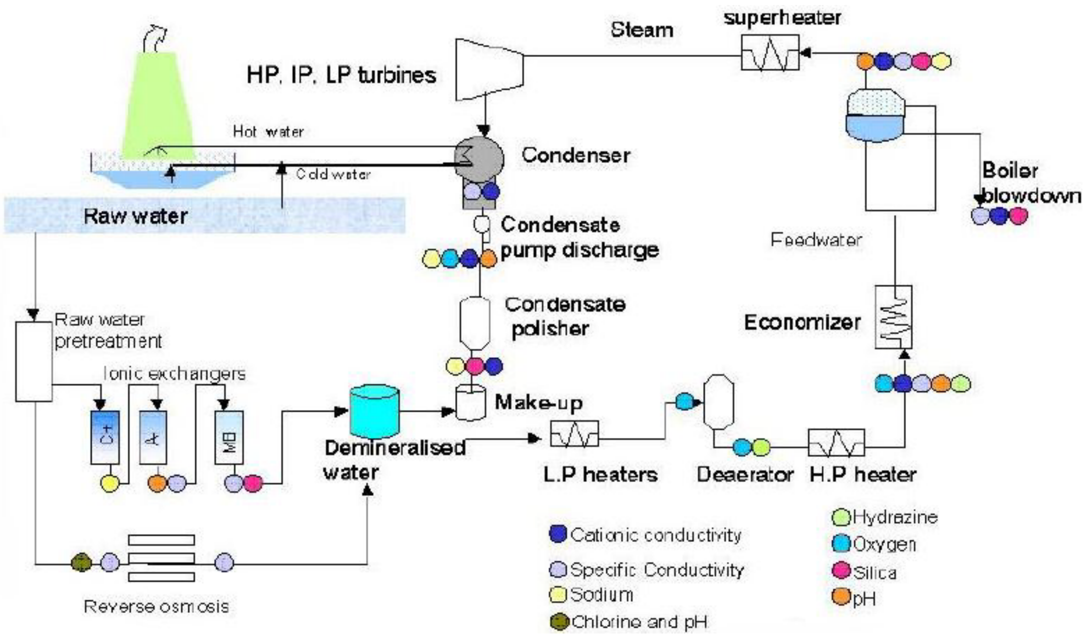
CAPITULO III

3. Water supply in CCTs

Water quality is of vital importance within a thermal power station to maintain efficiency in operation and thus reduce downtime due to corrosion and preventive and corrective maintenance.

The main phases and stages in which the water quality is measured will be seen in this part.

First, a schematic with the water supply equipment inside the thermal power station should be presented, this is shown below:



Before passing to water softening equipment, water taken from a natural source is necessary to undergo a pretreatment, this is a treatment of water purification, making it suitable for human consumption but not for cauldrons or other equipment of the thermal power station.

For water softening, there are mainly two methods, reverse osmosis or ion exchange, being the most efficient of these methods reverse osmosis, which allows to obtain higher levels of purity, both methods will be explained later.

After the treatment, the water obtained has, according to the scheme two paths:

- Towards the cauldron, to propel the steam turbines.
- Move towards the condenser unit.

Water treatment plant:

The purity of the water, is of vital importance to maintain the quality of the steam and to diminish the purge of the boiler.

The treatment plant must fulfill the following functions:

For the cooling system:

- Macromolecular purification.
- Microbiological purification of water.
- Circuit purge treatment.

For the steam line:

- Micromolecular and ionic water purification (demineralization).
- Elimination of dissolved oxygen and carbon dioxide in the water.
- Condensate treatment.
- The boiler bleed water must be recovered.
- Control of ionic concentration and lower heat loss.

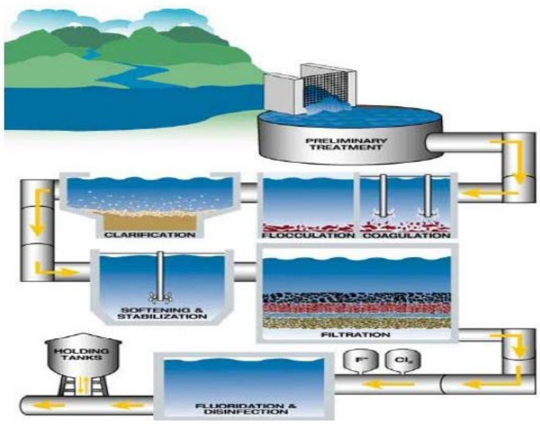
Solve the problem of treatment of the water used in the smoke and dust treatment lines, in the case of fossil fuel plants.

3.1. Drinking water

The drinking water is in an intermediate state of the treatment necessary for its use in the thermal plant.

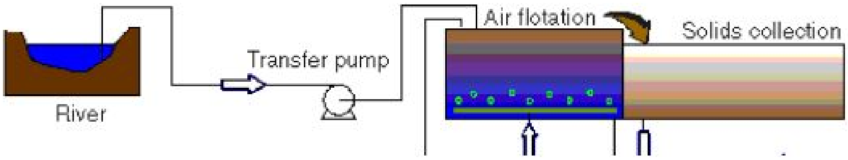
The water purification process can be carried out with one or more of the following unit processes, depending on the origin and quality of the water:

- Capture.
- Roughing.
- Aeration - preoxidation
- Coagulation - flocculation
- Decanting - filtration.
- Disinfection.
- Softening.
- These steps must ensure that the water obtained meets the standards required by national regulations for human consumption.
- The processes mentioned above are summarized in the following diagram:



The processes are shown below:

a) Uptake: From its natural source, to the initial stage of treatment.

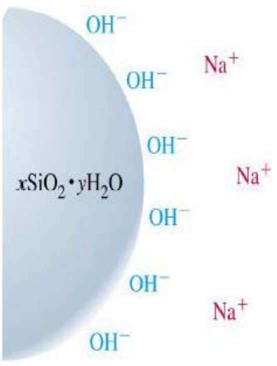


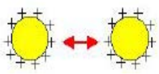
b) Roughing: Consists of the removal of solids by grids, filters and screens.

c) Aeration - Preoxidation: The aeration process allows the elimination of:

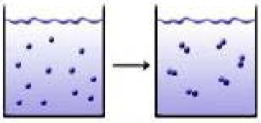
- Volatile organic compounds.
- Dissolved gases such as Radon, hydrogen sulphide, carbon dioxide, ammonia, etc.
- Oxidation of inorganic species such as ferrous or ferric.
- Contributes to the elimination of moderate amounts of suspended solids by decantation.
- Increase in dissolved oxygen.

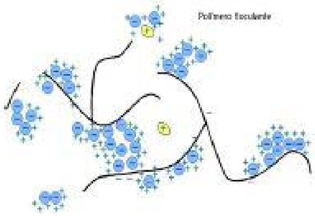
d) Coagulation: Particles in the waters of natural sources such as rivers or lakes are usually in the form of colloids that do not settle, they are responsible for turbidity and color. Most of these particles are stabilized by having surface electrostatic charges that prevent their agglomeration. To induce the precipitation of these particles, the addition of trivalent salts (aluminum or ferric) is necessary.



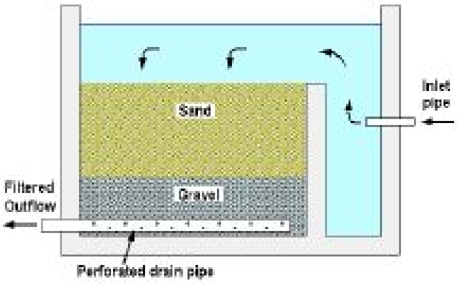


e) Flocculation: A flocculant is a chemical that favors the clustering of destabilized (coagulated) colloidal particles into larger particles (flocs).





f) Filtration: Filtration removes suspended particles, organic compounds and other substances that produce unpleasant odors.



g) Disinfection: It is a very important stage in the water purification, for industrial uses or for wastewater treatment, consists of the elimination of pathogens of bacterial, viral origin, or other types of microorganisms that can cause serious diseases in the human being, diseases such as hepatitis, cholera, dysentery, gastroenteritis, etc.

To achieve this, a disinfectant to be used in water purification must have the following properties:

- High capacity of destruction of microorganisms.
- Innocuous, odorless and should not produce any strange taste in the water, since it must be as neutral as possible to the senses of the human being.
- ▪Length of residence in prolonged water.
- Disinfectant performance should be rapid.
- Its effectiveness must be independent of temperature, pH, concentration and other external factors.

- Must be easy to handle and dosage.
- Existing processes to achieve this can be grouped into:
- Physical methods: UV radiation, application of heat.
- Chemical methods: Chlorination, ozone.

Disinfection with chlorine:

Chlorination is one of the most common methods for the elimination of microorganisms, the chemical reaction that happens when chlorine is added to water, is as follows and results in hypochlorous acid upon rapid hydrolysis:

$$Cl_2 + H_2O \rightarrow H^+ + Cl^- + HClO$$

$$K_{20^o} = \frac{[H^+][Cl^-][HClO]}{[Cl_2]} = 3.3 * 10^{-4}$$

Hypochlorous acid is a weak acid that dissociates according to the equation:

$$HOCl \rightleftarrows H^+ + OCl^- \quad K_i = 2.7 \times 10^{-8}$$

For pH greater than 3, the chlorine concentration is negligible when quantities of the order of 1 g/l are added.

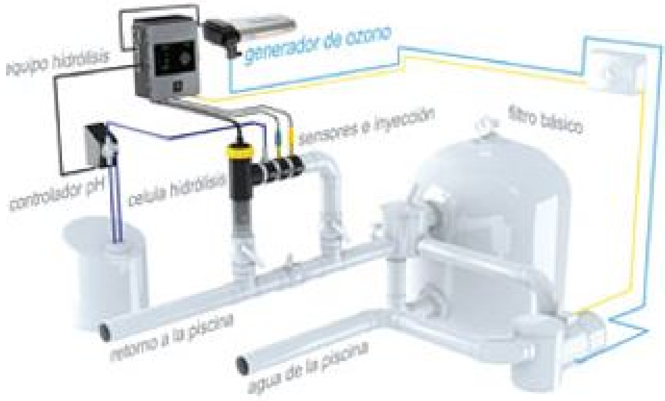
Chlorine gas is not always safe to handle, so it can be replaced with sodium hypochlorite or calcium hypochlorite.

Disinfection with ozone: The application of ozone to water as a disinfectant has the following advantages:

- It does not leave any harmful chemical residue in the water, since it dissociates in O2.
- Do not color the water.
- Does not alter pH.

▪ Eliminates odors and flavors of water.

Ozone is applied as follows:



Disinfection with UV light: This process has the advantages of not altering the properties of water, not generating toxic waste, being cheap and avoiding the growth and multiplication of microorganisms.

In this way the water is suitable for human consumption is guaranteed and for the subsequent treatment of softening that is given to the interior of the thermal power station.

3.2. Water Through Cisterns

The cisterns are a fundamental element in water supply, as it compensates for variations in water demand, filling up when there is little consumption, usually at night, and discharging water when demand increases during the day.

To ensure that water is potable, water must be handled with care while being transported after treatment at the water treatment plant, water must be stored in containers that protect it from further contamination.

Storage tanks must be fully covered and must not allow water to be contaminated with airborne microorganisms. The surface of these, nor should allow the proliferation of microbes.

From the point of view of its use, they can be:

- Public.
- Private

In contrast, from the point of view of their location, they can be:

- Underground.
- High.
- Surface.

Example of underground cistern for domestic use:

The potable water storage tanks for domestic use must comply with the following characteristics:

- Be made of a single piece of high technology polyethylene that guarantees its impermeability.
- Avoid leakage so that water is kept clean.
- The inside surface should prevent odor or taste from forming.
- The interior surface should be also antibacterial.
- The inflow and overflow tubes should be covered with a mesh to prevent the entry of mosquitoes and other animals.

3.3. Well water

Well water treatment will depend on the outcome of your water quality analysis. Some water quality problems are best handled through entry point applications such as color and odor problems or conditions such as hardness. Other pollutants can be better handled through point-of-use devices.

The following is a basic list of tests that receive water supply from wells, lakes, rivers or other untreated sources should consider:

- Microbiological testing for total coliforms and E. coli should be done annually to determine if bacteria are present in the water supply.
- To determine the impact of nearby agricultural operations or on-site septic systems, private well users should have their water analyzed each year for nitrates/nitrites.
- A hardness test can be performed to determine if a hard water condition exists.
- The pH level of your water should be checked to determine if your water is acidic. Water with a low pH (less than 7.0) is

acidic and may result in the leaching of copper and lead from residential plumbing. Copper leaching will be indicated with a bluish-green stain; an analysis for lead will need to be performed to determine if lead leaching is a problem.

- If you live in a region of the country where radon is known to be a problem, have your water analyzed for radon. If radon is detected, you may also want to have their indoor air analyzed for radon as well.

Tests with water supply

- If a rotten egg odor is emitted from your well water, you may want to consider doing a hydrogen sulfide and methane analysis.
- If there is a musty or moldy odor with your well water, an iron bacteria analysis should be conducted.
- If you are experiencing problems with red staining of plumbing fixtures, the iron level of the well water should be analyzed.
- If you are experiencing problems with brown or black staining of white laundry, have your water checked for manganese.

Problem	Likely Cause	Recommended Treatments
Hard water deposits on kettles, pots, hot water heaters, humidifiers	Excess calcium	Water Softener Reverse osmosis Low Maintenance Humidifier Tankless Water Heater

Rusty red or brown staining of fixtures or laundry and/or your water has a metallic taste	Excess iron	Water Softener Whole house iron reduction filter
Black staining of fixtures or laundry	Excess manganese	Water Softener Whole house iron reduction filter
Rotten egg smell from water	Hydrogen sulfide	Whole house iron reduction filter
Water has a laxative effect	Excess sulfates	Reverse osmosis
Water is gritty, muddy, or appears dirty	Excess sand, silt, soil, clay, and other sediments in the water	In case of serious, consider the possibility of a set of house-sediment filter, otherwise a point of use with a filter sediment filter system should be sufficient

The best time to sample your well water is when the probability of contamination is greatest. This is likely to be in early spring just after the thaw, after an extended dry spell, following heavy rains or after lengthy periods of non-use.

If you use a private laboratory to conduct the testing, nitrate and bacteria samples will typically cost between $10 and $20 to complete. Testing for other contaminants will be more expensive. For example, testing for pesticides or organic chemicals may cost from several hundred to several thousand dollars. The lab will supply you with a clean, sterile sample bottle and the necessary instructions. Samples collected in any other container will not yield meaningful results and will likely not be accepted by the laboratory. In all instances, samples should be refrigerated immediately and transported to the laboratory within 24 hours. Most laboratories mail back the sample results within days or several weeks. If a contaminant is detected, the results will include the concentration of the contaminant and an indication of whether this concentration exceeds a drinking water quality standard.

Once your water has been analyzed, you can compare your test results against EPA or state / provincial drinking water regulations to see if any contaminants are exceeding recommended levels. Once you have identified if any problems exist, you can begin your search for a specific treatment for your well water.

It is important that you conduct follow-up testing of the treated water to ensure that it has indeed solved your contamination problems. Follow-up testing should be conducted several times throughout the first year of operation of the treatment system and after any adjustments are made to the system.

You should continue to monitor the quality of your well water at least annually or more frequently if you have reason to believe a new contaminant or contaminants may have entered your water supply or that your system is not catching all intended contaminants.

Well Water Treatment

The treatment of well water will depend on the outcome of your water quality tests. Some water quality problems are better handled through point-of-entry applications, such as color and odor problems or conditions such as hardness. Other contaminants can be best handled through point-of-use devices (reverse osmosis, for example). Keep in mind that some treatment technologies may require that you pre-treat the water in order for the product to be effective. For example, reverse osmosis systems designed for arsenic or nitrate reduction will last longer if hard water is softened prior to entering the unit. In addition, arsenic can be present in water in two forms - if your water contains trivalent arsenic (Arsenic 3 or Arsenite), pre-chlorination will be required prior to using a reverse osmosis system.

Well Water Maintenance

Measures should be taken to protect your water supply from contamination. The following are a few suggestions:

- Periodically inspect the exposed parts of the well for problems such as corrosion cracks, either damaged, broken or missing cover or cover, and surface cracking solution.
- Slope the area around the well to drain surface runoff away from the well.
- Keep accurate records of all well maintenance.
- Hire only certified well drillers and contractors for any new well construction, modification, or abandonment and closure work.
- Avoid mixing or using pesticides, fertilizers, herbicides, degreasers, fuels, and other pollutants near the well. Hazardous chemicals also should be kept out of septic systems.
- Do not dispose of wastes in dry or abandoned wells.
- Do not cut off the well casing below the land surface.
- Pump and inspect septic systems as often as recommended by your local health department.

CHAPTER IV

WATER FOR STEAM GENERATION

CHAPTER IV

1. WATER FOR STEAM GENERATION

Water quality at power plants is critical to maintaining efficient operation and limiting downtime due to corrosion or preventative maintenance. The main phases and stages in which the water quality is measured are dealt with in this application note, together with the measured parameters.

Water treatment plant

The purity of the replenishment water is critical in maintaining the quality of the steam and in the purge limitation of the boiler.

Raw water pre-treatment

Raw water contains organic matter, inorganic salts, bacteria that must be removed before being purified

Main steps:

a) **Disinfection by chlorination (1-2 ppm) to prevent microbiological growth.**

   Parameters: Chlorine monitoring

b) **Softening by removal of hardness (calcium and magnesium).**

   Two processes can be carried out:

   - Lime soda process, where calcium is precipitated in carbonates and magnesium in magnesium hydroxide. These were set and leaked.
   - Cationic exchange of sodium, normally used in energy, as it avoids incrustation (sodium ions). Calcium, magnesium and other cations (iron, aluminum) are exchanged in sodium. The conductivity is quite high at the resin softening outlet.

c) **Dechlorination**

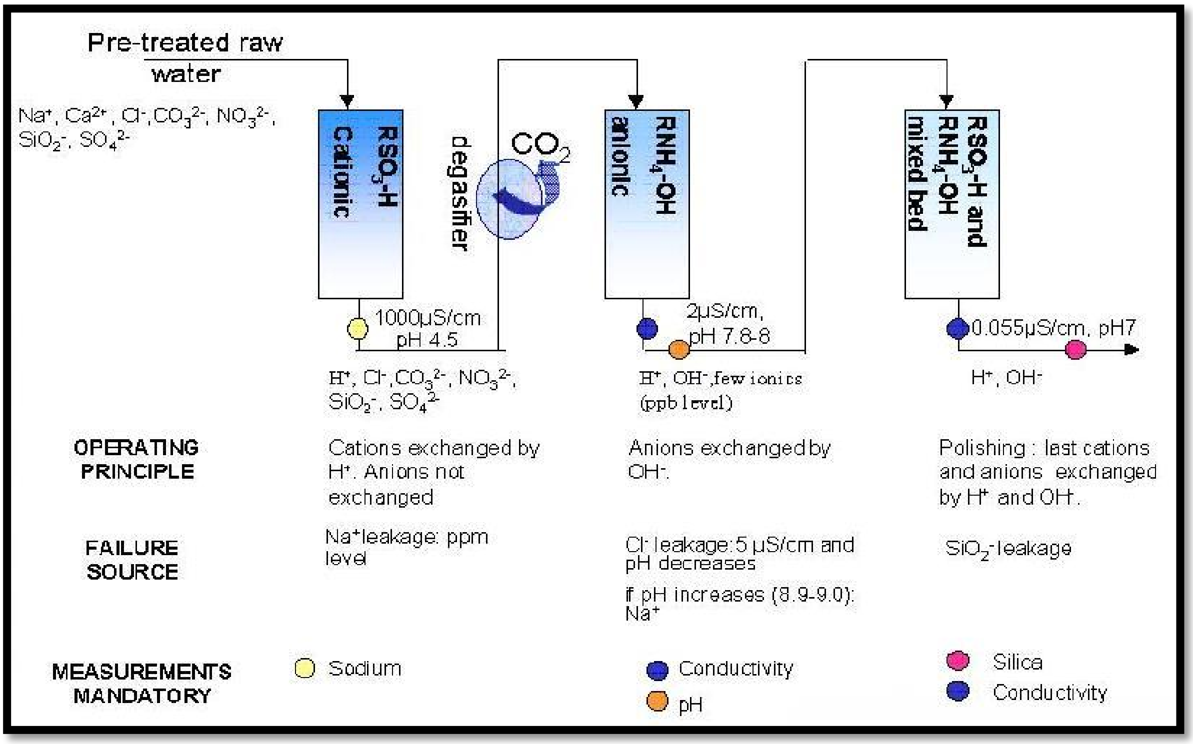
   - Coal beds: eliminates organic compounds and chloride.

- o Addition of sulfate oxidized bisulfate (removed by anion exchangers).

Water purification process

A demineralization plant usually consists of 2 specific ion exchangers and a mixed exchanger:

Demineralization plant



Cation exchanger

The first ion exchanger removes all cationic species (e.g., Ca 2+ from CaCO 3) and exchanges them in H + the H 2 CO 3 is degassed before the second ion exchanger.

Cationic exchangers are regenerated by HCl, H2SO4: all cationic species trapped in the resin are removed and replaced by H +. After completion of regeneration, the resin is filled with H + sites to be exchanged with cations again.

Parameters: Sodium measurement for the immediate detection of Na

Anion exchanger

The second ion exchanger removes all anionic species (nitrate, chloride, sulphates, silicates) and exchanges them with OH-. The water molecules are produced (H + from the cationic and OH- the anionic outlet).

In case of depletion anion exchanger, the first leak will be chloride due to its lower charge density. Anionic

Interchambers are regenerated by NaOH, elimination of all the anions trapped by OH-. When the generation is complete, the resin is filled with OH- sites.

Parameters:

- Ionic conductivity clearly indicates the leak if it reaches 5 - 6 mS. If the conductivity reaches 5 - 6 mS, this is a clear indication of ionic leakage.
- pH levels also indicate leaks: If the pH is 8.9 to 9.0, this indicates sodium leaks. If the pH drops, this indicates chloride leaks.
- Therefore, conductivity and pH are complementary measures at this stage.

Storage

The demineralized water is stored before being fed into the circuit.

La neutralización de los efluentes

Without proper treatment, effluents from the ion exchange resin regeneration are not always adjusted. Access by discharge into the medium (e.g. river). The addition of a neutralizing reagent is often.

Steam Generation Process

Principle of operation

Market: All industries that use steam (power plants, cogeneration units)

The main concerns in energy generation are the availability, reliability and life cycle of plants with a main objective:

The costs of saving. The operating principle is based on a source of energy: gas, coal, fuel or nuclear. Water is vaporized in a boiler and heated steam passing through a turbine, linked to an alternator, electricity production. The steam is condensed.

The specific limits are set for the different measured parameters. Three different levels of security are usually defined:

- Above level 1, the control panel must return to normal level within one week.
- Above level 2, within 24 hours.
- Above level 3, a shutdown within a few hours has the mandate to prevent corrosion damage.

Due to improvements in the design of power plants, the equipment requirements of water purity and water treatment turned more and more difficult.

Main source of plant failure

Main source of contaminants infiltration:

- Made water: demineralization plants failure, silicone resin fines reduce turbine efficiency; Of sodium (NaOH, NaCl) corrodes boiler tubes and turbine blades. Sulfate comes from waste chemicals used for regeneration, ion exchangers.
- Cooling water infiltration: Presents raw water (organic and inorganic) in the process. The intergranular tension can produce cracking by low corrosion. Chloride, sulfate creates corrosion cracking in the turbine and in the boilers.
- Air infiltration: source of dissolved oxygen (DO) and CO2. DO promotes corrosion and CO2 accelerates the attack on copper alloy tubes (pH decreases).

Corrosion

A layer of magnetite (Fe3O4) Protects the circuit against corrosion, which should not be suppressed or altered. The pH value in the process should minimize the solubility of the magnetite.

- NaOH: at low temperature, corrosion of the steel is inhibited by hydroxyl alkalinity (NaOH). At high temperature, magnetite can be destroyed by the high concentration of NaOH accumulated in cracks.
- The acid can cause H_2 to react with carbon to form methane (CH_4), which weakens the metal.

Deposits:

Calcium sulphates, calcium carbonate, silica, iron oxide can be deposited on supporting surfaces or blades and drastically reduce the efficiency of the power plant.

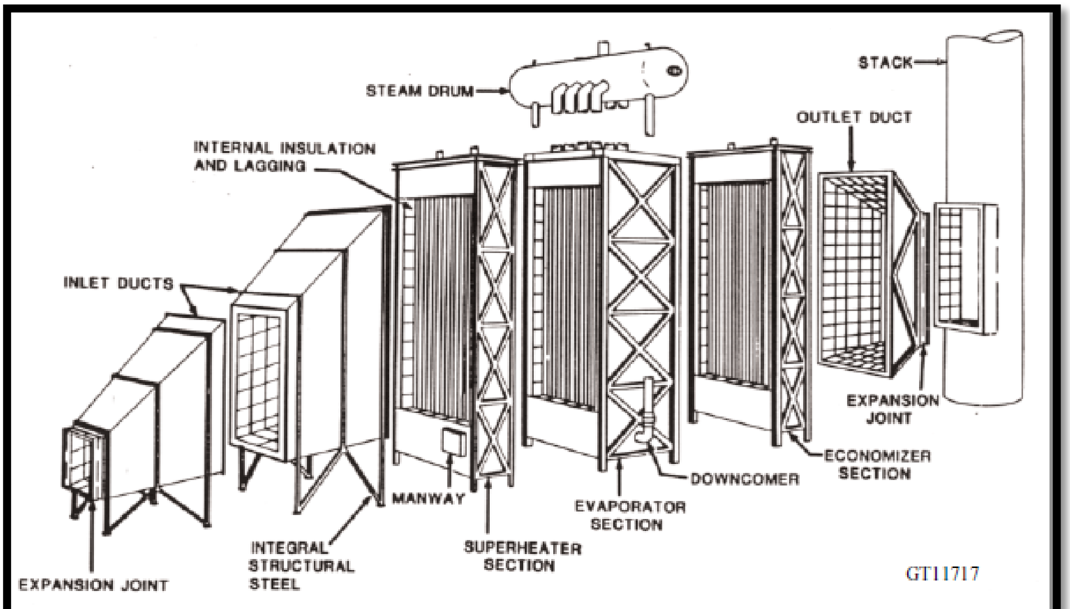
Principio de tratamiento de agua:

Therefore, high purity water is essential in preventing the introduction of impurities into the water circuit. As it is pure, it is very corrosive, it is necessary the conditioning of the water. This varies from plant to plant depending on the alloy used and the type of plant (pressure, pretreatment, feedwater contamination potential).

Discharge of the condensate pump.

Ammonia: It has a very volatile vapor partition, and can reach a high concentration in the condensate. Prevents corrosion in water. It has the highest neutralization capacity (ppm CO_2 per amine). The copper is dissolved:

Amines (such as morpholine): show less volatility than ammonia and can protect against corrosion of the boiler and condensate (water phases). Morpholine is decomposed into acetate (acid effect) but compensates for the acidity of boric acid and acetate. They can produce a taxiing effect avoiding the water that comes in contact with the circuitry.



Natural-circulation HRSG modular construction

THE HRSG

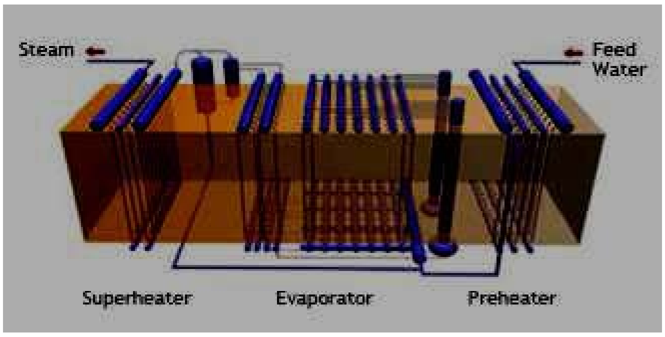
HRSGs are mainly of three types:

• Natural circulation HRSGs

• Forced circulation HRSGs

• ONCE THROUGH HRSGs

It has four basic components.:



• Evaporators (gas to wet steam heat exchanger)

• Economizers (gas to water heat exchanger)

• Superheaters / Gas Heaters (gas to dry steam heat exchanger)

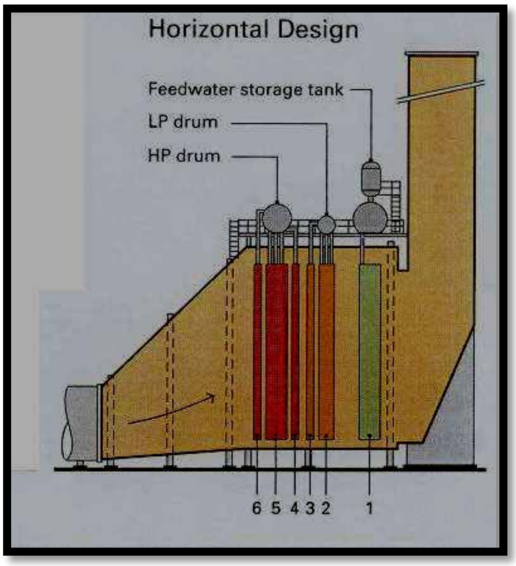
• Preheaters (gas to water / glycol / air etc. Heat exchanger)

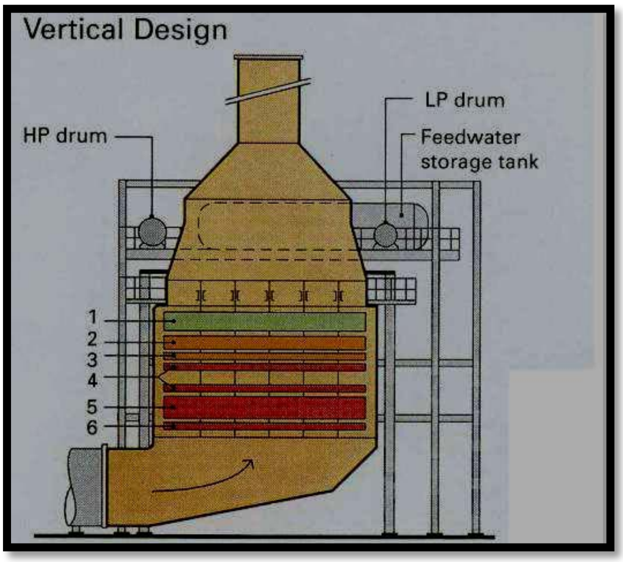
Feed water (economizer inlet)

To optimize the efficiency of the boiler, which extends its service life and ensure the quality of the steam, quality water supply requirements are essential. Oxygen measurements: <20 ppb

- Silica <20 ppb if once through the steam generator (OSTG)

- Hydrazine: <20 ppb for accurate dosing





Water from the boiler

Fouling due to hardness, silica, and deposits of corrosion products can decrease the heat exchange capacity and overall efficiency of the boiler. Steam quality varies with the concentration of impurities in the boiler and the potential mechanical drag of the water droplets of the boiler in the steam. The higher the operating pressure of the boiler, the greater the purity requirements as the entrainment of contaminants is promoted.

The concentration of impurities after each evaporation cycle is discarded by blowing in drum boilers (curative and preventive actions). If concentrations of impurities become greater than their solubility (the lower the pressure, the lower the solubility), deposits may occur. Evaporation, drying of moisture and chemical reactions on surfaces, or metal oxide can lead to deposits as well.

Main steam, superheated steam (heat recovery steam generator)

Boiler specifications do not guarantee the quality of the steam turbine. The solubility limits in the turbine define the feed levels of impurities in the water. Conformity with vapor limits helps minimize boiler purging. Steam is a good solvent under high pressure and carries on oxide, silicates, sulfates, carbonates, aluminates and chlorides, which can corrode the turbine. Low level of impurity is mandatory; CO_2 interference should also be avoided.

As the water can be injected directly into the turbine to increase output power, its quality must obviously be under control. The gas turbine compressor can also be washed to remove fouling deposits if the return pressure increase, and decreased output power realized.

The water quality must meet the following limits: 8 S / cm and a pH of 6.5 to 7.5.

- pH measurements:
  Copper tube capacitor: 8.8 to 9.3 pH
  Stainless steel tube condenser: 9 to pH 9.6
  If CCPP (drum LP and HP once through): Main LP of steam at boiler outlet: 9.5 to 9.9 pH

Cooling wáter

Principle of operation

The cooling water uses the raw water for cooling the condenser tubes and maintaining their efficiency. At the inlet of the condenser, the cooling water is quite cold, depending on the temperature of the river. After the condenser has cooled, it returns to the cooling tower at a higher temperature than at the condenser inlet where it is sprayed into the cooling tower and cooled through the air. Excess energy in the form of heat evaporates through the top of the cooling tower.

CHAPTER V

WATER IN THE CONDENSATION SYSTEM

CHAPTER V

2. WATER IN THE CONDENSATION SYSTEM

Cooling water system

Water cooling systems are open or closed, and the water flow is either bypass or recirculation. The three basic types of water cooling systems are single pass, closed recirculation (not by evaporation), and open recirculation (evaporator). True closed systems neither lose nor gain water during the service. Open systems, however, need to be added to water to compensate for losses.

Cooling water sources

There are two main sources of cooling freshwater salt and sewage. Fresh water is the primary source of makeup for the cooling of water systems. Fresh water can be surface water (rivers, streams, reservoirs) or groundwater (shallow water or deep wells). In general, groundwater supplies are more consistent in composition and contain less suspended matter than surface waters, building materials, which are directly affected by rainfall, erosion, and other environmental conditions. Because of the environment's consideration of the environment, the cost of water and the availability of water, some plants are using salt water and effluent wastewater from treatment plants as a source of cooling water. Closed attention to the design and treatment of cooling topic use of these water sources is critical for reliable performance and long life.

Chemical treatment of cooling water

In practical terms, there is no pure water, either naturally occurring or artificial. Most industrial water has a level of impurity usually measured in percentage or parts per hundred. The water chemist rarely deals with water sources that have percent impurity levels, with the exception of seawater (about 3% dissolved mineral impurities), with Nate waters (produced with some crude oils, sometimes containing 20 % To 30% of dissolved salts), brackish water, and certain industrial waste water.

- **Problems in ice water systems**

Cooling systems suffer from many types of corrosion and failure. Diversity of attack is due to differences in cooling water system design, temperature, flow, chemical water, alloy composition, and operation.

1) Corrosion: Corrosion is defined as the natural way of returning treated metals, such as steel, copper and zinc, to their native states as chemical or mineral compounds. In the presence of water and oxygen, nature relentlessly attacks steel, returning elemental iron (Fe0) back to an oxide, usually a combination of Fe2O3 and Fe3O4.

2) Deposition: Deposits are defined as conglomerates that accumulate on wet surfaces, and interfere with system performance, either by restricting flow gradually or by interfering with heat transfer. Deposits include scale, soils, or a combination of the two scale forms when the concentration of a min-dissolved eral exceeds its solubility limit and the mineral begins to precipitate. The most common example of deposition is calcium carbonate inlays formed when the Langelier index or stability index indicates a condition of CaCO3 in supersaturation, water in an insoluble form, such as silt, oil, process contamination or biological masses. The deposits are more often an accumulation of settled sediment or solids than to withdraw at some point in a system where the water velocity falls too low to support the material in the stream.

- **Water treatment**

  Corrosive inhibitor

Corrosion inhibitors are classified as:

1) Anodic corrosion inhibitors: anodic corrosion inhibitor function of interfering with the anodic reaction to break the electrochemical circuit. In order to inhibit corrosion, anodic inhibitors should reduce the rate of dissolution of the metal.

2) Cathodic corrosion inhibitors: cathodic inhibitors prevent the reduction of oxygen at the cathode. They reduce the rate of corrosion by forming a barrier film in the metal, restricting oxygen reduction at the cathode sites.

3) Typical corrosion inhibitors:

- Mainly anodic: chromate, nitrite, orthophosphate, bicarbonate, silicate, and molybdate;
- Mainly cathodic: Carbonate, polyphosphate, photophosphate and zinc;
- Both anodic and cathodic: organic filmers.

Inlay Inhibitor

Intake inhibitors and dispersants may be necessary to pre-ventilate the deposition of minerals in water, depending on the water chemistry and system conditions. Stabilized phosphate programs were among the earliest. The key to its success depends on polymers that can stabilize calcium phosphate in cooling water systems. The version of the stabilized phosphate program that runs at neutral cooling of the pH of the water depends on a close control of the pH of the system as well. The programs are a mixture of orthophosphate, polyphosphates, phosphonate, and polymers that provide scale inhibition. Inhibitors can be classified as:

1) Organic phosphorus compounds

These are the most used to prevent calcium and flakes in open recirculation systems based on iron. In general, 0.5-6.0 ppm of organic phosphorus (as PO4).

2) Polymer acrylates

Its main advantage over phosphorus-based compounds is that they do not decompose to orthophosphate to contribute to potential scaling. They degrade easily in waste treatment.

Cooling Chemical treatment of water control methods

Age method (traditional chemical controllers)

Most water treatment programs include a number of chemicals for the treatment of corrosion, scale, fouling and microbiological problems. These chemicals are prescribed for each individual system. The concentrations of chemical treatment CAL in the recirculation of the cooling water must be checked frequently and regularly. To relate all these parameters together will have these drawbacks as indicated by:

. remote control, staying in time;
a. There is no logic control;
b. Set points still change very rarely, once established;
c. Added PLC integration;
d. There is still no stress control
e. There is no online performance monitoring yet;

New method (Automatic dynamic chemistry treatment controller)

Automatic chemical treatment controller such as 3D TRASAR® was implemented in the ice water plant number 1). TRASAR 3D® products are part of an innovative water treatment program to avoid operating problems. TRASAR 3D compensates for both ordinary and special causes of TEM variation. 3D TRASAR programs provide a return on the user's investment through their unique control and diagnostic capabilities. The 3D TRASAR technology as described by is a combination of:

f. Proprietary chemicals and tracers;
g. Equipment;
h. Diagnosis;
i. Value added service.

CHAPTER VI

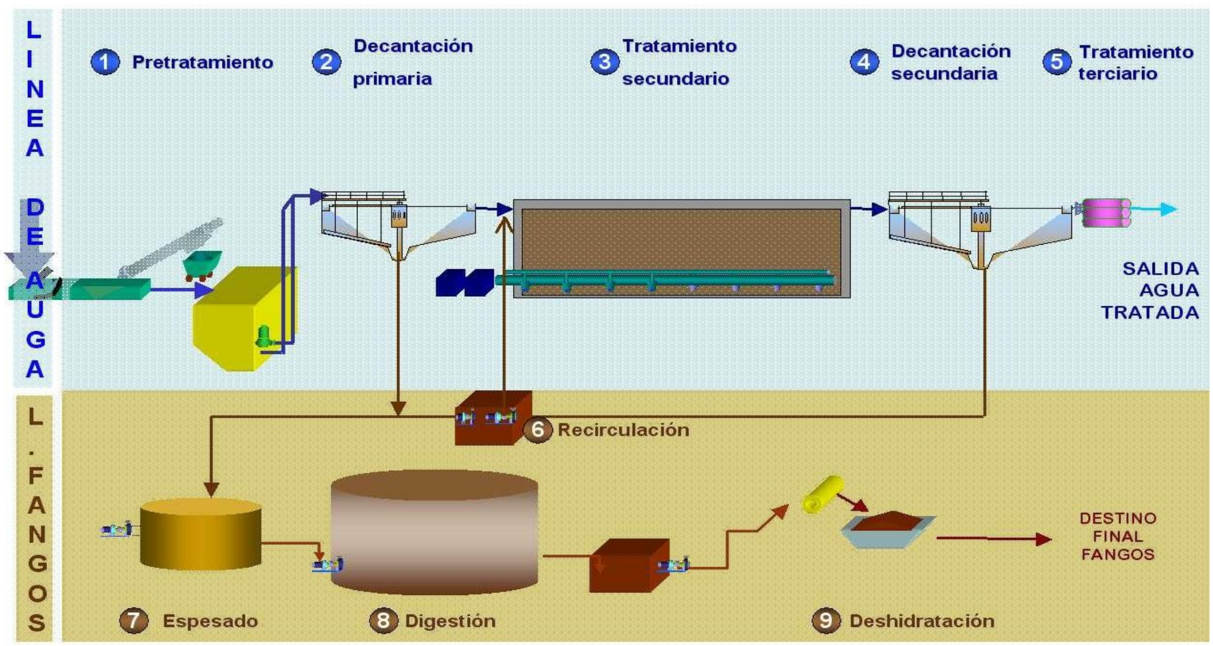
WATER TREATMENT

CHAPTER VI

3. WATER TREATMENT

Water treatment is the process of physic-chemical and biological nature, by which a series of substances and microorganisms are eliminated that imply risk for consumption or communicate an undesirable organoleptic aspect or quality and transform it into a suitable water for consumption.

Any water supply system that is not equipped with means of purification, does not deserve the sanitary qualification of water supply. In the potabilization of the water must be resorted to methods appropriate to the quality of the water source to be treated.



Canalization.

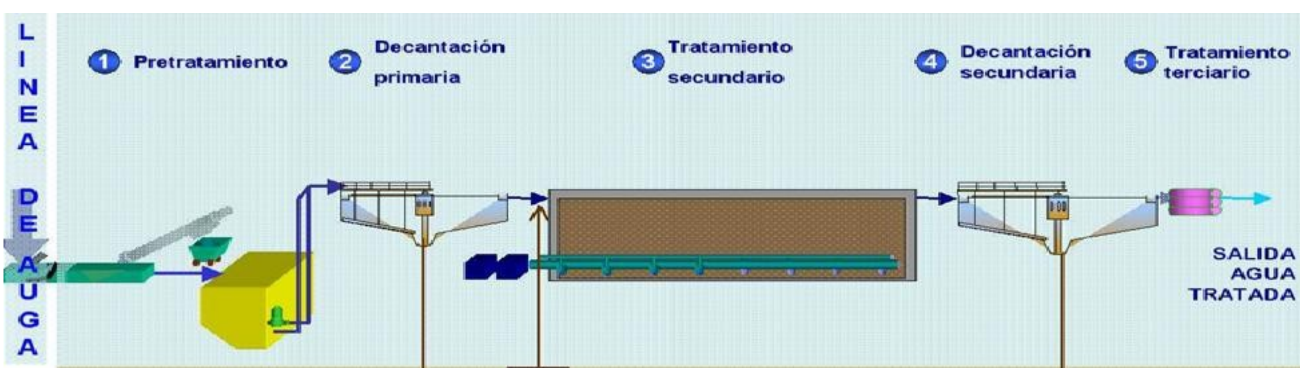
System of pipes and channels interconnected by a main drainage line that distributes wastewater to the treatment plant or sewage treatment plant.

Junction box.

Allows to divert the waste water from the main manifold to the pre-treatment unit "water line”.

LINE OF WATERS

Are the wastewater coming directly from the drainage network, are considered all drained water factors, (rain, domestic, industrial, service, etc.)



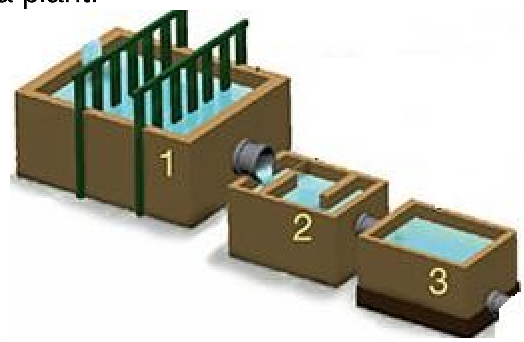
Within the context of the waterline and as the initial phase of all processes, there are devices that separate the largest floating solids and heavy solids from the water (inorganic matter); This step works specifically as a system of screening by different devices that are ordered according to their uptake (from major to minor size of materials) specifically the devices can be: thick wells, grates, choppers or "sieves <3mm" gritters, sanders , Degreasers; To all these devices we can call them in a system like sanitation network.

Basic example of pretreatment of a plant:

1.- Grids from highest to lowest

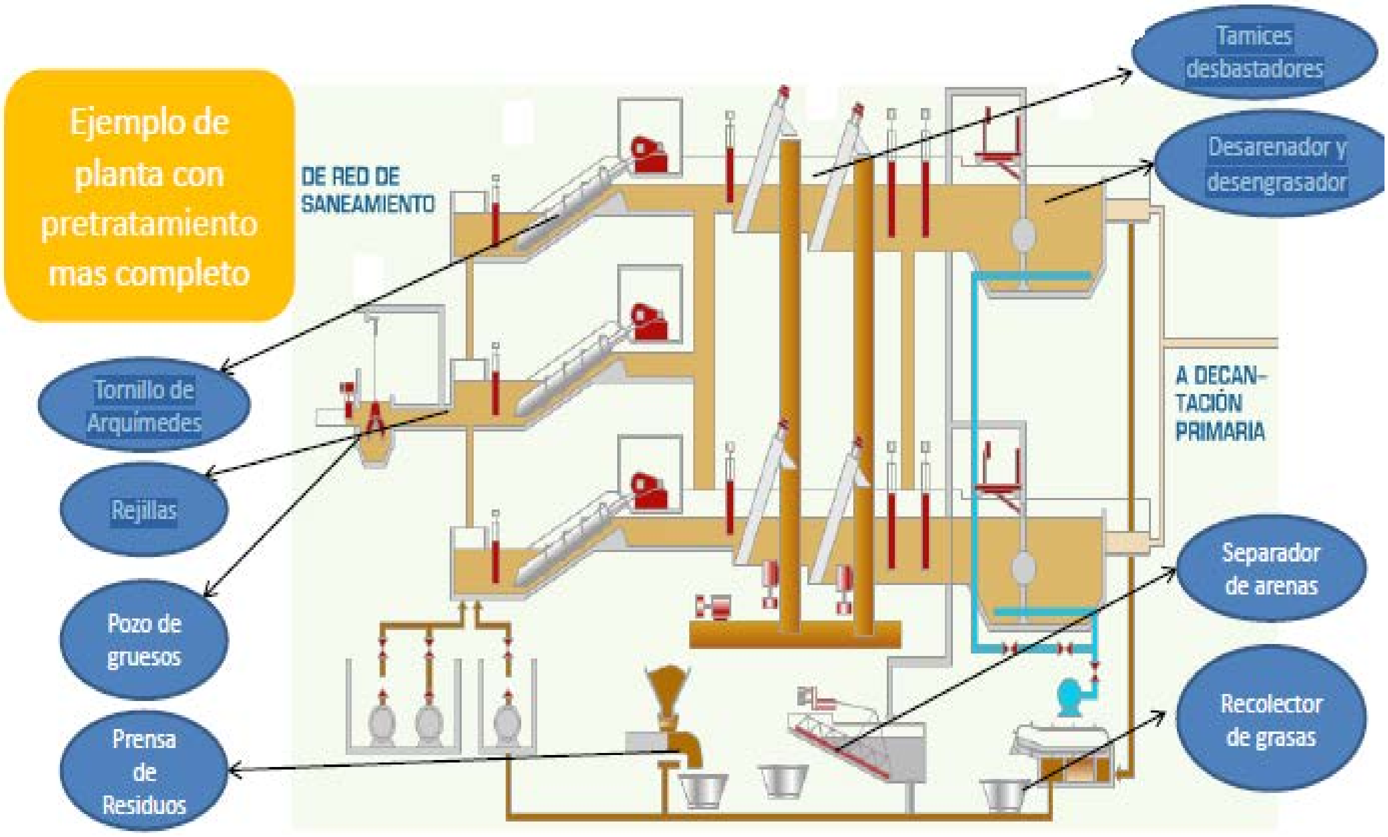
Size, 2.-Sanders and

3.-Degreasers



In some circumstances the pre-cast water may at some point occupy pumping by means of Archimedes screws that reduce the flow velocity and make the water cleaning efficient before reaching the primary settling.

- Objects that remain in this process are removed by means of bivalve bands and spoons to the inorganic garbage dump.
- Fats are collected by banding in containers.

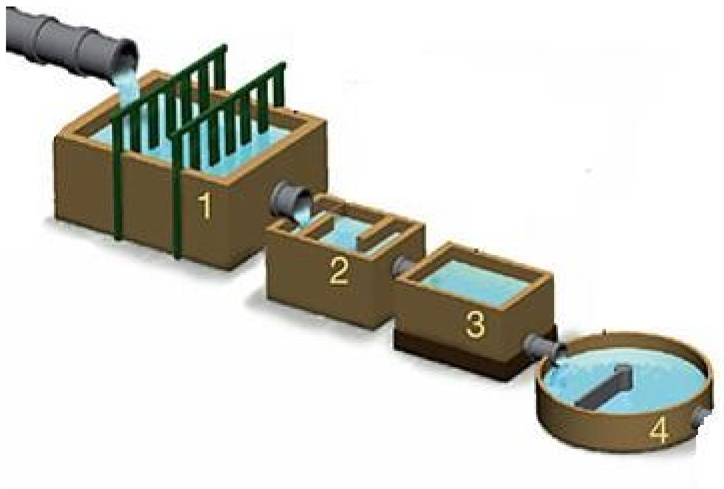


6.1. Classification of treatments

Primary decanting

Also, called primary treatment; Consists of a process of the same physical way, its mission is the separation of suspended particles not retained in the pretreatment.

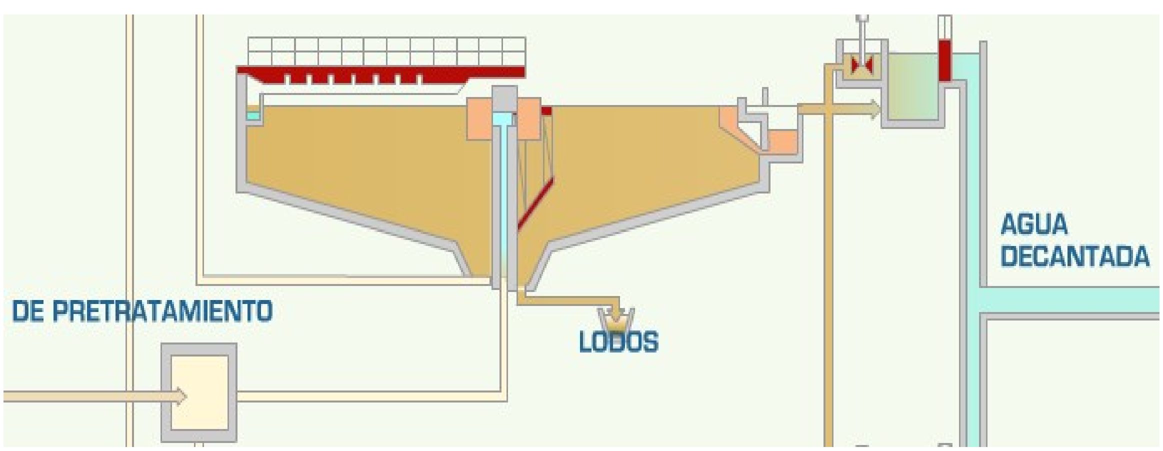
Decantation is the phenomenon caused by the force of gravity that causes suspended particles heavier than water to separate sedimenting, aided by a discharge of the pretreatment in the form of a cascade that reduces the speed of flow and reduces the time of sedimentation. Normally, in slurries called dynamic and conical, the sludge is periodically entrained to tanks by means of movable bridges with scrapers that run the bottom to be taken to treatment of sludge (seen later).



The primary treatment or primary decantation, allows to eliminate in an urban residual water approximately 90% of the decantable materials and between 50 and 70% of the materials in suspension. A reduction in BOD of about 35% is also achieved.

The primary decantation time is around 3 hours, after which the secondary treatment will be carried out where the biological reactor will be completely purified for reuse in agricultural irrigation, services, or returned to the river bed.

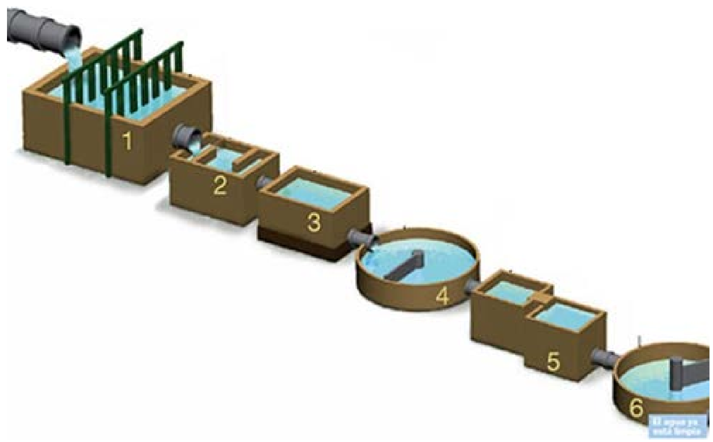
Other primary treatment processes include the air flotation mechanism, where solids in suspension with a density close to that of water, as well as oils and greases, are removed, producing very fine air bubbles that entrain the particles to the surface to Their subsequent elimination.



Secondary treatment

Also, called biological treatment; Seeks the transformation of dissolved organic matter into sedimentable solids that are easily removed from the process. In addition, the entrapment of colloidal and suspended solids is achieved.

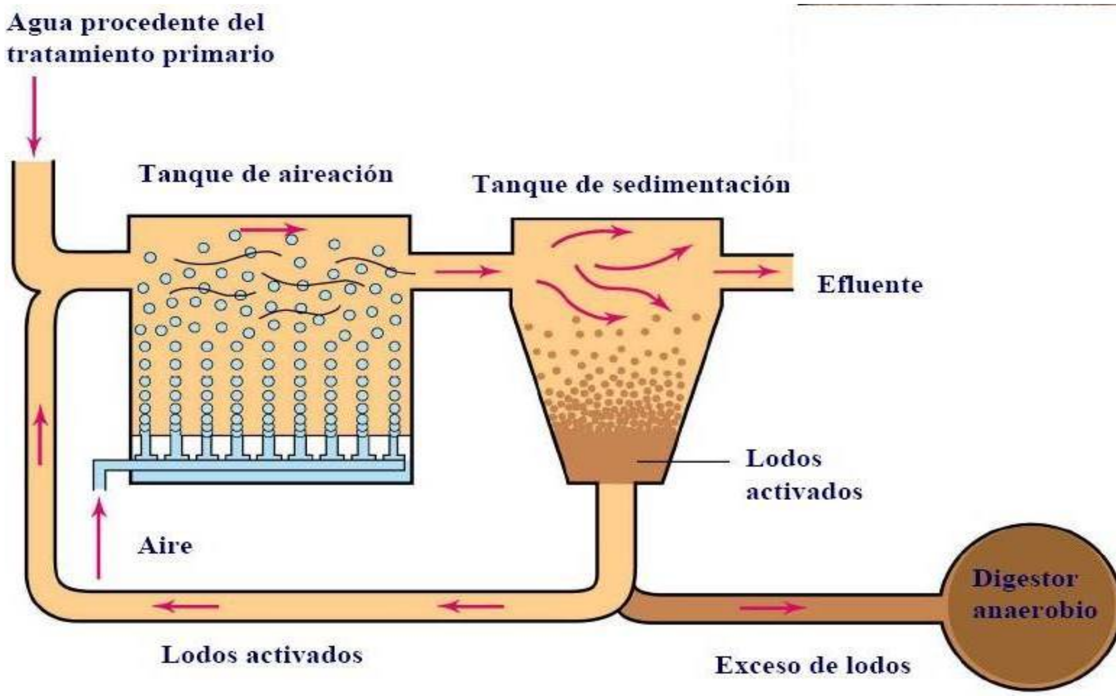
Biological treatment decreases BOD5.



The biological treatment is performed in several biological reactors that will occupy aeration to keep the aerobic agents and protozoa in constant degradation of organic matter.

In order to get oxygen into the microorganisms, and to produce the necessary agitation, there are usually surface electroagitators or air injection coming out of ceramic domes, as in this case,

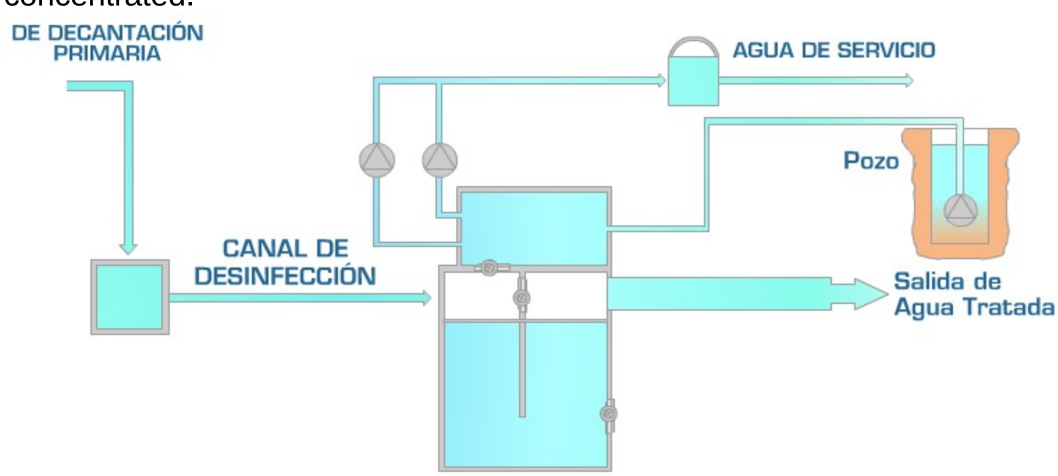
These domes are installed in the bottom and provide the air in the form of bubbles. Air is drawn from the atmosphere by several high-powered compressors.



Secondary decanting

Secondary decantation or final clarification is carried out from the biological reactors, in which it is carried out in several generally circular decanters equipped with scrapers which are suspended from a radial bridge, dragging the sludge towards the central zone of the decanter, from where said sludge Is recirculated by submersible pumps or Archimedes screws at the entrance of the biological treatment. With this recirculation, it is possible to concentrate the microorganisms to very high values.

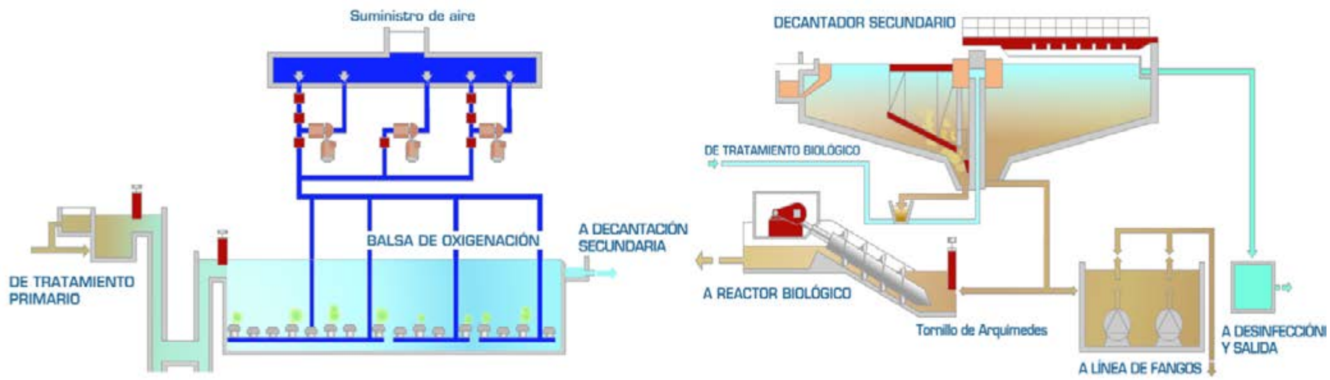
In order to keep the process controlled, the sludge must be continuously removed. Excess sludge purges can be performed from the biological reactor or from recirculation, the latter being more concentrated.



From the secondary decantation, the sludge deposited in the purge ones will go to the reactor again and others to the treatment of sludge; The water that is on the surface of the decanter will be poured into a canal that will go to a disinfection tank, where by chemical substances like chlorine will eliminate pathogenic microorganisms giving rise to the treated water, that will be used for agricultural irrigation, municipal services, Or in greater purification to pour to the rivers and lakes without greater impact.

The process of purification of the water line takes between 10 and 15 hours.

In order for the water to be fit for human consumption, a purification process with UVA, reverse osmosis, ozone, or chlorine should be carried out to a greater extent.



6.2. Types of Treatments

Treatment of reverse osmosis

Reverse osmosis (RO) is a technique for membrane-based water demineralization that acts as elective permeable barriers that allow some substances (such as water) to permeate through them while retaining other dissolved substances (such as ions). RO offers the finest filtration available today, rejecting most dissolved and suspended solids, while preventing the passage of bacteria and viruses, obtaining pure and sterilized water.

The space of the membrane holes is extremely low, so much so that it can be considered as a molecular filter, as a consequence of this, it is necessary to use considerable pressure to pass the water through them.

The residues or dirt that are trapped in the membrane are then washed away and washed by the flow of water that circulates, so that the system performs a process of self-cleaning constantly.

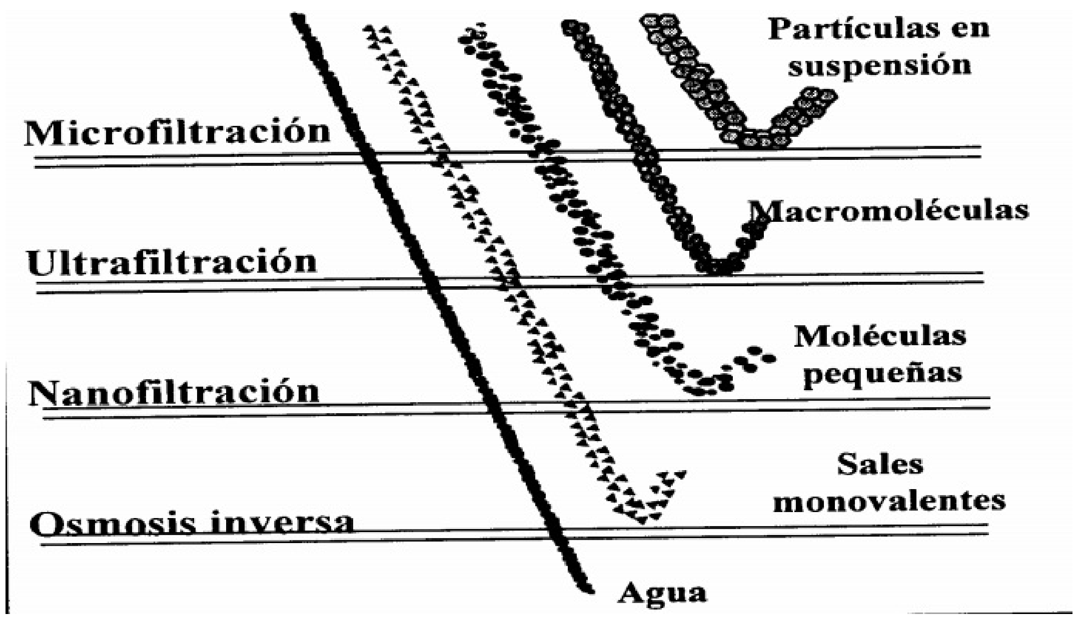


Fig.4: Filtered particle size range.

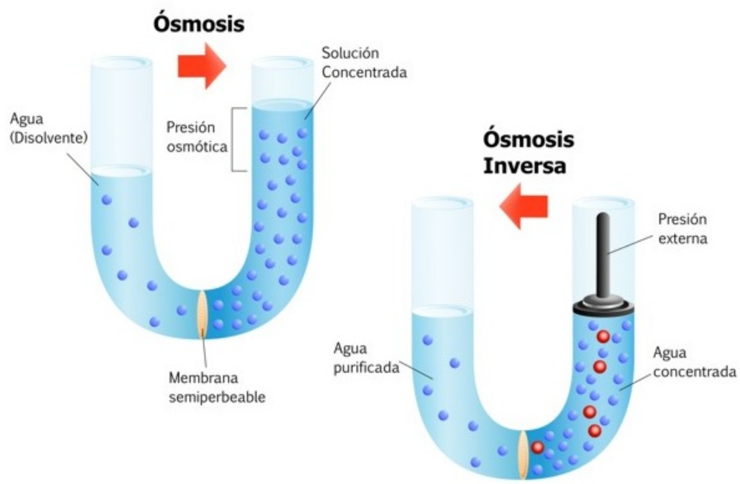
Figure 4 shows that the reverse osmosis process has the highest filtration power, filtering at the molecular level.

Operating principle:

In natural osmosis, when two solutions of different concentrations of a particular solute (e.g. salts) are brought into contact, a flow of solvent (e.g. water) is generated from the most dilute to the most concentrated solution, to equal the concentrations of both.

If our interest in the treatment is to obtain a stream of water as diluted as possible we must reverse the phenomenon. To do this, the natural osmotic pressure must be overcome by the opposite application of a higher pressure.

By inverting the phenomenon, you get what is known as reverse osmosis.



On the membrane:

It is a membrane that has a "microporous" area that rejects impurities but does not impede the flow of water.

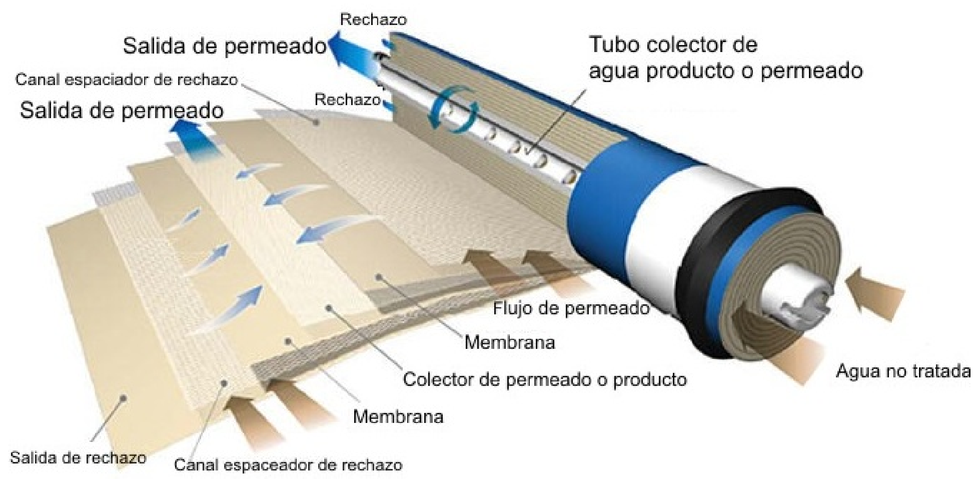
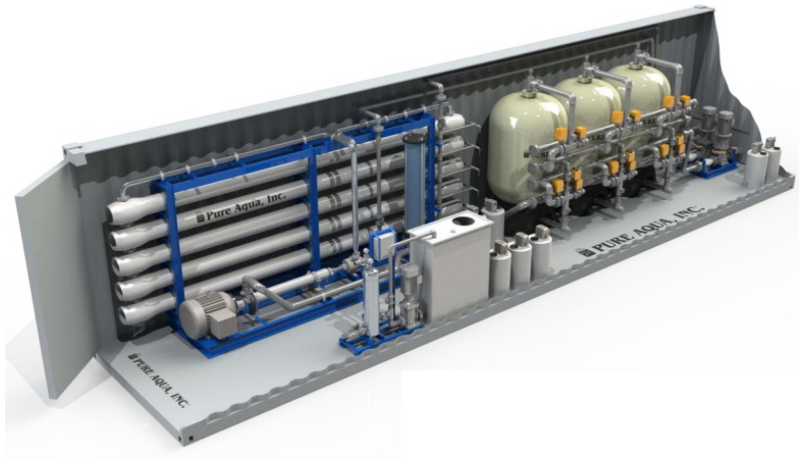


Illustration of the installation:



Reported Problems:

The problems that may occur in reverse osmosis treatment systems are the following:

a) Obstruction:

Membrane obstruction is a result of the deposition of suspended solids, organics and microbes on the surface of the membrane, typically on the supply / concentrate side. A clogged membrane has two major performance problems: higher operating pressure than normal pressure (to compensate for lower membrane flow at constant pressure) and a higher pressure drop than normal.

The causes of obstruction of a RO membrane are:

- Deposit of silt (slime) or other suspended solids that have been improperly removed by pretreatment.

- Inorganic inlays caused by the precipitation of poorly soluble salts or silica.

- Bilateral obstructions caused by excessive microbial growth.

b) Fouling:

The embedding of a RO membrane is the result of the precipitation of saturated salts on the surface of the membrane. An embedded membrane has three major performance problems: higher operating pressure than normal (to compensate for lower membrane flow at constant pressure), higher pressure drop and lower salt rejection than expected.

Membrane materials:

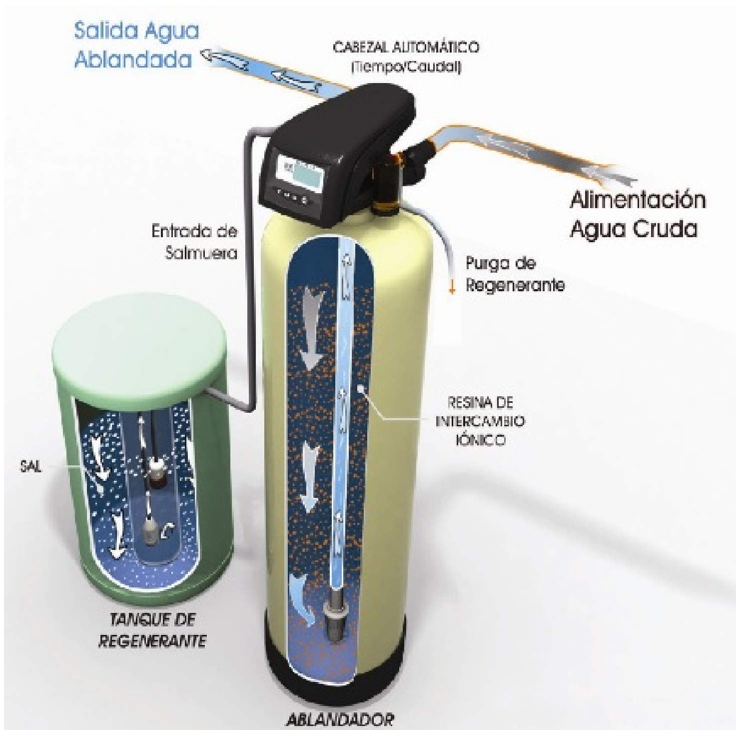
The most common and used materials are cellulose acetate and polyamides (thin lay), their performance is as follows:

PARAMETRO	MEMBRANA DE PELICULA DELGADA DE POLIMEROS	MEMBRANA DE ACETATO DE CELULOSA
Rechazo de sales	Más Alta (> 99,5%)	Más baja (Hasta 95%)
Rechazo de Sílice	> 96%	≈85%
Presión Neta	Más baja (10-15 bars[6])	Más alta (15-30 bars)
Carga en la superficie	Más negativa (Limita el uso de coagulantes cationicos en el pretratamiento)	Neutral (no limitaciones en pretratamiento con coagulantes)
Tolerancia al cloro	Pobre (hasta 1000 ppp-h. Necesita decloración)	Aceptable (continuo uso de 1-2 ppm de cloro es aceptable)
Frecuencia de limpiado	Más alta (semanas a meses)	Más baja (meses a años)
Requerimientos de pretratamiento	Alto (SDI < 4)	Más bajo (SDI < 5)
Tolerancia a la obstrucción	Aceptable	Buena
Remoción de Orgánicos	Alta	Relativamente más baja
Bio-obstrucción	Más susceptible	Menos susceptible
Bio-degradación	Ninguna	Más alta
Tolerancia al pH	Alta (2-13)	Limitada (4-8)
Temperatura	Hasta 30°C	Hasta 45°C

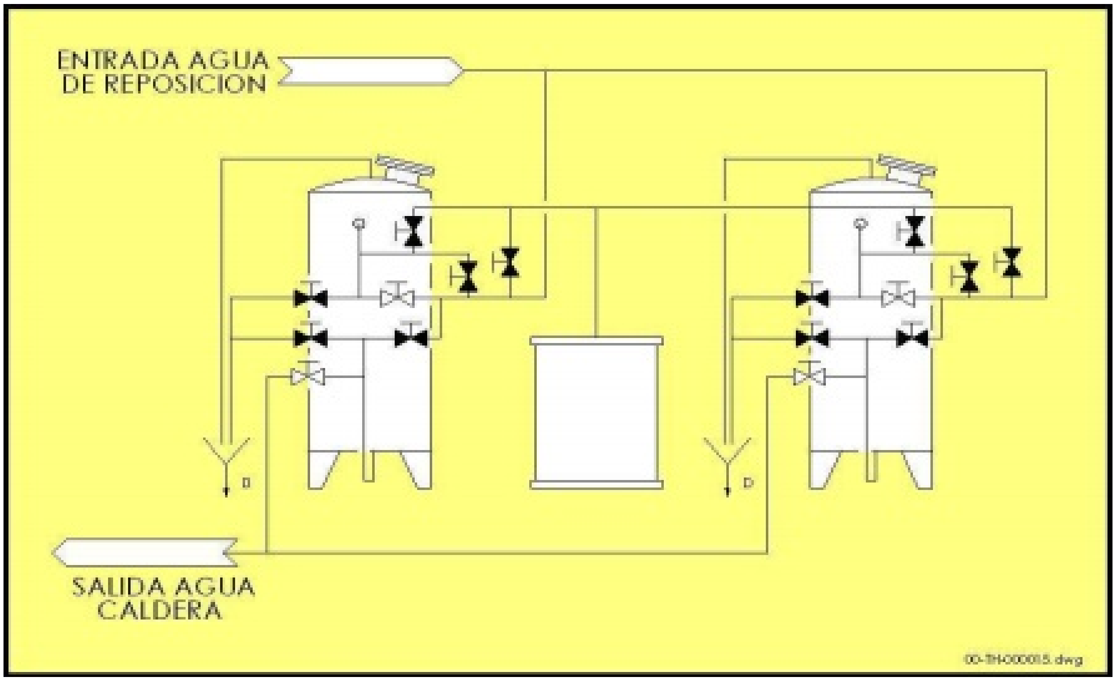
Ion Exchange Treatment

It is a separation process based on the transfer of fluid-solid matter, in this case the mobile Ca + 2 and Mg + 2 ions of the water to be treated are exchanged for the ions present in the resin used in this process.

The principle of operation of these equipment is based on a process called "ion exchange", which consists of the replacement of these ions by sodium (Na) to obtain water for use in boilers. The softeners are composed of resins, which possess a capacity for ion exchange of calcium and magnesium by sodium.



The following is a diagram of the installation of an ion exchanger:



The disadvantage of this process is that it does not filter particles and the resin wears off over time, losing effectiveness, so it is necessary to regenerate it.

The regeneration of the resin is carried out with sodium chloride (NaCl) of technical quality with a concentration of 150 to 250 gr / l of resin.

The chemical reactions present in this process are shown below:

Agua Dura	Resina			Agua Blanda
Ca(HCO3)2				
Mg(HCO3)2				
CaSO4				NaHCO3
MgSO4	+	R – Na	---->	Na2SO4
CaCl2				NaCl
MgCl2				
NaCl				

Degasser:

The function of a degasser in a thermal plant is to remove the oxygen and carbon dioxide dissolved in the feed water from the boilers to prevent corrosion or pitting problems.

The main components of a degasser are the following:

- Degassing tower.

- Feedwater pond.

- Manometer.

- Bimetallic thermometer.

-Water level.

- Vent valve.

- Water drain valve.

- Condensate return line check valve

- Replenishment water line check valve.

- Vacuum breaker valve.

- Float steam trap for overflow.

-Reducing Vapor pressure valve.

- Steam line filter.

- Steam line bypass valve.

-Security valve.

- Steam line bypass valve.

- Steam line check valve.

- Level control.

- Level control bottle.

- Control valves of level control.

- Level controller.

-Solenoid valve.

- Replacement water line filter.

- Replacement line water line valves.

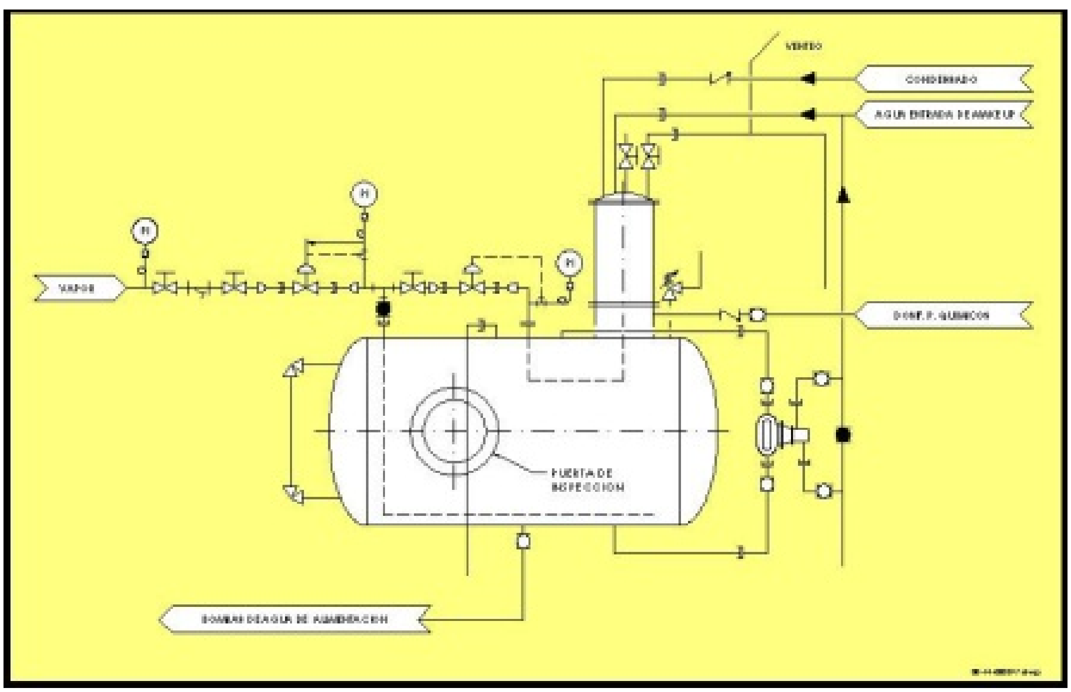
- Thermostatic valve (water temperature control storage tank).

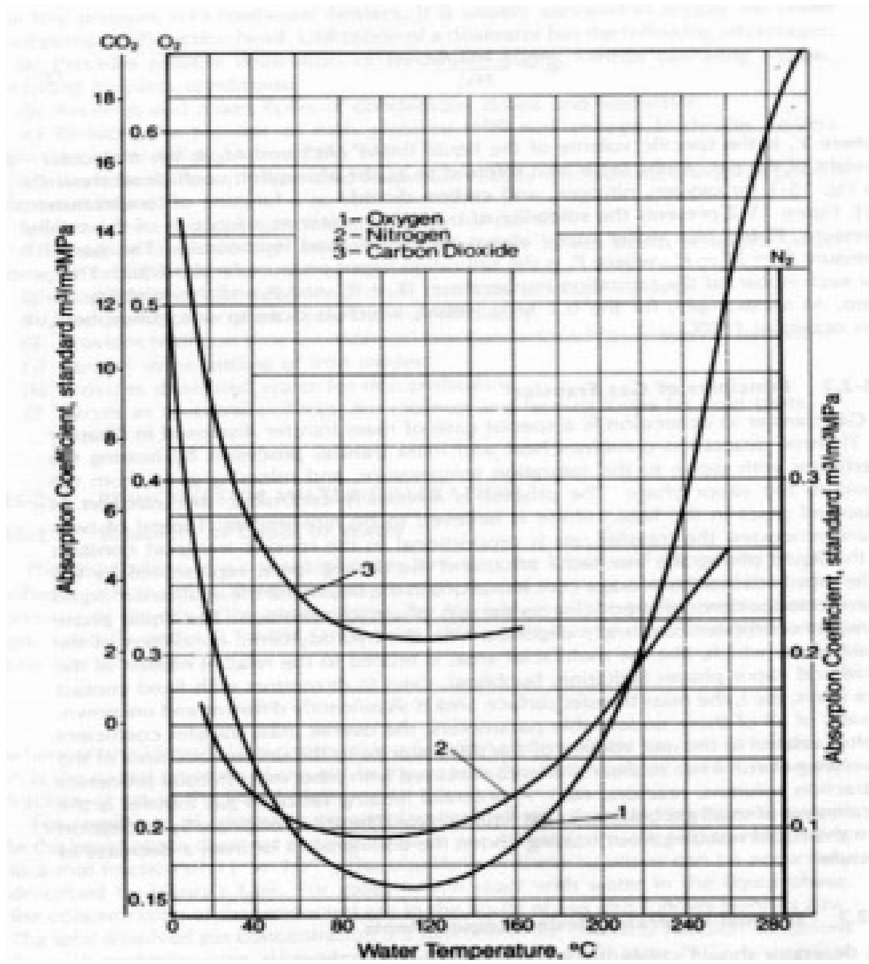
- Steam line filter (Heating of pond water).

- Steam line pass valve (Heating of pond water).

- Steam line check valve.

Degasser diagram:





The degassing process is as follows:

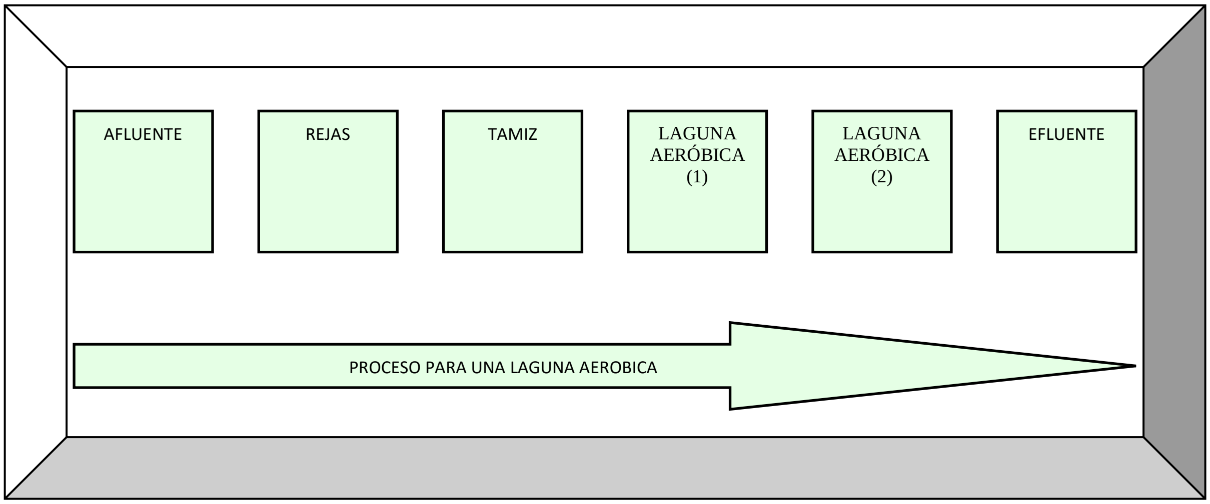
The degasser tower consists of trays and / or nozzles in which the surface of the water is increased, forming cascades or atomizing it to favor the release of the dissolved gases. The water flowing down the tower is heated to the back-flow steam boiling temperature. The amount of steam supplied to the base of the degasser is controlled by a pressure reducing valve, which is responsible for maintaining the boiling pressure of the water.

6.3. Oxidation Ponds

Oxidation ponds are shallow excavations in which a microbial population composed of bacteria, algae and protozoa (symbiotically suitable) develops and naturally eliminates pathogens related to human excreta, suspended solids and organic matter, Causing diseases such as cholera, parasitism, hepatitis and other gastrointestinal diseases. It is an easy and efficient method to treat sewage from sanitary sewage.

The system is initially composed of a group of traps that trap and separate solid elements that are not inherent to the design of the system. In the next stages, water and its residues are transferred to a lagoon system (one or more) where they remain in contact with the environment mainly the air, undergoing a process of oxidation and sedimentation, thus transforming organic matter into other types of nutrients that become part of a diverse community of plants and aquatic bacterial ecosystem.

After this process, the surface water of the ponds is free between 70 and 85% of chemical or biological oxygen demand, which are appropriate standards for the release of these surface waters into nature so that the latter can absorb Hazardous waste for the environment and its species.



There are other forms of ponds for the treatment of waste water, according to their form of operation can be classified in:

• Aerobic oxidation ponds (aerated): When there is oxygen at all depth levels.

• Anaerobic oxidation ponds (without aeration): when the organic load is so great that the fermentation without oxygen predominates.

• Facultative oxidation ponds: it is the case that it operates as a mixture of the two above, the aerobic top and the anaerobic bottom.

• Finishing ponds: These are those used to improve the quality of effluents from treatment plants.

There are many unfounded myths and fears about oxidation ponds, but they have many years of successful operation in the United States, Europe and Central and South America. Oxidation ponds are particularly appropriate because of their low cost and the simple method of building and maintaining them.

Properly designed and constructed, treatment ponds can effectively remove most of the contaminants associated with municipal and industrial wastewater and rainwater. Treatment swamps are especially effective in eliminating problems and pollutants such as the Biological Oxygen Demand (BOD), however, there are other pollutants that can be treated by this system of oxidation ponds such as suspended solids, nitrogen, phosphorus, Hydrocarbons and metals. Oxidation ponds are also an effective and safe technology for water treatment and recirculation if properly maintained and operated.

Oxidation ponds can be built and operated in a variety of geographic areas, including arid, tropical and mountainous regions. Even sewage with high levels of waste can be treated in extreme climatic conditions where freezing occurs. These projects can vary widely with respect to size, shape and location, with the main limiting factor being sufficient land available.

Maintenance associated with swamps for treatment is usually limited to control of invasive aquatic plants and vectors (e.g. mosquitoes). Vectors are controlled by practices known as Integrated Pest Management (IPM), for example by introducing mosquito fish or by creating habitat for swallows or other insect predatory birds. Sediment accumulation usually does not present as a problem in an oxidation lagoon that has been well designed and operated so very rarely or ever do you need to dredge these ecosystems.

SYSTEM BY ACTIVATED SLUDGE

Activated sludge is a treatment process whereby wastewater and biological sludge (microorganisms) are mixed and aerated in a tank called aerator, the biological flocs formed in this process are sedimented in a sedimentation tank, where they are recirculated back to the aeration tank.

In the process of activated sludge, the microorganisms are completely mixed with the organic matter in the residual water so that they serve as food for their production. It is important to indicate that the mixing or agitation is performed by mechanical means (surface aerators, blowers, etc.) which has dual function 1) produce complete mixture and 2) add oxygen to the medium for the process to develop. The schematic representation of the process is shown in the diagram below.

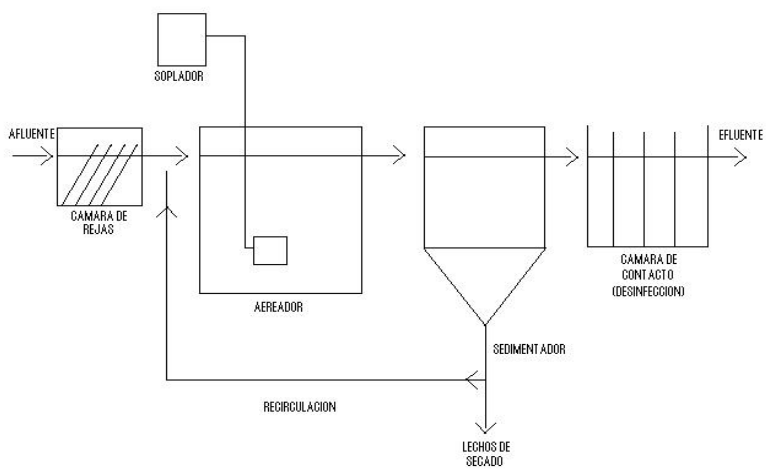


DIAGRAMA DEL PROCESO DE LODOS ACTIVADOS

Basic elements of activated sludge process facilities:

- Aeration tank: Structure where drainage and microorganisms (including return of activated sludge) are mixed. Biological reaction occurs.

- Sedimentation tank: The mixed drainage from the aeration tank is sedimented by separating the suspended solids (activated sludge), obtaining a clarified treated drainage.
- Aeration equipment: Injection of oxygen to activate heterotrophic bacteria.
- Sludge return system: The purpose of this system is to maintain a high concentration of microorganisms in the aeration tank.

A large proportion of sedimentable biological solids in the sedimentation tank are returned to the aeration tank.

- Excess of sludge and its disposal: The excess of sludge, due to bacterial growth in the aeration tank, is eliminated, treated and disposed.

BASIC OPERATION

a) Pretreatment / Adjustment of Wastewater

In some cases, the wastewater must be conditioned before proceeding with the process of activated sludge, this is because certain elements inhibit the biological process, some of these cases are:

Harmful substances to microbial activation (e.g. Cl2).

Large solid quantities -> Use of screens or grids, primary sedimentation tank (easily sedimented solids)

Wastewater with abnormal pH values -> Indispensable neutralization process.

Drains with large fluctuations in wastewater quality and wastewater including BOD concentration -> Equalization tank

b) Removal of BOD in an Aeration tank.

The raw sewage mixed with the activated sludge returned from the final settler tank is aerated to obtain 2 mg / l of dissolved oxygen or more, in this process a part of organic matter contained in the drains is mineralized and gasified and the other part is Assimilated as new bacteria.

3).- Liquid solid separation in the Sedimentation Tank

The activated sludge must be separated from the mixed liquor from the aeration tank. This process is carried out in the sedimentation tank, concentrating them by gravity. The purpose of this process is:

A) Obtain a clarified effluent with a minimum of suspended solids

B) Ensure the return sludge.

c)Unload of excess sludge

In order to maintain the concentration of the activated sludge in the mixed liquor at a certain value, some of the sludge is removed from the system to drying beds or thickeners followed by mechanical filters (press filters, tape filters etc.) for later dispose the dry sludge as solid residue.

An aspect related to the separation of sludge is the biological flocs of activated sludge, these are composed of heterotrophic bacteria and are the main element for purification, have two important characteristics in the process:

1). Efficient removal of organic matter.

2). Efficient separation of solids.

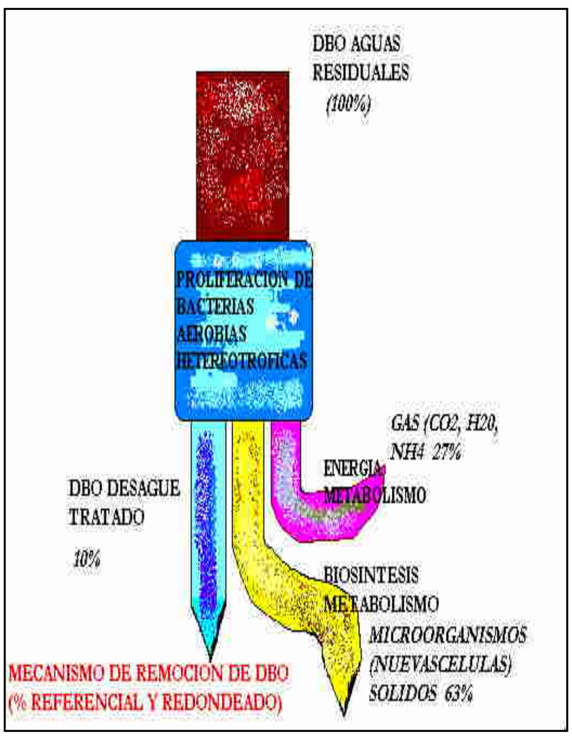
Bacteria

Bacteria play a preponderant role in biological treatment. Bacteria are classified according to their biochemical characteristics

a) Classification by source of energy and coal:

CLASSIFICATION	ENERGY SOURCE	ORGANIC COAL
AUTOTROPHY: Photosynthetic Chemimetry	------------------------------------ --------------------------------------- - Light Reaction Oxidation-Reduction Inorganic	------------------------------------ ------------ CO2 CO2
HETEROTROPHIC	Reaction Oxidation-Reduction Organic	ORGANIC COAL

b) Classification by way of life



1 - Suspended growth, with the existence of organic flocs (activated sludge).

2 - Adherent growth where the bacterial growth takes place in a support medium (stones, artificial PVC medium). Used in processes with percolator filters.

c) Classification by use of oxygen

Aerobic organisms exist only when there is a source of molecular oxygen.

Anaerobic organisms whose existence is conditioned to the absence of oxygen.

Facultative organisms have the ability to survive with or without oxygen.

OTHER MICROORGANISMS

These are animals, plants and protists, as a whole compared to the bacteria almost do not contribute to the purification process, but given that their size is more easily identifiable, they serve as indicator organisms in the control and management of the activated sludge process.

Basically, the removal of organic matter in wastewater is produced by two processes:

- Mineralization (gasification) by action of heterotrophic bacteria and by biosynthesis or growth of bacteria.
- Biological synthesis: manifested as the adsorption of substances from wastewater metabolized and manifested as new (cells) microorganisms.

Description of some variations of the activated sludge process:

Contact stabilization: In this system, the residual water and the activated sludge is mixed briefly (20 - 30 minutes), time necessary for the microorganisms to adsorb the organic contaminants in solution, but not that necessary for them to assimilate in the organic matter. The mixed liquor is sedimented and transferred to another aeration tank for a period of 2 to 3 hours and then mixed with the tributary by entering the first aeration tank.

Staged Aeration: This modification consists of the waste water flow being introduced into the aerator tank by several points.

In the feeding points, the demand for oxygen in the aerator is spread, resulting in a greater efficiency of oxygen use.

Extended aeration: Your flow chart is essentially the same as a complete mixing system except you do not have a primary settler.

The hydraulic retention time varies from 18 to 36 hours. This aeration period allows the wastewater and sludge to be partially digested in the aerator tank, allowing its disposal without the need for a large digestion capacity. One variation of the extended aeration system is the so-called oxidation trench.

6.4 Problems related to water

The rainwater collection systems date back to historical times, in the region of Mesopotamia have records with more than 5000 years. At the beginning of this century these systems for domestic use lost their importance due to the rapid growth of cities and water distribution systems at the household level.

In some regions of the countries of Latin America and the Caribbean for more than three centuries Rainwater Collection Systems have been used where the collection of water from roofs is stored in cisterns of different types and materials, which still represent the main source of water for domestic use.

In the colonial era, it was common to design various rainwater harvesting systems on haciendas, convents and dwellings; Vestiges of these technologies are observed in the convents of Santo Domingo (Oaxaca, Mexico), Acolman (Mexico City) and Zacatecas (Zacatecas, Mexico).

In the State of Campeche, Mexico, the use of rainwater is common for human consumption, since drinking water in cities contains high concentrations of salts and causes kidney stones. In contrast, in several countries, there is still a system of tank carts and tank tanks that distribute drinking water to various population centers, which represents a considerable expenditure by users, although it is sometimes subsidized by Government institutions.

6.4.1. The world dies of thirst

By 2025, 3 billion people may lack the basic requirements of vital water. Likewise, it is foreseeable that water becomes one of the main issues of conflict throughout this century; There is an urgent need to respond to Millennium Development Goal 10, which addresses the problem of water scarcity.

Freshwater distribution

The quality of water is a characteristic of vital importance in human consumption and domestic use, hence its preservation and management must be a constant concern of users and authorities.

The contributions of the hydrological cycle do not offer guarantees to the humanity, since only two thirds of the world population lives in zones that receive a quarter of the annual precipitations of the world. For example, 20% of the world's average annual run-off corresponds to the Amazon basin, a vast region with less than 15 million inhabitants, or a tiny fraction of the world's population. Similarly, the Congo River and its tributaries account for 30% of the annual runoff of the African continent, but that river basin contains only 10% of the population of Africa. More than half of the global runoff occurs in Asia and South America (31% and 25%, respectively). But if per capita availability is considered, North America has the largest amount of freshwater available, with more than 19,000 cubic meters per capita per year. In contrast, the per capita amount is barely more than 4700 cubic meters (including the Middle East) in Asia.

In Africa and the Middle East, regions of the world that face absolute water shortages or severe seasonal ones, are characterized by their high rate of population growth. In sub-Saharan Africa, the population is growing by 2.6% per year; In the Middle East and North Africa, at 2.2%. These population growth rates have serious implications for the per capita water supply.

At the "Fourth World Water Forum" held in March 2006 in Mexico City, commitments were made between all participating countries to provide water for all inhabitants of the planet in quantity and quality. Among the challenges of the millennium, the most important are self-sufficiency in water, food and environmental education.

Water stress and water shortage

As the population grows, the number of countries facing water scarcity increases. A country experiences water stress when the annual water supply drops to less than 1,700 cubic meters per person. When it falls to levels of 1,700 to 1,000 cubic meters per person, limited water conditions can be predicted and when annual water supplies fall below 1,000 cubic meters per person, the country faces water shortages; A situation that threatens food production, hampers economic development and damages ecosystems.

Water scarcity is considered to occur when demand exceeds supply, where population growth or practices that require excessive amounts of water, such as agriculture, are influenced. Currently, 70% of the world's total fresh water is used to produce food and fiber. It is a recent phenomenon, in 1950 no more than ten countries had this problem, in 1995, 31 countries with a combined population of more than 458 million inhabitants, faced water stress or water shortage. This represents an addition of only three countries since 1990, when 28 countries with a population of 335 million in total experienced water stress or water scarcity. But the number of people living in countries with water stress and water scarcity increased by almost 125 million in five years. The projection indicates that by 2050, sixty-six countries comprising two-thirds of the world's population will face this problem, water scarcity. The consequences of this phenomenon are social, economic, political and ecological (Figure 1.1).

Competition for fresh water supplies produces social, economic and political problems. River basins and other bodies of water do not respect national boundaries. For example, the use of water by an upstream country often ignores the supply available to downstream countries. At the dawn of the 21st century, there is a growing danger of armed conflicts arising from access to freshwater supplies.

It is worrying to observe the costs of water in different parts of the world, in Malaysia a cubic meter of water costs $ 20 USD, instead in the USA. The cost is $ 0.10-0.15 USD which indicates that a poor country pays up to 200 times more than a rich country. Bottled water has reached values per liter higher than those of milk and gasoline; So it can be considered that the increasing water scarcity will bring catastrophes of international level such as: war, famine, poverty and migration.

Here are some examples of how water scarcity is affecting countries around the world, as well as the conflicts that can be generated in: India, China, Middle East and Sub-Saharan Africa.

Consumption has tripled since the mid-twentieth century; Rich countries consume, on average, 12 times more water than poor countries. The UN argues that major European cities lose up to 80% of the water due to leaks in their pipelines. In Jakarta, Indonesia, more than $ 50 million is spent every year on boiling water for domestic use. 78% of rivers in China contain non-potable water, according to the government itself. Of the developing countries, more than 90% of the wastewater goes directly to lakes, rivers and coasts, without prior purification. Of the 3,119 cities in India, the second most populous country on earth, only eight currently have a complete wastewater treatment and treatment system.

The supply of fresh water is increasingly limited for the various communities, in millions of them will never reach the potable water network, the inadequacy of this natural resource will affect the economic development of many countries in the coming decades.

Huge amounts of water are being misused through inappropriate agricultural subsidies, inefficient irrigation systems, inadequate pricing, inefficient watershed management and other unsuitable practices.

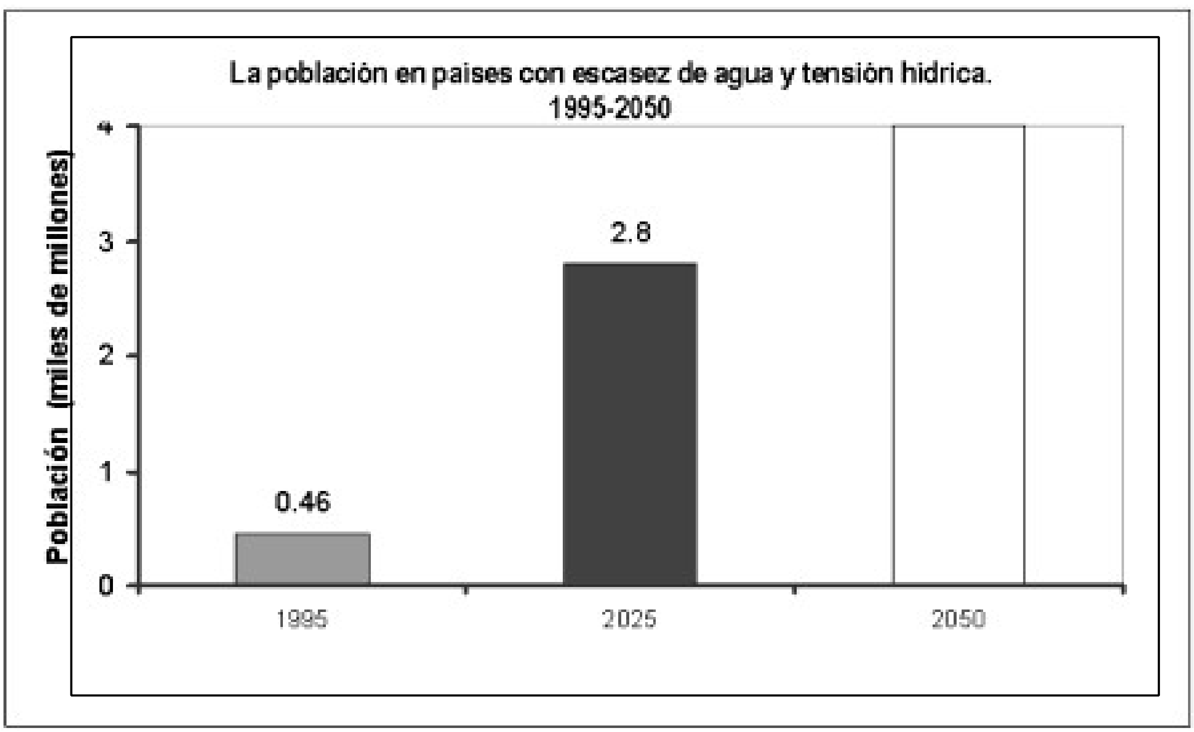


Figura 1.1 Tensión hídrica y escasez de agua.

Source: GARDNER-OUTLAW, T. and Engleman, R. (1997) "Sustaining water, easing scarcity: A second update." Washington, D.C., Population Action International, P.10

The water crisis

By the year 2025, approximately 48 countries, more than 2800 million inhabitants, will be affected by the scarcity of water. Nine other countries, including China and Pakistan, will be close to suffering from water shortages. Beyond the impact of population growth itself, freshwater consumption has been increasing in response to industrial and agricultural development, so that the growing demand of the population has tripled in this way the extraction of water has been overexploited. In addition, the supply of fresh water available to mankind is being reduced by constant contamination of water resources; It is worrying and alarming to observe the discharge of waste water to surface water bodies and the infiltration of agrochemicals to aquifers. (Anaya, 2001)

As population increases, the demand for fresh water for food production, industrial uses and mainly for domestic uses increases; In addition, for electric power generation, aquaculture, fishing, recreation, tourism, navigation, among others. The availability of fresh water imposes limits on the number of people that can inhabit an area and influences the standard of living. If requirements are consistently higher than available supplies, at some point overexploitation of surface and groundwater resources will lead to chronic water shortages (Figure 1.2).

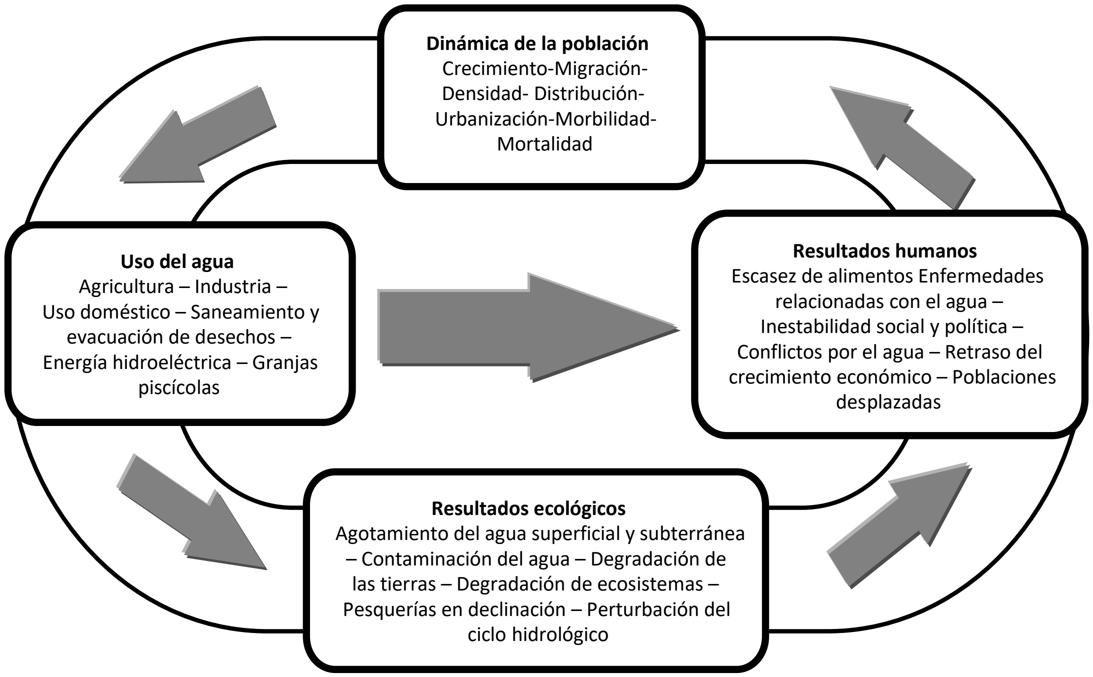


Figure 1.2 Links between population and freshwater.

Source: World Conservation Union (IUCN), (1996), PRB and USAID.

Water has been, is and will continue to be one of the most important renewable natural resources for the development and survival of humanity, its conservation will depend on the management that is given to it.

Water scarcity at the international level

Due to the increasing population explosion, the scarcity and deterioration of water quality is affecting the health and well-being of the population in developing countries (Guhl, 2006). Currently, 31 countries in Africa and the Middle East face severe limitations in relation to this vital liquid.

Declining fresh water in adequate quality and quantity is emerging as one of the most critical problems facing mankind, water is being extracted from rivers, lakes and aquifers more quickly than it takes to renew bodies of water. Another major problem is pollution that significantly affects water quality.

Rainwater, an essential component of the hydrological cycle, represents an element that should be fully exploited because it has undergone a natural purification process.

70% of the earth's surface is water, most of it is oceanic. In volume, only 3% of all the world's water is fresh water, and is generally not available in its entirety. Three-quarters of the fresh water is inaccessible in the form of ice caps and glaciers located in polar areas far removed from population centers; Only 1% is usable fresh surface fresh water. This is primarily the water found in lakes and rivers, shallow in the ground, from which it can be extracted without cost. The groundwater thus forms the second reservoir in order of importance. The average water reserve in riverbeds is low (0.006%), while the waters of all lakes and marshes represent only 0.29% of the total

This indicates that despite the enormous amounts of water in the world, it is not available uniformly in all regions. Only that amount of water is usually renewed with rainfall and snowfall, is therefore a sustainable resource (Figure 1.3). In total only one hundredth of one percent of the world's water supply is considered easily accessible for human use.

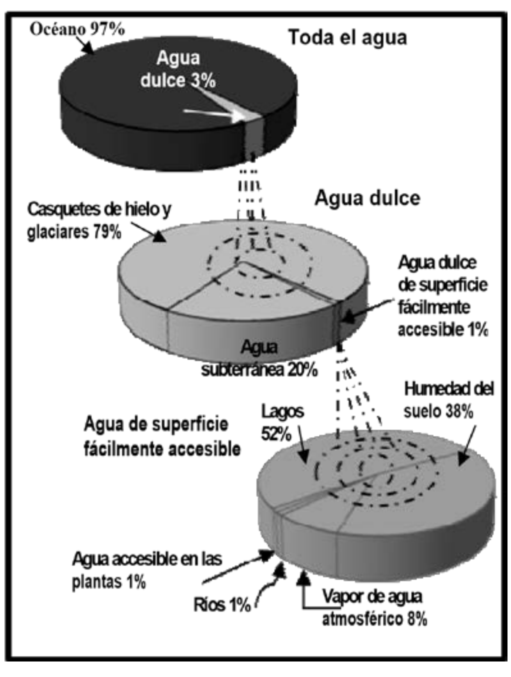


Figure 1.3 Distribution of water in the world.

Source: LEAN, G. and HINRICHSEN, D. (1994).

History of water supply and sanitation in Latin America and the Caribbean

In Latin America, the Mayas, Aztecs and Incas used Rainwater Harnessing and Utilization Systems that are still observed but not massively applied. The Aztecs and the Mayas developed technologies on the efficient use of rainwater; However, these have not been used on a large scale. The availability of water also shows significant differences within countries. The main priority of humanity is the availability of safe water, followed by food (4th World Water Forum, 2006).

Situation in Latin America and the Caribbean

The region of Latin America and the Caribbean is very rich in water resources. The Amazon, Orinoco, Sao Francisco, Paraná and Magdalena rivers transport more than 30% of the world's surface water. With 12% of the land area and 6% of the population, the region receives about 27% of the total runoff, mostly concentrated in the Amazon basins. However, the water supply of the region presents significant variability between sub-regions and localities, as well as in seasonal terms.

Two-thirds of the region is classified as arid or semi-arid, which includes large parts of central and northern Mexico, northeastern Brazil, Argentina, Chile, Bolivia, and Peru. The island of Barbados in the Caribbean is among the most arid countries in the world, and the island states of this sub-region have a considerably lower water resource per inhabitant than other island groups in the world (Gallardo, 2002).

Over the last decade, water-related environmental problems have increased in both urban and rural areas. Houses are still being built in sensitive areas and with high slopes in areas with aquifers. Freshwater resources are damaged while increasing demand for water. On the other hand, the use of contaminated water for drinking and bathing, spreads infectious diseases such as cholera, typhoid and gastroenteritis (UN, 2006, PAHO / WHO, 2005).

Contamination with fertilizers and pesticides, deforestation, sewage, dam construction and irrigation systems can severely affect the morphology of river basins, river system hydraulics, water quality and coastal resources in Latin America And the Caribbean. Agriculture contributes to water pollution, at the same time a victim of this problem. It contributes to it in that it releases pollutants and sediments into surface or groundwater; Improper cultivation practices lead to soil loss, contribute to salinization and lack of drainage in irrigated lands. But it is also a victim, because it must use contaminated surface and ground water that affects the quality of the harvests, in that way it transmits diseases to the producers and to the consumers.

Water availability in Latin America and the Caribbean

Water, especially to meet human needs and for uses of agriculture, is now and in the future a strategic element that must be regulated on a clear and sustainable basis from the point of view of access, financing, health and conservation.

The current population in Latin America and the Caribbean is approximately 550 million inhabitants; In general, the region presents good levels of water services; However, water supply covers about 85% of the population, while water sanitation covers 78%; Thus, 87% of the urban population has good water sanitation, but only 49% of the rural population has it. (Anaya, 2001)

In Haiti, water remediation accounts for only 28% of the population, and 46% of the vital water supply is urban and rural, and is the most affected country in the region. In contrast, the British Virgin Islands, Barbados and Montserrat have almost 100% in relation to the water supply to the population.

In the case of Mexico, water supplies cover 94% of the urban population and only 63% of the rural population; In relation to sanitation, it reaches 87% of the urban population and only 32% of the rural population. Another interesting case is Brazil, with a population of 170 million inhabitants where water supply reaches 95% of the urban population and only 54% of the rural population; In the case of sanitation, it reaches 85% of the urban population and only 40% of the rural population (CONAPO, 2005).

Rainwater harvesting systems (SCALL) for domestic use have cisterns constructed of various materials which represent an option to cope with water scarcity. Most of the countries in the region use rainwater collection technologies for roofs and floors, some (Virgin Islands, Barbados and Turks and Caicos Islands) have legislation and regulations to capture rainfall, achieving self-sufficiency.

Urban areas in Latin America and the Caribbean have potable water networks, although deficiencies in supply and sanitation exist in some countries. What is worrying is the rural areas where lack of water and sanitation causes gastrointestinal diseases and deaths in children and adults.

One of the solutions to address the shortage of drinking water is the efficient use of rainfall, i.e. rainwater, since one millimeter of rain equals one liter per square meter. Although there are techniques for collecting and using rainwater generated over 5000 years ago, they are not applied in a massive way, which leads to the reflection that traditional knowledge has not been rescued and applied. About 1.4 billion people worldwide lack access to piped water, one of the millennium goals is addressing this growing problem; However, to date, adequate, fast and economical solutions have not been implemented.

In the region of Latin America and the Caribbean, about 80 million people do not have access to piped water. This indicates the urgent need to consider rainwater as a solution to address the water supply at the family level and at the community level. It is possible to collect, store, purify and pack rainwater, as demonstrated by the International Center for Demonstration and Training in Rainwater Harvesting at the College of Postgraduates (CIDECALLI-CP).

CHAPTER VII

CALCULATIONS

CHAPTER VII

7. CALCULATIONS

D- 1 BOILER DISCHARGE CALCULATIONS. - The purge rate of a boiler is a critical performance check on the total solids dissolved (paragraph 4 - 4c)

A). The water added to the boiler must match the loss of water

F = E + B

Where:

F: pound of feed water / hour

E: pounds of steam generation / hour

B: pounds of purge / hour

B). The purge may be related to feed water using the cycles of concentration

C + E / B, or f = B x C

Where: C: cycles of concentration

F: pounds of feed water / hour

B: pounds of purge/ hour

It is common to express the purge as: % B = 100 / C

C). The relationship between feedwater purge, steam generation and cycles is represented as:

B = E / (C-I)

It is derived as follows:

(1) F = B x C (paragraph C - 1b)

(2) F = E x B (paragraph C-1a)

(3) B x c = E + B (replacing F in equation 2 with equation 1)

(4) B x C - B = E (replacing equation (3))

(5) B x (C - 1) = E (replacing equation (4))

(6) B = E / (C-1) (replacing equation (5))

D) The purge is never measured, but it can be calculated whether two quantities of feed water, cycles or steam generation are known. Concentration cycles can be determined by comparing the concentration of solids dissolved in the boiler water with the concentration in the feed water. The cycles can be calculated (note that the purge concentration is the same as the boiler concentration):

$$C = \frac{B_s}{F_s} \ o\ C = \frac{B\ \ mmh0}{F\ mmh0}$$

Where:

C = cycles of concentration

Bs = TDS erased, ppm

Fs. = TDS feed water, ppm

B mmho = conductivity of puring, micrometer

F mmho = conductivity of feeding water, micromho

D - 2 DETERMINATION OF WATER SUPPLY REQUIREMENTS

The purge calculations in paragraph D - 1 can be used to determine feed water requirements. Note that the feed water means the water that is supplied from the boiler and includes the make-up and return of the condensation.

a) Example D - 1. A 250-psi boiler operates at a conductivity level of 5500 mmho (see paragraphs 4-5 for guidance on the maximum permissible level). The feed water of the boiler has a conductivity of 275 mmho the concentration cycles are calculated as follows:

.

$$C = \frac{B}{F} = \frac{5500}{275} = 20$$

b) The percentage of the purge is:

$$\% LB = \frac{100}{C} = \frac{100}{20} 5\%$$

D – 3 DETERMINATION OF MAQUILLA REQUIREMENTS

Makeup is the water from the external water treatment system supplied to the deaerator, the criteria for the makeup treatment are covered in section 4 - II

a). Make-up is the difference between the return of the condensate and the feed water

M = F-R

Where: M =pounds of makeup / hour

F = pounds of feed water / hour

R = pounds of condensate return / hour

b). The condensate will not have any appreciable level of dissolved solids (or conductivity) unless there is a source of system contamination. This allows the percentage of makeup to be determined using the equation:

$$\%M = \frac{F}{M}\ x\ 100$$

Where: % M = makeup percentage

F mmho = conductivity of feed water, micromho

F mmho = conductivity of the makeup, micromho

c). Example D - 2. The conductivity of the makeup is 610 mmho for the cauldron in Example 4 -1. The makeup percentage is calculated

$$\%\ M = \frac{F}{M}\ x100 = \frac{275}{610} = \frac{275}{610}\ x100 = 45\ \%$$

(1) This means that makeup is 45% of the feed water. Calculate the return percentage of condensate

% R = 100 -% M = 100 - 45 = 55%

(2) The amount of makeup is calculated

$$= \frac{\%M}{100}\ x\ F = \frac{45}{100}\ x45,105 = 18{,}947\ pounds/hours$$

(3) The amount of condensate return is calculated

R = F - M = 42.105 - 18.947 = 23.158 pounds / hours

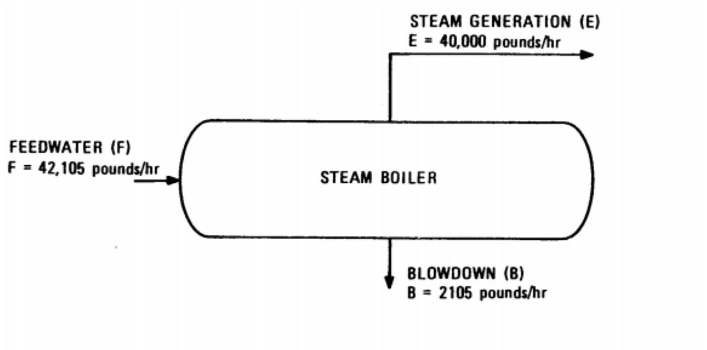


FIGURE D-1. EXAMPLE OF BOILER FEEDWATER, STEAM GENERATION AND BLOWDOWN RELATIONSHIPS

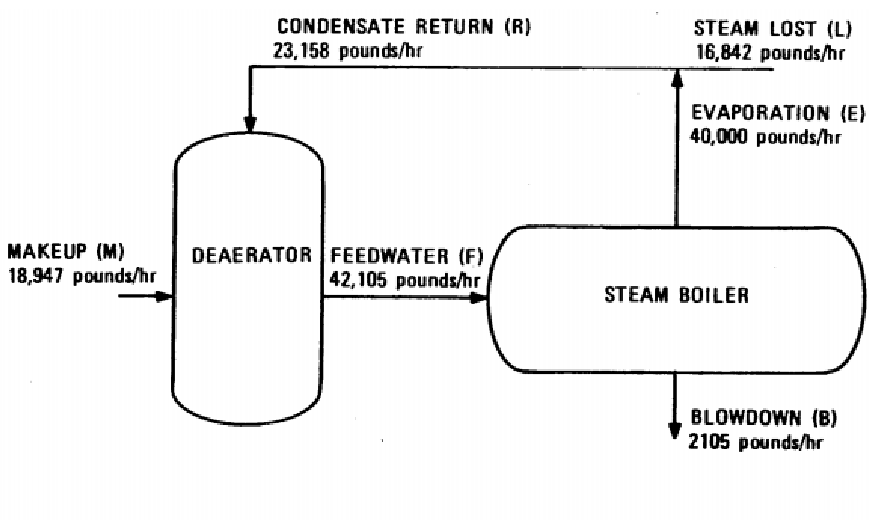


FIGURE D-2. EXAMPLE OF BOILER CALCULATIONS d). The difference between the vapor produced and the condensate returned is due to the vapor or condensate lost in the system. These losses can include leaks or steam consumption by the process equipment. Losses can be calculated as follows:

$$L = E\text{-}R$$

Where: L = vapor or condensate losses, pounds / hours

E =pounds of steam generated / hour

R = pounds of condensate return / hour

e). Example D-3, the steam and condensate losses for the boiler described in examples D-1 and D-2 can be calculated

$$L = E\text{-}R = 40{,}000 - 23{,}258 = 16{,}842 \text{ pounds / hour}$$

(1) this relation and the information of the previous examples are presented in figure D - 1 and figure D - 2

f). The monitoring of the system for solids generated and dissolved in the steam, and performing these calculations at a regular interval will provide a basis for evaluating the performance of the boiker system. An increase in vapor and condensate loss may indicate the development of a new leak or an increase in existing leakage. These calculations can provide a good basis for estimating steam savings from maintenance efforts

D - 4 DETERMINATION OF CHEMICAL TREATMENT REQUIRED

Chemical treatment programs involve the selection of the type of chemical to be used and the establishment of a level of treatment. These factors are discussed in paragraph 4-7. Blowing calculations can be used to determine the number of chemicals that need to be added to the target treatment.

A). Example D-4 the boiler in examples D-1, D-2 and D-3 must be operated with a phosphate level of 60 pm in the water in the boiler. The purge has been determined to be 2,105 pounds per hour. The addition of phosphate needed daily should be equal to the phosphate that is discharged with the purge. This is calculated as follows:

Phosphate losses = B x level = ($\frac{2.105\frac{lb}{dia}\,x\;24\frac{hr}{dia}\,x\;60\;ppm}{1,000,000} =$

$3.03\ 5\ pounds\ of\ phosphate\ per\ day$

The treatment chemical contains 40% phosphate, which means that there are 0.4 pounds of phosphate per pound of chemical.

Loss of phosphate required per chemical divided by 0.4

= 3.03 = 7.58 pounds / day = 0.4

CONCLUSIONS

• An adequate water treatment process reduces scheduled preventive maintenance shutdown times, increasing the overall effectiveness of the plant.

• Due to water scarcity and population increase, and as a result of increased water demand, it should be mandatory for thermal plants and other industries to have wastewater treatment plants.

• In order to guarantee the proper functioning of the equipment of the thermal plant, samples must be taken and the boiler feedwater analyzed continuously.

• The processes of water circulation, treatment, boiler bleed, steam flow, must be automated.

• The demands on water quality for boilers are much more demanding than those required for human consumption.

• Adequate treatment should be sought to minimize the number of unscheduled stops for corrective maintenance.

• The reverse osmosis process is of greater effectiveness than the ion exchange process.

BIBLIOGRAPHY

- Water catalog for the industry of Ondeo IS.
- Performance Analysis of Automated Control System for Condenser Water Treatment Unit - Department of Mechanical Engineering, College of Engineering, Umm Al-Qura University.
- Water Treatment Program Training Manual First Edition.
- Appendix D of Boiler Water Calculation.
- Energy Efficiency Handbook - Council of Industrial Boiler Owners