Material Selection

Utilities

Cooling Water Unit Description

Purpose of cooling water is to cool down hot stream

Cooling water unit components
- Cooling towers. to reduce returned cooling water by means of heat transfer between air and hot returned cooling water
- Chemical package: to protect piping against corrosion and keep PH in the range
- Pumps: to supply cooling water to process units.
- Filters: to remove particles from cooling water stream.
- Ponds: to store/ hold-up cooling water

Now let's detail it:

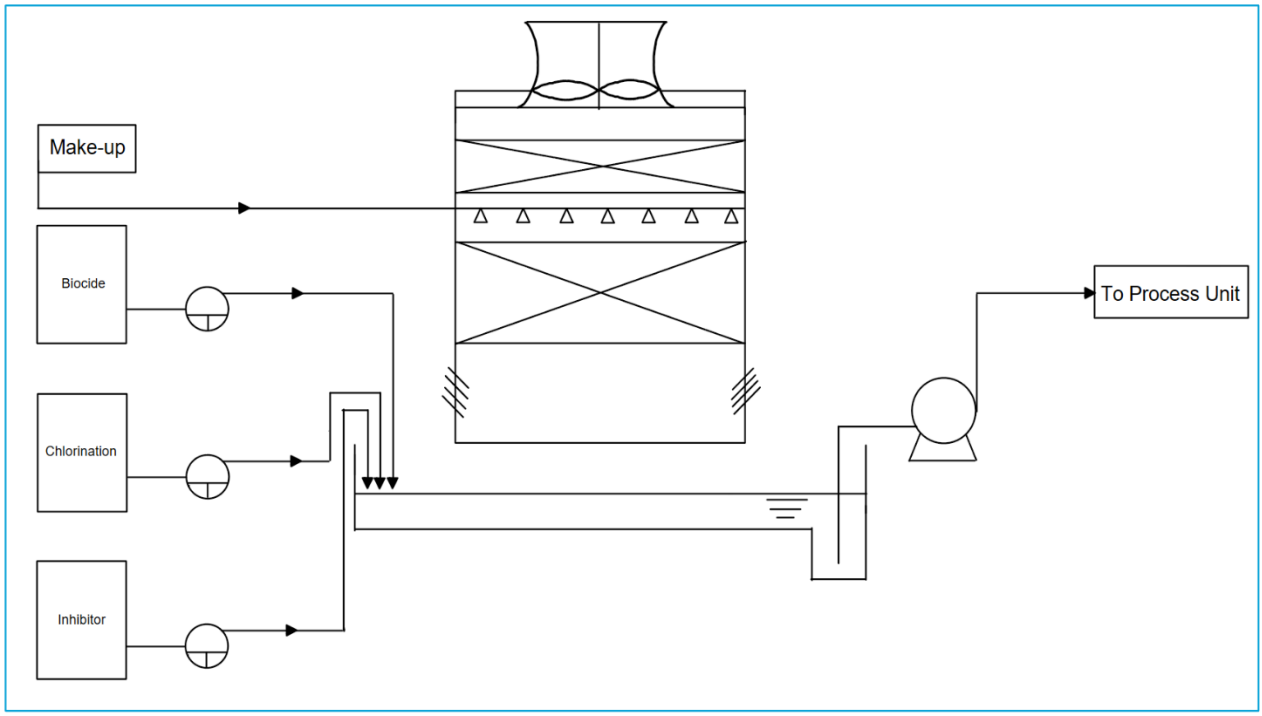
1. Cooling towers
- In order to increase heat transfer between air and hot returned cooling water, it is anormal practice to install packings.
- In order to take out the air we need to have a fan

Chemical package
- we need to have a dosage of chlorination to remove bacteria/ algae, a dosage of corrosion inhibitors to prevent corrosion, a dosage of dispersant to prevent agglomeration
- Since we need to store them, we need storage tanks for each chemicals
- We also need to pump the chemicals; therefore, we need pumps. Note that for chemicals it is a normal practice to use reciprocating pumps.

3. Make-up water
- Since we have evaporation, we need to add water to returned water to make up for the loss.
- In order to control its flow rate, we need a control value to regulate the flow. Notice that in control rooms we check level of Pond 1 (basin) instead of flow; thus we use a It not a FV

4.Pumps

- Since the demand of cooling water from process units is very high (5000-40000ton/hr.), then we need minimum 2 pumps.
- Because of energy optimization, it is a normal practice to use turbine-driven pumps alongside motor-driven pumps.
- We also need a circulation pump to send a part of cooling water to filters.

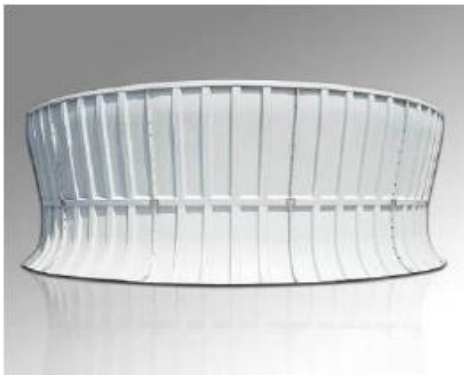


Material Selection

1. Cooling tower components

1.1. Fan stacks: This profile of fan stack is designed on basis of the theory of air channel uniformity. The profile of fan stack consists of three section, suction section, work section, velocity recovery section. The suction section is designed as the ellipse profile in order to decrease the resistance due to suddenly decrease of air path; the air is draught upper by fan at the work section. Some of velocity of exhaust air at velocity section is recovered due to the specially designed profile. So, it can greatly increase the power consumption of the fan, save the operation cost.

Material of construction: Fiberglass reinforced polyester (FRP)

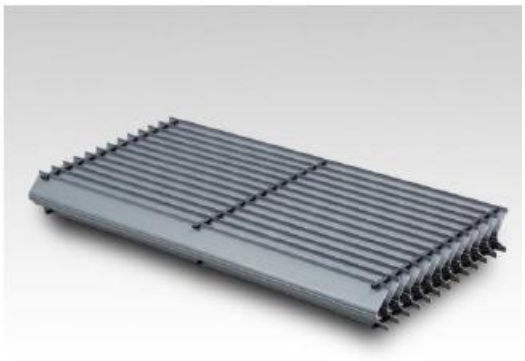


1.2. Fans: Axial flow fans are mounted for promoting airflow capacity for enough heat exchange which shall consists of multiple, manually-adjustable blades connected to an epoxy painted steel hub and gear reducer. These fans are of high efficiency, low noise, designed specially for cooling tower operation.

Material of construction: FRP

1.3. Drift eliminator: Their function is to greatly decrease the drift loss.

Material of construction: Advanced PVC with additive to improve the performance of resistance ageing and anti-ultraviolet.



1.4. Water distribution system: The optimized design of water distribution system is to distribute the water evenly on the filling plot area, and the water distribution pipe is designed on basis of hydraulic theory to minimum the head loss and to keep the same pressure for each nozzle which locates in different area, and ensure the uniformity of water distribution.

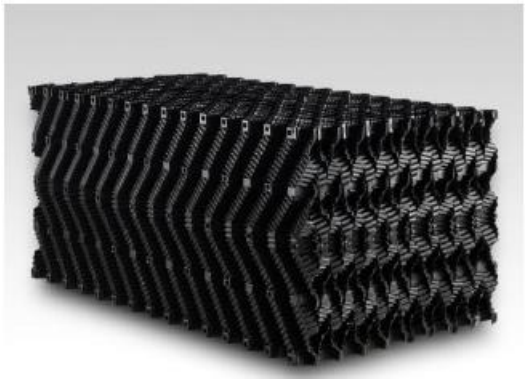
Material of construction: UPVC for branch pipe and ABS for spray nozzle. This kind of pipe has many advantages such as cold resistant, compress resistant, wearable, corrosion resistant, flammability resistant, lower flow resistance, strong strength etc.

1.5. Filling: Heat transfer is accomplished through film type fill formed of rigid polyvinyl chloride (PVC), resistant to decay and biological attack. Fill sheets shall be self-spacing, bottom support and will be supplied as nested sheets with glue.

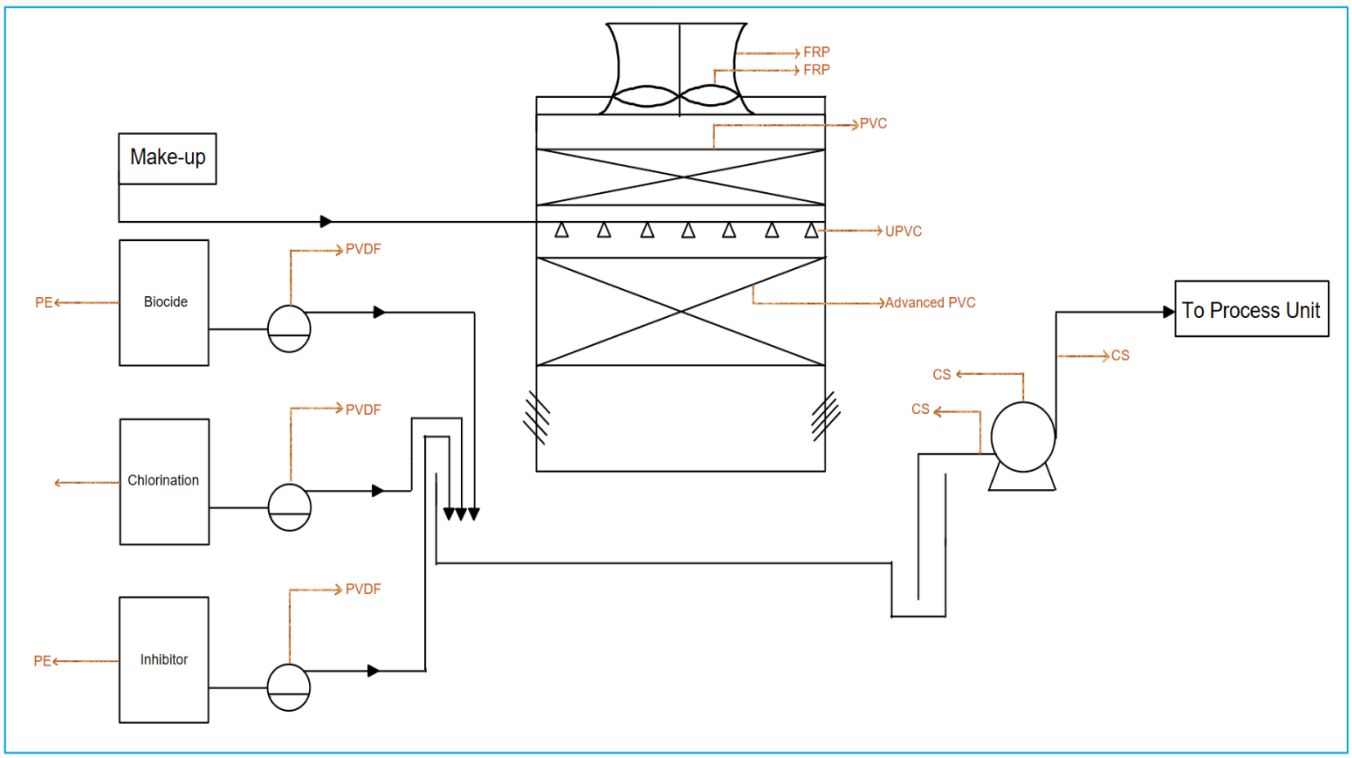
Material of construction: Advanced PVC

1.6. General notes:
To solve the corrosion problem completely in the concrete structure of cooling tower, the components inside of cooling tower shall be applied of the non-metal material as far as possible, for instance, the water distribution pipe is made of reinforced UPVC,

the filling, nozzle, and drift eliminator are made of plastic material, and fan stack is made of FRP. Furthermore, the application of non-metal also saves the cost for maintenance due to without maintenance regularly.



2. Piping
   Generally, CS is selected as the typical piping material.
3. Pumps: PVDF
4. Chemical storage tanks: PE



Polishing Unit Description

Purpose of polishing unit: to remove salt ions from condensate

Polishing wit components

- Cartridge filters: to remove large particles from water
- Resin (polymer-based material) to absorb ions such as Silica
- Heat exchanger: to protect resins against high temperature.
- Storage tanks: in order to store water we need storage tanks.
- Pumps: they are need to transfer and pressurize water
- Acidy Caustic soda storage tanks: to regenerate resins. Resins are saturated after a period of time.
- Pond: they are used to store waste from regeneration of resins.

Let's detail it:

1.Cartridge filters — Since we have high flow of condensate and plus, we have DMW from Outside Battery Limit (OSBL), then we need more than one for condensate, one for DMW, and standby for each.

2.Heat exchanger — Because of operating condition, it is efficient to use plate heat exchangers.

3.Intermediate Tank — Since water is going to be stored, then it is not toxic. Thus, we use atmospheric tanks.

4.Regeneration — We need to regenerate resins from time to time based on sequential procedure. In the procedure low concentrated acid should be used, otherwise, it might damage the resins. It means that we have to mix water with the acid before injecting the acid to mixed-ion exchanger. To do so, we need a pump to transfer water and a reciprocating pump to transfer acid. In addition, we also need a mixer to mix them.

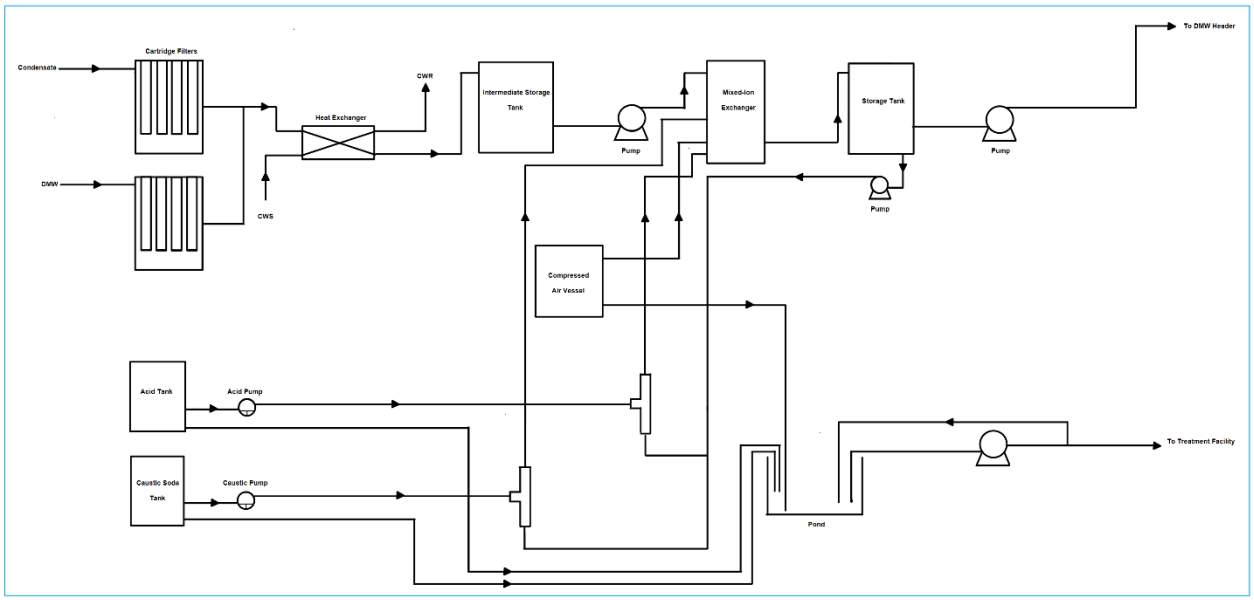
We need to regenerate resins from time to time based on sequential procedure. In the procedure low concentrated NaOH should be used, otherwise, it might damage the resins. It means that we have to mix water with the caustic soda before injecting the acid to mixed-ion exchanger. To do so, we need a pump to transfer water and a reciprocating pump to transfer acid. In addition, we also need a mixer to mix them.

5.Pond — The waste produced during regeneration of resins is discharged to the pond. Since the waste cannot be treated inside the plant, we have to use a pump in the design to send the waste water outside the plant.

5.Compressed air vessel — A part of the regeneration procedure incorporates air injection. So we need to have a compressed air vessel to supply the air.

The waste water which is going to be transferred to outside the plant, should be approximately neutralized. So we are supposed to also consider a pipe from caustic tank to the pond and a pipe from acid tank to the pond. To perform the mixing better we use two strategies, first, we consider a circulation route for the pump and secondly, we install pipes with holes at the bottom of the pond, through which the compressed air is injected and creates turbulency.

By considering the aforementioned, then our PFD becomes like next page:



Material Selection

Due to corrosiveness of DMW the general material used is SS. Now let's move with the process!

1.All of the piping used shall have a material of SS, typically SS304.
3.The material used for cartridge filters is SS, typically SS304
3. The material used for heat exchangers is SS, typically SS304 and the sealing material is EPDM
4.The materials used for DMW pumps casing and impeller are SS304

Tanks: For tanks it is normal practice to have CS as the base material and a liner rubber or resistant painting as protection against DMW.

5.DMW tank materials are generally CS but with internal painting resistant to DMW.

4.The material used for ion-exchange reactors is CS + Rubber Liner
6.The material used for caustic and acid tank is CS+ Rubber Liner
7.The material used for mixer is CS+PTFE

Cautions and Our Mistake

Don’t make the same mistake if you are designing a polishing unit!!

Regardless of the production pf a plant, whether it is methanol, ammonia or ethylene and so on, you always need a polishing unit to treat condensate. The most important part of a polishing unit is resin reactors. The resin absorbs cations and anions till it reaches its maximum capacity which is indicated by an increase in conductivity or PH or SiO2 content. Therefore, it needs regeneration from time to time.

Operational problem:
In order to regenerate the resins, acid and caustic with usual concentration of 1-4 % are used but the acid and caustic are purchased from other companies with higher concentration- caustic48% and sulfuric acid 98%- and then they are diluted with DM water to reach 1-4% concentration. When acid and DM water are mixed due to exothermic reaction and mixing process of these two components, after a while, transferring pipeline becomes corroded in different parts and creates operational hazard and halt the process. Note that according to sulfuric acid curve the highest corrosion rate occurs around 87-89% of sulfuric acid, not in 98%!!

Solutions and Precautions:
I have checked up to five polishing unit vendor documents and most of them had this problem but one of them less than others. Herein are the tips:

1. Augment process protection: it means that add more isolation valve before mixing point to prevent DM water from backflowing to acid line. Secondly, add more drain in different parts so that accumulated acid in pipeline after regeneration is drained properly. Lastly, use double check valve but different types according to API.

2. Utilize lining for part of the pipeline: the most common materials are PVDF, EPDM, Glass and PTFE.

Note that if you purchase 98% sulfuric acid, PVDF is not suitable for this application since according to compatibility chart it is not compatible with sulfuric acid with concertation higher than 93%.

Glass is resistant against sulfuric acid but according to their handbook they are brittle and does not possess sufficient mechanical strength. One company used it and after 5 months they had to replace it.

EPDM is suitable for application with acid concentration lower than 50%. Nonetheless, in one company it was used for lining of their check valves with higher concentration and it had worked well.

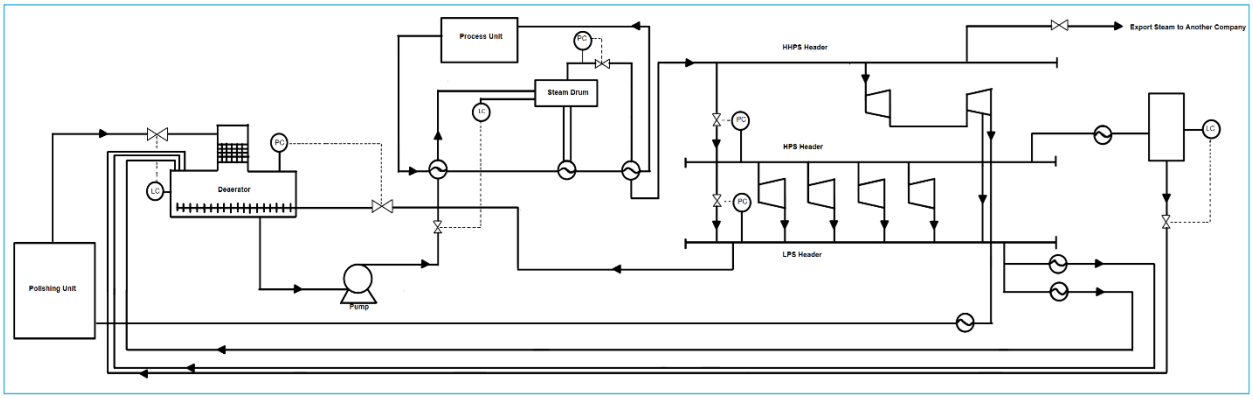
PTFE is suitable for all temperature and concentration rating of sulfuric acid.

My final recommendation is to design a part of mixing pipeline with PTFE lining, utilize a mixing of EPDM and PTFE for check valves and increase process protection. Do not make the egregious mistake by ignoring these precautions in order to optimize the cost!!

Steam System : to provide end-users with demanded steam condition.

Components of a steam system

- Deaerator: DMW produced in polishing unit now should be converted to boiler feed water (BFW) and then the BFW will go through steam drums and shell and tube heat exchangers and as a result steam is produced. In order to convert DMW to BFW, water quality should be improved. Oxygen should be removed, which is done by means of deaerator.
- Chemical Packages: In order to make sure that all oxygen is removed we are supposed to use oxygen scavengers. Also, in order to maintain PH, we use Amines. Lastly, we use scale inhibitors to prevent scale agglomeration in the steam drum and heat exchangers.
- BFW Pumps: They are the most important pumps in each process plant which supply BFW to steam drums. It is a normal practice to use turbine-driven pumps alongside motor-driven pump to manage energy in the unit.
- Steam Drum: Steam drum is used to distribute BFW to shell and tube heat exchangers to produce steam and then the saturated steam is freed from water droplet. It all happens in the steam drum.
- Heat Exchanger: The hot stream passes through tube And the BFW, through downcomers, comes down from steam drum to shell side. BFW receives the heat from tube side and becomes vapor and moves upward to steam drum.
- Superheaters: They are just shell and tube heat exchangers which are located after steam generators to simply superheat the steam by 50 to 100 C.
- HHP Header: It is simply a distributor of HHPS to end-users such as turbines.
- HPS Header: It is simply a distributor of HPS to end-users such as turbines and heat exchangers.
- MPS Header: It is simply a distributor of MPS to end-users such as heat exchangers.
- LPS Header: It is simply a distributor of LPS to end-users such as reboilers and deaerator.



Material Selection

Let's divide the system to different components:

1.Control valves
- 1.1. PV for HHPS: since the temperature is more than 427C, then based on valve body material selection design criteria, A217 WC6 is selected.
- 1.2. PV for HPS and LPS: since the temperature is less than 427C, then based on valve body material selection design criteria, A216 WCB/WCC is selected.

2.Piping
- 2.1. Since here we are dealing with non-corrosive application, then based on the Table A-2 CS as base and A106 as detail is selected.

3.BFW pump

Based on Table A-2, since the temperature is less than 230C and we are dealing with non-corrosive application, then CS is selected.

4.Deaerator
- 4.1. Dome: Since the oxygen is de-aerated from this section, it is mandatory to select SS or in detail SS304 min. as the material.
- 4.2. Packed bed
  - 4.2.1. Inlet distributor: Since here we are dealing with showering of DMW via distributor, then the material should be SS304.
  - 4.2.2. Packings: The same applies here. SS is selected.
  - 4.2.3. Support grid: The same applies here. SS304 is selected.
- 4.3. Vessel

  Since chemicals like oxygen scavenger and LPS are added, the water in this part is considered as treated water and as a result, CS could be selected.

5.Steam turbine

Based on the Table A-2, CS is selected.

6.Heat Exchangers

Based on the Table A-2, CS is selected for tubes, baffles, and channels.