## Coagulation principles

**Coagulation** destabilizes the particles' charges. Coagulants with charges opposite to those of the suspended solids are added to the water to neutralize the negative charges on dispersed non-settable solids such as clay and organic substances.
Once the charge is neutralized, the small-suspended particles are capable of sticking together. The slightly larger particles formed through this process are called microflocs and are still too small to be visible to the naked eye. A high-energy, rapid-mix to properly disperse the coagulant and promote particle collisions is needed to achieve good coagulation and formation of the microflocs. Over-mixing does not affect coagulation, but insufficient mixing will leave this step incomplete. Proper contact time in the rapid-mix chamber is typically 1 to 3 minutes.

## Flocculation

Following coagulation, flocculation, a gentle mixing stage, increases the particle size from submicroscopic microfloc to visible suspended particles.

The microflocs are brought into contact with each other through the process of slow mixing. Collisions of the microfloc particles cause them to bond to produce larger, visible flocs. The floc size continues to build through additional collisions and interaction with inorganic polymers formed by the coagulant or with organic polymers added. Macroflocs are formed. High molecular weight polymers, called coagulant aids, may be added during this step to help bridge, bind, and strengthen the floc, add weight, and increase settling rate. Once the floc has reached its optimum size and strength, the water is ready for the separation process (**sedimentation**, floatation or filtration). Design contact times for flocculation range from 15 or 20 minutes to an hour or more.

## Coagulation flocculation separation

In water treatment, coagulation and flocculation are practically always applied subsequently before a physical separation. The **Coagulation-Flocculation** process consists of the following steps:

- **Coagulation**-flocculation: The use of chemical reagents to destabilise and increase the size of the particles; mixing; increasing of flog size,

- A physical separation of the solids from the liquid phase. This separation is usually achieved by sedimentation (decantation), flotation or filtration.

The common reagents are: mineral and/or organic coagulants (typically iron and aluminium salt, organic polymers), flocculation additives (activated silica, talcum, activated carbon…), anionic or cationic flocculants and **pH** control reagents such as acids or bases. Certain heavy metal chelating agents can also be added during the coagulation step.

## Jar test

The jar test is used to identify the most adapted mix of chemical compounds and concentrations for coagulation-flocculation. It is a batch test consisting of using several identical jars containing the same volume and concentration of feed, which are charged simultaneously with six different doses of a potentially effective coagulant. The six jars can be stirred simultaneously at known speeds. The treated feed samples are mixed rapidly and then slowly and then allowed to settle. These three stages are an approximation of the sequences based on the large-scale plants of rapid mix, coagulation flocculation and settling basins. At the end of the settling period, test samples are drawn from the jars and turbidity of supernatant liquid is measured. A plot of turbidity against coagulant dose gives an indication of the optimum dosage (i.e. the minimum amount required to give acceptable clarification). The criteria thus obtained from a bench jar test are the quality of resultant floc and the clarity of the supernatant liquid after settling. The design of the full-scale plant process is then done based on the bench-scale selection of chemicals and their concentrations.

Unfortunately, the jar test suffers from a number of disadvantages, despite its widespread application. It is a batch test, which can be very time-consuming. And the results obtained from a series of jar tests might not correspond to the results obtained on a full-scale plant.


Filtration:

If properly formed, the addition of chemicals for promoting coagulation and flocculation can remove both suspended and colloidal solids. After the floes are formed, the solution is led to a settling tank where the floes are allowed to settle.

While most of the flocculated material is removed in the settling tank, some floe do not settle. These floes are removed by the filtration process, which is usually carried out using beds of porous media such as sand or coal. The current trend is to use a mixed – media filter which consists of fine garnet in the bottom layer, silica sand in the middle layer and coarse coal in the top layer which reduces clogging.

Ultra Filtration:

a. Selectively filters only molecules of a specified size and weight.

b. Removes e.g. various viruses.

c. Used for sterilization, clarification, wastewater treatment.

d. Membrane size 1 _ – 0.01 µm. is used

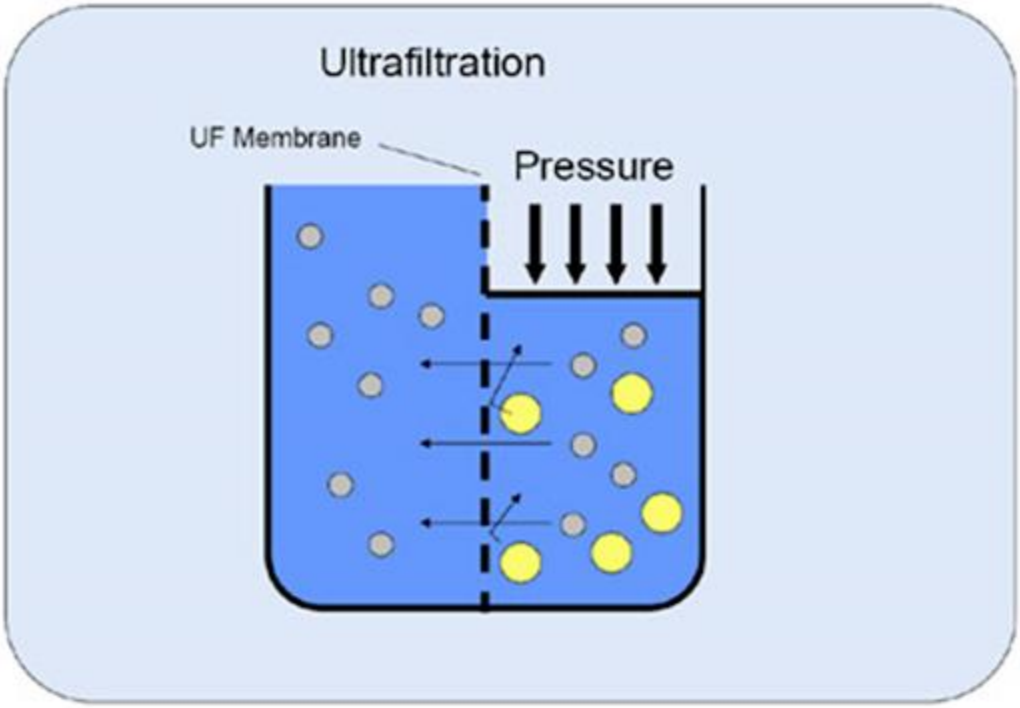
This is a dynamic filtering process with a predominance of physical (mechanical) phenomena in which chemical phenomena are also involved. The membranes used, polymeric or mineral, allow dissolved salts to pass while they reject high molecular weights selectively.

The selectivity depends on the membrane structure and is defined as the cut-off of molecular weight, which the membrane can separate with an efficiency of 90 % (although this definition may not be rigorous depending on the molecular shape)

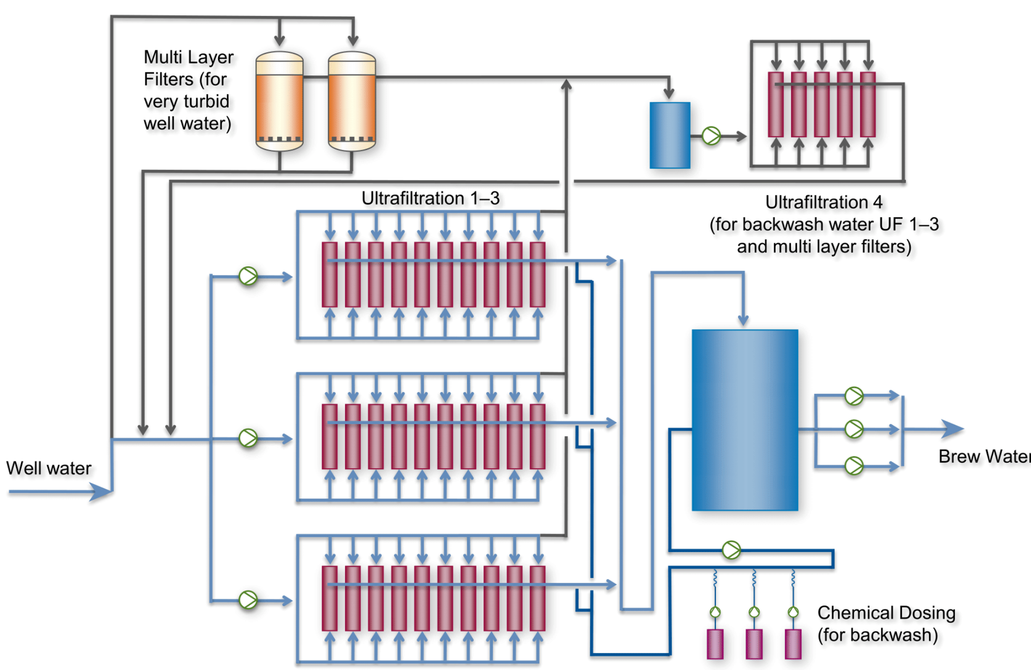
Commercial membranes applied in ultra filtering can separate substances with a molecular weight between 1.000 and 10.000. Ultra filtering systems generally work in a pressure range between 1.5 and 7 bar With industrial discharge waters the fluxes of permeate generally fluctuate between 0.5 and 1 – 5 m3 / h / m2 surface, depending on the concentration of the substances to be separated, with energy consumptions varying between 2 and 20 KWh per m3 of permeate. The single pass ultra filtering process is the simplest and most commonly used process for water treatment because it allows the recovery of high percentages of permeate (approximately 90-95 %).

There has been a relatively recent application of this technique in the metal finishing sector for the recovery of degreasing baths (the first cleaning bath in metal-finishing processes, for pieces which are still dirty with lubricating substances).

The solution to be treated is passed through the membrane at a certain speed and under hydrostatic pressure, obtaining a concentrated fraction of oils and grease for disposal, while the filtrate is recovered and reused to prepare new baths.




## Ultrafiltration with Backwash Water Recycling




Ultrafiltration 1
Ultrafiltration 2
W.E.T.