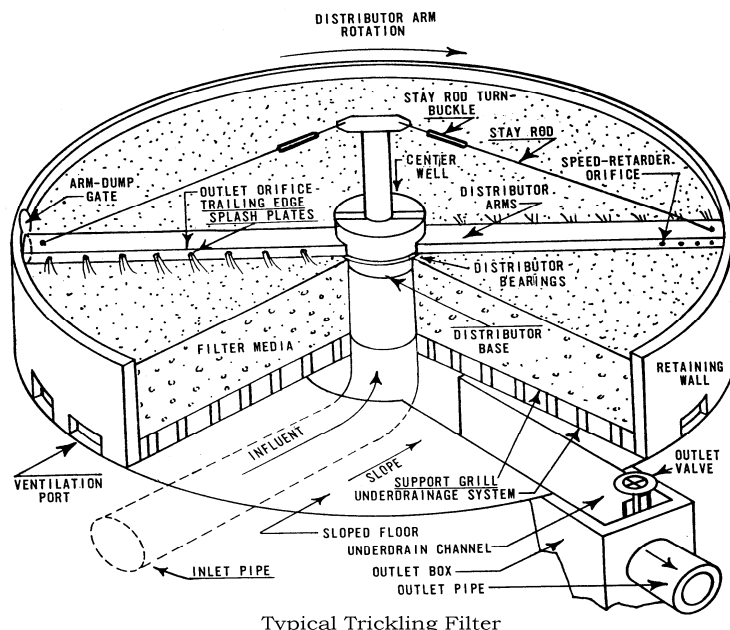


SECONDARY TREATMENT – FIXED MEDIA

The first secondary treatment processes were trickling filters. They are the original "fixed media" processes. Trickling filters have been in use for almost 100 years. The other members of the fixed media family include high rate trickling filters and rotating biological contactors (RBCs). Standard rate trickling filters and high rate trickling filters are very similar in construction. They both have a tank that contains a media that provides a surface for living microorganisms to grow. A distribution arm rotates over the top of the media showering the primary clarifier effluent over the media. The flow passes over the media and is collected at the bottom of the tank by means of an underdrain system. The trickling filter effluent then goes to the secondary clarifier.

High rate filters differ from standard trickling filters in two areas. Standard rate trickling filters use a bed of rocks as the filter media. High rate filters usually use a plastic media or redwood slats. High rate filters also are much taller than standard filters. A conventional trickling filter is only about 6-8 feet deep. A high rate trickling filter may be 20-25 feet high. The plastic media has a much greater surface area than the rocks in a standard unit. This means that higher hydraulic and organic loading is possible on high rate unit. High rate filters have lower removal efficiencies and are sometimes used as "Bio-roughing" filters. They are used upstream of conventional activated sludge processes to prevent organic shock loads where BOD strengths fluctuate due to industrial flows from food processing plants. BOD loading for standard rate trickling filters is about 15-20 pounds per day/1000 cu.ft. Hydraulic loading ranges are from 1-4 mgd/acre (25-100 gpd/sq.ft.) BOD loading for high rate filters can be as high as 40-60 lbs per day/1000 cu.ft. Hydraulic loading for high rate filters runs from 10-40 mgd/acre. BOD loading is always based on the primary effluent BOD samples.



ZOOGLEAL FILM

The microorganisms that grow on the trickling filter media create a layer of slime that is known as the "Zooglear Film". The bacteria and protozoa that make up this film are responsible for eating the raw organic material, both suspended and dissolved, that remains in the primary effluent. As the layer gets thicker it is washed off of the media by the water flow. This process is known as sloughing. The sloughings are collected in the secondary clarifier as sludge and removed from the process. Snails and psychoda flies (filter flies) also live in the media. They can be a nuisance but can be controlled. If the slime layer gets too thick it can fill the gaps between the rocks. This results in ponding of water on top of the media. Air must pass between the rocks to keep everything aerobic in the filter. Ponding creates dead spots where there is no ventilation. When this occurs, septic conditions and odors begin to develop in the filter.

With enough air and the constant dosing/resting cycle created by the rotating distributor arm, these aerobic organisms will stay healthy and hungry. The growth of the zooglear film represents the conversion of dissolved organic compounds (sugars, starches, and fats) into solids (bugs) that can be removed from the process by physical separation in the secondary clarifiers.

TRICKLING FILTER OPERATIONS

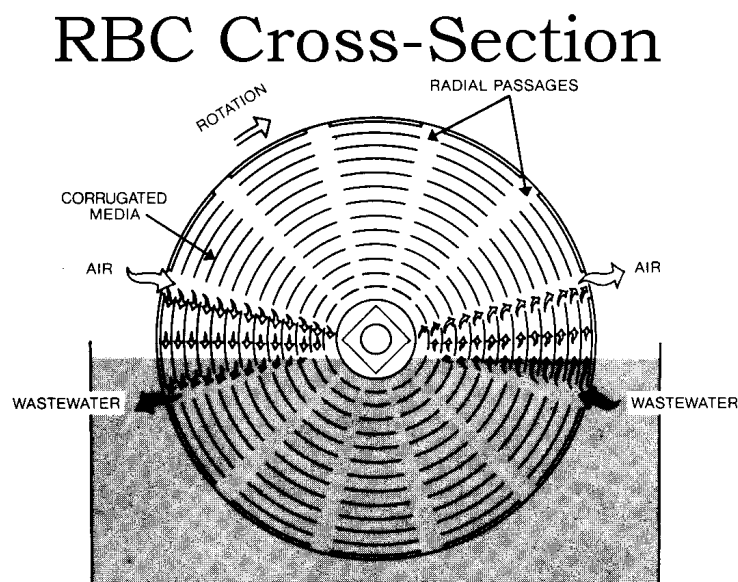
One of the big problems with trickling filters is that the BOD removal efficiency is only about 80-85%. This usually results in effluent BOD strengths that do not meet permit requirements. Trickling filters are sometimes placed in series, or stages, so the flow passes through two filters. The second filter's removal of BOD from the first stage effluent greatly increases the overall removal efficiency. Removal efficiencies are calculated by comparing the BOD strength in the primary clarifier effluent and the secondary clarifier effluent.

Recirculation of the trickling filter effluent back through the trickling filter is another means of achieving higher removal efficiencies. Either the filter effluent or the secondary clarifier effluent is returned to the filter for a second pass. It is required for all high rate filters and many standard filters have been re-fitted for recirculation. Adjusting the recirculation rate is the only real process control for most trickling filters. Recirculation flows need to be increased at night to maintain flows high enough to keep the distributor turning at the right speed. Increasing recirculation can also be beneficial for filter fly control and preventing ponding. The higher flows wash the larvae out of the filter and increase the rate of sloughing.

As flows drop off at night, the DO and pH in the filter will drop. This can also lead to septic conditions in the filter. Increasing the recirculation will aerate the flow, increase the ventilation draft, and reduce the detention time in the filter. This will usually bring the effluent DO back up to the normal 1.5-2.0 mg/l range. If the filter experiences an upset, increasing the recirculation will probably help bring it back. But the recovery process could take several days to restore a healthy growth on the media. Normal recirculation rates will need to be increased during colder weather to maintain removal efficiencies. The lower temperatures will reduce biological activity and single-pass efficiencies.

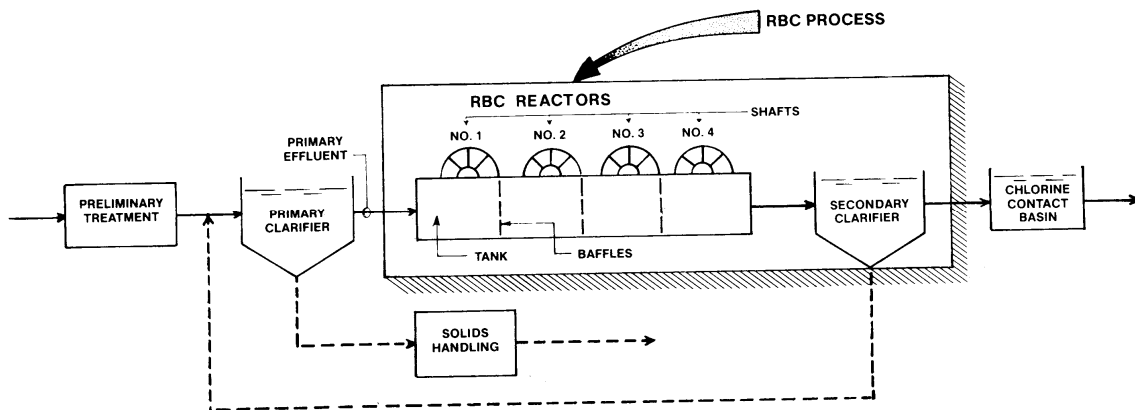
ROTATING BIOLOGICAL CONTACTORS (RBC)

Rotating biological contactors operate under the same fixed media/slime principle as a trickling filter. The difference is the fixed media disks rotate in the water. The media is attached to a rotating horizontal shaft and is about 40% submerged in main tank. As the media rotates it picks up some wastewater that runs down the media as it comes out of the water. This creates contact time with the organisms that are growing on the media and allows for air circulation throughout the core of the media. This is how aerobic conditions are maintained. RBCs should be preceded by primary treatment. Grit and sludge accumulation beneath the disks can cause septic conditions to develop.



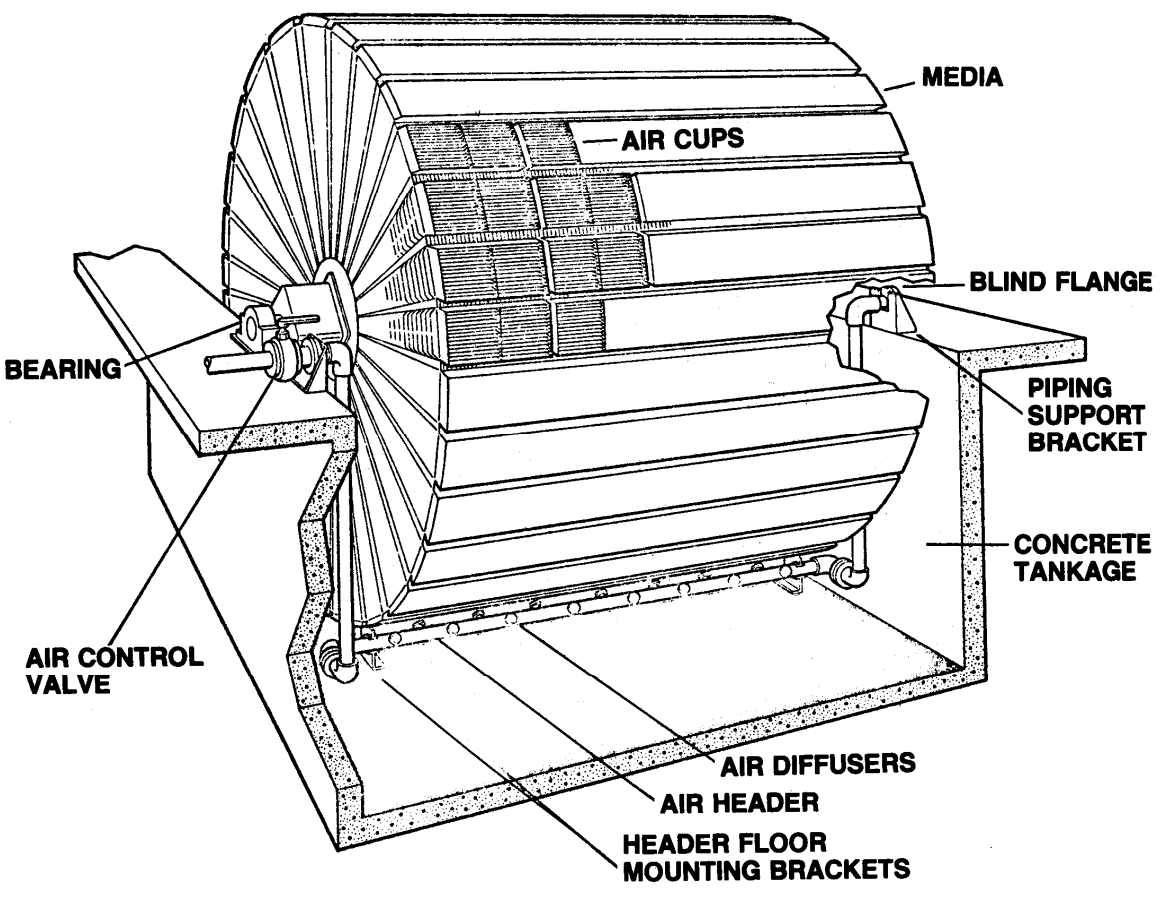
End-view sketch illustrates exchange
of air and wastewater

The growth on the media sloughs off as it gets heavier just like a trickling filter. It must be carried out of the tank to a clarifier. This requires that a minimum velocity be maintained to keep the sloughings in suspension. This is sometimes accomplished by the addition of aeration. Aerated RBCs do not carry as much biomass on the media due to the scouring effects of the air diffuser. In some cases RBCs have been converted to a hybrid activated sludge process by aerating and returning secondary sludge to the process (RAS) to build up mixed liquor suspended solids. Since most RBC systems are plug flow processes, the first stages will have more growth on the media than the latter stages.



The rotating media is usually mechanically driven with a sprocket and chain drive. Some units are air-driven. The aeration diffusers are located under the disks and the rising air turns the media. The rotational speed is adjusted by adjusting the airflow. The key operational issue in a RBC is that the media must never stop turning. The rotational speed provides the main source of aeration in an un-aerated RBC. It must be maintained at 1.0-1.5 rpm. In the event of a power failure, the media should be rotated 1/4 turn every 4 hours. When the media is allowed to stop for too long the growth of the film layer will overload the submerged portion of the media as the exposed areas of the media lose their growth. This creates an unbalanced condition that will overload the drive unit.

RBCs are usually designed in stages. This is also done in activated sludge processes. When RBCs are designed for nitrification, the media growth and DO levels are different in the front and back stages. The front stages will be removing BOD. The DO can be as low as 1 mg/l in the first stage and the growth will be a gray shaggy mass. As the middle stages move to nitrification, the DO levels will need to rise to 2-3 mg/l and to 4-5 mg/l in the final stage. The biomass will be thinner and dark brown in color. When BOD overload occurs, the growth will turn black. A toxic upset will result in a milky-white appearance.



Air Driven RBC

BASIC STUDY QUESTIONS

1. What are the components of a:
 - A. Trickling filter
 - B. RBC
 2. How do you keep a distributor arm turning during low flows?
 3. What is the material that sloughs off the media called?
 4. What should precede a RBC in the treatment process?
4. High rate filters are different from standard rate filter in that:
 - A. They take higher organic loads
 - B. They don't use rocks
 - C. They are taller
 - D. All of the above

ADVANCED STUDY QUESTIONS

1. How do you control filter flies and ponding in trickling filters?
2. What is the most important operational consideration with an RBC?
3. List four things that can be accomplished by increasing recirculation rates in trickling filters?

BASIC SAMPLE TEST QUESTIONS

1. What should the effluent DO be in a trickling filter?
 - A. 0 mg/l
 - B. 0.4-0.8 mg/l
 - C. 1.5-2.0 mg/l
 - D. 6.0-8.0 mg/l
2. Which of the following is a problem in trickling filters?
 - A. Snails
 - B. Ponding
 - C. Psychoda flies
 - D. All of the above
3. To provide adequate ventilation you should always make sure:
 - A. The blowers are running
 - B. The underdrain is no more than 50% full
 - C. There is ponding on the surface

ADVANCED SAMPLE TEST QUESTIONS

2. What is the BOD loading for a high rate trickling filter?
 - A. 10-15 lbs/day/1000 cuft
 - B. 20-30 lbs/day/1000 cuft
 - C. 40-60 lbs/day/1000 cuft
 - D. 80-100 lbs/day/1000 cuft
3. Healthy growth on the first stage of an RBC will be:
 - A. Gray
 - B. Brown
 - C. Black
 - D. White
4. The DO in the last stage of a nitrification process in an RBC should be at least:
 - A. 1 mg/l
 - B. 2 mg/l
 - C. 4 mg/l