FAQs

1. **Question:** Explain equipment requirements for the activated sludge process.

   Answer: Activated sludge process includes an aeration tank, aeration, system-settling tank, return sludge, and waste sludge.

   Aeration tank

   The aeration tank is designed to provide the required detention time (depends on the specific modification) and ensure that the activated sludge and the influent wastewater are thoroughly mixed. Tank design normally attempts to ensure no dead spots are created.

   Aeration

   Aeration can be mechanical or diffused. Mechanical aeration systems use agitators or mixers to mix air and mixed liquor. Some systems use a sparge ring to release air directly into the mixer. Diffused aeration systems use pressurized air released through diffusers near the bottom of the tank. Efficiency is directly related to the size of the air bubbles produced. Fine bubble systems have a higher efficiency. The diffused air system has a blower to produce large volumes of low pressure air (5 to 10 psi), air lines to carry the air to the aeration tank, and headers to distribute the air to the diffusers that release the air into the wastewater.

   Settling tank

   Activated sludge systems are equipped with plain settling tanks designed to provide 2 to 4 h hydraulic detention time.

   Return sludge

   The return sludge system includes pumps, a timer or variable speed drive to regulate pump delivery and a flow measurement device to determine actual flow rates.

   Waste Sludge

   In some cases, the waste activated sludge withdrawal is accomplished by adjusting valves on the return system. When a separate system is used it includes pumps, a timer or variable speed drive, and a flow measurement device.

2. **Describe the process of activated sludge process.**

The conventional Activated Sludge Process (ASP) is a continuous treatment that uses a consortium of microbes suspended in the wastewater in an aeration tank to absorb, adsorb, and biodegrade the organic pollutants. Part of the organic composition will be completely oxidized to harmless end products and other inorganic substances are utilized to provide energy to sustain the microbial growth and the formation of biomass (flocs). The flocs are kept in suspension either by air blown into the bottom of the tank (diffused air system) or by mechanical aeration. The dissolved oxygen level in the aeration tank is critical and should preferably be 1–2 mg/L and the tank must always be designed in terms of the aeration period and cell residence time.

The mixture flows from the aeration tank to a sedimentation tank where the activated sludge flocs form larger particles that settle as sludge. The biological aerobic metabolism mode is extremely efficient in terms of energy recovery, but results in large quantities of sludge being produced (0.6 kg dry sludge per kg of BOD_5 removed). Some of the sludge is returned to the aeration tank but the rest must be processed and disposed of in an environmentally acceptable manner. Many variations of the ASP exist, but in all cases, the oxygen supplied during aeration is the major energy-consuming operation. With ASPs, problems generally encountered are bulking, foam production, precipitation of iron and carbonates, excessive sludge production, and a decrease in efficiency during winter periods.

3. What are the important factors guiding activated sludge design?

In activated sludge systems, the cells are separated from the liquid and partially returned to the system; the relatively high concentration of cells then degrades the organic load in a relatively short time. Therefore, there are two different resident times that characterize the systems: one is the hydraulic residence time (θH) given by the ratio of reactor volume (VR) to flow of wastewater (QR):

$$\theta H = \frac{V_R}{Q_R}$$

The other is the cell residence time (θC), which is given by the ratio of cells present in the reactor to the mass of cells wasted per day. Typical θH values are in the order of 3–6 hours, while θC fluctuates between 3 and 15 days.

To ensure the optimum operation of the activated sludge process, it is generally necessary to provide primary treatment and flow equalization prior to the activated sludge process. Pilot or laboratory-scale studies are required to determine organic loadings, oxygen requirements, sludge yields, and sludge settling rates for high-strength wastes. Along with these, it is also used to generate several information required to design an activated sludge system such as

- BOD_5 removal rate
- Oxygen requirements for the degradation of organic material and the degradation of dead cellular material (endogenous respiration)
- Sludge yield, determined from the conservation of soluble organics to cellular material and the influx of inorganic solids in the raw waste
- Solid/liquid separation rate: the final clarifier would be designed to achieve rapid sedimentation of solids, which could be recycled or further treated. A maximum surface settling rate of 16.5 m^3/day has been suggested for seafood-processing wastes

The suspended solids concentration in the aeration tank liquor, also called mixed liquor suspended solids (MLSS), is generally taken as an index of the mass of active micro-organisms in the aeration tank. However, the MLSS will contain not only active micro-organisms but also dead cells as well as inert organic and inorganic matter derived from the influent sewage. The mixed liquor volatile suspended solids (MLVSS) value is also used and is preferable to MLSS as it eliminates the effect of inorganic matter.

4. What is loading rate? Discuss its parameters.

The loading rate expresses the rate at which the sewage is applied in the aeration tank. A loading parameter that has been developed empirically over the years is the hydraulic retention time (HRT), ϴ, d.

$$\Theta = \frac{V}{Q}$$

Where,

V: Volume of aeration tank, m^3, and

Q: Sewage inflow, m^3/day

Another empirical loading parameter is volumetric organic loading which is defined as the BOD applied per unit volume of aeration tank, per day.

A rational loading parameter which has found wider acceptance and is preferred, is specific substrate utilization rate, U, per day which is defined as:

$$U = \frac{Q\,(S_0 - S)}{VX}$$

A similar loading parameter is mean cell residence time or sludge retention time (SRT), Θ_c, day:

$$\Theta_c = \frac{VX}{Q_W X_S}$$

Where

S_0 and S are influent and effluent organic matter concentrations respectively, conventionally measured as BOD_5, (g/m^3),

X and X_S are MLSS concentration in aeration tank and waste activated sludge from secondary settling tank under flow, respectively, (g/m^3) and

Q_w waste activated sludge rate, (m^3/d).

Under steady state operation the mass of waste activated sludge is given by

$$Q_W X_S = YQ(S_0 - S) - k_d XV$$

where,

Y: Maximum yield coefficient (microbial mass synthesized/mass of substrate utilized)

k_d : Endogenous respiration rate constant, (d^{-1}).

From the above equations it is seen that

$$1/\Theta_c = YU - k_d$$

Since both Y and k_d are constants for a given waste, it is, therefore, necessary to define either Θ_c or U.

If the value of S (i.e., effluent organic matter) is small compared to S_0 (influent), which is often the case for activated sludge systems treating municipal sewage, U may also be expressed as Food applied to Microorganism ratio,

$$F/M = QS_0 / XV$$

The Θ_c value adopted for design controls the effluent quality, settleability and drain ability of biomass. Other operational parameters which are affected by the choice of Θ_c values are oxygen requirement and quantity of waste activated sludge.

5. **Explain sludge recycle.**

The MLSS concentration in the aeration tank is controlled by the sludge recirculation rate and the sludge settle ability and thickening in the secondary sedimentation tank.

$$\frac{Q_R}{Q} = \frac{X}{X_S - X}$$

where,

Q_R : Sludge recirculation rate, m^3/d.

The sludge settleability is determined by Sludge Volume Index (SVI) defined as volume occupied in ml by one gram of solids in the mixed liquor after settling for 30 min and is determined experimentally. If it is assumed that sedimentation of suspended solids in the laboratory is similar to that in sedimentation tank, then Xs (waste activated sludge from secondary settling tank under flow) = 10^6/SVI. Values of SVI between 100 and 150 ml/g indicate good settling of suspended solids. The Xs value may not be taken more than 10,000 g/m^3 unless separate thickeners are provided to concentrate the settled solids or secondary sedimentation tank is designed to yield a higher value.

6. **Discuss aeration facility for activated sludge plant?**

The aeration facilities of the activated sludge plant are designed to provide the calculated oxygen demand of the wastewater against a specific level of dissolved oxygen in the wastewater. Aerators are rated based on the amount of oxygen they can transfer to tap water under standard conditions of 20°C, 760 mm Hg barometric pressure and zero DO. The oxygen transfer capacity under field conditions can be calculated from the standard oxygen transfer capacity by the formula:

$$N = \frac{N_S (C_S - C_L) \times 1.024^{(T-20)}\alpha}{9.17}$$

where,

N : Oxygen transferred under field conditions, kg O_2/kW/hr

Ns : Oxygen transfer capacity under standard conditions, kg O_2/kW/hr

Cs : Dissolved oxygen saturation value for sewage at operating temperature, mg/l

C_L : Operation DO level in aeration tank usually 1 to 2 mg/1

T : Temperature, °C

A: Correction factor for oxygen transfer for sewage, usually 0.8 to 0.85

Values of Cs is calculated by arriving at the dissolved oxygen saturation value for tap water at the operating temperature and altitude and then multiply it by a factor which is usually 0.95 for domestic sewage without undue industrial effluents and with TDS in the normal range of 1,200 to 1,500 mg/l.