WORKING OUT REACTOR VOLUME

NUMBER OF REACTORS

The number of reactors depends on wastewater flow to be handled. With small wastewater flows small reactors can be anticipated and for wastewater flows below 500 m^3/d single reactor can serve the purpose. However, if continuous operation is necessary, the minimum number of reactors should be two. For reasons of flexibility of operation it is recommended to construct two UASB units at each plant site. Maintenance of entire treatment system also becomes more flexible as one reactor can be taken out of operation for maintenance.

REACTOR SHAPE

Reactor shape can be circular or rectangular. With small reactors up to 200 to 300 m^3 circular shape can be adopted. For reactor volume exceeding 300 m^3 rectangular reactors may prove to be economical with modular arrangement.

REQUIRED REACTOR VOLUME

The UASB reactor volume depends on number of factors including:

- Maximum total daily COD load,
- The admissible liquid surface load,
- The minimum temperature of wastewater,
- The strength of the wastewater, the characteristics of the wastewater (e.g. the complexity of polluting compounds and their biodegradability)
- The permissible space loading rate at a specific sludge hold-up,
- The required treatment efficiency, and
- Required extent of sludge stabilization.

ADMISSIBLE LIQUID SURFACE LOAD

For properly granulated sludge in UASB reactor the liquid surface load can be approximately 3 m/h for soluble organics and 1 to 1.25 m/h for partially soluble organics in wastewater [Lettinga and Hulshoff, 1991]. Temporarily for 2 h superficial velocities up to 6 m/h and 2 m/h can be tolerated for soluble and partially soluble wastewaters, respectively. The high superficial velocities may result in wash out of poorly settleable granular sludge, but may not lead to any serious problems. For flocculent type of sludge, the admissible maximum superficial velocities are 0.5 m/h, with temporary (2 to 4 h) admissible peaks up to approximately 2 m/h. For well settling thick sludge the value can be set 50% higher.

WORKING OUT REACTOR VOLUME

The volume of the reactor can be worked out by using formula,

$$\text{Reactor volume} = \frac{\text{Inflow } (m^3/d) * \text{ COD } (kg/m^3)}{\text{OLR } (kg\ COD/m^3 d)}$$

The sludge volume required for designed sludge loading rate can be worked out by assuming average concentration of sludge between 30 to 50 g VSS/L [Weiland and Rozzi, 1991]. Depending upon the sludge volume required, volume of the reactor is finalized such that the volume of sludge should be less than 50% of total reactor volume. Then check for HRT is taken by using formula,

$$\text{HRT (h)} = \frac{\text{Volume (m}^3\text{)}}{\text{(Inflow (m}^3\text{/d) / 24)}}$$

For rather exceptional case, where instead of organic loading rate the liquid surface load would represent the limiting factor. The allowable HRT is determined by the surface area and the height of the reactor according to the equation:

$$HRT = A.H / Q$$

Where, H is reactor height (m), A is surface area of reactor (m^2), Q is flow rate (m^3/h), and HRT is Hydraulic Residence Time (h).

The admissible superficial liquid upflow velocity will ultimately determine HRT fro a given reactor height.

REACTOR HEIGHT

The height of UASB reactor needs to be assessed with respect to two operating conditions such as, i) reactor should contain as much sludge as possible, and ii) wastewater upflow velocity should be as low as possible. In treating completely soluble wastewater reactor height up to 10 m or even higher can be used, resulting in lower reactor space requirements [Lettinga and Hulshoff, 1991]. Also, the cost for feed inlet distribution and GSS device will be reduced due to lower plan area. For partially soluble wastewaters, the admissible heights are obviously much lower, *i.e.* for treating dilute wastewater like domestic sewage reactor heights of 3 to 5 m are recommended; and for wastewaters with COD exceeding 3000 mg/L reactor height of 5 to 7 m can be accepted. It is essential to maintain sludge blanket between sludge bed and GSS device, the height of reactor tends to increase. The maximum reactor height can be set at 8 m. On the other hand lower upflow velocity implies shallow reactors. Thus, with this point of view and with consideration of ease of construction, the reactor height should be at least 4 m (2 to 2.5 m for sludge bed, 0.5 to 1 m for sludge blanket and 1 to 1.5 m for GSS).