G.S.S.DESIGN

In order to achieve the highest possible sludge hold-up under operational condition, it is necessary [at least very beneficial] to equip the UASB-reactor with a GSS device [GSS-Gas Solids separator] in i.e. it does not necessarily constitute a very expensive part of the reactor. Relatively a lot of research has been spent in resent years for developing new more exclusive, system. The last word on the design of the GSS device certainly has not yet been said. It is an area of continuous innovation. The objectives of the GSS-device are summarized as followed, at least as they are relevant for the treatment of soluble non-complex types of wastewaters.

Main objectives of the GSS-device for UASB-systems treating soluble type of wastewaters.

1. To separate and discharge biogas from the reactor.
2. To prevent as effectively as possible the washout of viable bacterial matter.
3. To enable the sludge to slide back into the digester compartment.
4. To serve as a kind of barrier [stopper] for rapid excessive expansions of a sludge blanket [which is mainly composed of flocculent sludge] into the settler.
5. To provide a polishing effect.
6. To prevent the washout of floating granular sludge.

In case of washout of viable sludge, or fine dispersed solids in general [e.g. for reasons of treatment efficiency] should be kept at a minimum, a baffle must be placed in front of the effluent weir in order to retain floating sludge. Special construction for such a baffle is required in the case where heavy granular sludge flotation would occur, e.g. when very high sludge loading rate are imposed or in the presence of proteins or fats. Especially for the treatment of very dilute wastewater, it is essential to achieve an almost complete retention of the viable sludge. A sophisticated GSS-device is required in that case. Special measures have to be taken in treating industrial effluents containing higher concentration of proteins and/or fats. The presence of these compounds will stimulate foaming and flotation of the sludge and consequently the washout of viable biomass.

The formation of a thick scum layer in the gas bowl may sometimes give some problems, because it hampers the easy release of the biogas. This may occasionally result in a partial escape of biogas via settler, which obviously is quite detrimental for settling out the sludge. In those cases where heavy scum layer formation cannot be avoided, specific provisions have to be taken to remove the floating matter from the reactor and/or to agitate it sufficiently in order to get it settled down. For removing the scum layers, suction could be applied using a bent pipe, which can be brought beneath the gas bowl and moved, which sucking slowly over the total length of the GSS-device. A similar [or the same] pipe could be used for recirculating biogas through the scum layer, e.g. by returning it in the reactor immediately beneath the scum layer.

Scum layer formation generally also occurs at the liquid interface in the settler, particularly if a baffle has been placed in front of the effluent weir. In the case where the installation of a baffle in front of the effluent weir is omitted, floating particles very likely including floating granular sludge, will rinse out of the reactor. The liquid surface area will remain almost clean in that case, but obviously the concentration of SS in the effluent will be higher. When excessive scum layer formation occurs, the installation of a skimmer looks appropriate. Special baffles

constructed from a steel screen which extend well above the liquid interface, may be required for retaining heavily floating granular sludge particles.

As at a certain fixed space load, the specific gas production rate [m^3/ m^2. day] increase proportionally with the reactor height. Special attention has to be given to the construction of the GSS-device in the case of taller reactors in order to prevent foaming problems.

Summary of tentative guidelines for the design of the gas-solids separator device [Lettinga and Hulshoff 1991]

- The slope of the settler bottom [i.e. inclined wall of the gas collector] should be between 45-60^O.
- The surface area of the apertures between the gas collectors should be 15-20 % of the reactor surface area.
- The height of the gas collector should be between 1.5-2 m for reactor height of 5 to 7 m.
- A liquid-gas interface should be maintained in the gas collector in order to facilitate the release and collection of gas bubbles and to combat scum layer formation.
- The overlap of the baffles installed beneath the apertures should be 10-20 cm in order to avoid upward flowing gas bubbles to enter the settler compartment.
- Generally scum layer baffles should be installed in front of the effluent weirs.
- The diameter of gas exhaust pipes should be sufficient to guarantee the easy removal of the biogas from the gas collection cap, particularly in the case of foaming.
- In the upper part of the gas-cap, anti-foam spray-nozzles should be installed in case the treatment of the wastewater is accompanied by heavy foaming.

The volume of GLS separator device can be 16 to 25 % of the reactor volume [Hashemian and James, 1990]. The opening in the lower part of the settler must not impose very high velocity in this area because it could prevent the return of solids of the settler to the reactor bottom [Tilche and Vieira, 1991]. The maximum liquid velocity at entry of GSS should be restricted to 2 to 5 m/h and the settling compartment should be designed to keep surface hydraulic load below 0.7 m/h [Lin and Yang, 1991]. It is recommended that the upflow velocity in the settler should not exceed 1.5 m/h [Weiland and Rozzi, 1999] and the surface overflow rate equal to 20 to 28 m^3/m^2.d at peak flow can be adopted for design of GSS. The area of the gas water interface should be sufficient enough for effective separation of gas and liquid. The area of gas water interface can be worked out in such a way that the gas loading is less than 3 m/h. It is also important that sufficient surface is left for gas release. The height of the settler can be between 1.5 to 2.0 m for high strength wastes and between 1.0 to 1.5 m for low strength wastes. Due attention has to be paid to the geometry of the unit and its hydraulics, to ensure proper working of the GLS separator.