

Biogas Digester Construction Photos & Details

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Anaerobic Digestion

The process by which anaerobic bacteria decompose organic matter into methane, carbon dioxide, and a nutrient-rich sludge involves a step-wise series of reactions requiring the cooperative action of several organisms. In the first stage, a variety of primary producers (acidogens) break down the raw wastes into simpler fatty acids. In the second stage, a different group of organisms (methanogens) consume the acids produced by the acidogens, generating biogas as a metabolic byproduct.

On average, acidogens grow much more quickly than methanogens. They are also much hardier organisms, able to survive a broader range of temperature and pH conditions.

Problems with Conventional Single-Stage Digesters

As a result of these dependencies, single-stage digesters, where both species are cultured together in the same environment, are inherently unstable. In such systems, any imbalance between the two organisms creates a positive feedback (runaway) situation which can quickly bring the entire process to a halt. That is, a slight drop in methane production rate without a corresponding reduction in substrate production will cause volatile acids to accumulate, causing the pH to drop, killing more methanogens, causing further accumulation of acids...and so on, until the system crashes.

Conventional single-stage digesters are not only unstable, they are also relatively inefficient. For example, if the system is operated at a hydraulic retention time (HRT) conducive to growth of acidogens (2-3 days), any methanogens present will be washed out of the system faster than they can reproduce, preventing them from ever becoming established. On the other hand, if the system is operated at an HRT conducive to growth of methanogens (20-25days), the faster growing acidogens will be maintained at the low growth rates of the endogenous growth phase - essentially at starvation level.

Acid/Methane Tank Baffle Construction:

Tools required for welding plastic:
Welder, small air compressor, HDPE
welding rod.



Looking down into open tank, showing
3/4" HDPE tube bent into hoop and
welded into tank. Hoop acts as support
blocking for baffle partitioning vertical
tank into two chambers.



Closeup of hoop welded to wall of HDPE tank.



Assembled baffle plate, top view: Disk is cut from 1/4" HDPE sheet, holes/fittings in baffle are for 3/4" gas vent, 2" transfer pipe (center), 2" influent in.



Assembled baffle plate ready for installation in tank.

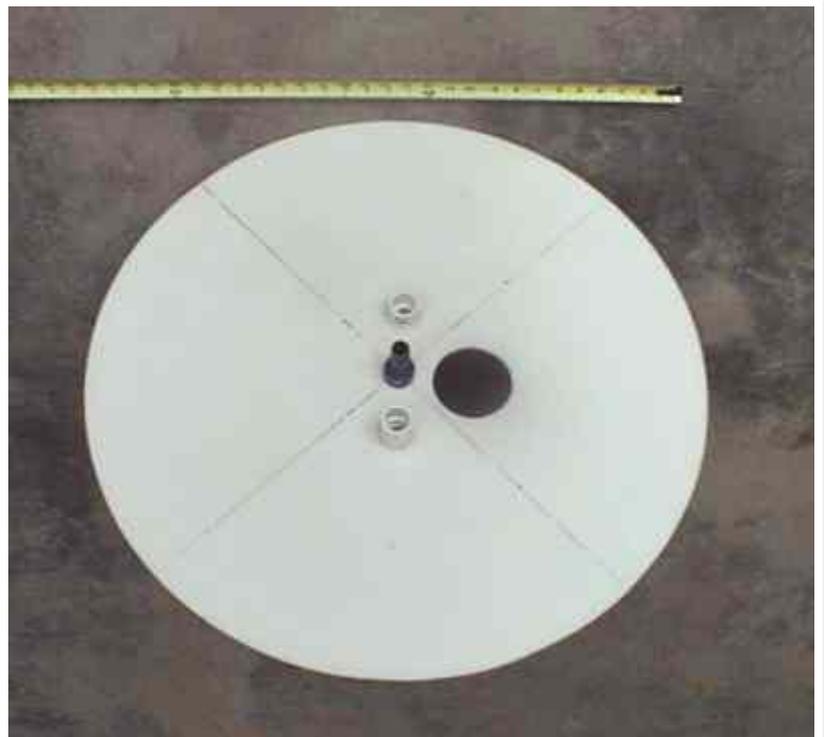


Looking down in tank with completed baffle plate in place. Baffle is attached to support blocking (3/4" tube hoop) with self-tapping stainless steel screws, sealed with silicone caulk. (Note: 3/4" hose connecting gas vent to lid is not shown.)



Digester Lid Construction

Cut tank lid from 3/8" thick HDPE sheet to fit inside flange of open top HDPE tank. (Diameter varies depending on tank selected -- which will depend on amount of material to be digested. Use [design tool](#) to select tank.) Holes cut in tank are for influent/effluent heat exchanger assembly, biogas out, biogas recirculation, and gas vent from acid reactor. Top view.



Closeup view of underside of lid showing silicone caulk bead and fittings. Large hole is caulked in preparation for inserting 4" ABS heat exchanger assembly (see photos below).



Assembled lid with gas vent hose and gas recirculation conduit attached to fittings.



Influent/effluent heat exchanger, assembled from 4" ABS pipe with 2" PVC inside



Closeup of top of HX assembly showing 2" PVC bulkhead fitting inserted into hole drilled through 4" ABS cap.



Completed digester prior to final installation of lid and wrapping with insulation. Heat tape is wrapped around tank and attached with aluminum tape.

(Note also an immersion well installed in lid, for temperature measurement -- not included in construction drawings.)



Biogas Digester Operation

Incoming Waste

A system can be designed to digest a wide variety of organic wastes, from kitchen scraps to sewage, to livestock manure, to industrial wastes. The ideal feedstock is a 6-8% slurry with a Carbon to Nitrogen ratio of about 30:1. Incoming waste material should be macerated, and as close to the operating temperature (95 degF) of the digester as possible. The small scale system described below will handle the toilet wastes produced by a family of 6, each flushing a 1-1/2 Pint/flush toilet 5 times per day.

Gas Handling:

Gas can be stored in low pressure gas bags (i.e. truck tire inner tubes, etc.), rigid tank(s) with floating cover and water seal, compressed and stored in pressure tank, and/or burned as it is produced, (minimizing storage requirements). For safety reasons, it is recommended that the gas be burned as soon as possible, avoiding the requirement to store and handle larger quantities of flammable gas.

The gas produced typically consists of about 30% CO₂ and about 60-65% methane, depending on the content of the wastes. Small amounts of hydrogen, hydrogen sulfide, and nitrogen gas will also be produced, as well as water vapor.

One use of this gas is to heat domestic hot water in a gas-fired tank-type water heater installed between the cold water inlet and the conventional (backup) water heater. A small, weighted inflatable gas bag will be used to collect up to an hour's worth of gas (i.e. about 5 cu ft at design conditions), and to provide required pressure for proper burner operation.

Gas burner should be as small as possible, with intermittent ignition with continuous retry and maximum lock-out time. Sufficient hot water storage capacity should be provided to make use of all available energy without having to store flammable gas. This may require addition of one or more insulated storage tanks piped together, and a small circulator pump and controls.

Digester Effluent:

Effluent from the digester will be returned to the conventional backup sewer system. A hydraulic loading rate (total liquid throughput) of about 60 gallons/ day is assumed. Estimated solids loading will be about 35 lbs/day. Assuming that volatile solids will be reduced by about 60-70% in the digester, additional volatile solids entering the sewer system will be about $35 - (35 \times .65) \sim 12-15$ lbs/day.

Digester Sludge:

The volume of sludge solids accumulating in the digester will depend on the digestibility of the influent material and the extent to which digester contents are mixed (i.e. kept in suspension and discharged with effluent), or allowed to settle. Tanks are designed to facilitate sludge removal (e.g. quick disconnect fittings provided for connection to vacuum pump, etc.). To reduce solids loading on backup sewer system and recover sludge solids as a valuable soil amendment, a settling tank can be installed in the line between the effluent overflow and the sewer system