

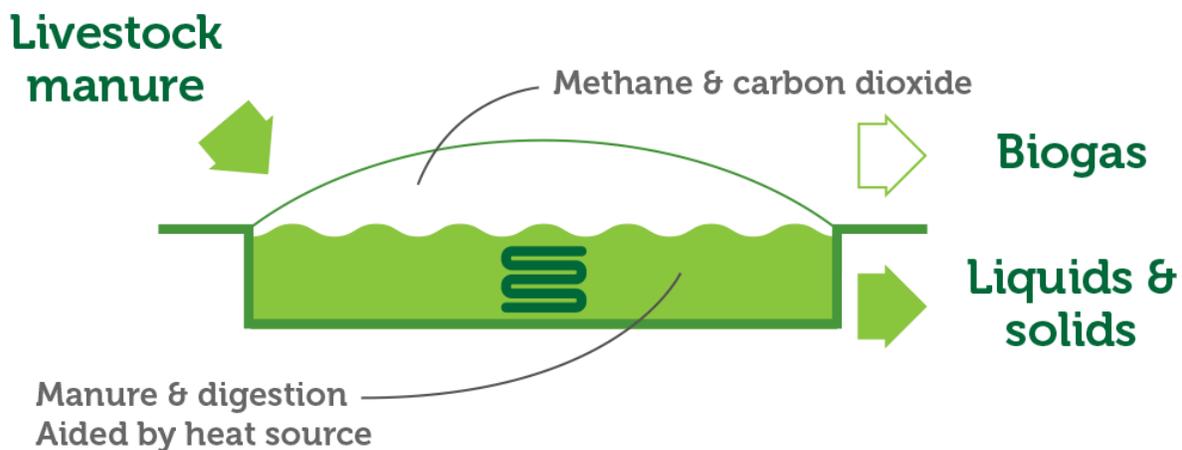
Plug-Flow Digesters: Technical Details

Information excerpted from: *Biomethane from Dairy Waste: A Sourcebook for the Production and Use of Renewable Natural Gas in California*

Description of Plug-Flow Digester

A plug-flow digester is used to digest manure from ruminant animals (dairy, beef, sheep) that can be collected as a semisolid (10% to 60% solids) daily to weekly with minimal contamination (dirt, gravel, stones, straw) and delivered to a collection point.

Plug-Flow Digester: How it Works

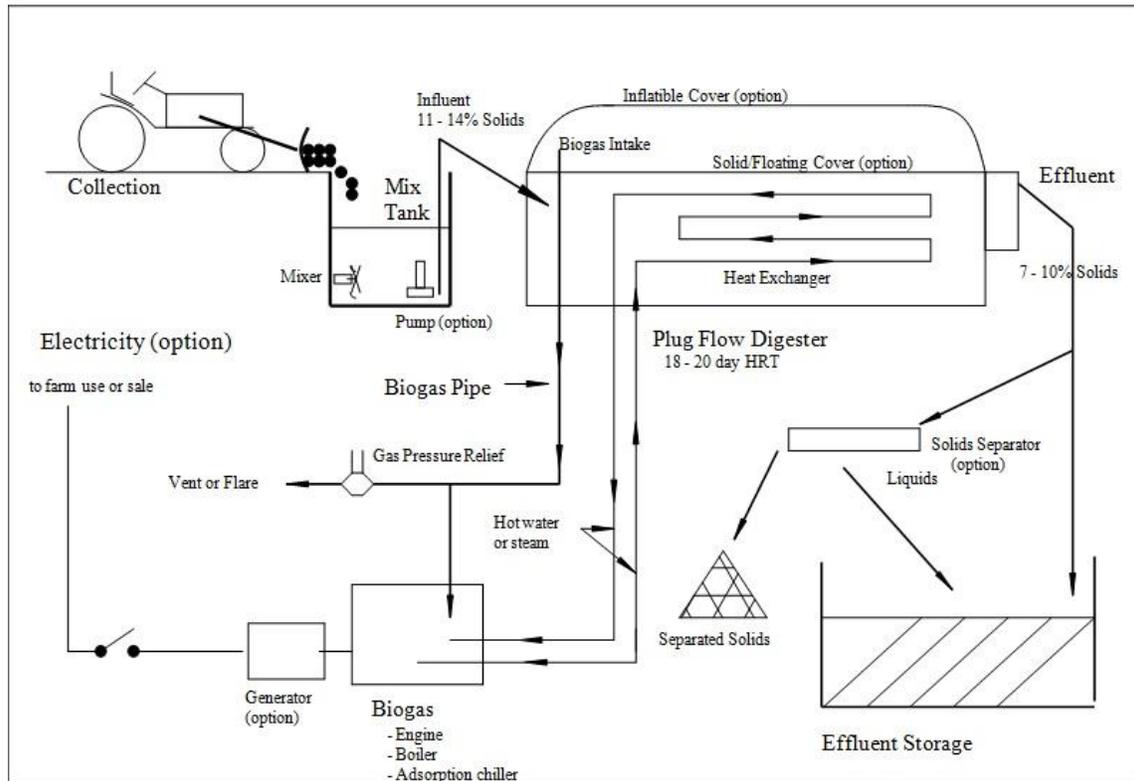


Components of Plug-Flow Digester

A plug-flow digester system generally includes a mix tank, a digester tank with heat exchanger and biogas recovery system, an effluent storage structure, and a biogas utilization system. Post digester solids separation is optional.

- *Collection/mix tank.* A mix tank as described above for a complete digester is used to achieve a solids concentration between 11% and 14% solids.
- *Plug-flow digester.* A plug-flow digester is a heated, in-ground concrete, concrete block or lined rectangular tank. The digester can be covered by a fixed rigid top, a flexible inflatable top or a floating cover to collect and direct biogas to the gas utilization system.
- *Biogas utilization system.* The recovered biogas can be used to produce space heat, hot water, cooling, or electricity.
- *Solids separator (optional).* A mechanical separator may be installed between the plug-flow digester outflow and the effluent storage structure.
- *Methane recovery system.* A plug-flow digester is covered by a gas tight fixed solid top, a flexible top, or a floating cover to collect and direct biogas to the gas utilization system.
- *Solid cover.* A solid cover is constructed to avoid cracking and leaks. Solid covers should resist corrosion. A solid cover allows for minimal gas storage.
- *Inflatable Cover.* A coated fabric is generally used for inflatable covers. An inflatable cover can be designed for some gas storage. Wind protection may be necessary. The cover must have a gas tight seal.
- *Floating cover.* A floating cover is designed to lie flat on the digester surface.

Biogas Utilization with Plug Flow Digester



Design Criteria and Sizing the Plug-Flow Digester

- **Location.** If a manure pump is installed to pump the 12% solids manure, the digester can be located within a 300 ft radius of the mix tank at a convenient location with good access.
- **Mix tank.** The mix tank can be round, square, or rectangular. A pump may be required to move manure to the plug flow digester.
- **Hydraulic retention time and sizing of plug-flow digester.** A plug-flow digester will function with an HRT from 12 to 80 days. However, an HRT between 15 and 20 days is most commonly used to economically produce 70% to 80% of the ultimate methane yield.
- **Dimensions.** The depth of a plug-flow digester can be between 8 feet and 16 feet depending upon soil conditions and the required tank volume. The width:depth ratio is usually greater than 1 and less than 2.5. The length:width ratio should be between 3.5 and 5.
- **Heat exchanger.** An external heat exchanger or an internal heat exchanger is required to maintain the digesting mixture at the design temperature. Hot water circulated through the heat exchanger is heated using biogas as a fuel for a boiler or waste heat from a biogas fueled engine-generator.
- **Operating temperature.** The daily temperature fluctuation should be less than 10 F. Most plug flow digesters operate in mesophilic range between 95o F to 105o F with an optimum of 100o F. It is possible to operate in the thermophilic range between 135 to 145o F, but the digestion process is subject to upset if not closely monitored.
- **Insulation.** A plug flow digester surface may be insulated to control heat loss.
- **Construction materials.** The digester can be constructed as a lined trench or as a reinforced concrete or block tank.
- **Methane recovery system and covers.** See discussion of methane recovery system above under complete mix digesters.

Operation and Maintenance of Plug-Flow Digesters

Proper operation and maintenance of plug-flow digesters is necessary for successful operation.

- *Mix tank — operation.* On a daily or every other day basis, collectible manure is pushed, dragged or dumped into the mix tank. If necessary, dilution water or drier manure is added to the collected manure and mixed to achieve the design total solids mixture. The mixed manure is released via gravity gate or pumped into the digester.
- *Mix tank — maintenance.* Mix tank maintenance consists of normal maintenance of pumps and mixers per manufacturers recommendations. The mix tank will require occasional cleaning to remove accumulated sand, gravel, steel and wood.
- *Plug-flow digester — operation.* A plug-flow digester is fed from the mix tank daily or every other day. The digester heating and mixing system should be checked daily to verify operation.
- *Plug-flow digester — maintenance.* The digester temperature should be checked daily. The effluent outlet and digester gas pressure relief should be checked weekly to be sure that they are operating properly. The heat exchanger pump should be lubricated per the manufacturer's recommendations. Sludge accumulation may require sludge removal every 8 to 10 years.
- *Cover — maintenance.* The cover should be visually inspected weekly for rainwater accumulation, cracks, tearing, wear, and tensioning.

