Understanding Design Codes and Standards for Biogas Systems

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WEF MOP 8, 2017 Edition Chapter 25 Stabilization

4 Gas Production
4 Volatile solids loading/destruction
   1. Typical AD = 13-18 cf/lb VS destroyed
   2. Fats = 20-25 cf/lb VS destroyed
   3. Proteins/Carbs = 12 cf/lb VS destroyed
4 Additional factors:
   1. Temperature
      a. Mesophilic vs Thermophilic
      b. Single vs Multi-Staged Operation
   2. pH/Alkalinity
      Optimum pH for Methane Production
      = 6.8 – 7.2
3. **SRT/HRT**
   Solids retention time \( SRT = \frac{M}{\text{solids removed}} \).
   Hydraulic retention time \( HRT = \frac{\text{volume of solids into the digester(s)}}{\text{solids removed (inflow and outflow rate)}} \).

4. **Mixing Efficiency**
   Example: Linear Motion Mixer
   Efficient mixing optimized digester gas production

5. **Organics Loading Rate and Frequency**
   A. Typical sustained peak VS loading rate = \( .12 - .16 \text{ lb VS/cfd} \)
   B. Typical maximum VS loading rate = \( .2 \text{ lb VS/cf/day} \)
2017 MOP 8, Chapter 25, Fig. 25.33  Diagram of a gas control system
Proper Selection of Safety Equipment

3. Referenced Standards (best design practice or, in some jurisdictions, code):

- ANSI/CSA B149.6-15 Code for Digester Gas, Landfill Gas, and Biogas Generation and Utilization;
- NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection Facilities; and
- GLUMRB (Ten States Standards) Recommended Standards for Waste Water Facilities or applicable local Design Standard
MOP 8

Design Parameters

1. Gas Velocity = 12 fps
2. Digester Cover
   a. PRV Valve/Flame Arrester redundancy (fixed or floating)
   b. Appurtenances for access and sludge sampling
3. Gas Holder – membrane gas holder; balance system and maintains system operating pressure
Design Parameters

4. Moisture Removal
   a. Sediment Traps and drip traps

   b. Gas Drying Systems –
      • Coalescing filter – remove particulates
      • glycol chiller - cool the gas to desired temperature
      • compressor - reheat gas creating a dew point barrier so that no additional moisture can form.
Design Parameters

5. H2S Removal
   a. Chemical addition
   b. Polishing using media – example: iron sponge

\[
2 \text{Fe}_2\text{O}_3 + \text{H}_2\text{O} + 6\text{H}_2\text{S} = 2\text{Fe}_2\text{S}_3 + 7\text{H}_2\text{O} + \text{heat}
\]

Iron sponge regenerated:

\[
2\text{Fe}_2\text{S}_3 + 3\text{O}_2 = 2 \text{Fe}_2\text{O}_3 + 6\text{S} + \text{heat}
\]
Design Parameters

c. Biological Treatment –

1. The sulfur oxidation bacteria thrives and multiplies on a packed media inside a closed acid-proof tank.
2. sulfur from the H$_2$S
3. carbon from the CO$_2$
4. oxygen from atmospheric air
5. nutrients (nitrogen, phosphorus and potassium) from the treated effluent
6. Temperature between 86-130°F (30-55°C).

The sulfate is discharged with the effluent from the gas cleaner which contains up to 8% SO$_4$. 
MOP 8

Design Parameters

   c. Biological Treatment –
Proper Selection of Safety Equipment

1. Pressure/Vacuum Relief Valve and Flame Arrester – Relieves the digester of an overpressure or vacuum condition.

MOP 8, Fig. 25.37
Proper Selection of Safety Equipment

2. Flame Arresters, Flame Trap Assemblies – Must be installed within 15 feet of a potential flame source.

Flame arresters installed within 15 feet of potential flame source.

MOP 8, FIG. 25.34
Proper Selection of Safety Equipment

3. Waste Gas Burner – Safe and effective method of combusting excess biogas produced. Two types:

- Open-Type or Candle-stick Flares
- Enclosed Flares
9. Digesters and Gas Storage Tanks, Gas Storage tanks or spheres >15 psi; membrane gas holder

Redundancy: A pair of flash-back (flame) arrester and pressure/ vacuum relief valves.

a) connected to the digester roof, as close as practicable to the digester holding space;

b) piped in parallel, with a three-way manual change-over valve.

c) Vented separately when inside an enclosure.

d) equipped with the flash-back (flame) arresters installed upstream from the pressure/ vacuum relief valves

e) And tested before going into service.
9.7.2
Suitable protection against weather either with insulated enclosure with ventilation and accessibility for Servicing or with jackets.
9.7.3
No Isolation valves or any obstructions (except for flame arrester) in the gas connection between the digester gas holding space and the digester excess gas pressure/ vacuum relief valve. Note: This is a listed prohibited practice.
ANSI/CSA B149.6

Code requirements for the various accessories on the digester cover (fixed or floating);
9.3 Access holes (only fixed or floating cover)

9.3.1
Digester Roof, 50 feet and greater (15m) >= 3 access holes. 1 pc minimum 42” size ID.

9.3.2
Digester Roof, Less than 50 feet (15m) >= 2 access holes. 1 pc minimum 42” size ID.

9.7.4
Secondary, emergency pressure-relief system
a) installed without the use of a flash-back (flame) arrester,
b) set higher than relief setting of PRV Valve
c) And tested before going into service.
ANSI/CSA B149.6

Emergency pressure relief manhole cover

42" access manway
Important Factors for design:

1. 2% Slope for pipe (including bleed vents)
2. Gas piping and tubing systems:
   (a) SS; (b) plastic; and (c) copper (vent lines).
   Cast iron pipe and fittings (including flanges) shall not be used.
3. Plastic pipe and fittings made of polyethylene or glass fiber-thermosetting resin. Only installed outdoors.
4. Plastic not subjected to 100 deg. F.
5. Copper OK for vent and bleed lines. No copper for buried piping.
6. 1/8 in thick neoprene gasket with 40 hardness.
Important Factors for design:

7.  Bleed vents

8.13.1 *Valves*, regulators, manometers, and other control devices that require venting, separate or manifolded under the following conditions:

8.13.2
Bleed vents from relief *valves* and regulators with internal relief shall be vented separately and shall not be manifolded with vents from other devices. The internal area of a bleed vent shall not be less than that of the vent opening.

8.13.3
Bleed vents from control devices (other than relief *valves* and regulators with internal relief) may be vented through a common manifold that shall have an area not less than twice the total area of the connected vents

ANSI/CSA B149.6
Important Factors for design:

8. Instrumentation

A liquid-filled manometer that does not require any power shall be provided on low-pressure gas lines (up to 760 mm water column) to indicate the pressure for:

(a) in each digester;

(b) to the waste gas burner upstream from the overpressure control valve; and

(c) to the boilers upstream from the backpressure control device (if provided).

A suitable vacuum/pressure measurement device that does not require any power shall be provided where the vacuum or pressure is greater than 760 mm water column (1 psig).
ANSI/CSA B149.6

ANSI/CSA B149.6, Clause 6.4 Waste Gas Burners

6.4.1 - waste gas burner tip = minimum 15 feet (4 m) above grade or maintenance platform level. 
waste gas burner stack termination = at least 5 feet (1.5 m) above any obstruction.

6.4.3 - waste gas burner and ignitor = minimum 50 feet (15 m) from digester perimeter or other combustible gas source.

6.4.4 - open-type stack tip = minimum 25 feet (7.5 m) from any other stack tip or exhaust vent termination. Enclose-type waste gas burner stack = minimum 10 feet (3 m) clearance.
ANSI/CSA B149.6, Clause 6.4 Waste Gas Burners

6.4.5 - Except if enclosed flare - stack location = minimum 25 feet (7.5 m) from property line or a road. Enclosed flare = 10 feet.

6.4.6 - Enclosed-type stack location = minimum 10 feet (3.0 m) road or provided with barrier to protect against damage to the stack.

6.4.7
Safety fencing minimum (25 feet) 7.5 m horizontally from the stack when accessible to public.
Pilot fuel (Natural Gas or Propane only, and not Biogas). No sparking raw biogas.
Localized (Regional) Design Standards

1. Recommended Standards for Wastewater Facilities (10-STATE STANDARD)

MEMBER STATES AND PROVINCE: ILLINOIS, NEW YORK, INDIANA, OHIO, IOWA, ONTARIO, MICHIGAN, PENNSYLVANIA, MINNESOTA, WISCONSIN, MISSOURI
Ten State Standard

2014 edition, Chapter 84;

- **84.132 Access Manholes**
  
  30” size allowed and will not fit a personnel with OSHA required pack entering confined space.

- **84.43**
  
  Minimum pipe size is 4”.
  
  No float operated condensate traps.
Ten State Standard

2014 edition, Chapter 84;

- 84.461
  Located at least 50 feet away from any plant structure.
  Sufficient height to protect personnel.

- 84.462
  Provided with an automatic ignition system with pilot sensing.
NFPA 820

Table 6.2.2.(a) Solids Treatment Process, Rows 10-29

Example:

![Diagram of Anaerobic Digester with Fixed or Floating Cover Above Grade Not Enclosed in a Building. Illustration of Table 6.2.2.(a), Rows 16a and 16b.]
NFPA 820

Table 6.2.2.(a) Solids Treatment Process, Rows 10-29
**NFPA 820**  
2016 Edition  
Table 6.2.2.(a) Solids Treatment Process, Rows 10-29  

Example:

<table>
<thead>
<tr>
<th>Row</th>
<th>Line</th>
<th>Location and Function</th>
<th>Fire and Explosion Hazard</th>
<th>Ventilation</th>
<th>Extent of Classified Area</th>
<th>NEC Area Electrical Classification (All Class I, Group D)</th>
<th>Materials of Construction</th>
<th>Fire Protection Measures</th>
</tr>
</thead>
</table>
| 19  |      | ANAEROBIC DIGESTER GAS STORAGE  
Storage of sludge gas | Gas storage piping and handling | NNV         | Within a 3 m (10 ft) envelope of tanks, valves, and appurtenances | Division 1                                           | NC, LC, or LFS         | Hand FE; CGD if enclosed in building |
| 20  | a    | WASTE GAS BURNERS  
Combusting excess gas | Gas piping and appurtenances | N/A         | Within 3 m (10 ft) envelope of all fixtures, appurtenances, and housing | Division 1                                           | NC                      | NR                      |
|     | b    |                       |                           |             | Envelope 4.6 m (15 ft) above Division 1 envelope and 1.5 m (5 ft) on all sides | Division 2                                           | NC                      | NR                      |

Row and Line – Refers to specific figures in Appendix A.6.2.  
NNV – Not normally ventilated.  
NC – Non combustible; LC – Limited Combustible; LFS – Low flame spread index per Chapter 8.  
Fire Protection Measure: Hand FE – Fire extinguisher; CGD – Combustible gas detection System; NR – No requirement or call fire department!