Understanding Design Codes and Standards for Biogas Systems

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MOP 8

WEF MOP 8 2017 EDITION CHAPTER 23 STABILIZATION

- **GAS PRODUCTION**
- **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**
- **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

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3. SRT/HRT

   SOLIDS RETENTION TIME SRT = M OF SOLIDS/ SOLIDS REMOVED.

   HYDRAULIC RETENTION TIME HRT = VOLUME OF SOLIDS INTO THE DIGESTER(S) / SOLIDS REMOVED (INFLOW AND OUTFLOW RATE).

4. MIXING EFFICIENCY

   DIFFERENT TECHNOLOGIES EXAMPLE: LINEAR MOTION MIXER

5. ORGANICS LOADING RATE AND FREQUENCY

   A. TYPICAL SUSTAINED PEAK VS LOADING RATE = .12 - .16 LB VS/CF/DAY

   B. TYPICAL MAXIMUM VS LOADING RATE = .2 LB VS/CF/DAY

6. PRE TREATMENT – E.G., THERMAL HYDROLYSIS THAT INCREASES GAS PRODUCTION.

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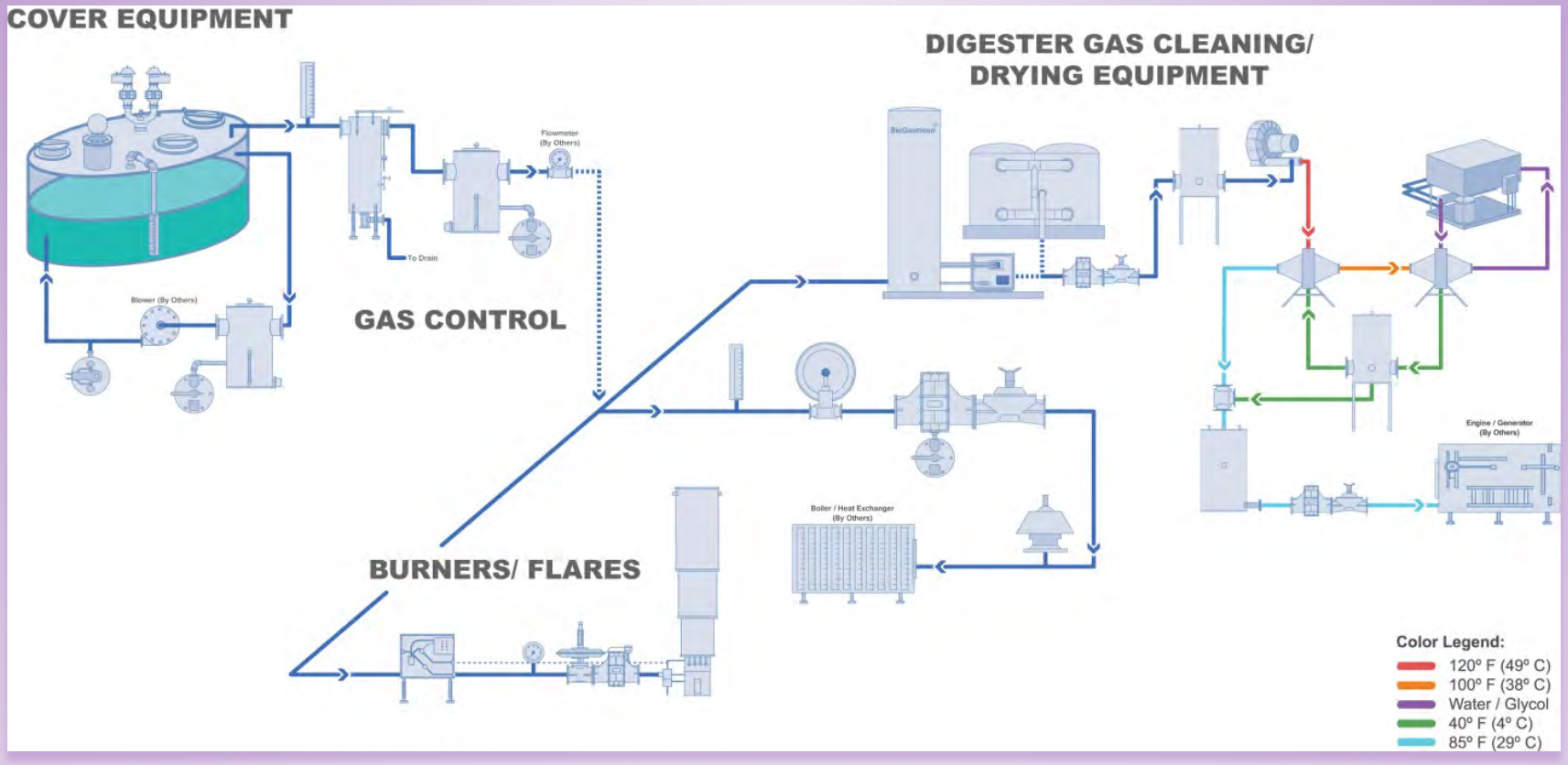

2017 MOP 8, Chapter 25, Fig. 25.33 Diagram of a gas control system

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Design Parameters

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

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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.**

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Design Parameters

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

$$2\ Fe_2O_3 + H_20 + 6H_2S = 2Fe_2S_3 + 7H_20 + heat$$

Iron sponge regenerated:

$$2Fe_2S_3 + 30_2 \quad = \quad 2\ Fe_2O_3 + 6S + heat$$

Wood chips impregnated with rust

MOP 8, FIG. 25.37

MOP 8

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_2S**
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.

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Design Parameters

c. **Biological Treatment –**

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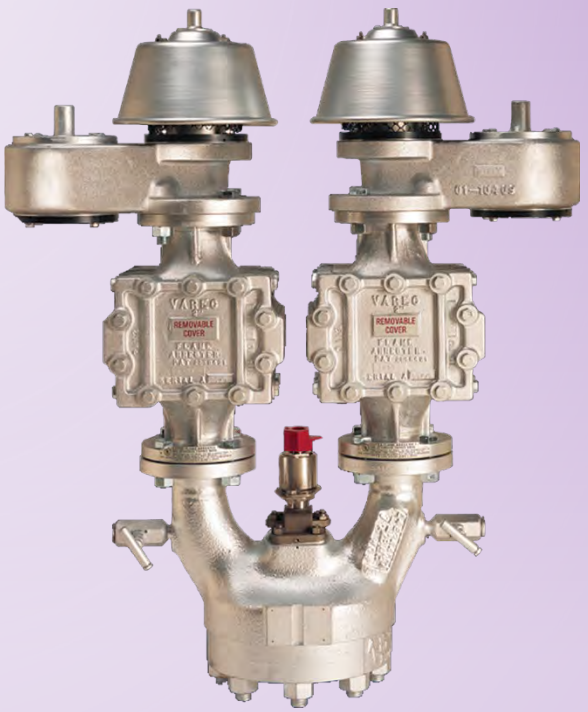
Proper Selection of Safety Equipment

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

Pressure/Vacuum Relief Valve and Flame Arrester

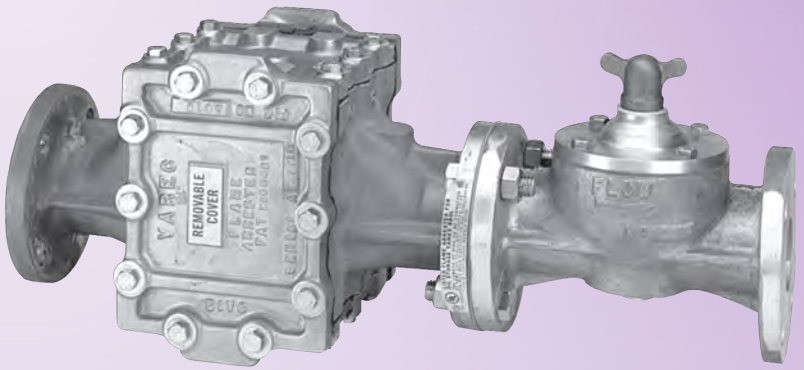


MOP 8, Fig. 25.37

MOP 8

Proper Selection of Safety Equipment

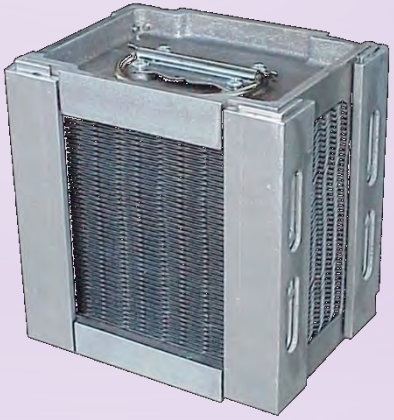
2. **Flame Arresters, Flame Trap Assemblies – Must be installed within 15 feet of a potential flame source.**

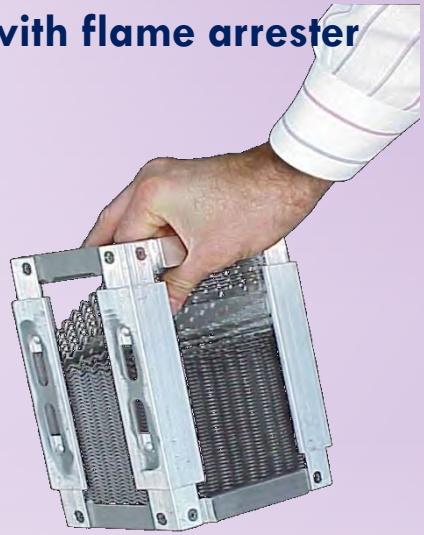


Thermal shut-off valve with flame arrester – flame trap assembly

Flame arresters installed within 15 feet of potential flame source.

MOP 8, FIG. 25.34





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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

MOP 8, FIG. 25.36
Enclosed Flares

MOP 8

Proper Selection of Safety Equipment

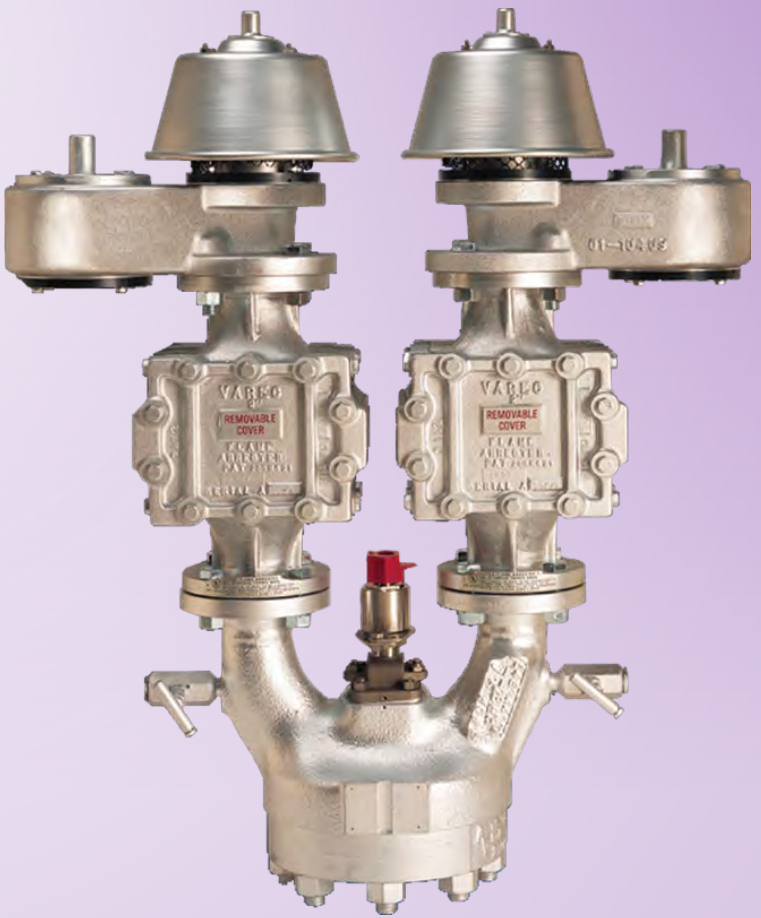
3. **Referenced Standards (best design practice or, in some jurisdictions, code):**
   - **ANSI/CSA B149.6-15 Code for Digester Gas, Landfill Gas, and Biogas Generation and Utilization;**
   - **NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection Facilities; and**
   - **GLUMRB (Ten States Standards) Recommended Standards for Waste Water Facilities or applicable local Design Standard**

ANSI/CSA B149.6

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.**



ANSI/CSA B149.6

9.7.2
Suitable protection against weather either with insulated enclosure with ventilation and accessibility for
Servicing or with jackets.

ANSI/CSA B149.6

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 <u>without</u> 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

Digester cover complete with:

1. **Redundant PRV/Flame Arrester**
2. **Use of Three-way manual change-over valve as Safety Selector Valve**
3. **Secondary Pressure Relief System with the use of Emergency pressure and vacuum relief manhole cover**
4. **48” access manway – 2 or more for 75-foot cover**

ANSI/CSA B149.6

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.**

ANSI/CSA B149.6

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

Vent lines equipped with flame checks to prevent flame propagation on vent lines.

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

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.

ANSI/CSA B149.6

ANSI/CSA B149.6 – Additional Requirements for Waste Gas Burners

Pilot fuel (Natural Gas or Propane only, and not Biogas). No sparking raw biogas.

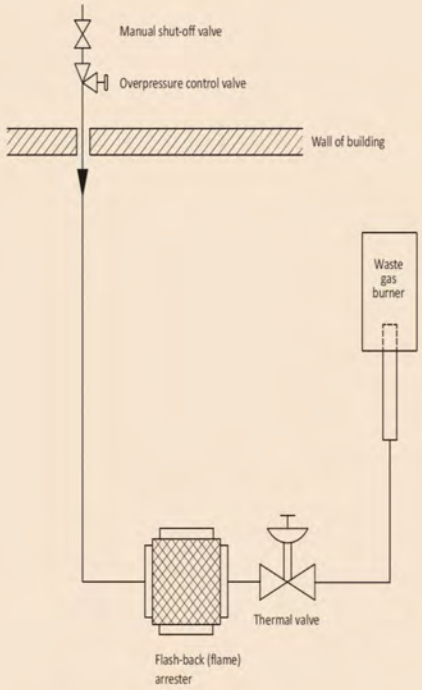


Figure B.3
Possible arrangement for waste gas flare stack burners burning digester gas
(See Clause D.5.)

LOCAL STANDARDS

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

2. **PA DEP Domestic Wastewater Facilities Manual – Guide for Design of Sewer Systems, Pump Stations and Treatment Plants**

3. **TR-16 Guides for the Design of Wastewater Treatment Works - published by New England Interstate Water Pollution Control Commission – Seven member states are Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.**

TEN STATE STANDARD

2014 edition, Chapter 84;

- **84.132 Access Manholes**

  2 X 30” size allowed and will not fit a personnel with OSHA required pack entering confined space.

- **84.42**
  - **Water Seal equipment not to be installed.**
  - **Automatic shut-off valve under Safety relief devices is not allowed per ANSI/CSA B149.6**

- **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.

TR-16

2011 Edition (As revised in 2016), Chapter 11.4:

- **11.4.3.1**
  1. **Reference to NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection facilities**

- **11.4.3.2**
  1. **Reference MOP 8 and allows safety shut-off valves under pressure/vacuum relief valve and flame arrester**
  2. **No water seal equipment used. P-traps for draining not allowed.**
  3. **Gas safety equipment and gas compressors housed in separate room with exterior entrance.**

- **11.4.3.3**
  1. **Max gas velocity is 12 fps at specified flow rate for pipe sizing.**

TR-16

2011 Edition (As revised in 2016), Chapter 11.4

- **11.4.3.6 – WASTE GAS BURNER**
  1. **Waste gas burner located at least 25 feet from any plant structure at ground level.**
  2. **Can be located on the roof of a building if removed from a tank. Tip must be unaffected by prevalent winds.**
  3. **Provided with automatic ignition and pilot flame monitoring.**

- **Access Hatches**
  - **2 X 36-in hatches – not large enough to fit personnel with OSHA pack.**

NFPA 820

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

Example:

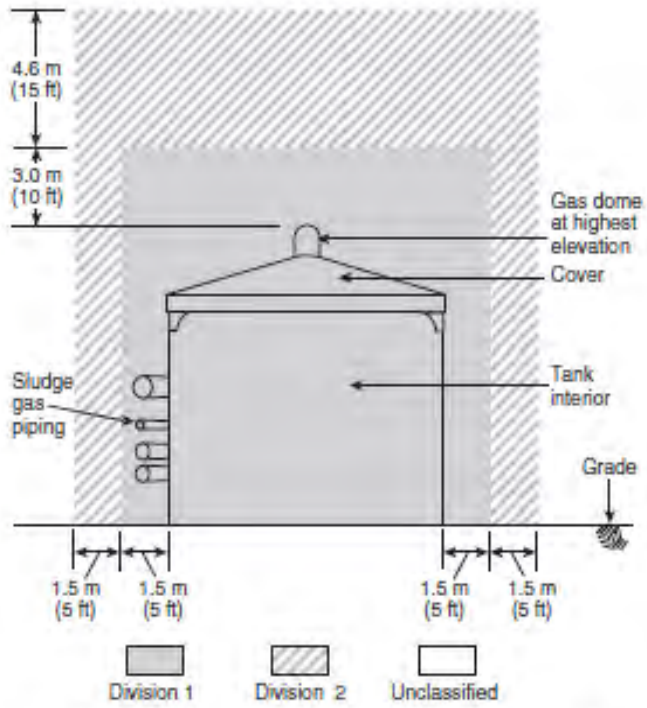


FIGURE A.6.2(a) Anaerobic Digester with Fixed or Floating Cover Above Grade Not Enclosed in a Building; Illustration of Table 6.2.2(a), Rows 16a and 16b.

NFPA 820

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

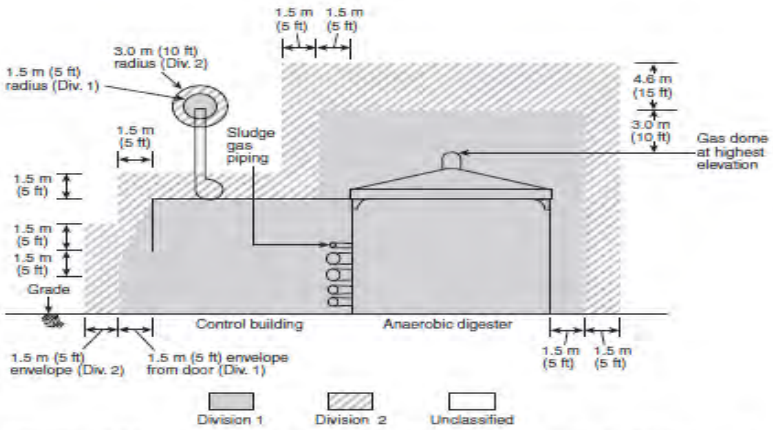


FIGURE A.6.2(b) Anaerobic Digester Control Building Containing Sludge Gas Piping and Using Ventilation Method (A); Illustration of Table 6.2.2(a), Row 17a.

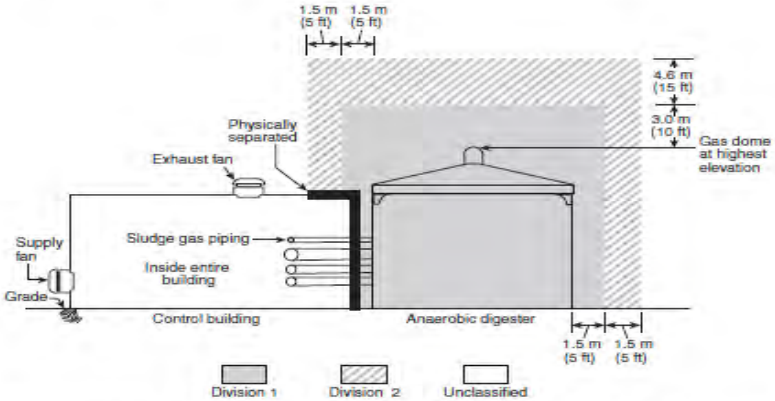


FIGURE A.6.2(c) Anaerobic Digester Control Building Containing Sludge Gas Piping and Using Ventilation Method (C); Illustration of Table 6.2.2(a), Row 17c.

NFPA 820

2016 Edition
Table 6.2.2.(a) Solids Treatment Process, Rows 10-29
Example:

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b,c,d]	Extent of Classified Area	*NEC* Area Electrical Classification (All Class I, Group D)[d]	Materials of Construction[e]	Fire Protection Measures
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!