Alternative Fuel Systems - sales and technical guide

SECTION 1: INTRODUCTION

Cleaver-Brooks defines alternative fuel(s) as that which is other than standard commercially available fuel; used with a burner/boiler combination. Standard, commercially available fuels include natural gas, light oil, and heavy oil. Hence, all other fuels including but not limited to digester gas, landfill gas, solvents, waste oils, hydrogen, town gas, or biogas are considered nonstandard, waste, or alternative.

Over the years, Cleaver-Brooks has offered alternative fuel systems and gained considerable experience in this field, including custom designs engineered around specific onsite requirements.

We have developed standard systems to fire digester and landfill gas. All other fuels will require up-front evaluation.

SECTION 2: DIGESTER AND LANDFILL GASES

2.1 Definition and sources

Digester gas typically refers to gas produced by the fermentation of organic matter such as manure, wastewater sludge, municipal solid waste, or any other biodegradable feedstock, under anaerobic (absence of oxygen) conditions. Digester gas is also called biogas, swamp gas, landfill gas, or sewer gas, depending on where it is produced. Each variant has different levels of methane and carbon dioxide with other minor gases. However, in general the heating value and composition of these gases is essentially known, and therefore they can be used as a fuel in Cleaver-Brooks boilers.

2.2 Characteristics of digester gas

Characteristics of digester gas vary depending on the source. Typical chemical breakdown variations and properties are presented in the following tables.

Table 1. **Typical analysis of digester gas**

Component	Chemical Formula	% Vol
Methane	CH4	50-65
Carbon Dioxide	CO2	35-50
Hydrogen Sulfide	H2S	Trace – 2
Water Vapor	H2O	3-6
Other Gases	CO, N2, O2	1-10

Table 2. **Digester and natural gas comparison**

Characteristic	Units	Digester Gas	Natural gas
Heating Value	Btu/Scf	500-600	950-1100
Specific gravity (Air = 1.0)	N/A	0.85 – 0.95	0.6 – 0.64
Hydrogen Sulfide	% Vol	Trace - 2	None
Water Vapor	% Vol	3 – 6 (Saturated)	None
Temperature	degF	75-120	Ambient
Supply Pressure	IWC	6-15	27.7 – 277 (1 – 10 PSIG)

2.3. Digester/landfill gas system evaluation

2.3.1. Digester gas has only about half the heating value of natural gas, is heavier than natural gas, and is typically supplied at a lower pressure than natural gas. These facts create the need for a system that can handle high flow rates of gas with minimum pressure drop.

2.3.2. The higher flow rates also have a major impact on burner design and performance. A special burner should be used to provide adequate gas velocities for good mixing but without excessive pressure drop.

2.3.3. Digester gas usually contains some hydrogen sulfide (H_2S), and is saturated with water. These characteristics create a corrosive environment for the gas piping, valving, exhaust breeching and stack, should condensation occur. We therefore require (contact) components be resilient to these conditions, using materials such as stainless steel, providing better corrosion resistance than carbon steel.

2.3.4. Digester gas systems are usually hot water or low pressure steam systems because they are often used for heating at the site location. These boilers produce low flue gas exit temperatures adding to the corrosive issues in the boiler system.

2.3.5. The digester gas supply is not always reliable and can be frequently interrupted. Therefore, the boiler system must be capable of responding to interruptions or inadequate supply of digester gas while continuing to meet the plant's heat demand.

2.3.6. Often natural gas is used as a primary backup when digester gas supply interruptions occur. Normally, this is accomplished by the use of a dual canister gas burner housing with a control system that can automatically change over to the backup fuel.

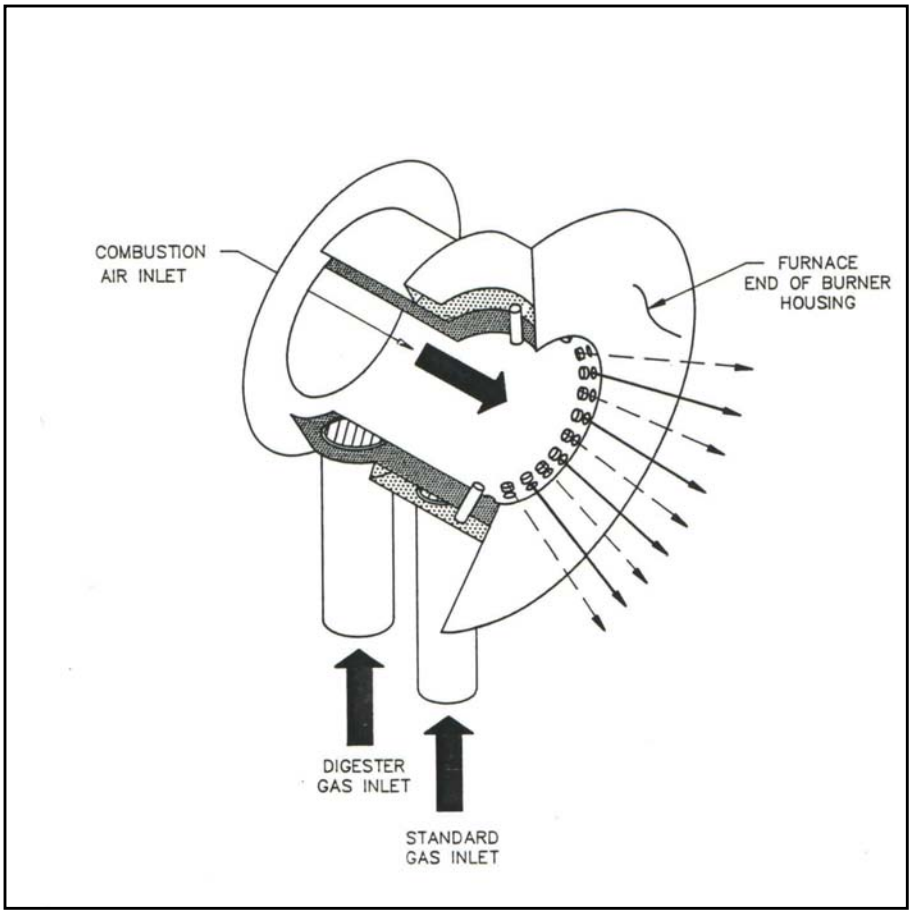

Figure I5-1. Dual Canister Burner

2.4. Components

Sulfur in any gas can be combined with hydrogen in the combustion process resulting in (corrosive) hydrogen sulfide. During cold startups, and if the combustion gas is cooled below its dew point, condensation occurs and the hydrogen sulfide condenses with the water vapor. This product is extremely damaging to carbon steel and to some gasket materials. Therefore, it is imperative the correct materials are selected to ensure long life of the equipment.

2.4.1. Gas Train - Separate gas trains are supplied for natural gas and digester gas. Corrosion resistant components are used for valves and switches on the digester gas train. In addition, all digester gas trains are supplied with two automatic safety shut off valves regardless of insurance requirements This is to ensure that the corrosive gas does not leak into the boiler when not in use. These automatic shut off valves have electric or pneumatic spring-return actuators.

2.4.2. Gas Pressure Regulator - Since digester gas is usually supplied at relatively low pressure (6-15" W.C.), the gas pressure regulator must be capable of operation at high gas flow rates with minimum pressure drop. Since most regulator suppliers' sizing data is based on natural gas, a correction factor is used to properly size the regulator.

2.4.3. Dual gas burner - For integral head firetube boilers firing digester gas with a

backup gas, Cleaver-Brooks uses our patented dual canister housing burner (see figure 1). The design of this burner system allows separate combustion control for two gases with different fuel characteristics.

The dual canister burner components are sized such that the digester gas system components are designed based on the digester gas fuel composition. The backup fuel system is separately designed based on the backup fuel composition.

Hence, different materials may be used for each fuel to ensure long component life, maximum burner efficiencies, and safety.

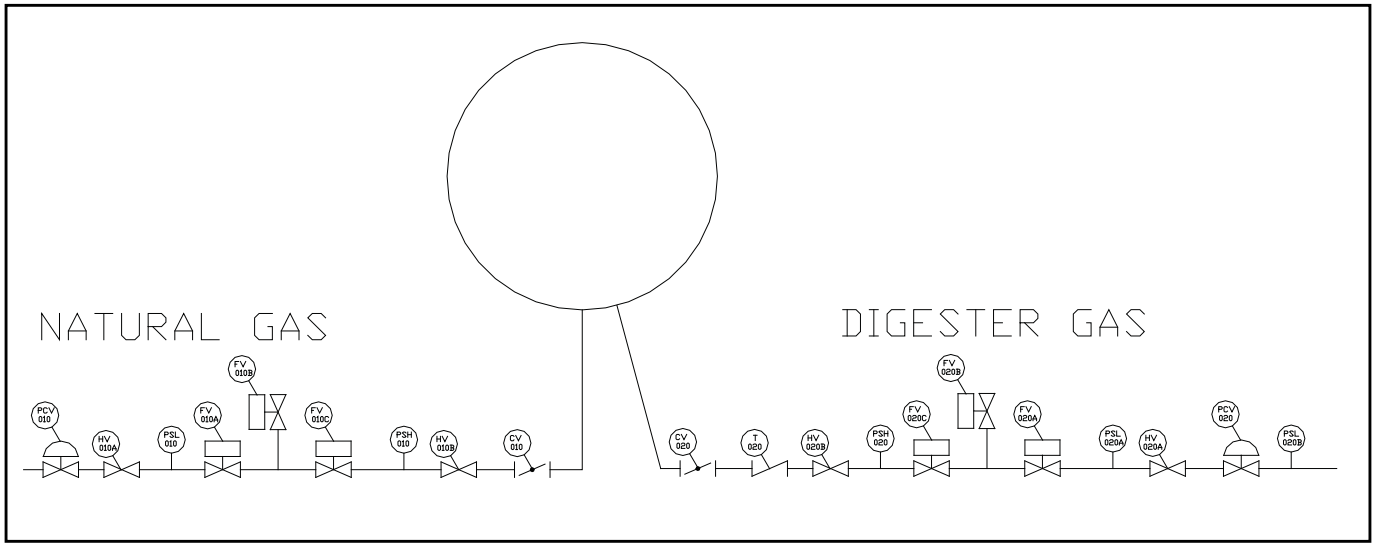

Figure I5-2. Dual Gas Train Schematic

***Table 3.* Gas Train Components**

Natural Gas Tag #	Digester Gas Tag #	Function
PCV-010	PCV-020	Gas Pressure Regulator
HV-010A	HV-020A	Manual Shut Off Valve
PSL-010	PSL-020A	Low Gas Pressure Switch
FV-010A	FV-020A	Automatic Shut Off Valve
FV-010B	FV-020B	Vent valve
FV-010C	FV-020C	Automatic Shut Off Valve
PSH-010	PSH-020	High Gas Pressure Switch
HV-010B	HV-020B	Manual Shut Off Valve
CV-010	CV-020	Firing Rate Modulating Valve
NA	PSL-020B	Automatic Fuel Changeover Switch *
NA	T-020	Flame Arrester with Check Valve*

* Optional components

2.5. Control Schemes

Over the years Cleaver-Brooks has used many different control schemes for firing digester gas. Most of these schemes were customized to the specific customer needs. Control scheme selection can be based on a number of factors including digester gas pressure, boiler size, number of boilers in a plant, and availability of digester gas. The most common control schemes are described below.

2.5.1. Automatic fuel changeover - The purpose of this control scheme is to automatically switch from digester gas to a back up fuel whenever digester gas supply becomes insufficient to meet the control settings. This option requires an automatic fuel changeover pressure switch, which is typically installed prior to the digester gas pressure regulator. When the boiler demand exceeds availability of the digester gas fuel, digester gas pressure drops, tripping the changeover pressure switch. The controls will modulate to the minimum firing position. Once minimum burner position is proven, the burner shuts down and then re-starts, firing the back up fuel. When digester gas pressure is restored, the aforementioned sequence is reversed, and the burner re-starts, firing digester gas.

2.5.2. Preferential firing - The purpose of this control scheme is to fire all the digester gas available. In order for this control scheme to work, another boiler is required to maintain adequate steam pressure (water temperature) when the digester gas supply cannot meet heat/process load demand.

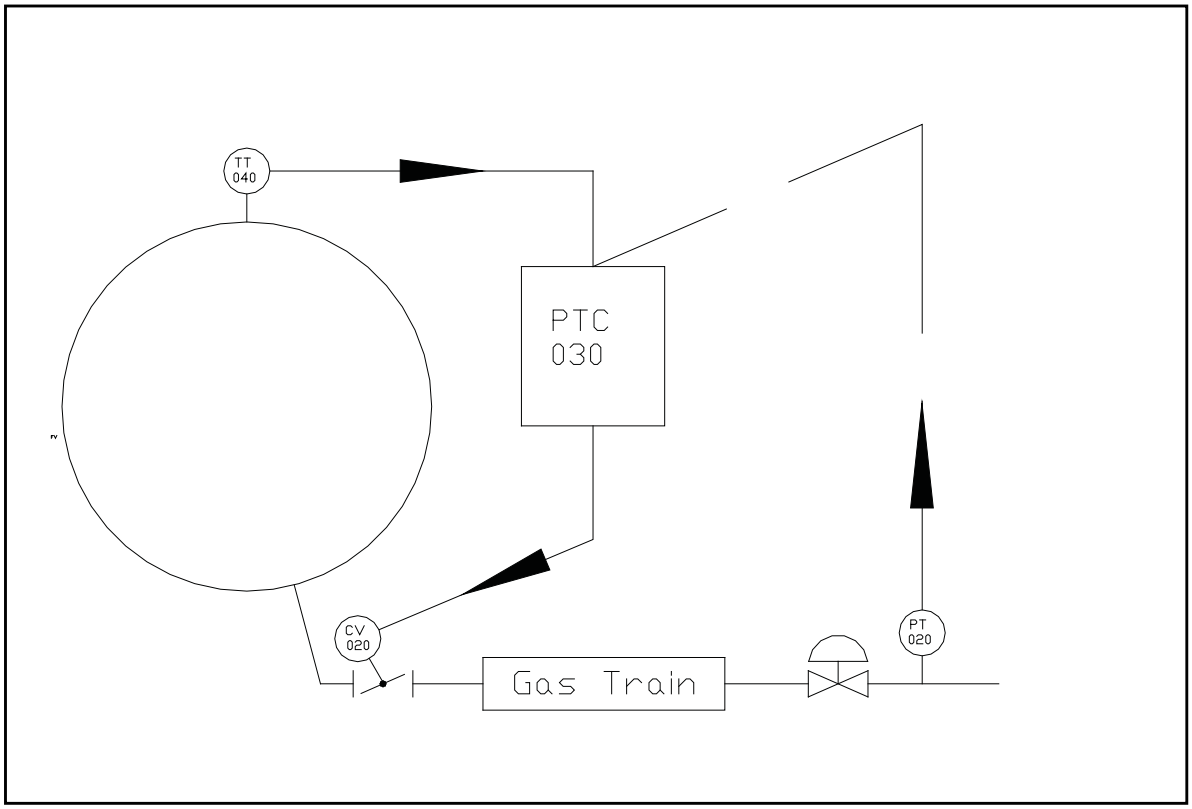

Figure I5-3. Preferential Firing Control Scheme

Pressure/Temperature controller PTC-030 receives boiler outlet temperature signal from temperature transmitter TT-040 and digester gas pressure signal from

pressure transmitter PT-020. Output to the firing rate control valve CV-020 is based on these two signals. When digester gas pressure is above set point, firing rate is based on the heat demand, i.e. boiler outlet pressure/temperature. When digester gas pressure drops below set point, firing rate signal is reduced to maintain digester gas pressure. Hence the control scheme ensures that all available digester gas can be burned. Automatic fuel changeover and low fire hold is incorporated into the control algorithm of PTC-030.

2.5.3. Simultaneous Firing - This control scheme will require up-front evaluation on a job-to-job basis.

SECTION 3. FUELS REQUIRING SPECIAL ENGINEERING.

The following is a list of fuels which will require special engineering:

- Hydrogen
- Refinery gases
- Contaminated air
- Coke oven gas
- Solvents
- Waste oil

SECTION 4. UNACCEPTABLE FUELS.

The following fuels are not acceptable for use in Cleaver-Brooks boilers:

- Solid fuels
- Acids
- Radioactive material
- Caustics