

Attachment B – Technical Site Profiles for PWD NEWPCP and SWWPCP

Northeast Water Pollution Control Plant Site (NEWPCP)

Technical / engineering description of the biogas system, the process and its components.

Sludge Gas Production

At NEWPCP, raw biogas is produced in eight (8) Anaerobic Digesters (300,000 ft³ capacity per tank) via methanogenesis. Sludge is fed into each digester at about 107,000 gpd with a detention time of 19-21 days. Complex organic material in the sludge is converted into smaller by-products including hydrogen, volatile fatty acids, and CO₂, which are then utilized by methanogens to reduce CO₂ to CH₄. The produced biogas is approximately 64 mol% CH₄, 36 mol% CO₂, 0.3 mol% N₂, and <3 ppm of total sulfur. Exact mole fractions of CH₄ and CO₂ vary but are relatively steady (see [Figure A-2](#)). In general, produced biogas can either be 1) Flared, 2) Combusted at Cogen to produce heat and electricity, or 3) Combusted in the digester gas-powered 600 HP Cleaver-Brooks boiler in the Sludge Thickener Building (Boiler #4). The only place where mixed gas is used (i.e. a blend of natural gas and biogas) is at Cogen.

Generated biogas leaves each digester through 8" stainless steel pipes at a pressure of approximately 7-10" of water column (0.25 – 0.36 psig) before it joins a 20" combined digester gas pipe. Rotary displacement gas flowmeters are located on each of the eight 8" lines for individual digester gas flow and the signal is sent to Citect (SCADA) for remote monitoring. Recently, a Kurz 454FTB-WGF thermal mass flowmeter was installed on the 20" combined line to measure total gas production but is still being configured. The flow through the combined pipe (ASTM A778, 316L) ranges from 0 – 1736 scfm and passes through several condensate traps as it leaves the SDT and enters the sludge gas facility (SGF).

Sludge Gas Storage, Compression, & H₂S Removal

Untreated biogas enters the Sludge Gas Storage tank (capacity of 50,000 ft³, scaled height of 0-33 ft), which has both a mechanical reading (piston/diaphragm) and a radar reading. The level reading from the PWD PLC is transmitted via an isolated analog 4-20mA signal and is used to control flare operations as well as the Balance of Plant (BOP) PLC at Cogen, which controls

each engine's remote load setpoint (if in Biogas mode) or the ratio of natural gas to biogas (if in Mixed Gas mode). Both the remote load setpoint (Biogas mode) and the mix ratio (Mixed gas mode) at Cogen adjust proportionally to the tank level using High SP and Low SP adjustable setpoints. For flare operations, the first burner comes on at 20 ft and turns off at 18 ft. The second burner comes on at 22 ft and turns off at 20 ft. The third and fourth burners follow the same +2 pattern—the third turns on at 24 ft (off at 22) and the fourth turns on at 24 ft (off at 26). Each flare burns approximately 600 scfm of biogas.

After the gas storage tank, sludge gas enters the hydrogen sulfite removal system, where a carbon-based media (DARCO BG1 Activated Carbon) scrubs the H₂S (adsorption). The basis of design is to reduce sulfur compounds (as S) to <2 ppmv. The H₂S removal system consists of two parallel trains of coalescing filters (CF-1 and CF-1A) for moisture and particulate removal, and an H₂S removal vessel that operates under vacuum pressure on the suction side of the compressors. Condensate traps drain collected water and are equipped with level switches and automatic drain valves to ensure no gas can escape. Differential pressure is monitored across both the H₂S skid and the coalescing filters. The partially treated biogas can then bypass the compressors and be redirected to the sludge gas flares (low pressure side) or it can be compressed through the high-pressure line. Both lines contain drip traps that are emptied routinely. The discharge side of the compressors has a back-pressure relief valve (spring-loaded with a diaphragm) that will dump back into the low-pressure side if the gas pressure exceeds ~7.5 PSI. If one of the two compressors is not in operation, the storage tank will fill with gas. Once the level reaches the upper setpoint, biogas is flared.

Dehydration

Once the partially treated biogas is compressed to a setpoint of ~4.5 PSI, it travels via a 16" gas pipe to Cogen's gas pretreatment room where a Biogas Isolation Stop Valve (FCV-1300) is located. The valve is controlled by the master biogas permissive and will close if the permissive is lost. Next, biogas passes through the tube-side of the first heat exchanger (HX-1) where it is pre-cooled. Temperature and pressure are monitored on both the inlet and the discharge. Downstream, a second heat exchanger (HX-2) further cools the biogas using an air-cooled chiller (air to glycol heat exchanger). Once again, the discharge temperature and pressure is monitored. The outlet temperature must be between 33-50 °F to meet the cooling permissive while the Dehydration skid is running. A PID function maintains the biogas temperature (TIT-1308) by adjusting the Chiller glycol Mixing valve (TCV-1308). The glycol flow, temperature, and pressure through the chiller loop is monitored as well. After HX-2, biogas passes through a coalescing filter (CF-2) that removes all free moisture through a two-stage filter. CF-2 is equipped with water level sensors, level switches, and motorized drain valves to direct the condensate to the integral sump (and out to the open floor drain) and to prevent biogas from escaping. Alarms are in place for low and high water levels. The discharged biogas pressure is monitored before the biogas enters the reheating loop, on the shell side of HX-1. A temperature control valve (TCV-1302) is in

place to bypass the reheating loop if necessary (setpoint is 80 °F). A third gas-to-hot water heat exchanger (HX-3) provides additional reheating capability, utilizing heat from the hot water loop to ensure the biogas temperature remains above 75 °F. A three-way (TCV-1321) temperature control valve on the hot water side serves as a closed loop control of the exit gas temperature (TIT-1321). The relative humidity (AIT-1321) is also monitored with a trip point at 60% (target is <40%).

Siloxane Removal

The Siloxane Removal System contains three components: 1) the 3 siloxane removal vessels (SiO-1, SiO-2, and SiO-3), 2) the outlet filter (CF-3), and 3) the recirculation blower. The basis of design is to reduce total siloxanes (as Si) to <400 ppbv through adsorption, using a form of activated carbon (NORIT® SILPURE). The three siloxane vessels are piped in a lead/lag/polish orientation. Manual valves are in place to rearrange the order as needed and each vessel is also equipped with a bypass valve and pressure relief valve. Since turbulent flow is required for sufficient contact between the biogas and the media pores, a variable-speed recirculation blower is used to maintain a target gas flow (900 scfm) through the siloxane removal tanks and starts automatically with the dehydration skid. Once the engines are running, it turns on whenever biogas flow through the siloxane tanks dips below the minimum air requirement (600 scfm). If the dehydration skid is running and biogas flow through the siloxane removal system dips below 400 scfm for 10 minutes, an alarm is triggered and the recirculation blower permissive will trip. A third and final particulate filter (CF-3) removes any remaining particulate matter entrained in the gas before it reaches the engine room via a 10" biogas header. The header is equipped with temperature (TIT-1440) and pressure (PIT-1445) transmitters. PIT-1445 must be between 1.16 – 7.5 PSI or the biogas permissive is not met.



PHILADELPHIA
WATER

Cogeneration Process Flow Diagram NE Water Pollution Control Plant

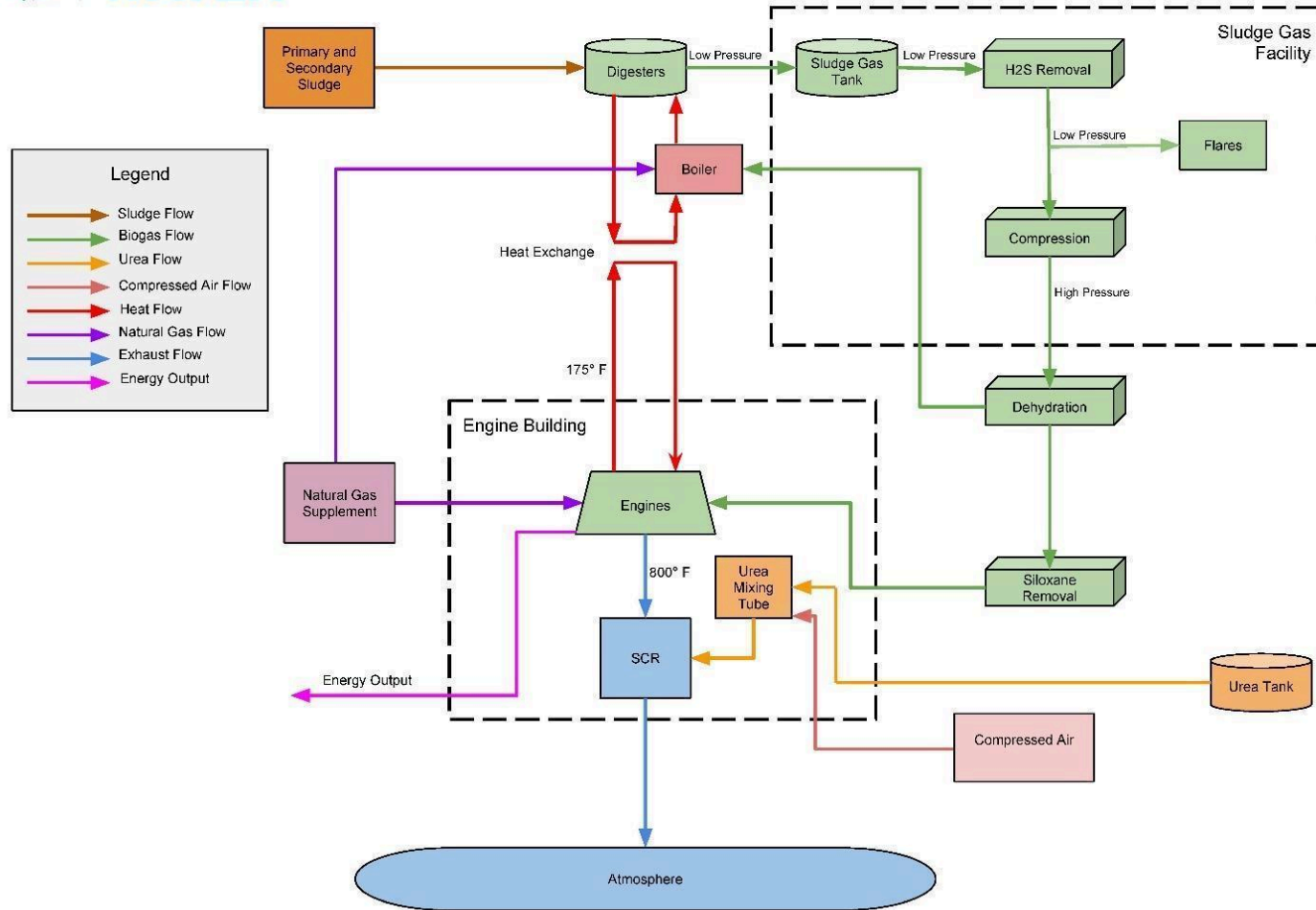


Figure A-1: Overall Process Flow Diagram for Biogas at NEWPCP.

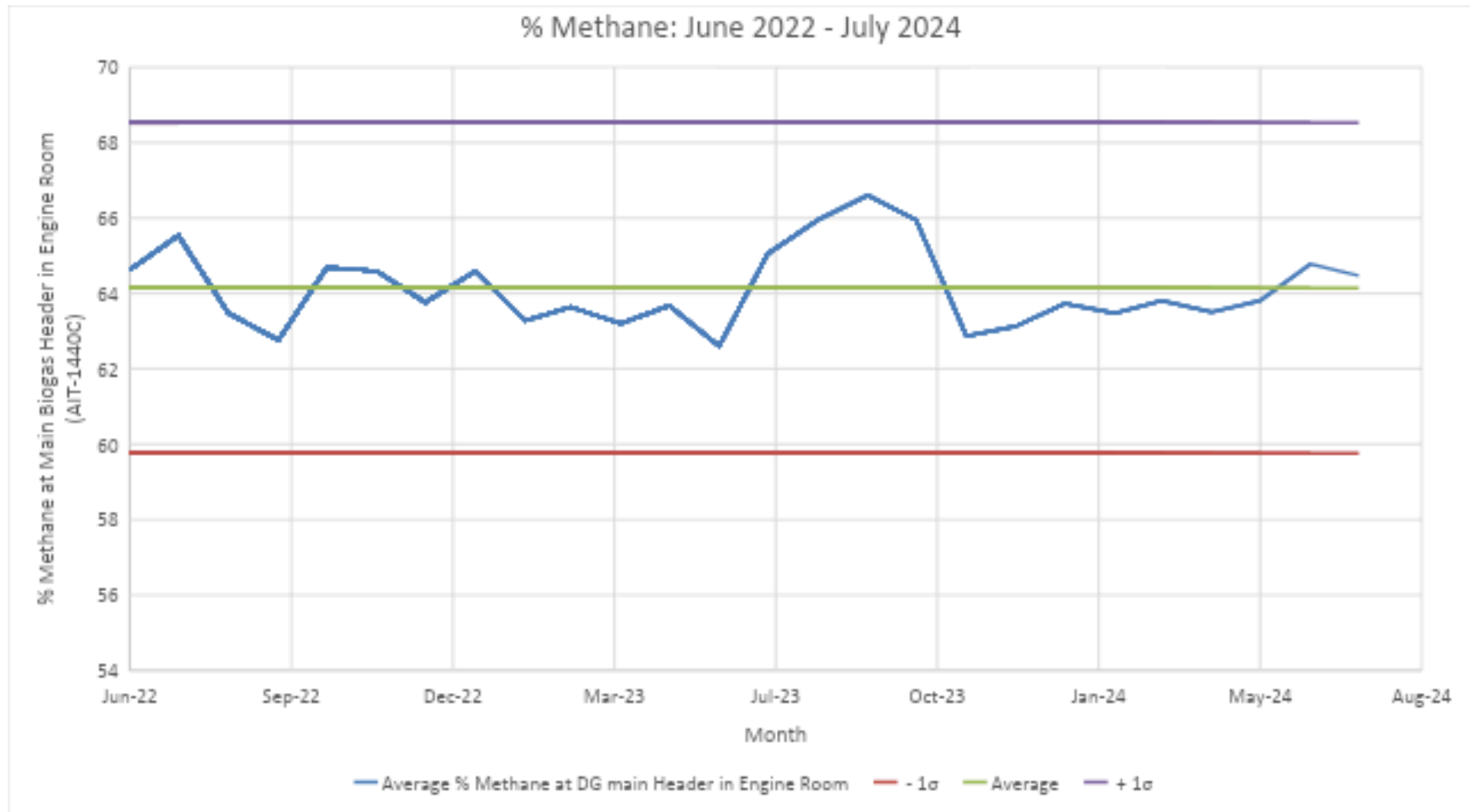


Figure A-2: % Methane in NEWPCP Treated Biogas for June 2022 through July 2024. Raw data was provided by AIT-1440C and collected in 30-minute averages. A monthly average was then generated from these data points. The upper and lower bounds represent ± 1 standard deviation (4.38) from the 792-day sample mean ($n = 38,016$), which was 64.1%.

Biogas Measurement and Calculation

PWD side

Biogas flow is measured at several points before Cogen:

1. Rotary displacement gas flowmeters are located on each of the eight 8" lines for individual digester gas flow and the signal is sent to Citect (SCADA) for remote monitoring. At the SDT, the totalizers are read and recorded every morning at 7 am by an operator. The difference between the current day's 7 am reading and the previous day's 7 am reading is used to quantify gas production for the previous day (cubic feet).
2. A new thermal mass flowmeter (Kurz 454FTB-WGF) was recently installed on the 20" combined digester gas line (before the sludge gas compressor facility) to measure total (cumulative) gas production. The electrical wiring has not yet been completed so the meter is not active yet but the work is in progress.
3. A differential pressure (Venturi) meter is located on the discharge side of the gas compressor in the SGF. The signal is sent to SCADA. Gas pressure is also recorded.

Cogen/Ameresco Side

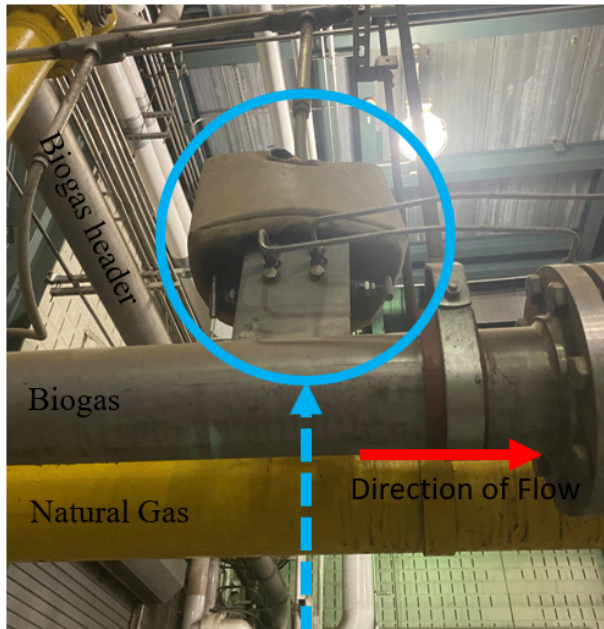
It is important to first point out that Biogas and Natural Gas (PGW) are fed to the engines through two separate gas trains—one for natural gas and one for biogas. The flowmeters (**Figures B-1 & B-2**) are **upstream** of the gas pressure control system, fuel gas regulator (Tecjet), and gas mixer housing. Thus, **mixed-gas mode does not affect the accuracy of natural gas or biogas flow measurements**. It is also important to note that Cogen is the only location on the plant where two different types of gas (PGW natural gas and Biogas) are mixed.

1. **Natural gas flow** is measured at each individual engine using thermal mass insertion meters (FIT 2111, 2211, 2311, and 2411). Again, this is prior to any mixing. The natural gas flow indication is used in a totalizer calculation to display the total natural gas used. The data is recorded on each engine's Di.ANE panel and is uploaded automatically to Ameresco's web portal. The monthly sum is compared to PGW invoices for data validation.
2. **Biogas flow** is measured at several points within Cogen:
 - a. Gas Pretreatment Room : Discharged biogas flow on the outlet of the siloxane skid (FIT-1445)
 - b. Engine Room
 - i. Biogas flow is measured twice (two separate meters) on the **main** 10" biogas line before it branches off to each engine's biogas gas train. FIT-1440A is a thermal mass insertion flowmeter and FIT-1440B is an in-line ultrasonic flowmeter. The two meters agree with a high degree of precision. FIT-1440B is also equipped with a

% methane sensor, which is used in the BTU calculation and is displayed in the Ameresco portal as AIT-1440C. The main biogas header is also equipped with a pressure transmitter (PIT-1440).

- ii. Biogas flow is also measured on the **individual** biogas trains to each of the 4 engines, prior to any mixing. The four in-line venturi flow meters (FIT-2101,2201,2301,2401) are equipped with a multivariable transmitter to provide a compensated mass flow measurement in SCFM.

Documentation for measuring and verifying quantities of biogas separately from quantities of natural gas brought into the system.



Biogas Flowmeter located on the engine's biogas gas train after it splits from the main header (FIT-2X01) where $x = 1,2,3,4$ for the 4 engines



Remainder of the biogas and NG gas trains including the Gas pressure control systems, micro filters, pre-pressure controllers, solenoid valves (with leak test), and Tecjet gas proportioning valves.

Natural Gas Flowmeter (FIT-2X11) where $x = 1,2,3,4$

Figure B-1: The biogas flowmeters and natural gas flowmeters on each of the engines are located upstream of any gas mixing in the respective gas trains.

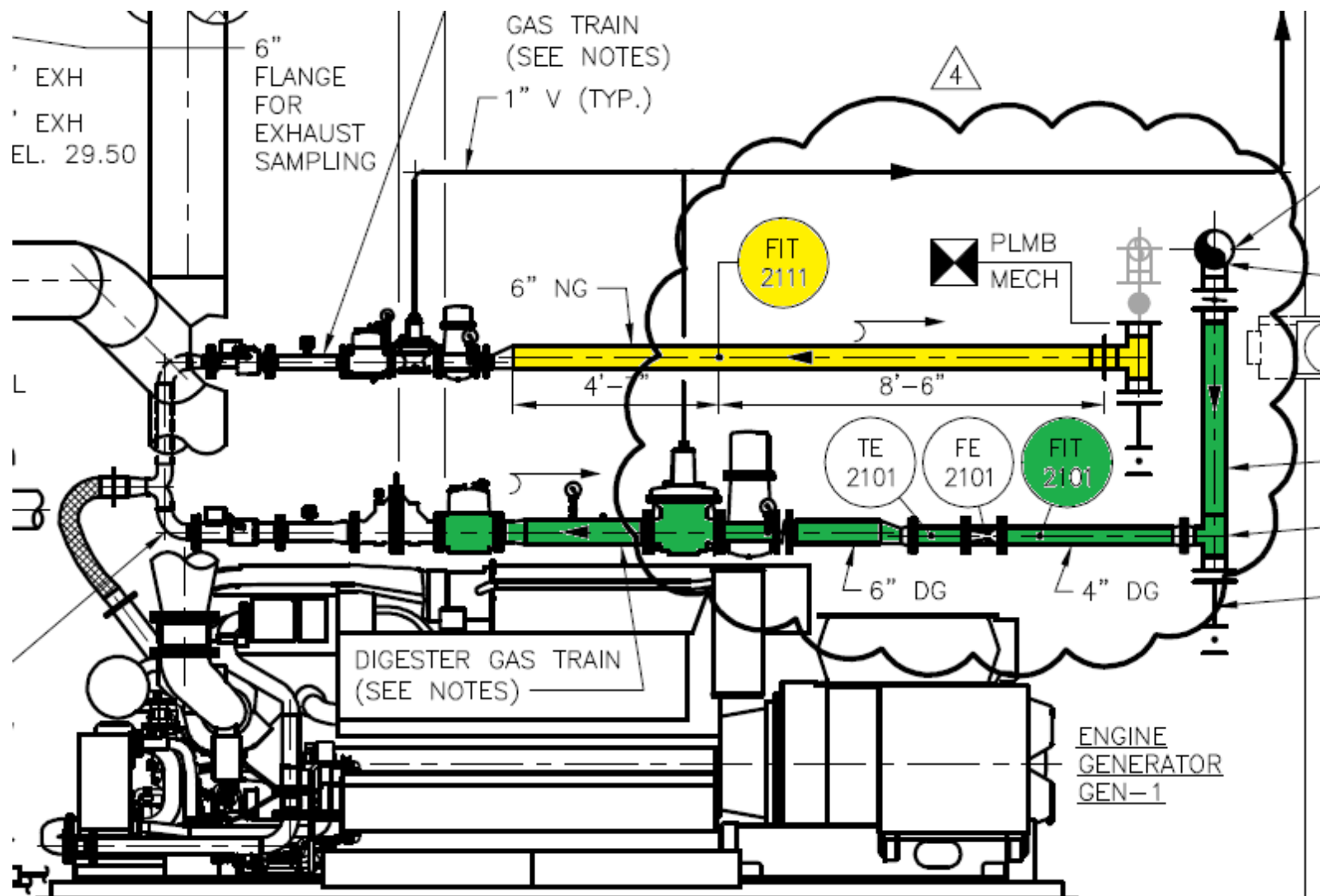


Figure B-2: A side-profile from the design specs also shows that the gas trains are isolated and flow measurements are taken before any gas mixing occurs.

Table 1: Gas Flow Measurement Table

See Attachment B-1 – NE WPCP Gas Meter information

The numbers in red in Figure C correspond with those in the Attachment B-1

Table 2: Master List of Gas Measurement Transmitters within Cogen

Flow Indicating Transmitters (FE/FIT)	
Tag Name	Description/Location
FE/FIT-2311	NG TO ENGINE 3 FLOW
FE/FIT-2111	NG TO ENGINE 1 FLOW
FE/FIT-1445	DG TO SILOXANE REMOVAL FLOW
FE/FIT-2301	DG TO ENGINE 3 FLOW
FE/FIT-2101	DG TO ENGINE 1 FLOW
FE/FIT-1440 A	DG TO ENGINES FLOW
FE/FIT-1440 B	DG TO ENGINES FLOW
FE/FIT-2401	DG TO ENGINE 4 FLOW
FE/FIT-2211	NG TO ENGINE 2 FLOW
FE/FIT-2411	NG TO ENGINE 4 FLOW
FE/FIT-2201	DG TO ENGINE 2 FLOW

Pressure Indicating Transmitters (PIT)	
Tag Name	Description
PIT-1308	DG TO CF-2 PRESSURE
PIT-1211	H2S SKID OUTLET PRESSURE
PIT-1206	H2S SKID INLET PRESSURE
PIT-1445	DG FROM SILOXANE REMOVAL PRESSURE
PIT-1302A	DG FROM CF-2 INTO HX1 PRESSURE

PIT-1320	DG OUTLET OF HX-1A PRESSURE
PIT-1302B	DG FROM HX1 TO HX3 PRESSURE
PIT-1301B	DG FROM HX1 TO HX-2 PRESSURE
PIT-1301A	DG INTO HX1 PRESSURE
PIT-2802	NG PRESSURE
PIT-1440	DG TO ENGINES PRESSURE

Temperature Indicating Transmitters (TIT)	
Tag Name	Description
TIT-1301A	DG INTO HX1 TEMP
TIT-1440	DG TO ENGINES TEMP
TIT-1302B	DG FROM HX1 TO HX3 TEMP
TIT-1308	DG FROM HX-2 TO CF-2 TEMP
TIT-1301B	DG FROM HX1 TO HX-2 TEMP
TIT-1321	DG HX-3 OUTLET TEMP
Gas Analyzers	
Tag Name	Description/Location
AIT-1321	DIGESTER GAS RELATIVE HUMIDITY (Hazardous Gas Analyzer)
AIT-1440C	DG TO ENGINES CH ₄ (Hazardous Gas Analyzer)
AT-1240	CH ₄ AT CONDENSATE TRAP NO.1 (Gas Analyzer)

Table 3: List of Gas Measurement Transmitters within the Plant (NEWPCP)

See Attachment B-1 – NE WPCP Gas Meter information

The numbers in red in Figure C correspond with those in the Attachment B-1

*Please refer to **Figure A-1** and **Figure C** (below).*

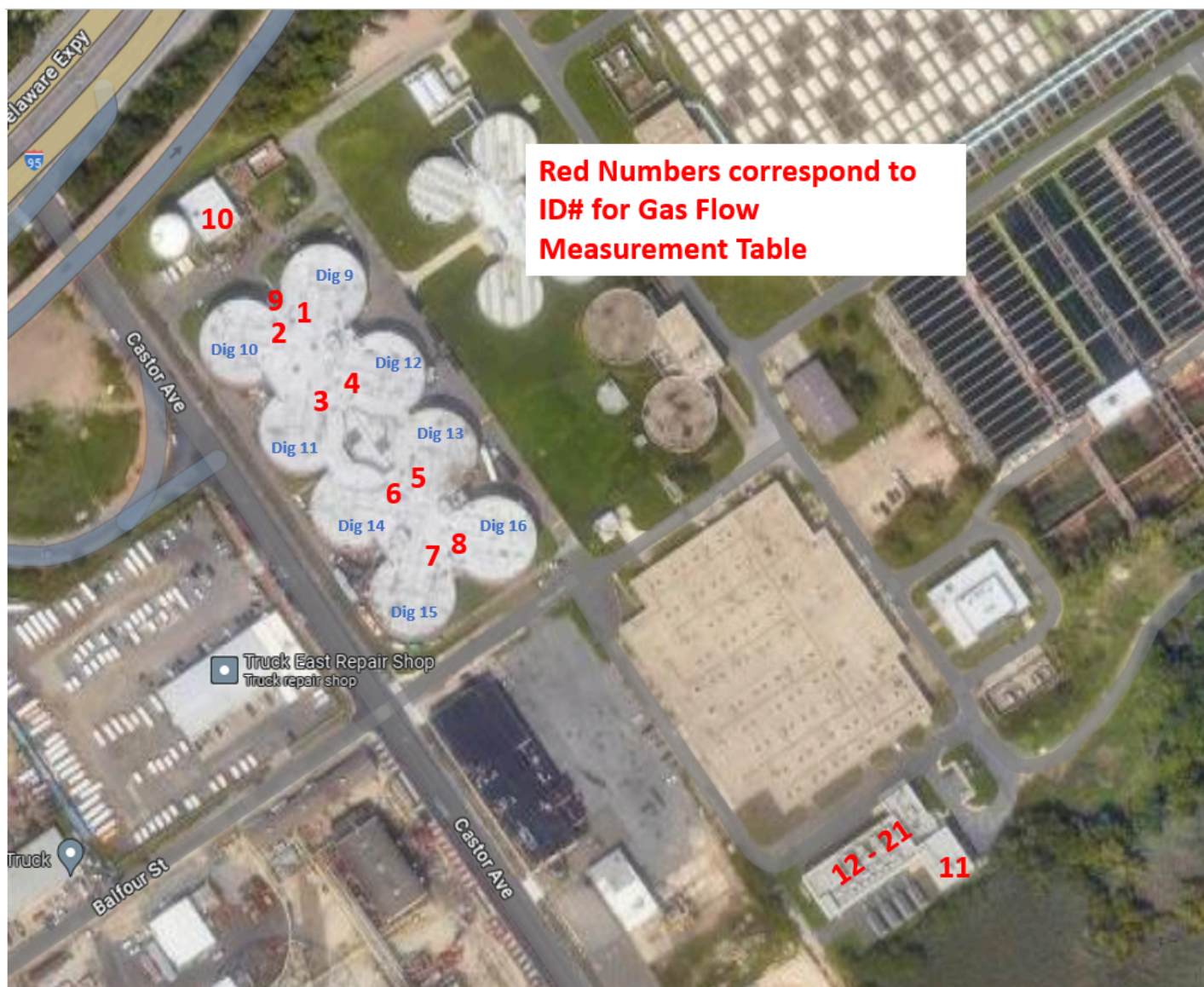


Figure C: Mapped locations of Gas Flow meters on the NEWPCP plant and at Cogen. Values in red correspond to Table 1: Gas Flow Measurement Table.

1. Outlet Biogas Parameters – *outlet side of digester*:

SOURCE	Untreated	Partially Treated (Leaving SGF)	Cogen Sample Point (Treated)	Unit
FLOW	0 - 1736			Scfm
PRESSURE	0.25 – 0.32	4 – 7.5		psig
TEMPERATURE				F
METHANE (CH ₄)	63.73*	62.80*	62.82*	%mol
CARBON DIOXIDE (CO ₂)	35.98*	36.98*	36.92*	%mol
NITROGEN (N ₂)	0.30*	0.26*	0.25*	%mol
TOTAL N ₂ + O ₂				%mol
TOTAL INERTS (CO ₂ + N ₂ + O ₂)				%mol
WATER VAPOR (H ₂ O)				lbs/MMscf
HYDROGEN SULFIDE (H ₂ S)	1.88	ND	ND	ppm
TOTAL SILOXANES				mg/Si/m3
HHV	647	637.6	638	BTU/scf
TOTAL VOCS				mg/m3

*2023-2024 Average

ND = Not Detected