QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PLAN
FOR
NEW HOPE VIEW FARM ANAEROBIC DIGESTER GAS (ADG) SYSTEM
Agreement # 33429

September 2015

Submitted to:

New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203-6399

and

New Hope View Farm, LLC
5937 State Route 11
Homer, NY 13045

Submitted by:

CDH Energy Corp.
P.O. Box 641
Cazenovia, NY 13035

PROJECT PARTICIPANTS

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NYSERDA Technical Consultant (TC)	CDH Energy Corp. Contact: Daniel Robb P.O. Box 641 Cazenovia, NY 13035 (315)-655-1063 X 20 Email: danrobb@cdhenergy.com
NYSERDA CHP Website Contractor (CHP Website Contractor)	CDH Energy Corp. Contact: Hugh Henderson P.O. Box 641 Cazenovia, NY 13035 315-655-1063 Email: hugh@cdhenergy.com

Introduction

This plan describes the approach that will be used to monitor the performance of the anaerobic digester gas (ADG) system that is currently being installed at New Hope View Farm, LLC, ("The Farm") in Homer, NY, to produce biogas and electricity. Biogas will be used to fuel one engine-generator to produce power that will be consumed on site and/or exported back to the local utility. A monitoring system will be installed to measure and collect the data necessary to quantify the electric power produced and amount of biogas used by the engine-generator. The data will serve as the basis for payment of ten (10) years of performance incentive payments, which The Farm has applied for under a Standard Performance Contract with NYSERDA based on a Total Contracted Capacity of 370 kW.

ADG System Description

The digester system at the farm was designed by PlanET Biogas USA. The power plant equipment will be provided by 2G Cenergy while the hydrogen sulfide removal equipment will be supplied by PlanET Biogas. Gas and power metering are provided by ABB and Schweitzer Engineering Laboratories, Inc. (SEL). The site will operate one 370 kW synchronous engine-generator. The farm are all consolidated and already operating 3-phase power, however the existing substation is not sized to handle the anticipated power exported from the farm. So a new 3-phase line is being run to the farm from a larger 14.6 kVa transfer station nearly one (1) mile away. The electrical system includes synchronizing and paralleling switchgear as well as interconnection and protective relays. The farm expects to export a portion of the generated electricity, and has been approved for net metering.

Newly installed fully mixed, soft cover, heated, PlanET digester; 82 ft ø, 26ft tall.

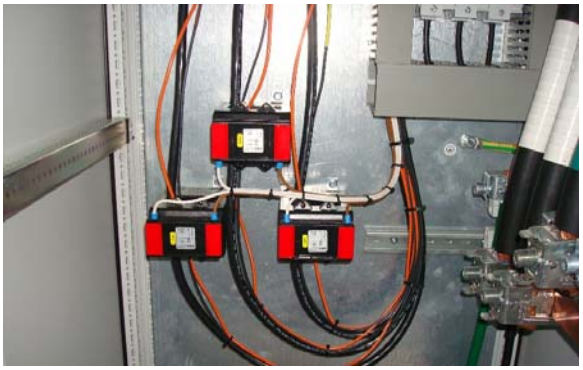
Enclosure housing engine, generator, hot water heat recovery, gas analyzer, and power and gas metering equipment.

Manure pumps, supply to digester or slurry storage tank.

Digester effluent solids / liquids separator.

Digester controls container, houses compressed air system and digester control panels.

Revenue grade SEL-753 generator power meter.



Power meter CT's, located in engine control panel.

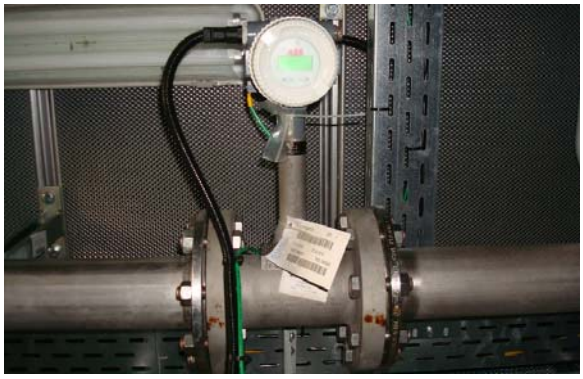


ABB Model FV4000-VT4 biogas to engine flowmeter.

INCA 4002 gas analyzer.

Heat recovery piping; 3x sets of supply and return piping. One set currently used for digester heating, other two sets are spares for future expansion.

Figure 1 - Photos of System Components

Table 1 - Biogas Systems at New Hope View Farms

Digester	PlanET Anaerobic Digester, fully mixed, soft cover, heated, 124,760 cf capacity, 32 day retention time
Feedstock	Dairy Manure (approximately 1,100 milking cows), and industrial organic food wastes
Engine	MAN (2G-CYNERGY) / 2G-KWK-370BGG, 1,800 RPM, 370 kW on biogas
Generator	Leroy-Somer / LSA 47.2 – 480 VAC, 3 Phase
Biogas Conditioning	PlanET Biogas supplied H_2S abatement system consisting of Eco Cover Plus net and oxygen pump. System is capable of reducing H_2S below required 400 ppm levels.
Engine Backup/startup Fuel	Permanent natural gas boiler installed on site for supplemental heating when necessary. No backup or startup fuel on site.
Heat Recovery Use	Digester heating
Additional Heat Recovery	Barn Heating

Figure 3 shows the farm layout and general site plan. Manure is provided to either the new continuously stirred tank reactor (CSTR) or the existing slurrystore manure storage tank from the three (3) dairy barns at the facility. A PlanET Vario solids input system will also be installed on a concrete pad adjacent to the digester, which will allow for solid manure or food waste to be fed into the digester. The digester has a 32 day retention time, after which effluent flows from the digester into decommissioned RCM digester which is now to be used as uncovered digestate storage. The existing flare from the old RCM digester will be upgraded and re-commissioned for use with the new CSTR digester.

New digestate piping will be installed from the uncovered digestate storage (old RCM digester) to the existing separator building. The separator building will house two (2) (an existing and new) FAN separators for solids recovery.

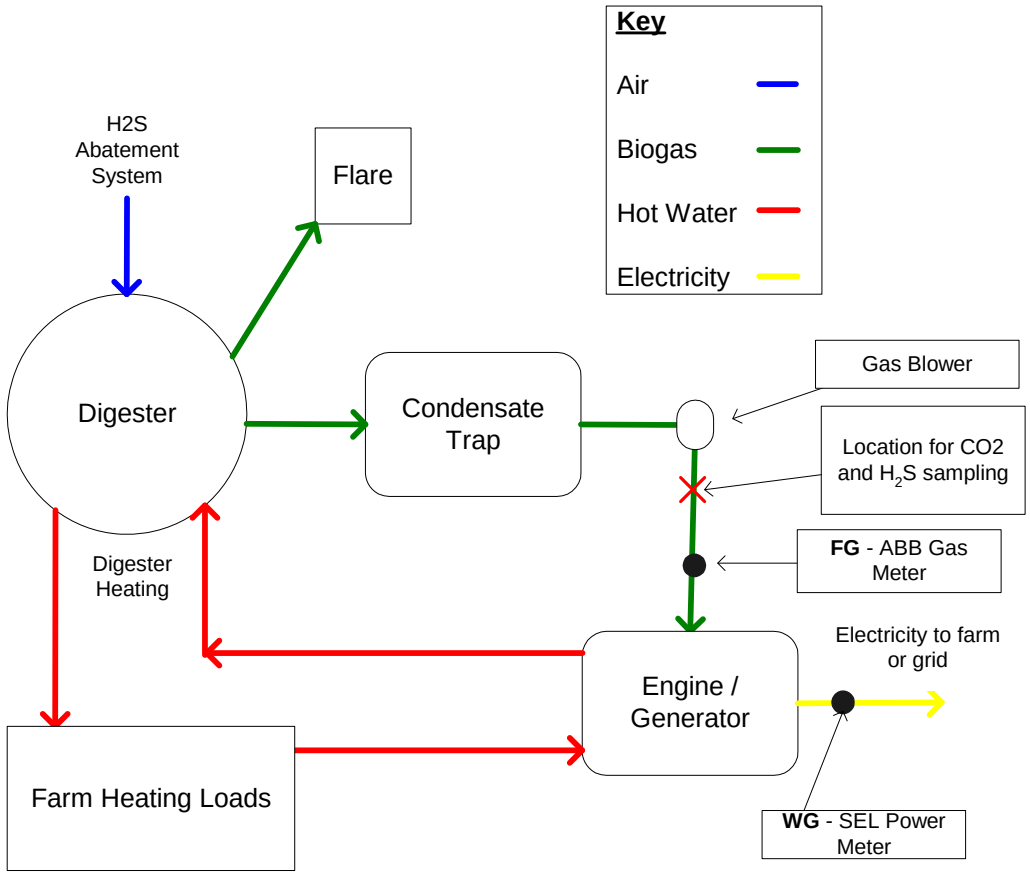


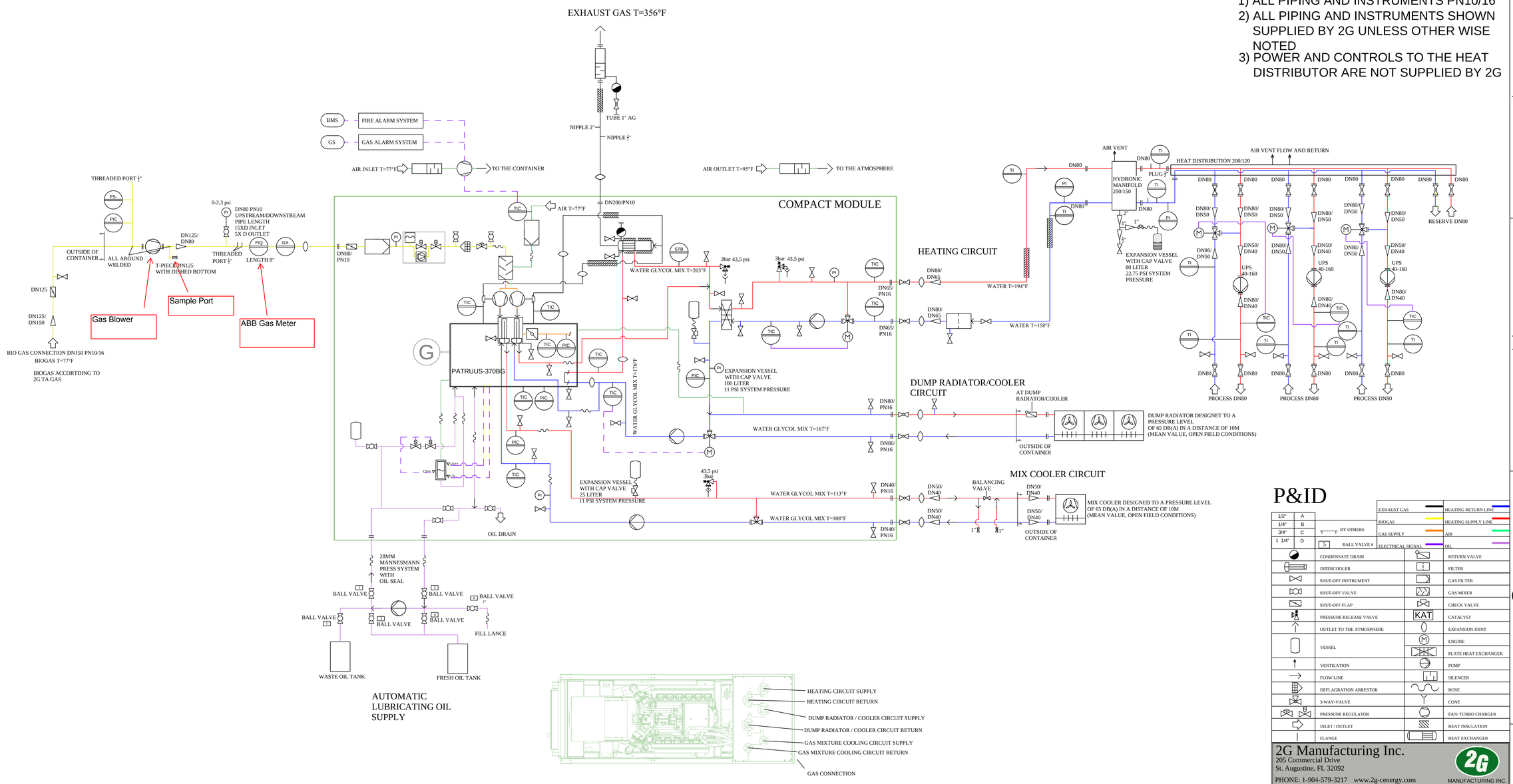
Figure 2. Digester Process Diagram

Figure 2 shows the single line process diagram for the digester and engine system. Biogas from the digester is either used in the engine-generator or flared. The biogas flare operates to maintain the digester static pressure requirements. The sulfur abatement system consists of a polyethelene fabric that is hung above the digestate level in the tank, and a small pump. The pump injects a small percentage of air in with the biogas which causes the sulfur to precipitate out of the gas and bond with the fabric, effectively reducing the H_2S levels in the biogas.

When the gas leaves the digester, to be combusted in the engine, it is first de-watered and then pressurized. Biogas travels thru underground pipes, en-route to the engine, which cools the biogas and condenses out any moisture. The condensed moisture flows to underground condensate pits for storage. The dry biogas then passes thru a blower which pressurizes the biogas for proper combustion. An ABB biogas flowmeter measures the biogas flow to the engine-generator (FG).

Heat is recovered from the engine exhaust in the form of hot water. This hot water is pumped thru piping lining the perimeter of the bottom of the digester to help maintain a temperature of around 100 °F. The facility plans to expand the heat recovery system in the future to use some of the recovered heat to assist in milk pasteurization or for space heating.

1) ALL PIPING AND INSTRUMENTS PN10/16
2) ALL PIPING AND INSTRUMENTS SHOWN SUPPLIED BY 2G UNLESS OTHER WISE NOTED
3) POWER AND CONTROLS TO THE HEAT DISTRIBUTOR ARE NOT SUPPLIED BY 2G



P&ID

1/2"	A
1/4"	B
3/4"	C
1 1/4"	D

T BY OTHERS

5 BALL VALVE #

EXHAUST GAS		HEATING RETURN LINE	
BIOGAS		HEATING SUPPLY LINE	
GAS SUPPLY		AIR	
ELECTRICAL SIGNAL		OIL	
CONDENSATE DRAIN		RETURN VALVE	
INTERCOOLER		FILTER	
SHUT-OFF INSTRUMENT		GAS FILTER	
SHUT-OFF VALVE		GAS MIXER	
SHUT-OFF FLAP		CHECK VALVE	
PRESSURE RELEASE VALVE		CATALYST	
OUTLET TO THE ATMOSPHERE		EXPANSION JOINT	
VESSEL		ENGINE	
		PLATE HEAT EXCHANGER	
VENTILATION		PUMP	
FLOW LINE		SILENCER	
DEFLAGRATION ARRESTOR		HOSE	
3-WAY-VALVE		CONE	
PRESSURE REGULATOR		FAN/ TURBO CHARGER	
INLET / OUTLET		HEAT INSULATION	
FLANGE		HEAT EXCHANGER	

Pipe / Flange Size

Europe	US
DN 32	1 1/4"
DN 40	1 1/2"
DN 50	2"
DN 65	2 1/2"
DN 80	3"
DN 100	4"
DN 125	5"
DN 150	6"
DN 200	8"
DN 250	10"
DN 300	12"
DN 350	14"
DN 400	16"

2G Manufacturing Inc.
205 Commercial Drive
St. Augustine, FL 32092
PHONE: 1-904-579-3217 www.2g-cenergy.com
FAX: 1-904-579-3217 E-MAIL: info@2g-usa.com
MANUFACTURING INC.

CUSTOMER NAME: BILL HEAD FARM PlanET		DELIVERY ADDRESS: SYRACUSE, NEW YORK	
DRAWING NAME: PATRUUS 370BG BIO GAS P&ID	ID NUMBER: G3937	COMMISSION NUMBER:	
FILE NAME: PATRUUS 370BG BIO GAS P&ID		DRAWN BY: GJB	DATE DRAWN: 6-30-2014
PROJECT MANAGER: J.WINFREE	SCALE: NA	CHECKED BY:	DATE CHECKED: .....

DATE:	NAME:	CHANGE:	REV:	CHECKER:
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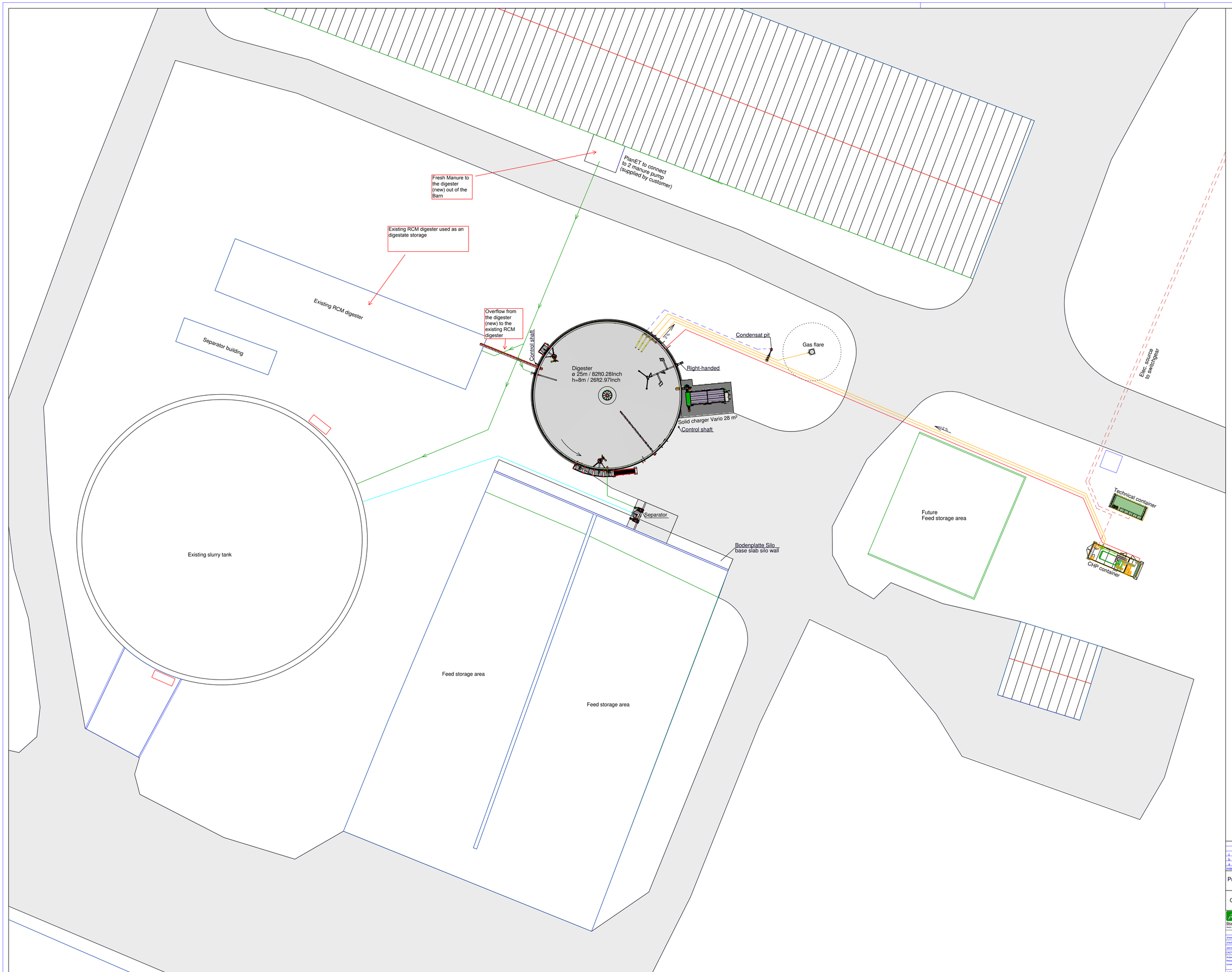

Legende / Key:

- Substratüberlaufleitung/Substrate overflow pipe PE DN 300
- Biogasüberlaufleitung/Biogas overflow pipe PE DN 200
- Bodenentnahmeleitung/Base drain pipe PE DA 160
- Biogasleitung/Biogas pipe PE DA 160
- Substratdruckleitung/Substrate - feed pipe PE DA 160
- Effluentleitung - Effluent pipe PE DA 63
- Heizleitung/Heating pipe PE X DN 50
- Kondensatpumpenleitung/Condensate - pump line PE DN 40
- Sickersaftpumpenleitung/Effluent - pump line PE DA 63
- Absperrschieber/Butterfly Valve
- Absperrklappe/Gate Valve

index	changes	date	name
c	Schachtfutter Gaserin. und Heizung versetzt	17.11.2014	Drosdeck
b	Bodenplatte geändert	22.10.2014	Drosdeck
a	Behälter 3,3m verschoben	13.10.2014	Drosdeck

Project: New Hope View Dairy LLC

Client: New Hope View Dairy LLC
5937 State Route 11
13045 Homer NY USA

PlanET Biogas USA Inc.
Biogas made easy & secure

PlanET Biogas USA
5937 State Route 11
Homer, New York
USA 13077

weight:

scale: 1:200

	date:	name:
drawn by:	16.07.2014	Drosdeck
checkd by:		
standard:	DIN 2768m	
cad/C:\DB3E7555.SZA	DIN A 0	

Trassenplan

Pipe layout

drawing nr.: 02 - 00 - 01 - 013176

index: c

projectnr.: NB73022.11

page: 1 of 1

repl. for:

repl. by:

origin:

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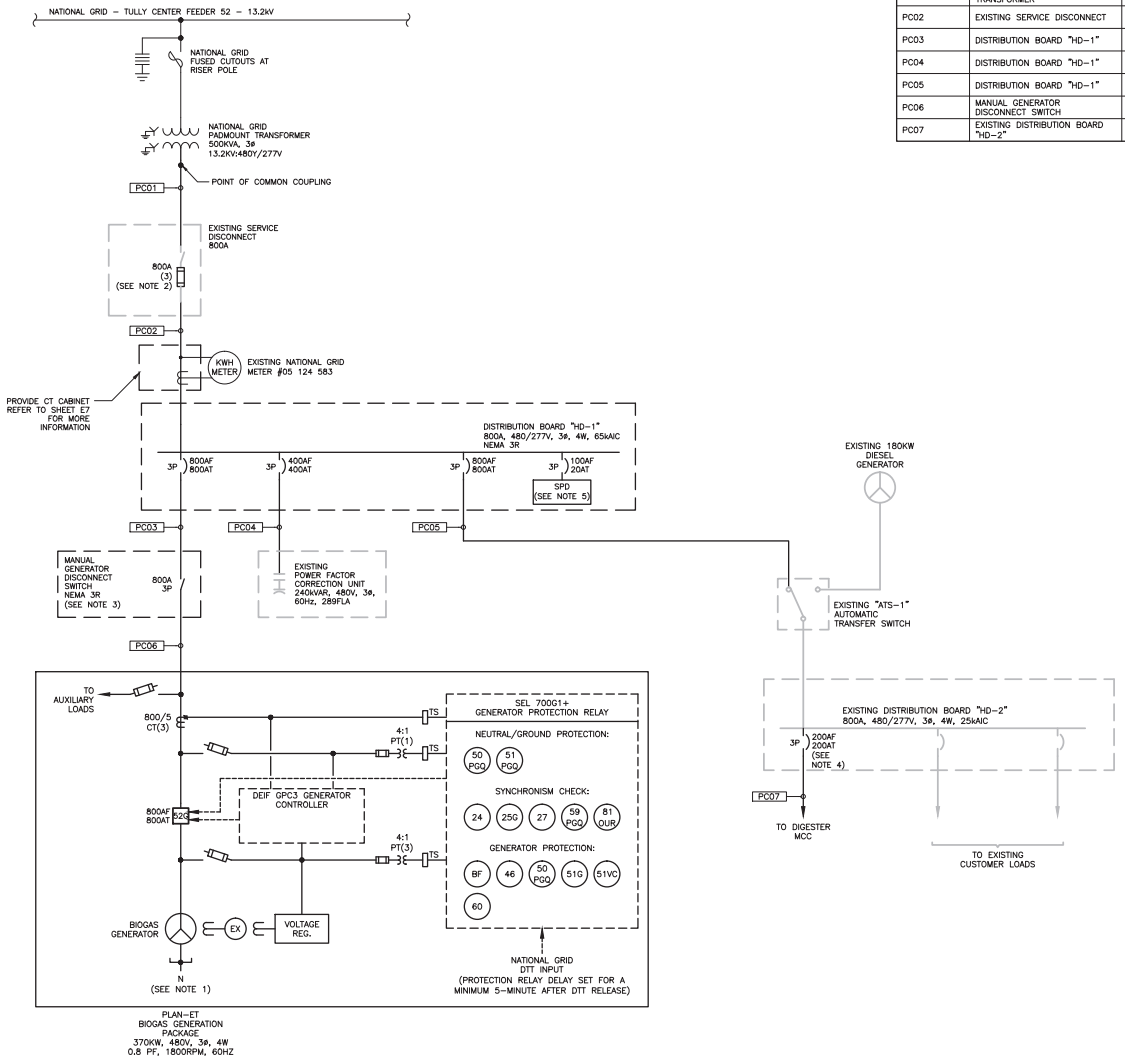
17.11.2014

SAVED: 12/9/14 2:18 PM

POWER CIRCUIT – CONDUCTOR AND CONDUIT SCHEDULE

DESIGNATION	FROM	TO	CONDUIT QTY/SIZE	CONDUCTORS QTY/SIZE	REMARKS
PC01	NATIONAL GRID PADMOUNT TRANSFORMER	EXISTING SERVICE DISCONNECT	SEE REMARKS	2 SETS OF (4)–#500kcmil	ROUTE SERVICE LATERAL CONDUCTORS IN EXISTING (2) 4" CONDUITS.
PC02	EXISTING SERVICE DISCONNECT	DISTRIBUTION BOARD "HD–1"	(2) 4"	2 SETS OF (4)–#500kcmil & #1/0AWG GND	–
PC03	DISTRIBUTION BOARD "HD–1"	MANUAL GENERATOR DISCONNECT SWITCH	(2) 4"	2 SETS OF (4)–#500kcmil & #1AWG GND	–
PC04	DISTRIBUTION BOARD "HD–1"	EXISTING POWER FACTOR CORRECTION UNIT	4"	(3)–#600kcmil & #3AWG GND	–
PC05	DISTRIBUTION BOARD "HD–1"	EXISTING AUTOMATIC TRANSFER SWITCH "ATS–1"	(2) 4"	2 SETS OF (4)–#500kcmil & #1/0AWG GND	–
PC06	MANUAL GENERATOR DISCONNECT SWITCH	BIOGAS GENERATOR	(3) 5"	2 SETS OF (4)–#500kcmil & #1AWG GND	–
PC07	EXISTING DISTRIBUTION BOARD "HD–2"	DIGESTER MCC	2–1/2"	(4) #4/0AWG & #2AWG GND	SEE DUCTBANK DETAIL FOR UNDERGROUND CONDUIT SIZING.



ONE-LINE DIAGRAM
NOT TO SCALE

PROTECTIVE RELAY FUNCTIONS:

- BF – BREAKER FAILURE
- 24 – VOLTS–PER–HERTZ RELAY
- 25G – SYNCHRONIZING DEVICE
- 27 – UNDERVOLTAGE RELAY
- 46 – NEGATIVE SEQUENCE OVERCURRENT RELAY
- 50 PGQ – INSTANTANEOUS OVERCURRENT RELAY PHASE / GROUND / NEG. SEQ.
- 51 PGQ – INVERSE TIME OVERCURRENT RELAY PHASE / GROUND / NEG. SEQ.
- 51VC – VOLTAGE RESTRAINED/CONTROLLED TIME OVERCURRENT RELAY
- 59 PGQ – OVERVOLTAGE RELAY PHASE / GROUND / NEG. SEQ.
- 60 – LOSS OF POTENTIAL
- 81 OUR – FREQUENCY RELAY OVER / UNDER / RATE

NOTES:

1. GENERATOR NEUTRAL SHALL BE CONNECTED TO THE CUSTOMER DISTRIBUTION SYSTEM NEUTRAL. NEUTRAL SHALL BE BONDED TO GROUND AT THE SERVICE DISCONNECT ONLY.
2. EXISTING FUSED DISCONNECT WITH NEW FUSE AS INDICATED.
3. PROVIDED NON–FUSED MANUAL GENERATOR DISCONNECT SWITCH IN NEMA 3R ENCLOSURE WITH VIEWING WINDOW AND LOCKING PROVISIONS FOR OWNER AND NATIONAL GRID PADLOCKS. PROVIDE ENGRAVED THERMOSET LABEL WITH 3/8" LETTERING READING "BIOGAS GENERATOR DISCONNECT SWITCH". FASTEN LABEL WITH STAINLESS STEEL SCREWS.
4. INSTALL NEW BREAKER IN EXISTING DISTRIBUTION BOARD AS INDICATED. CIRCUIT BREAKER TYPE AND INTERRUPTING RATING SHALL MATCH EXISTING. EXISTING CIRCUIT BREAKERS: SQUARE D TYPE KA.
5. DISTRIBUTION BOARD SHALL BE FURNISHED WITH SURGE PROTECTIVE DEVICE AND ASSOCIATED CIRCUIT BREAKER AS INDICATED. REFER TO SPECIFICATIONS ON SHEET E9 FOR MORE INFORMATION.

IT IS A VIOLATION OF LAW FOR ANY PERSON, UNLESS ACTING UNDER THE DIRECTION OF A LICENSED ENGINEER, TO ALTER THIS DOCUMENT.

THIS DRAWING WAS PREPARED AT THE SCALE INDICATED. INACCURACIES IN THE STATED SCALE MAY BE INTRODUCED WHEN DRAWINGS ARE REPRODUCED BY ANY MEANS. USE THE GRAPHIC SCALE BAR TO DETERMINE THE ACTUAL SCALE.

IN CHARGE OF	RGH			
DESIGNED BY	TMH			
CHECKED BY	RGH			
DRAWN BY	GWD			

NO.	DATE	REVISION	INT.
1	12/09/2014	INTERCONNECTION DESIGN PACKAGE	TMH
0	11/17/2014	INTERCONNECTION DESIGN PACKAGE	TMH

O'BRIEN & GERE ENGINEERS, INC

PLANET BIOGAS SOLUTIONS, INC.
NEW HOPE VIEW DAIRY PROJECT
Homer, New York

ELECTRICAL
ONE-LINE DIAGRAM

FILE NO. 23789.52371 -E2
DATE 12/09/2014

E2

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ADG System Capacity Payment Descriptions

This Section describes the Capacity Incentive Payments included in the Agreement, the payment milestones to be achieved in order to receive payment, and the deliverables to be provided in achieving these milestones.

Capacity Payment #1: Up to 15% of Total Capacity Incentive or the total of initial payments whichever is less.

Payment Milestones: Initial payments made for major equipment and other work, such as the engine generator system, the anaerobic digester system, the gas scrubbing equipment, and other major components and fees for system design, engineering, CESIR study and other "soft costs".

Deliverables: Documentation that initial payments have been made to suppliers or service providers for major project components.

Capacity Payment #2: Up to 40% of the Total Capacity Incentive less the amount paid for the first milestone

Payment Milestones: Delivery of power generation equipment on-site and approval of QA/QC Plan. In the Agreement, Section B: ADG System of the Application Form the planned MAN engine and generator assembled by 2G Cenergy are stated to have a capacity of 370 kW. The Contracted Capacity in Exhibit A is 370 kW.

Deliverables: (a) A QA/QC Plan approved by NYSERDA and (b) Delivery receipts, photos or other documentation acceptable to NYSERDA of delivery of the engine and generator equipment as described in the Agreement Section B and adequate explanation of any deviations. *(If the installed equipment deviates from that listed in the Application Package, an explanation of the deviation must be provided for determination by NYSERDA whether the installed equipment adequately meets the terms of the Agreement.)*

Capacity Payment #3: 20% of the Total Capacity Incentive for the New Anaerobic Digester

Payment Milestones: Completed installation of the New Anaerobic Digester. In the Agreement, Section B: ADG System of the Application Form, the following System capabilities are identified:

- Working volume capacity of the mixed digester is stated to be 124,760 cf.
- PlanET eco cover plus is stated to keep H_2S levels below 400 ppm for up to 7,000 scfh.
- Estimated Annual biogas generation totals 60,371,120 scf/y.

Deliverables: Site inspection and verification by the NYSERDA technical consultant that the installation is complete and operational in accordance with the approved QA/QC Plan. The digester can be considered complete and operational if the digester structures, piping, controls and equipment are all installed for the feeding mixing, heating and unloading of digester feedstocks and for gas treatment and flaring. The completed installation may be documented with (a) a listing of the digester structures, piping, controls and equipment for feeding, mixing,

heating and unloading and gas treatment and flaring and other major equipment to be installed in the design and (b) provision of as-built drawings, photos, verification by on-site inspection by the NYSERDA technical consultant, and/or other means satisfactory to NYSERDA documenting that these have been installed and are ready to operate to produce and manage the annual biogas production total of 60,371,120 scf identified in the Section B: ADG System in the Agreement. *(If the installed equipment deviates from that listed in the Application Package, an explanation of the deviation must be provided for determination by NYSERDA whether the installed equipment adequately meets the terms of the Agreement.)*

Capacity Payment #4: 20% of Total Capacity Incentive for New Power Generation Capacity

Payment Milestones: New Power Generation Capacity operational and interconnection completed.

Deliverables: Documentation that (a) the interconnection acceptance test has been accepted by the utility and interconnection approval has been obtained from the utility and (b) the new power generation equipment is complete and operational in accordance with the approved QA/QC Plan. The New Power Generation Capacity can be considered complete and operational if it has produced electricity at a minimum average of 75% capacity factor or 277.5 kWh/h for at least one hour.

Capacity Payment #5: 20% of Total Capacity Incentive for Commissioning of the New Power Generation using Anaerobic Digester Gas.

Payment Milestones: Successful commissioning and operation of the new power generation system at a minimum average of 75% capacity factor or 277.5 kWh/h for at least 7 consecutive days and demonstration of (a) the ability to upload information to NYSERDA's DG/CHP Integrated Data System website, (b) high quality gas cleanup documented to produce measured H2S output less than 400 ppm, and (c) higher cost grid upgrade needed for interconnection greater than $200,000.

Deliverables: A Project Commissioning Report documenting the completion of all elements of the Commissioning process required by the QA/QC Plan and successful uploading of data to the website that is adequately consistent to NYSERDA's satisfaction with the data recorded on site.

The Project Commissioning Report shall consist of the compilation of information prepared in meeting the deliverables requirements for all payment milestones including:

1. Documentation that construction of the ADG-to Electricity System is complete;

2. Documentation that the System has been interconnected with the utility grid:

3. Documentation that the System's New Equipment has satisfactorily operated for at least seven consecutive days, which is defined as operation with an minimum average 75% Capacity Factor of the Total Contracted Capacity or 277.5 kWh/h;

4. Documentation that the System has demonstrated the ability to upload information to NYSERDA's CHP Data Integration Website in conformance with the following section of the QA/QC Plan: Monitoring System Equipment, Installation, Operation, and Maintenance;

5. Documentation that the gas cleanup produces measured H2S output less than 400 ppm in accordance with the section below on QA/QC Procedures for Documenting High Quality Gas Cleanup

6. Documentation of payment to the utility of greater than $200,000 for the cost of grid upgrades for the project. (When available an addendum to the Project Commissioning Report shall be made which provides the final grid upgrade costs after actual cost reconciliation.)

7. As-Built Diagrams of the installed system, including an explanation of any deviation of the equipment from that listed in the Application Package. Diagrams may consist of electronic copies of as-built drawings.

Monitoring System Equipment, Installation, Operation, and Maintenance

Figure 2 shows the general location of the meters used to measure biogas input to the engine-generator (**FG**) and the generator electrical output (**WG**). Information on these data points is shown in Table 2.

Table 2 - Monitored Points for ADG System

Point Type	Point Name	Description	Instrument	Engineering Units	Expected Range
Modbus	WG	Engine-Generator Power	SEL-753 Power Quality and Revenue Power Meter	kW	0 - 440 kW
4-20 mA	FG	Engine Biogas Flow	ABB Model FV4000-VT4	SCF	0 – 10,000 SCFH

The electrical output of the engine-generator (**WG**) will be measured with the SEL-753 power meter. The power meter is revenue grade and meets ANSI C12.20 0.2. The power meter will be installed in the electrical disconnect cabinet located in the enclosure that houses the engine. The power meter will be installed according to the requirements in the appropriate operator guide. The CT inputs to the power meter will be fused in order to protect the power meter.

The biogas input to the engine will be measured by an ABB FV4000-VT4 mass flow meter (**FG**). The meter is capable of providing a temperature compensated pulse output. The meter will be installed and maintained according to the "ABB FV4000-VT4 Manual," by the facility. A log of maintenance activities for the meters will be maintained at the site.

The lower heating value for the biogas will be calculated using the average CH_4 value as measured by the INCA 4001gas analyzer. A monthly average of the 15-minute CH_4 values will be calculated and included in the sites annual reports. The Farm staff will be responsible for all required maintenance on the gas analyzer system. The sampling point for the gas analyzer is marked in Figure 3 as "Gas Sampling". The gas analyzer will also be measure and report biogas H_2S levels.

The natural gas boiler fuel flow will not be continuously metered or logged at this site since it cannot be used by the engine to produce power. The natural gas will be used to run the boiler during the startup process for the digester. As the digester heats up and begins producing combustible biogas the facility will switch over from the natural gas boiler to the biogas engine generator. In the event the gen-set is down for any length of time the farm will be able to use the natural gas boiler to provide heat for the digester.

The facilities control system has the capability to trend gas flow, generator power, and gas analyzer readings from the meters described above. The control system will produce daily data files consisting of 15-minute interval data. Data will be transferred to CDH servers nightly via email.

Management of Monitoring System Data

The Farm will perform the following quality assurance and quality control measures to ensure the data produced from our system accurately describes system performance.

On a daily basis, The Farm equipment manager will perform inspections of the digester and engine-generator equipment and record findings into the project log.

On a weekly basis, The Farm equipment manager will perform inspections of the QA/QC meter installations and complete the routine maintenance on the meters, noting any abnormalities or unexpected readings. The Farm will also maintain a daily log of the cumulative power generation (kWh) from the SEL-735 meter (**WG**) and gas flow (ft^3) recorded by the ABB gas meter (**FG**) in the event that data transfer to the NYSERDA CHP Website fails or other anomalies occur.

On a weekly basis, The Farm staff will review the data stored in the NYSERDA CHP Website (chp.nyserda.org) to ensure it is consistent with our observed performance of the ADG system and logged readings. The Farm will review the data using the reporting features at the website, including:

- Monitored Data – Plots and Graphs
- Monitored Data – Download (CSV File)

In addition, The Farm staff will also setup and use the email reports that are available at the CHP Website to help track the system performance, including:

- An email report sent out if data is not received at the web site or does not pass the quality checks.

The data collected from the site will be evaluated for the quality of the data for each base time interval using range and relational checks. The expected sensor ranges (see Table 2) will be used to develop the range check values for the base time intervals.

The relational check will compare the kWh production data and gas production data for each base time interval to ensure that both meters are reading properly. This check is to ensure that both meters are operating properly; power cannot be produced without gas, and gas cannot be combusted by the engine without producing power.

Data that passes the range and relational quality checks will be used in the preparation of performance incentive requests. However, hourly data is available from the NYSERDA CHP Website, when looking at Monitored Data – Plots and Graphs, using the “Download Plot Data” button if the data quality flag of “Data Exists” is selected. To download all data for multiple points at once, holding control will allow you to select multiple values. Once the desired values are selected the “Update Report With New Parameters” button will update the plot and the data download to reflect the selected points. In the event of a communications or meter failure, the farm will work with CDH Energy to resolve the issue in a few days.

If unanticipated loss of data occurs when the engine-generator continues to produce electricity, The Farm intends to follow the procedures outlined in Exhibit D, of their contract, i.e. use data from similar periods – either just before or after the outage - to replace the lost data. The Farm understands that they can use this approach for up to two 36 hour periods within each 12-month performance period. If more than two such data outages occur, The Farm will provide information from other acceptable data sources (e.g., weekly recorded logs) to definitively determine the amount of power that was being produced from biogas during the period in question.

QA/QC Procedures for Documenting High Quality Gas Cleanup

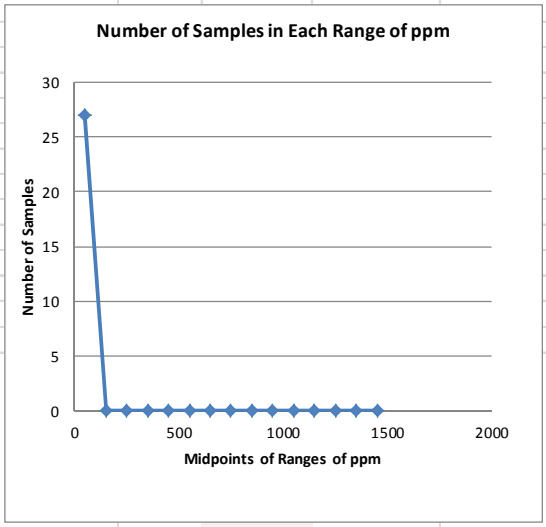
Payment of this incentive shall ultimately be based on adequate measurements of the ability of the High Quality Gas Cleanup Equipment (HQGCE) to reduce H_2S levels to less than 400 ppmv. Measurements can be made with continuous automatic gas sampling and analysis, by daily testing with manual sampling equipment, or by other methods found acceptable to NYSREDA. For this project the INCA 4001 gas analyzer will be used to measure the H2S concentrations.

The following paragraph describes how the measured H_2S data is used to determine if the site has achieved the required output level to receive the added incentive for the High Quality Gas Cleanup Equipment (HQGCE). H_2S data must be collected for at least 25 days within a consecutive 30-day period during which the ADG systems is operating at at least 75% of design production rate for biogas (60,371,120 scf/yr as identified in the Agreement) and with CH_4 levels reaching the 50% or higher. CH_4 can be determined by measuring the CH_4 directly, or calculated by measuring the CO_2; where $CH_4 = (1 - CO_{2\ Measured})$. Since the scrubbing at this site is integrated into the digester pre and post scrubbing measurements are not able to be taken. The single H_2S measurement from the INCA 4001 gas analyzer will be used to ensure that H_2S levels remain below 400 ppm . For the purposes of payment approval, adequate measurements of the ability of the HQGCE to achieve H_2S removal to less than 400 ppmv shall be considered to be documented if 75% or more of the 25 to 30 samples taken in the 30-day time period show H2S levels in the output of the HQGCE to be less than 400 ppmv.

The worksheet below will be used as a template for documenting the capabilities of the HQGCE. Biogas flow and H_2S levels in the biogas will be documented for each the 25 to 30 days that samples are taken. CO_2 or CH_4 content of the input gas will be measured for at least for 7 of those days at intervals spread over the 30 days. If the percentage of cumulative samples with 399 ppm H2S and below is 75% or more of the total number of samples, the worksheet can be submitted to document adequate compliance with the requirement for payment of the HQGCE incentive. NYSERDA may direct its technical contractors to sample the biogas, determine H_2S removal efficiency, and compare the results to the data originally provided by the operator.

Worksheet to Document Ability of High Quality Gas Cleanup to Produce Measured H2S Concentrations Less than 400 ppm for 75% of Samples

		Data to be completed by operator					Analysis which can be done by Technical Consultant					
A	B	C	D	E	F		G	H	I	J	K	L
Day	Date of sample	Daily scf biogas generation input to gas cleanup	CH4 percent in biogas input to gas cleanup	Hydrogen Sulfide ppm in biogas before clean up	Hydrogen Sulfide ppm in biogas after clean up		Sorted Hyrdogen Sulfide Data	Range of H2S concentration ppm	Mid range values for graph	Number of samples in each range	Cumulative number of samples less than range maximum	Percentage of cumulative samples less than range maximum
0	3/3/2014	160,513		2,000	0							
1	3/4/2014	160,011		2,000	0			0 to 99	50	27	27	100%
2	3/5/2014	156,159		2,000	0			100 to 199	150	0	27	0%
3	3/6/2014	156,204		2,000	0			200 to 299	250	0	27	0%
4	3/7/2014	155,945		2,000	0			300 to 399	350	0	27	0%
5	3/8/2014	154,594		2,000	10			400 to 499	450	0	27	0%
6	3/9/2014	145,602		2,000	0			500 to 599	550	0	27	0%
7	3/10/2014	139,760		2,000	0			600 to 699	650	0	27	0%
8	3/11/2014	127,743		2,000	0			700 to 799	750	0	27	0%
9	3/12/2014	107,860		2,000	0			800 to 899	850	0	27	0%
10	3/13/2014	100,471		2,000	0			900 to 999	950	0	27	0%
11	3/14/2014	101,197		2,000	0			1000 to 1099	1050	0	27	0%
12	3/15/2014	101,433		2,000	0			1100 to 1199	1150	0	27	0%
13	3/16/2014	108,064		2,000	0			1200 to 1299	1250	0	27	0%
14	3/17/2014	73,655		2,000	0			1300 to 1399	1350	0	27	0%
15	3/18/2014	108,464		2,000	0			1400 to 1499	1450	0	27	0%
16	3/19/2014	48,572		2,000	0			1500 or more		0	27	0%
17	3/20/2014	100,746		2,000	0					Total Samples	27	
18	3/21/2014	84,813		2,000	0							
19	3/22/2014	114,458		2,000	0							
20	3/23/2014	74,167		2,000	0							
21	3/24/2014	99,262		2,000	0							
22	3/25/2014	122,195		2,000	0							
23	3/26/2014	124,320		2,000	0							
24	3/27/2014	127,771		2,000	0							
25	3/28/2014	129,684		2,000	0							
26	3/29/2014	135,332		2,000	0							
27	3/30/2014	135,187		2,000	0							
28		103,327										
29		137,576										
30												
		3,595,086	#DIV/0!	2,000	0.37	27						
		Total scf Biogas Generated in 30 Days Greater Than 3,757,881 scf	Average CH4 Percentage (> 50%)	Average ppm H2S in Input Biogas	Average ppm of H2S Output Samples	Number of H2S samples						



Annual Performance Reports

The farm will prepare Annual Performance Reports summarizing the monthly data over the 12-month performance period. The reports will include a table (example provided below) showing the monthly kWh production, biogas use by the engine, and other data listed in Table 3, and if used, any heating oil or other fuel used for the engine. As described earlier in the QA/QC Plan, The Farm may use hourly CSV data downloaded from the Website that meets range and relational checks, or if need be, The Farm may use their own on-site sources along with a narrative adequately justifying why their data and calculations are more appropriate. The methods for calculating these values are provided below.

Table 3 - Summary of Monthly Data for Annual Performance Reports

Start Date of Reporting Period	Number of Days in Each Period	Electricity Production, $kWh_{generator}$	Biogas Used by Engine, (cubic feet)	LHV_{biogas} (Btu/cf)	Biogas Energy Content, Q_{biogas} (BTU)
TOTALS					

The Farm will calculate monthly values for lower heating value of the biogas (LHV_{biogas}) and total energy content of the biogas (Q_{biogas}) as follows.

Monthly Biogas Lower Heating Value

The available 15-minute readings of CH_4 concentration in the biogas taken by the gas analyzer will be used to calculate the average monthly Biogas Lower Heating Value using the following equation:

$$LHV_{biogas} = LHV_{methane} \cdot CH_4$$

where:

$LHV_{methane}$ - lower heating value of methane (911 Btu/ft^3 at standard conditions, 60 °F and 1 atm)

CH_4 - monthly average percent of methane in biogas from gas analyzer data

Monthly Biogas Energy Content

Calculate the average monthly Biogas Energy Content using the following equation:

$$Q_{biogas} = CF \cdot LHV_{biogas}$$

where:

CF - volume (cubic feet or ft^3) of biogas in month

Reasonable Electrical Efficiency

The Annual Performance Report will also provide a comparison of power output and fuel input for the engine to confirm their reasonableness. For instance, the electrical efficiency – measured as power output ($kWh_{generator}$) divided by the energy content of the fuel input (Q_{biogas}) in similar units and based on lower heating value – should be in the 25% to 35% range over any interval.

Appendices

Cut sheets and Manuals for:

Patruus Series 370 kW Biogas Engine

Leroy Somer LSA 47.2 Generator

SEL-753 Power Quality and Revenue Power Meter

ABB FV4000 Gas Meter

INCA 4001 Gas Analyzer

2G CENERGY®
Advanced Clean Energy Technologies

Technical Spec Sheet | BIOGAS CHP Module | Energy Conversion System | 60Hz - 480V - 3Ph

patruus® Series BIOGAS

CHP Cogeneration System

With Thermo-Dynamics Technology
Digital 2G® GEM
General Electronic Management

370 ekW
60Hz

02/2013

Basic Description

CHP Module | 370 kW/h 480V - 60Hz - 3Ph

Advanced CHP Technologies

Unique Features with Added Value

Reliable, rugged and highly durable factory-designed, production line assembled, professionally packaged, and post-production tested **2G® Biogas Cogeneration Module**, supplied in an "all-in-one" package that is "connection-ready". Manufactured at 2G® ISO compliant production facilities in the USA . This CHP (Combined Heat & Power) cogeneration equipment is a fully integrated power generation system, with state-of-the-art technology that results in optimum performance and efficiency. The 2G® CHP module integrates all cogeneration components into one unique package that converts energy more efficiently than conventional CHP systems.

The robust design utilizes full authority electronic engine management, incl. CHP performance monitoring that provides prolonged life, low maintenance, and high efficiency. Items such as, engine & system controls, synchronizing and paralleling switchgear, heat recovery (both for engine jacket water and exhaust), the entire thermal heat technology system, pumps, piping, plumbing, etc., are all included "within the module" dramatically reducing the risk of cost overruns and performance issues associated with conventional "site built" systems.

The 2G® CHP module allows for optimized efficiency by maximizing heat recovery and applying a more efficient combustion technology, leading to a higher electrical output.

Optional Sound Attenuation

Small Footprint

Comprehensive Basic Scope of Supply

- **High Efficiency Biogas Engine (Lean Burn Technology)**
- Advanced and Optimized Exhaust Gas Turbocharger
- **Electrical Jacket Water Heater System in Cold Regions**
- Extra Large Oil Capacity Sump with Oil Refill Automatic
- **Pressure Lubrication System with Gear Pump**
- Advanced CHP Type Air Cleaner System
- **Gas Train & Biogas Fuel System compliant with NFPA 37, tested and approved to UL, CSA, EU, and DIN Standards**
- Biogas Blower, Explosion-proof tested and ATEX certified
- **Advanced High Efficiency Two-Stage Fuel Mixer**
- Proprietary Air/Fuel Ratio Controller
- **Digital Microprocessor Controlled Electronic Ignition**
- Heat Value Fluctuation Detection
- **Vibration Detection & Detonation Protection**
- Complete Heat Recovery System , Factory installed
- **Self-Cleaning Jacket Water Plate Heat Exchanger**
- High Efficiency Stainless Steel Exhaust Heat Exchanger
- **Exhaust System incl. Flex Connector & Silencer**
- Ultra Low Emissions Capability
- **Thermal Heat Distribution Connections fully integrated**
- Thermo Dynamics Technology
- **Advanced Cooling System, Mixture Inter-Cooler & Dry Radiator / Re-Circulation Cooling System (beltless)**
- General Digital Control System with Protection Devices
- **Heat Value Fluctuation Detection Technology**
- Utility Grade Switchgear (CSA, UL, NEMA, IEEE, CE)
- **Grid Interconnection Relays per CSA/UL & IEEE 1547**
- Electronically operated Circuit Breaker
- **Optimized High Efficiency Synchronous Generator**
- Electrical Load Share Governor System
- **24V Electrical Starter, Battery Rack & Cables**
- Integrated High Performance Battery Charger
- **Central Wiring Harness incl. Sensors**
- Torsion-resistant Design with Solid Frame Structure
- **Heavy Duty Oscillation Decoupling Devices**
- Multiple Deck Design with integrated Spill Tray
- **Biogas Micro Filtration System**
- Fluidistor Gas Flowmeter & Gas Vacuum Sensor
- **Gas Pressure, Gas Temperature, and Ambient Air Temperature Sensors**
- Double Magnet Valve & Zero Pressure Regulator
- **By-Directional Deflagration Flame Arrestor, ATEX Cert.**
- Set of Pressurization & Expansion Vessels & Valves
- **Three Way Valve & Electrothermic Actuator**
- Set of GRUNDFOS VersaFlo© self-lubricated Main Hot Water Circulation Pumps and Sensors
- **Optional Thermal Distribution Assembly fully integrated**
- Water Circulation Dirt Collection Unit
- **On-Line Remote Monitoring & Control**

2G CENERGY®
Advanced Clean Energy Technologies

Made in the U.S.A.

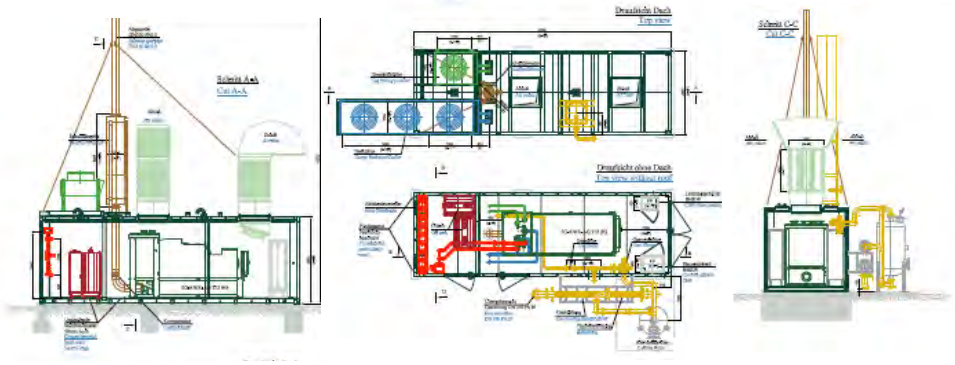
CHP Module | Fully Containerized Option

A genuine “Plug & Play” Biogas CHP Solution

2G® advanced container modules are designed for easy operation, to minimize floor space, and to contain the entire CHP cogeneration plant in one unit “all-in-one”. Due to a compact layout with integrated control-and switchgear equipment, as well as a ventilated noise protection enclosure, these modules can be placed anywhere, even in residential areas. A smart and economical alternative to traditional inside installations; highly efficient and much more cost-effective.

This containerized modular System is guaranteed less expensive than a traditional Inside Building Installation

Containerized CHP modules provide many advantages. All heat exchanger and heat recovery systems are fully integrated. Heat circulation piping and distribution are an integral part of our containerized solutions. Insulated piping, pre-plumbing, all connection-ready. The floor plan allows for easy access to all system components, comfortable movement, and efficient service & maintenance. 2G® modules are especially built, not just modified shipping containers. Standard connections and terminations are used throughout to minimize the installation and connection effort. All units are designed for extreme fast integration and very easy operation. Installation time is typically 2 days.



Available in 20’, 23’, 30’, 40’, and 50’ Length. 10’ High and 10’ Wide.

Your Benefits

- **Reduced Cost and decreased Project Lead Time**
- **Reliability and Top Performance “all-in-one” Factory tested**
- **Less technical Risk & more economical**
- **Optimal Solution with significant Advantages for the Owner**
- **Versatile, flexible, scalable, and unrestrained Mobility**

Anaerobic Farm Digester Biogas CHP Power Generation Plant with “Plug & Play” Container Module.

Landfill Gas (LFG) Power Generation Plant with “Plug & Play” Container Module, including Gas Conditioning & Treatment System.

Municipal Dry Anaerobic Digester Biogas CHP Power Generation Plant with “Plug & Play” Container Module, including Gas Conditioning & Treatment System.

Multiple Process Control

Total Integration including Paralleling Capability

Advanced CHP Control Technology | Unique Features with Added Value

Standard Equipment included

GEM is equipped with a fully integrated electronic Governor Control (Speed & Load Sharing, kW / kVAR), and a variety of control modules consisting of:

- **Actuators**
- **3-Phase Monitoring of Voltage & Current**
- **Load Management**
- **Power Function Regulation**
- **Select Switch for Droop Mode**
- **Controls for Stability & LoadGain**
- **Speed Sensing & Control**
- **Load Sensor**
- **Ramp Generator for Ramp Time and Idle**
- **Digital Generator Control**
- **Voltage Regulator Sensing & Control**
- **Rheostat for Control of Speed for Synchronization**

The Generator Protection Unit DEIF GPU-3 is a compact microprocessor-based protection relay containing a wide variety of vital functions for advanced synchronous generator protection.

Multiple Process Control Features for the entire CHP System:

In addition to the basic power generation system & paralleling / synchronization and load management control functions, GEM also controls space ventilation, combustion air flow, adjustments based on ambient air & temperature, gas pressure, gas volumes, gas treatment incl. re-heating, gas & smoke safety devices, flare, communication interface with digester or other customer PLC's, thermal energy & heat extraction management, pumps & hot water circuits, A/C system, space heating, oil replenishing, emissions, catalytic converter, SCR, and much more.

GEM provides total integration including paralleling capability, grid or load-share mode, precise frequency & voltage regulation, alarm & status message display, protection, output metering, auto-shutdown, auto-restart, and a comprehensive user interface. All mounted inside a NEMA type enclosure.

- **Ammeter**
- **Undervoltage / Overvoltage**
- **Wattmeter**
- **Reverse Power Relay**
- **Loss of Exitation Relay**
- **Overcurrent Relay**
- **Auxiliary CB's, Relays & Timers**
- **Generator Main CB (Circuit Breaker) electronically operated including Indicator Lights, installed in its own protected Enclosure Panel**
- **Voltmeter**
- **Frequency Meter**
- **Power Factor Meter**
- **Directional Power**
- **Reverse VAR Relay**
- **Negative Sequence**
- **CT / PT Functions**
- **Voltage Restraint**
- **Underfrequency / Overfrequency**
- **Digital Governor Control**
- **Synchronization Relay**
- **Phase Balance Relay**
- **Ground Fault Relay**

User Interface Protocols

PROFI PROCESS FIELD BUS BUS

Modbus

Customers have the option to select Profibus or Modbus configurations. Operators intending to interface with AB PLC's are required to install the AB FLEX I/O PROFIBUS adapter or similar network interface translators.

UL C CSA US

IEEE

All Functions per CAS/UL & IEEE 1547 Requirements

Cutting Edge Technology

- **Fully integrated & Factory tested**
- **Providing more Capability in less Space**
- **Enhanced Protection & greater Flexibility**
- **Comprehensive Functions for Diagnostics**

Engine data	Hz	60
Mixture cooling to	℉	122
Rated speed	rpm	1800
ISO standard power (mech.)	kW	386
Air ration (Lambda)	λ	1.48
Arrangement of cylinders		V
Number of Cylinders		12
Bore	in	5.0
Stroke	in	5.6
Engine displacement	l	21.9
Direction of rotation (look on		left
balance wheel)		
body of balance wheel		SAE 1
tooth rim with number of teeth	Z	160
compression ratio	ε	12.0:1
average effective pressure	psi	168
average piston speed	ft/s	335

Power data	Hz	60
Load	%	100
Ignition timing	℃BTDC	18
ISO standard power (mech.)	kW	386
Electrical Power	kW	370
Cooling water heat	kW	235
Mixture heat (low temperature circuit)	kW	40
Mixture heat (high temperature circuit)	kW	18
Waste gas heat up to 356 ℉	kW	200
useable thermal power at 356 ℉	kW	474
radiant heat of module (max.)	kW	66
nominal power	kW	999

Temperatures and pressures		
Waste gas temperatur after turbine	℉	914
exhaust back pressure	psi	0.58
Heating water return temperature (max)	℉	158
Heating water flow temperature (max)	℉	194
Pressure decrease heating circuit (max)	psi	2.18
maximum backpressure at the air intake	psi	0.22

Exhaust emissions at 100% Load and 15% residual oxygen		
NOx	g/bhp-hr	< 1.0
	ppm	< 91
CO	g/bhp-hr	< 2.5
	ppm	< 300
HCHO	g/bhp-hr	< 0.07
	ppm	< 13.4
NMHC	g/bhp-hr	< 0.2
	ppm	< 36

Engine utilities		
Lubricate consumption	g/kWh	0.5
Filling capacity lubricant min./max.	U.S. gal	16 / 24
Filling capacity cooling water	U.S. gal	6
Operating pressure (max.)	psi	44
Cooling water recirculated quantity	gpm	172
Cooling water temperature min.	℉	176
Cooling water temperature max.	℉	190
Balance (inflow/exit, max.)	K	6
Mixture inflow temperature after damper max.	℉	1 22
Mixture cooling water, inflow temperature	℉	113
low temperature circuit (max.)		
Mixture cooling water recirculated quantity	gpm	26
low temperature circuit (max.)		
Mixture cooling water inflow termperature	℉	18 5
high temperature circuit (max.)		
Mixture cooling water recirculated quantity	gpm	58
high temperature circuit (max.)		

Efficiencies

Load	%	100	75	50
Electrical	%	37.0	35.9	33.5
Mechanical	%	38.6	37.5	35.4
Thermal	%	47.5	48.1	51.2
Total (el. + th.)	%	84.5	84.0	84.7
Power number		0.78	0.75	0.65

Mass flows and volume flows

Combustion air mass flow	lb/h	4,038
Combustion air volume flow	cfm	910
Supply air volume flow	cfm	8,533
Heating wate r volume flow (max.)	gpm	120

Load	%	100	75	50
Combusti ble mass flow	lb/h	450	348	248
Combustibl e volume flow	cfm	98	76	54
Waste gas mass flow, wet	lb/h	4,488	3,329	2,282
Waste gas mass flow, dry	lb/h	4,175	3,078	2,099
Waste gas volume flow, wet	cfm	925	686	470
Waste gas volume flow, dry	cfm	813	600	409

Technical basic conditions

Power conditions acc. To DIN-ISO-3046
Norm conditions: air pressure: 14.5 psi, Air temperature: 77 ℉, rel. Humidity: 30%. Gasquality accorcing "2G TA 04 Gas".
All data are related to full load engine running at denoted media temperatures and are subject to technical advancements.
Equipment as well as installation systems have to meet all technical instructions of 2G. The technical data are based on a gas mixture of 60% CH_4 and 40% CO_2 with a calorific value of 580 Btu/cu ft and a methane no. > 100

Generator data

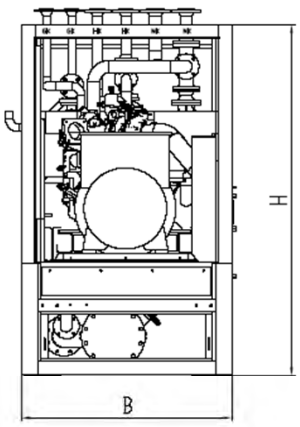
Manufacturer		Leroy Somer
Type		LSA 47.2 M7
Power	kVA	463
Voltage	V	480
Frequency	Hz	60
Rated speed	1/min	1800
Nominal current	A	556
Cos φ		0,8 - 1
Efficiency (full load) at Cos φ = 1	%	95.9
Efficiency (full load) at Cos φ = 0,8	%	94.7
Reactance X"d	%	12.3
Reactance Xi = X2	%	14.2
Mass moment of inertia	kg m²	7.4
Stator circuit		Star
Ambient air temperature	°F	104
Protection class		IP 23

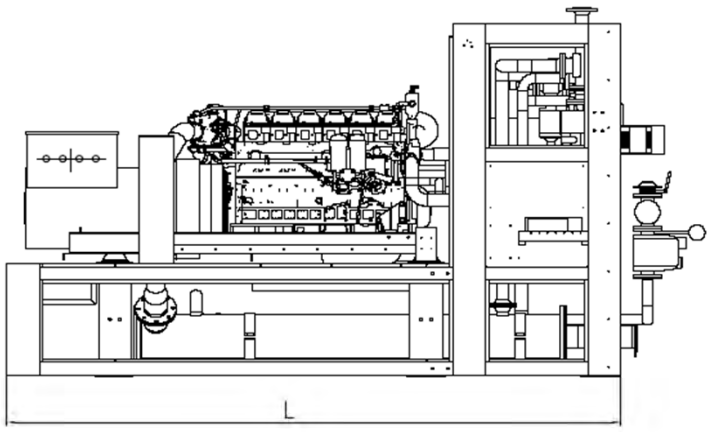
Cos φ has to be between 0,8 and 1,0 within the complete range of capacity. Only inductive power output permitted.

Main dimensions and weights

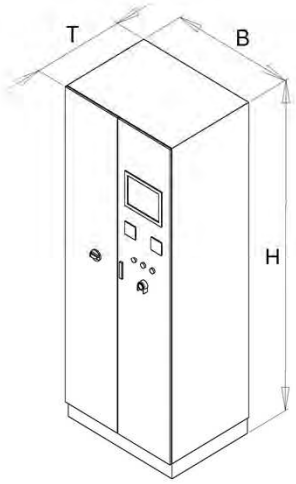
Module:		
Length (L):	in	156
Height (H):	in	87
Width (B):	in	59
Weight (approx.)	lb	13,007
Control cabinet		
Height (H)	in	83
Width (B)	in	39
Depth (T)	in	24
Weight (approx.)	lb	441
Power switch cabinet		
Height (H)	in	79
Width (B)	in	24
Depth (T)	in	20
Weight (approx.)	lb	331

CHP module:

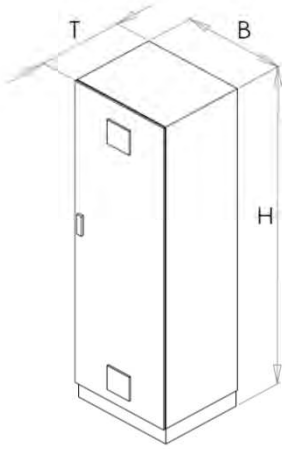




Control cabinet:



Switchgear:



2G CENERGY®
Advanced Clean Energy Technologies

CHP Cogeneration Energy Conversion Systems

Low Emissions & BACT (Best Available Control Technology) Ultra-Low Emissions Capable

All 2G® CHP systems and engines include BACT (Best Available Emissions Control Technology), are in compliance with Federal EPA Rules & Regulations and carrying the voluntary Manufacturers EPA Emissions Certificate of Compliance in accordance with EPA – Subpart JJJJ of Part 60 (Digester Gas, Biogas, LFG, Natural Gas) lean burn Gas Engine (IC Internal Combustion) - 73 FR 3591. All specified emission values < less than / without after treatment. For lower values an Oxidation Catalyst can be installed (optional). For CARB and South California AQMD, emissions can be drastically reduced with 2G®'s SCR Exhaust Gas Treatment Module). Please contact us if you have to comply with specific local regulations and site-specific limitations.

All Data according to full load and subject to technical development, modification and change. Exhaust gas emissions correspond to dry exhaust gas and 10% residual Oxygen O_2. Lean burn and BACT technology and provide exhaust emissions well below EPA Federal Guidelines & Regulations. Additional emissions treatment and reduction technologies (Oxi-Cat, SCR, De-Nox, etc.) are available as an option if required.

Electrical output based on ISO standard and conditions according to ISO 3046/1, VDE 0530, and to SAE J1349 with respective tolerance. Technical data is based on a gas quality 55% CH_4 and carbon dioxide CO_2 <45% and a heat value of >5 kWh/Nm³. For conditions or fuels other than standard, consult 2G-CENERGY®.

Tolerances: electrical output ISO 3046/1, fuel consumption +/- 5%, thermal output +/- 8%. Typical heat data is shown, however no guarantee is expressed or implied. Data will vary due to variations in site and ambient conditions.

All electrical systems comply with DIN, VDE, CE, and CSA certifications, and NEMA / UL compliant designs / configurations. The generator is compliant with international standards & regulations IEC 60034, NEMA MG 1.22, ISO 8528/3, CSA, UL 1446, UL 1004B, DIN 6280-3, VDE 0530, ÖVE-M 10, ISO 8528-3, BS 5000, IEC 34, designed and manufactured in an ISO 9001 and ISO 14001 environment.

Gas treatment might be necessary (depending on the actual gas quality). Applicable gas types: Low BTU (weak gases), e.g. Biogas, Landfill Gas, Sewage Gas, Coal Mine Gas. Other specialty gases upon request (High BTU Wellhead Gas, Wood Gas, Syngas, Coke Gas, Pyrolysis Gas).

The Manufacturer reserves the Right to change or modify technical Details without prior Notice.

2G CHP Systems are designed, and manufactured in Accordance with all applicable Standards.

c UL us CSA CE ISO

2G CENERGY®
Advanced Clean Energy Technologies

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Fax: +1-904-406-8727
Email: info@2g-cenergy.com
Website: http://www.2g-cenergy.com

Proven Technology incl. Performance Guarantee

- **Modular, All-In-One, Fully integrated & Factory tested**
- **Plug & Play, more Cost-effective, more economical**
- **Versatile, flexible, scalable, and unrestrained Mobility**
- **Reliable, proven, with unmatched Quality & Performance**

SEL-735 Power Quality and Revenue Meter

Now with
IEEE C37.118-2011
Synchrophasor
Measurements

The SEL-735 meter combines leading power quality capabilities with exceptional revenue metering accuracy at an economical price. Power quality reports with IEC 61000-4-30 compliance help identify and troubleshoot problems in power system equipment. Advanced communications deliver critical and historical information in real time to virtually any communications system. The SEL-735 is the essential meter for substation, power plant, and industrial metering.

Features and Benefits

- High Precision Revenue Metering Guarantee: 0.06%, 0.02% typical.
- Capture every power quality disturbance with preconfigured logs and triggers.
- Compare power quality measurements across the system with IEC 61000-4-30 power quality compliance.
- Perform statistical calculations while reporting only critical information to save system bandwidth.
- Standardize on one revenue meter for generation, transmission, distribution, intertie, main entrance, and submeter applications.
- Perform real-time monitoring of the Power System with IEEE C37.118-2011 compliant synchrophasors.
- Deliver complete billing data to Itron® MV-90® software over any communications port.
- Integrate into virtually any system with copper or fiber-optic Ethernet, serial, multidrop, infrared, or telephone modem communications.
- Simultaneously communicate with as many as ten other devices using industry standard protocols, including DNP, synchrophasors, Modbus®, and IEC 61850.

One Package, Three Flexible Solutions

Three SEL-735 variants provide a meter for any application and any budget.

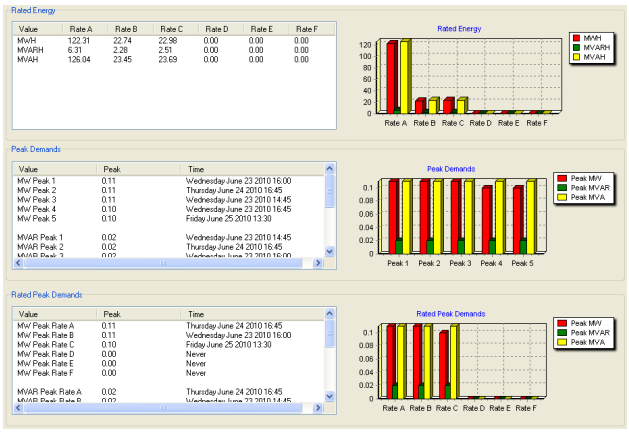
Metering, General	SEL-735 Basic PQ	SEL-735 Intermediate PQ	SEL-735 Advanced PQ
Stated list price	$1,500	$2,000	$2,500
Watt-hour Accuracy	0.06%	0.06%	0.06%
Voltage Range	5–300 V_{L-N}, 9–520 V_{L-L}	5–300 V_{L-N}, 9–520 V_{L-L}	5–300 V_{L-N}, 9–520 V_{L-L}
Current Range	0.001–22 A	0.001–22 A	0.001–22 A
Form Options (Elements)	5, 9, and 36 (2, 3, 2-1/2)	5, 9, and 36 (2, 3, 2-1/2)	5, 9, and 36 (2, 3, 2-1/2)
Load Profile Recorders x Channels	1 x 16	12 x 16	12 x 16
Memory	32 MB	128 MB	128 MB

IEC 61000-4-30 and IEC 61000-4-7 Power Quality	SEL-735 Basic PQ	SEL-735 Intermediate PQ	SEL-735 Advanced PQ
Measurement Aggregation Algorithm			
Aggregation 10/12 cycle	S[a]	S	S
Aggregation 150/180 cycle, 10 min.	S	S	S
Aggregation 2 hour	A[a]	A	A
Power Quality Parameters			
Power frequency	A	A	A
Magnitude of the supply voltage	A	A	A
Flicker	–	S[b]	S[b]
Supply voltage dips and swells	–	A	–
Voltage interruptions	–	A	–
Supply voltage imbalance	A[c]	A[c]	A[c]
Voltage harmonics	–	–	A
Current harmonics	–	–	I[d]
Power harmonics	–	–	I[d]
Voltage interharmonics	–	–	A
Current interharmonics	–	–	I[d, e]
Real-time clock uncertainty	A	A	A
Maximum Harmonic Order	15th	63rd	63rd
Waveform Capture			
Samples per cycle	16	16 and 128	16, 128, and 512
Duration (cycles)	15	15, 30, 60, 120, 300, 600	15, 30, 60, 120, 300, 600
Number of Events	64	15–3142	4–3142
COMTRADE Reports	Y	Y	Y

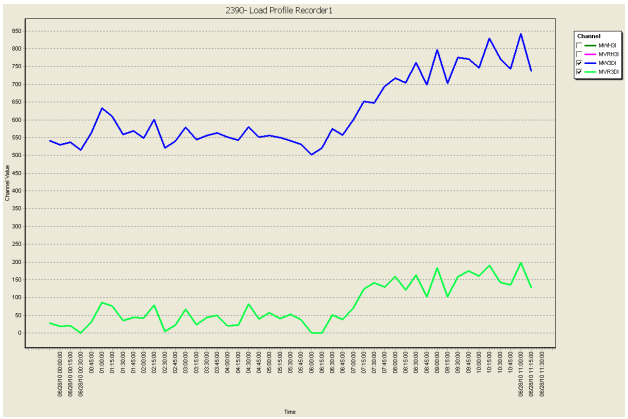
[a] A and S refer to IEC 61000-4-30:2008 Class A and Class S compliance, respectively.
[b] Refers to IEC 61000-4-15:2010 as referenced by IEC 61000-4-30:2008.
[c] Compliance dependent on specific settings. Refer to "IEC 61000-4-30 Testing and Measurement Techniques—Power Quality Measurement Methods."
[d] Refers to IEC 61000-4-7:2002 Class I compliance.
[e] Meets Class I compliance if nominal current is 2 A or higher and Class II compliance if nominal current is 1 A.

Power Dashboard

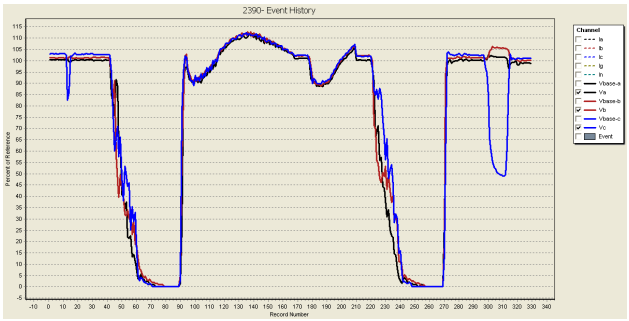
View the state of the power system using no-cost ACSELERATOR QuickSet® SEL-5030 Software. Quickly assemble an overview of the most important system parameters. Load profile trending displays voltage, current, power, and harmonic information. Record years of voltage, current, power, frequency, and harmonic information on a per-phase basis.



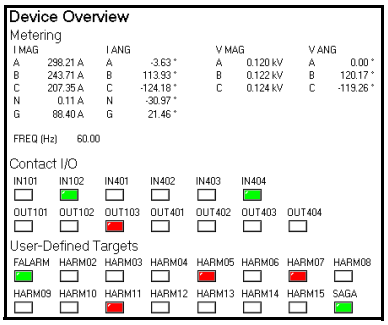
TOU stores and resets peak demand data



Load Profile trends power draw and energy consumption



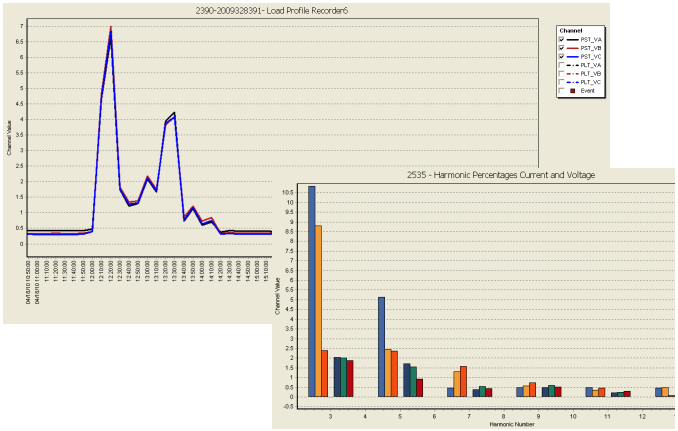
Voltage/Sag/Swell/Interruption reports system interruptions with 1 ms resolution



Meter monitoring software standard with the SEL-735

Power Quality Measurements

- IEC 61000-4-30 power quality compliant
- Statistical trending of virtually any parameter, including:
  - Voltage and current
  - Frequency
  - Harmonics up to the 63rd
  - Total harmonic distortion (THD)
  - Unbalance—symmetrical components
- Sags, swells, and interruptions
- Flicker measurement
- Waveform capture up to 512 samples/cycle

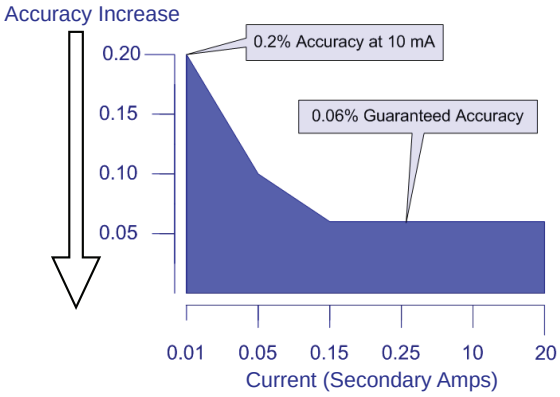


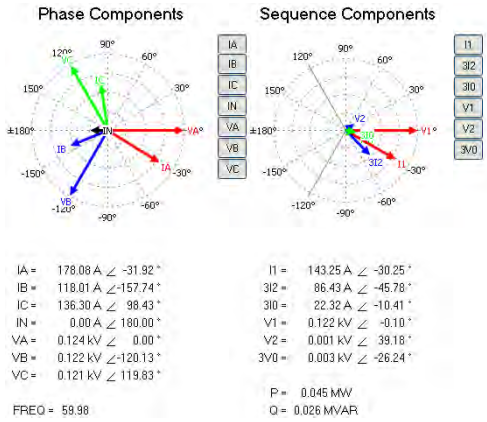
Flicker and harmonics reports help locate system disturbances

High-Function Metering for Substations, Power Generation, and Industrial Loads

Revenue metering applications require a diverse set of features to cover both new and legacy metering requirements. The SEL-735 supports a large feature set to cover a wide range of metering needs.

- 4-Quadrant Metering
- Multiple Load Profile Recorders
- Time-of-Use Metering
- Transformer/Line-Loss Compensation



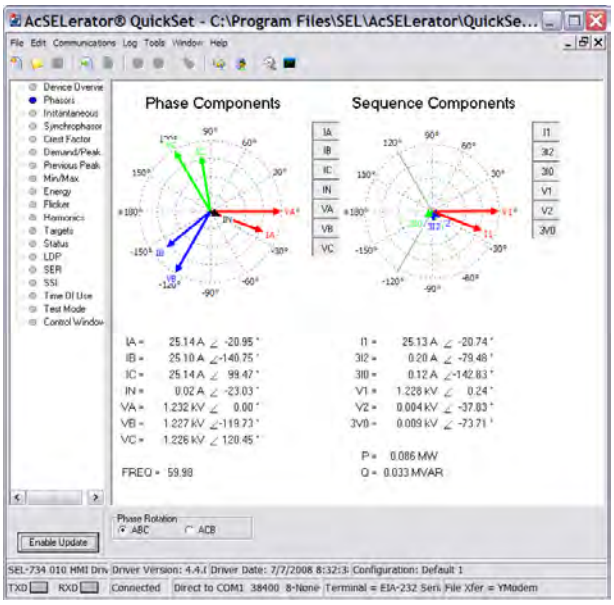


High Accuracy Metering for High Value Applications

Many new metering installations, such as distributed generation, operate over a very large current range. The SEL-735 provides high accuracy over an extended operating range with a 0.06% Wh guarantee. Typical Wh accuracy errors of 0.02% are better than the accuracy of many measurement standards.

Simplified Setup and Troubleshooting

- Use AcSELerator QuickSet to customize your metering. Set and edit meter configuration, settings, and logic.
- View the HMI screens in AcSELerator QuickSet to check wiring connections, phase rotation, and power flow direction.
- Voltage and current sequence elements allow fast troubleshooting of miswired installations.



Feature Overview

- Form 5, 3-Wire Delta, Form 9, 4-Wire Wye, and Form 36, 4-Wire Wye metering connections
- ANSI C12.20 0.2 (Form 5 and Form 9), ANSI C12.1 (Form 36), and IEC 62053-22 0.2 S accuracy class leading
- Rack-mount, panel-mount, easily extractable meter (EXM), wall-mount, and NEMA enclosure options
- Simultaneous Ethernet, EIA-485, EIA-232, telephone modem, and optical probe communications
- Real Time Synchrophasor data with IEEE C37.118-2011
- Enhanced SELogic® control equations
- Communication protocols
  - SEL ASCII
  - Modbus RTU/TCP
  - SEL Fast Operate/Fast Meter
  - Mirrored Bits® communications
  - SEL Distributed Port Switch (LMD)
  - DNP3 Serial and LAN/WAN
  - IEC 61850
  - IEEE C37.118.2
  - MV-90
  - Telnet
  - SNTP and FTP
- Inputs/outputs
  - 2 digital inputs, 3 electromechanical outputs
  - 4 digital inputs, 4 KY outputs with programmable Ke
  - 4 digital inputs, 4 electromechanical outputs
  - 4 analog outputs, 4 KY outputs with programmable Ke

See model option table for available configurations and options.

Data Sheet D184S035U02 Rev. 12

FV4000, FS4000
Vortex Flowmeter / Swirl Flowmeter

2-wire Compact Design
Digital Signal Processor
Converter Technology

For metering liquids, gases and steam

FV4000 Vortex flowmeter

FS4000 Swirl flowmeter for very short steadying zones

Approvals for explosion protection
- ATEX
- IEC
- $_{c}FM_{us}$
  Zone 1, Zone 2, dust ignition protection

Magnetic pen operation
- Configuration also possible with closed housing

Integrated switching output
- Used as limit contact or pulse output

Compensation of temperature influences by means of temperature measurement integrated as an option

Power and productivity
for a better world™

Contents

1 Principles of measurement 4
1.1 Principle of measurement for Vortex flowmeter 4
1.2 Principle of measurement for Swirl flowmeter 4
2 Overview of flowmeters 5
3 General specifications 7
3.1 Nominal diameter selection 7
3.2 Measured value deviation for flow measurement 7
3.3 Measured value deviation for temperature 7
3.4 Permissible pipeline vibrations 7
3.5 Reference conditions for flow measurement 8
3.6 FV4000-VT4 / VR4 flowrates 8
3.7 FS4000-ST4 / SR4 flowrates 9
3.8 Static overpressure in the case of fluids 9
3.9 Overload capability 9
3.10 Temperature of medium 10
3.11 Flowmeter insulation 10
3.12 Ambient conditions 10
3.13 Installation Requirements 11
3.14 Recommended inflow and outflow sections 11
3.15 Installation at high media temperatures > 150°C (302°F) 12
3.16 Installation for pressure and temperature measurement 12
3.17 Installation of final controlling equipment 12
3.18 Process connections 13
3.19 Materials 13
3.20 Weights 13
4 Dimensions 15
4.1 FV4000-VT4/VR4 (TRIO-WIRL V), wafer design 15
4.2 FV4000-VT4/VR4 (TRIO-WIRL V), flange design, DIN 16
4.3 FV4000-VT4/VR4 (TRIO-WIRL V), flange design, ASME 18
4.4 FS4000-ST4/SR4 (TRIO-WIRL S) 20
5 Transmitter specifications 22
6 Communication 23
6.1 2-wire technology design 23
6.2 4 ... 20 mA / HART 23
6.3 PROFIBUS PA 25
6.4 FOUNDATION fieldbus 26
7 Ex relevant specifications for transmitter 27
7.1 Ex "ib" / Ex "n" design for VT41/ST41 and VR41/SR41 (4 ... 20 mA / HART) 27
7.2 Ex "d" / Ex "ib" / Ex "n" design for VT42/ST42 and VR42/SR42 (4 ... 20 mA / HART) 29

7.3 FM approval design for the USA and Canada for VT43/ST43 and VR43/SR43 (4 ... 20 mA / HART).....31
7.4 Ex "ia" design for VT4A/ST4A and VR4A/SR4A (fieldbus).....34
8 Ordering information.....36
8.1 FV4000-VT4/VR4 Vortex flowmeter.....36
8.2 FS4000-ST4/SR4 Swirl flowmeter.....39
9 Accessories.....42
10 Questionnaire.....43

1 Principles of measurement

1.1 Principle of measurement for Vortex flowmeter

The operating principle of the Vortex flowmeter is based on the Karman street. As the fluid flows over and under the solid body, vortices are shed alternately above and below. The shedding of these vortices due to the flow forms a vortex trail (Karman street).

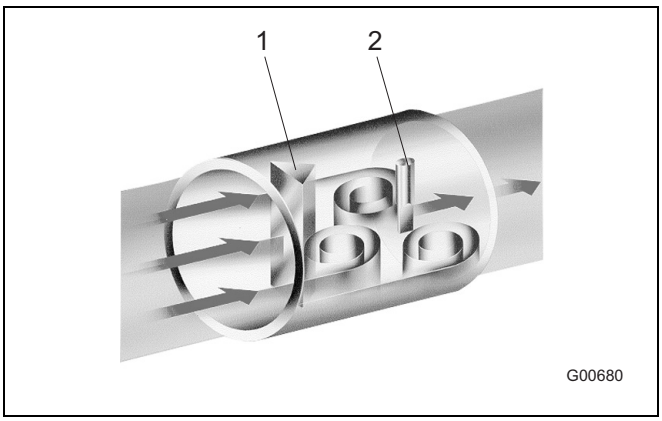


Fig. 1: Principle of measurement, FV4000

1 Solid body
2 Piezo sensor

The frequency *f* of vortex shedding is proportional to the flow velocity *v* and inversely proportional to the width of the solid body *d*:

$$f = St \times \frac{v}{d}$$

St, known as the Strouhal number, is a dimensionless number which has a decisive impact on the quality of vortex flow measurement.

If the solid body is dimensioned appropriately, the Strouhal number *St* will be constant across a very wide range of the Reynolds number *Re* (Fig. 2).

$$Re = \frac{v \times D}{\vartheta}$$

= Kinematic viscosity

D = Nominal size of meter tube

Consequently, the vortex shedding frequency to be evaluated is dependent solely upon the flow velocity and not at all upon media density and viscosity.

The local changes in pressure induced by vortex shedding are detected by a piezo sensor and converted into electrical pulses corresponding to the vortex frequency.

The frequency signal from the flowmeter sensor, which is proportional to the flow, undergoes downstream processing in the transmitter.

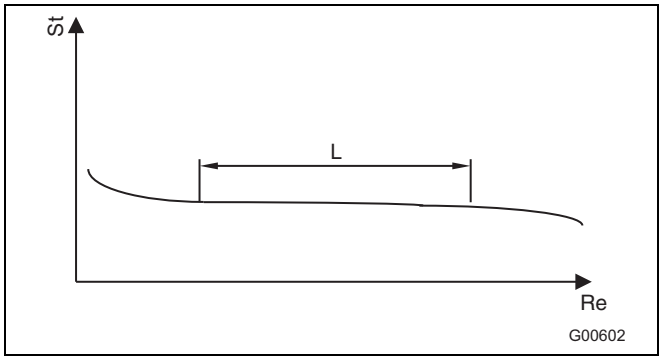


Fig. 2: How the Strouhal number is dependent upon the Reynolds number

St Strouhal number
Re Reynolds number
L Linear flow area

1.2 Principle of measurement for Swirl flowmeter

The inlet pipe converts the axial flow of the incoming media into rotational movement. In the center of this rotation a vortex core is formed which is forced into a secondary spiral-shaped rotation by the backflow.

The frequency of this secondary rotation is proportional to the flow and, if the internal geometry of the meter exhibits an optimum design, will be linear over a wide flow range. This frequency is measured by a piezo sensor. The frequency signal from the flowmeter sensor, which is proportional to the flow, undergoes downstream processing in the transmitter.

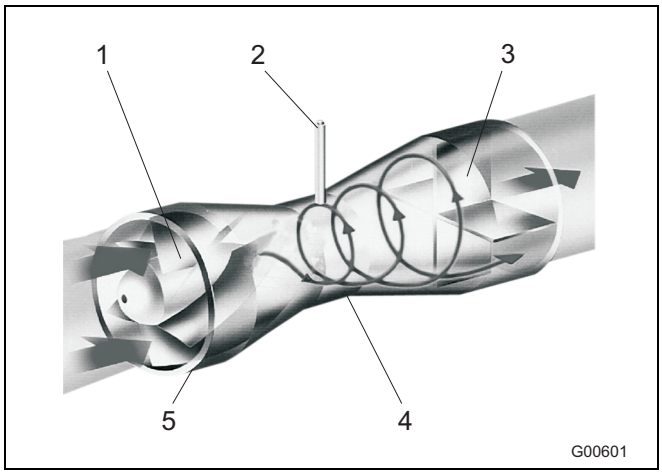
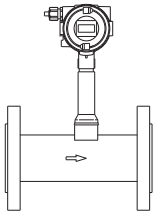
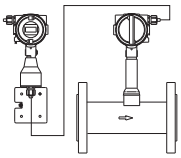
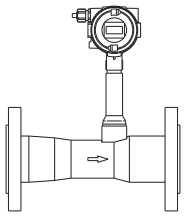
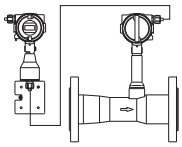


Fig. 3

1 Inlet pipe
2 Piezo sensor
3 Outlet pipe
4 Stagnation point
5 Housing

2 Overview of flowmeters

		FV4000-VT4 (TRIO-WIRL VT)	**FV4000-VR4** (TRIO-WIRL VR)	**FS4000-ST4** (TRIO-WIRL ST)	**FS4000-SR4** (TRIO-WIRL SR)
		 G00740	 G00742	 G00741	 G00743
Measured value error	Fluids	≤ ± 0.75 % of flow rate under reference conditions		≤ ± 0.5 % of flow rate under reference conditions	
	Gases and steam	≤ ± 1 % of flow rate under reference conditions			
Reproducibility		DN 15 ≤ ± 0.3 % of flow rate		DN 15 ≤ ± 0.3 % of flow rate DN 20 or higher ≤ ± 0.2 of flow rate	
		DN 15 to DN 150 ≤ ± 0.2 of flow rate			
		DN 200 or higher ≤ ± 0.25 % of flow rate			
Permissible viscosity for fluids (> 7.5 mPa s, field calibration required for FS4000)		DN 15 ≤ 4 mPa s		DN 15 to DN 32 ≤ 5 mPa s	
		DN 25 ≤ 5 mPa s		DN 40 to DN 50 ≤ 10 mPa s	
		DN 40 or higher ≤ 7.5 mPa s		DN 80 or higher ≤ 30 mPa s	
Typical span		1:20		1:25	
Typical inflow / outflow sections		15 x DN / 5 x DN		3 x DN / 1 x DN	

Sensor

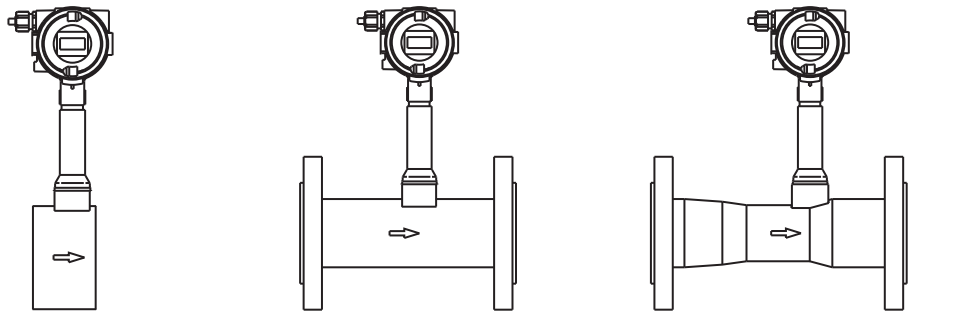
Process connection (DIN, ANSI. JIS)	Flange	DN 15 to DN 300 (1/2" to 12")		DN 15 to DN 400 (1/2" to 16")	
	Wafer flange	DN 15 to DN 150 (1/2" to 6")		-	
Sensor design	Single sensor	Yes, optional with integrated temperature measurement (DN 50 or higher)			
	Double sensor				
Fluid temperature	Standard	-55 ... 280 °C (-67 ... 536 °F)		-55 ... 280 °C (-67 ... 536 °F)	
	High temperature (DN 25 or higher)	-55 ... 400 °C (-67 ... 752 °F)		-	
Ingress protection		IP 65 / IP 67 / Nema 4X			
Materials	Sensor	Stainless steel opt. Hast. C / Titan		Stainless steel opt. Hast. C / Titan	
	Inlet / outlet pipe	-		Stainless steel opt. Hast. C	
	Solid body	Stainless steel opt. Hast. C		-	
	Meter housing	Stainless steel opt. Hast. C		Stainless steel opt. Hast. C	
	Sensor gasket	Graphite, Kalrez, Viton, PTFE		Graphite, Kalrez, Viton, PTFE	
Only FVR4000 or FSR4000	Signal cable length between sensor and transmitter	-	max. 10 m (32.8 ft)	-	max. 10 m (32.8 ft)

Transmitter

Supply power	For analog output 4 ... 20 mA	14 ... 46 V (Ex ib ≤ 28 V)
	For PROFIBUS PA and FOUNDATION fieldbus	I < 10 mA (9 … 32 V; Ex ia ≤ 24 V)
Sealing concept		Dual sealing acc. to ANSI / ISA-12.27.01 (VT43/VR43/ST43/SR43)
Display	2 x 8-digit /2 x 16-digit	Local display / totalization with magnetic pen operation / Parameters via HART protocol / PROFIBUS PA / FOUNDATION fieldbus adjustable
External FRAM		Yes, for saving transmitter parameterization data as well as flowmeter sensor calibration data
Contact output	(Optocoupler for standard) NAMUR contact (Ex ia / ib)	Can be parameterized as limit contact (flow, temperature), alarm output or pulse output
Saturated steam calculation / Temperature compensation		Yes, if sensor is fitted with temperature measurement device
Communication		HART protocol, PROFIBUS PA (Profile 3.0), FOUNDATION fieldbus

Designs

There are generally two different designs.



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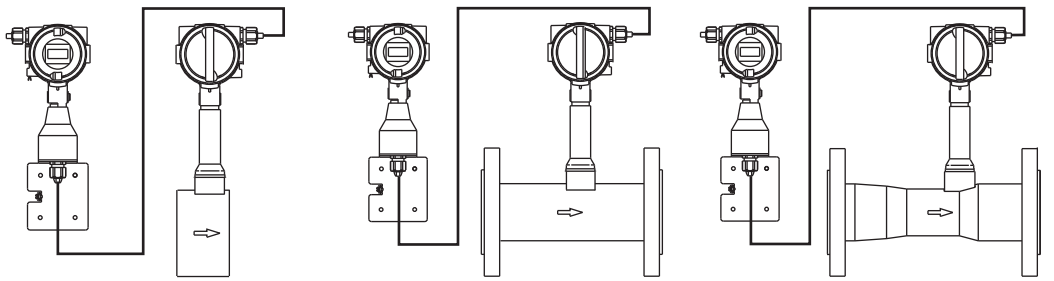
Vortex flowmeter **FV4000-VT4** Wafer flange design	Vortex flowmeter **FV4000-VT4** Flange design	Swirl flowmeter **FS4000-ST4** Flange design

Fig. 4: Integral mount design: The transmitter is installed directly on the sensor.



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Vortex flowmeter **FV4000-VR4** Wafer flange design	Vortex flowmeter **FV4000-VR4** Flange design	Swirl flowmeter **FS4000-SR4** Flange design

Fig. 5: Remote mount design: The transmitter can be installed up to 10 m away from the flowmeter sensor. The cable is permanently connected to the transmitter. It can be made shorter if required.

3 General specifications

3.1 Nominal diameter selection

The nominal diameter is selected on the basis of the maximum operating flow Qv max. If maximum spans are to be achieved, this should not be less than half the maximum flowrate for each nominal diameter (Qv max DN), although reduction to approx. 0.15 Qv max DN is possible. The linear lower range limit value is dependent upon the Reynolds number (see accuracy information).

If the flow to be measured is the standard flow (standard condition: 0 °C (32 °F), 1,013 mbar) or mass flowrate, this must be converted to the operating flow and the most appropriate nominal device diameter must be selected from the flow range tables (Tables 1, 2, 3).

= Operating density (kg/m³)

$_N$ = Standard density (kg/m³)

P = Operating pressure (bar)

T = Operating temperature (°C)

Qv = Operating flow (m³/h)

Qn = Standard flow (m³/h)

Qm = Mass flowrate (kg/h)

= Dynamic viscosity (Pas)

= Kinematic viscosity (m²/s)

1. Conversion of standard density (n) --> operating density ( )

$$\rho = \rho_n \times \frac{1{,}013 + \rho}{1{,}013} \times \frac{273}{273 + T}$$

2. Conversion to operating flow (Qv)

a) From standard flow (Qn) -->

$$Q_V = Q_n \frac{\rho_n}{\rho} = Q_n \frac{1{,}013}{1{,}013 + p} \times \frac{273 + T}{273}$$

b) From mass flowrate (Qm) -->

$$Q_V = \frac{Q_m}{\rho}$$

3. Dynamic viscosity ( ) --> kinematic viscosity ( )

$$\nu = \frac{\eta}{\rho}$$

Calculating the Reynolds number:

$$Re = \frac{Q}{(2827 \cdot \nu \cdot d)}$$

Q = Flow in m³/h

d = Pipe diameter in m

= Kinematic viscosity m²/s (1 cst = 10^{-6} m²/s)

The current Reynolds number can also be calculated using our AP-Calc calculation program.

3.2 Measured value deviation for flow measurement

Deviation in percentage terms from the measured value under reference conditions (including the transmitter) in the linear measuring range between Re min and Qmax (see "Measuring ranges" table).

	FV4000-VT4/VR4	FS4000-ST4/SR4
Fluids	≤ ± 0,75 %	± 0,5 %
Gases / Steam	≤ ± 1 %	
Current output		
Additional measurement uncertainty	< 0,1 %	
Temperature effect	< 0,05 % / 10 K	

Misalignment associated with installation or deinstallation may affect the measuring error.

Additional measuring errors may occur if there are deviations from the reference conditions.

3.2.1 Reproducibility as a percentage of the measured value

DN	Inch	FV4000-VT4/VR4	FS4000-ST4/SR4
15	1/2“	0,3 %	
25 ... 250	1“ ... 6“	0,2 %	
200 ... 300	8“ ... 12“	0,25 %	0,2 %

3.3 Measured value deviation for temperature

Measured value deviation (including transmitter)

± 2 °C

Reproducibility

≤ 0.2 % of measured value

Product selection and dimensioning program

Important

The ABB "AP-Calc" program can be used free of charge when selecting an appropriate flowmeter for a given application. The program runs in a Microsoft WINDOWS ® environment.

3.4 Permissible pipeline vibrations

Guide values: The values specified for acceleration g are intended as guide values. The actual limits will depend on the nominal diameter, the measuring range within the entire measuring span, and the frequency of the vibrations. Therefore, the acceleration value g has only limited meaning.

FV4000:

Fluid: max. 1.0 g, 0 … 130 Hz

Gas / steam: max. 0.3 g, 0 … 130 Hz

FS4000:

Fluid: max. 0.3 g, 0 … 130 Hz

Gas / steam: max. 0.3 g, 0 … 130 Hz