QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PLAN

FOR

CRE-SPRUCE HAVEN LLC ANAEROBIC DIGESTER GAS (ADG) SYSTEM

Agreement # 31851

February 28, 2014

Submitted to:

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

and

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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 Spruce Haven Farm (The Farm) in Union Springs, 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 502 kW.

ADG System Description

The digester system at The Farm was designed by Larsen Engineers. The power plant equipment will be provided by Martin Machinery while the gas conditioning equipment will be supplied by Energy Cube, LLC. Gas and power metering are provided by Sage Metering Inc. and Wattnode. The site will operate one 520 kW synchronous engine-generator. A single biological scrubber will be located near the digester. Gas conditioning equipment, piping and controls will be located next to the engine skid in the generator building. All the electrical loads at the farm are 3-phase, 277/480 volt electrical service which accommodates the interconnection of the generator system. The electrical system includes controls to synchronize the generator to the grid as well as a protective relay and controls to automatically isolate the units from the utility grid in the event of a utility power outage. The farm does expect to export a portion of the generated electricity, and has been approved for net metering.

Photo of land available for project taken from north end of East Lagoon, facing east. Part of the excavation work has been already accomplished in 2012 but not visible in this photo dated Dec. 2011.

Photo of East Lagoon. Taken from north end of East Lagoon, facing south.

Raw manure collection pit currently installed on farm.

Figure 1 - Photos of Site and System Components

Table 1 - Biogas Systems at Spruce Haven Farm

Digester	RAD2 (Recirculated Anaerobic Ditch Digester), hybrid of a completely mixed and plug-flow digester, flexible cover, heated, 1.5 million gallon capacity, 28 day retention time
Feedstock	Dairy Manure, approximately 3,359 animals (cows and heifers)
Engine	Guascor HGM 240, 1,800 RPM, 520 kW on biogas
Generator	Stamford HCM534C2 – 480 VAC, 3 Phase, limited to 502 kW output.
Biogas Conditioning	Energy Cube biological H_2S scrubber, de-watering system, and blower, rated for 600 scfm at 4,000 ppm.
Engine Backup/startup Fuel	*Propane Boiler* – Used to heat digester until sufficient biogas is produced to run biogas boiler. *Biogas Boiler* – Used for digester heating until digester produces sufficient biogas to run engine *Natural Gas or Propane for Engine Start-up* – Used to temporarily fuel the engine generator to allow the acceptance test for interconnection to occur before the digester is completed and is producing enough biogas to run the engine.
Heat Recovery Use	Digester heating and scrubber heating
Additional Heat Recovery	Excess heat may be used to heat the sand separator building (future use)

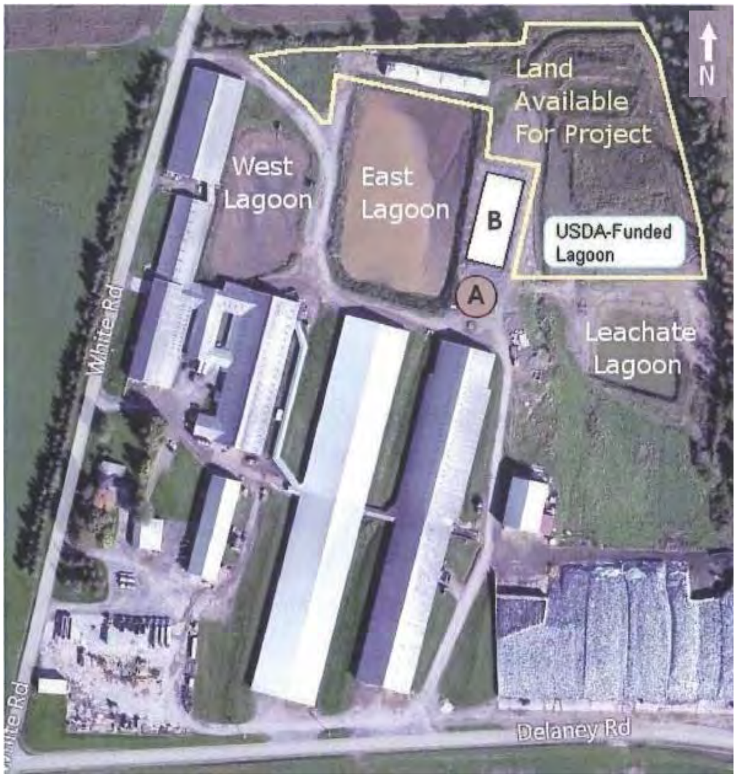


Figure 2 – Site Plan

Figure 2 shows the farm layout and general site plan. Manure is collected with sand, which is used as bedding. Raw sand-laden manure is conveyed directly from the free-stall barns to a concrete holding tank. The sand-laden manure is then diluted with a small amount of thin, solids free manure and pumped to the primary sand separator where 85 % of the sand is removed. The manure is then pumped through the secondary separator (hydrocyclone) where an additional 10% of sand is removed. The remaining manure then passes through 80 ft sand-lane (tertiary separation). This then is processed through a rotary drum separator to remove any solids and generate the thin, solids-free manure used to dilute the raw sand-laden manure. Un-used dilution liquid is recombined with separated organic solids and is then transferred by gravity to a 50,000 gallon concrete holding tank which also acts as the fourth and final sand settlement point.

A 2” manure pump will pump 50-100 gpm of raw feedstock into the system recirculation line prior to the slurry heater. A 4” manure pump will recirculate digester contents at a flow rate or 450-650 gpm. Raw feedstock will mix with recirculated digester contents which contain active bacterial cultures, and will be heated by excess heat generated by the cogen system and returned to the lagoon. A back-up boiler will also be installed in the event of cogen inoperability. A series of 4 rotary mixers keep the digester contents fully mixed. Digester effluent will flow by gravity to an external effluent sump tank where an additional 4” manure pump will be activated by fluid level sensors to convey effluent to the existing manure storage lagoons.

Gas generated will be collected and passed through a biological scrubber system to remove excess hydrogen sulfide. The gas will then be dried and used as fuel in the cogen system. Excess gas will be flared.

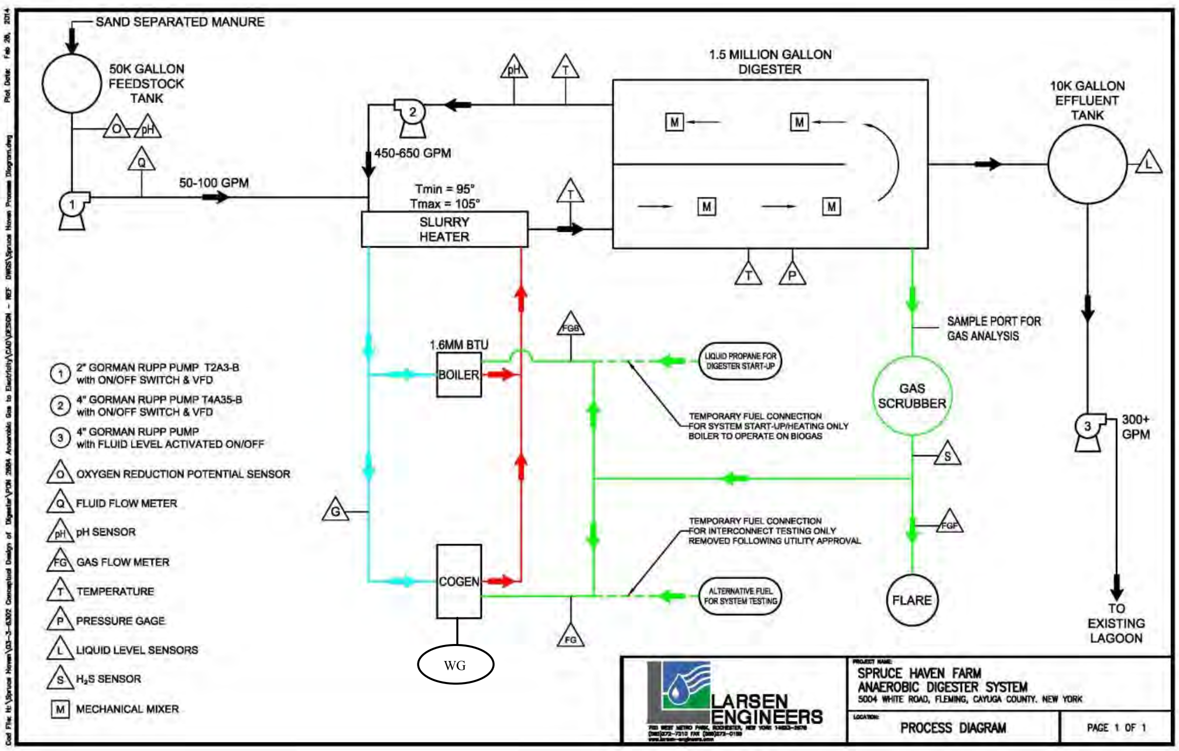


Figure 3. Digester Process Diagram

Figure 3 shows the process diagram for the digester and engine system. Biogas from the digester is either used in the engine-generator or flared. The flexible membrane cover will be allowed to inflate to provide biogas storage. The biogas flare will be actuated by the digester system PLC supplied by Martin Machinery if internal gas pressure reached the upper threshold limit as indicated by the gas pressure meter. An additional mechanical emergency relief valve will vent biogas to maintain the digester static pressure requirements.

Sage Prime metering devices measure gas flow to the flare (FGF) and to the engine-generator (FG). To reduce the biogas H_2S levels, the biogas for the engine passes through the scrubber system. This system is made up of one biological scrubber. Gas enters through the reactor at the bottom of the tank. Clean air is added at the inlet point and is controlled by the residual oxygen measured in the treated gas. When gas flows are low or nonexistent, the air supply switch is switched off. Once the gas is scrubbed it continues into the utility building where it is then de-watered and pressurized, via the gas conditioning equipment provided by Martin Machinery, before being combusted in the engine.

Heat is recovered from the engine exhaust in the form of hot water. This hot water is circulated through the heat exchanger where it provides heat to the digester contents, pumped by the recirculation pump. A portion of the heat is also used to maintain a set temperature in the biological scrubber. The facility also plans on using some of the recovered heat to help heat the sand separator building in the future.

Figure 4 shows the one-line electrical diagram.

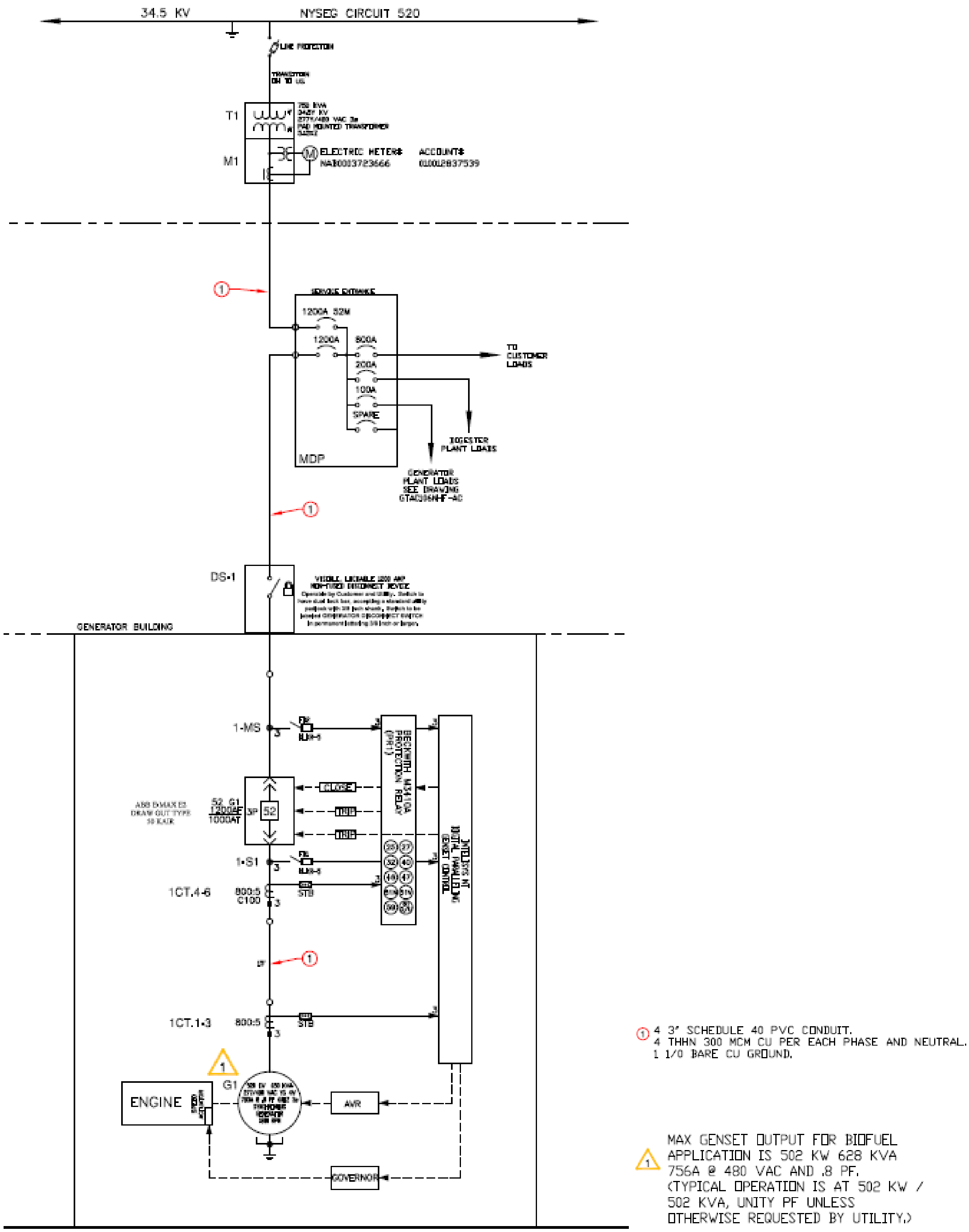


Figure 4 – One Line Electrical Diagram

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, Spruce Haven Submittal-R1, the planned Guascor engine and generator assembled by Martin Machinery are stated to have a capacity of 520 kW and the Energy Cube Gas Cleanup Equipment to have throughput of 600 scfm. The Contracted Capacity in Exhibit A of the Standard Performance Contact Agreement (SPCA) between CRE - Spruce Haven LLC and NYSERDA is 502 kW after factoring in system controls to limit output.

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 designed to be 1,500,000 gallons.
- Energy Cube Gas Cleanup Equipment is anticipated to have a throughput of 600 scfm.
- Design biogas power generation utilization rate is designed to be approximately 7,040 scf/hr.

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 design biogas power generation utilization rate of approximately 7,040 scf/hr identified in the project Application Package to PON 2684 Appendix B Section B as a total of 61,628,352 scf/yr. *(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 376.5 kWh/h for at least one hour. The use of an alternative non-biogas fuel (such as natural gas or propane) is allowed for a very limited test period solely to allow the power generation system to be run for the interconnection acceptance test to be completed by the utility. The power generation equipment will be provided with a temporary connection to the alternative fuel source, which will be removed once the test is completed. All temporary fuel connections must conform with relevant code requirements and engineering standards.

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 376.5 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, and (b) high quality gas cleanup documented to produce measured H_2S output less than 400 ppm.

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 376.5 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 H_2S output less than 400 ppm in accordance with the section below on QA/QC Procedures for Documenting High Quality Gas Cleanup;

6. 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 3 shows the general location of the meters used to measure biogas input to the engine-generator (**FG**), biogas sent to the flare (**FGF**), biogas sent to the boiler (FGB) 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	Pulse Output Wattnode Model WNA-3Y-480-P	kW	0-600 kW
Modbus	FG	Engine Biogas Flow	Sage Metering Inc. Model SIP-05-06-DC24-DIGGAS (0-150 scfm)	SCF	0 – 9,000 SCFH
Modbus	FGF	Flare Biogas Flow	Sage Metering Inc. Model SIP-05-10-STC-05-DIGGAS (0-150 scfm)	SCF	0 – 9,000 SCFH
Modbus	FGB	Boiler Biogas Flow	Sage Metering Inc. Model SIP-05-06-DC24-DIGGAS (0-150 scfm)	SCF	0 – 9,000 SCFH

The electrical output of the engine-generator (**WG**) will be measured with the Pulse Output Wattnode power meter. The power meter will be installed in a stand alone cabinet on the side of the engine by the electrical contractor. 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 a Sage Prime mass flow meter (**FG**). The meter is capable of providing a temperature compensated pulse output, 4-20 mA output, or Modbus 485 output. There is a second Sage Prime mass flow meter **(FGF)** that meters the gas flow to the flare and a third Sage Prime mass flow meter (**FGB**) metering flow to the boiler. The meters will be installed and maintained according to the "Sage Thermal Gas Mass Flow Meter Operations and Instruction Manual for Models SIP/SRP," by the facility. A log of maintenance activities for the meters will be maintained at the site.

The gas meter is currently spanned for 0 – 150 scfm. Using engine ratings, this should be a large enough range to measure all gas flow, however when using LHV and efficiencies seen previously at other farms, the gas flow may exceed 150 scfm. If this is the case the meters will need to be re-spanned so they can measure a higher flow rate. This can be done on site, without removing the meters, with the purchase of a communications kit and software from Sage.

The lower heating value for the biogas is estimated to be 600 Btu/ft^3, based on typical biogas at other farms. This value will be verified based on measurements of methane and carbon dioxide using the Landtec GA3000PLUS analyzer, which can be programmed for continuous monitoring. The Farm staff will log the results in the project log once a week, at a minimum. The sampling point is located on the effluent of the biological scrubber and is marked in Figure 3 as “H_2S Sensor (S)”.

The boiler backup/startup fuel flow (propane) will not be continuously metered or logged at this site since it cannot be used by the engine to produce power. The propane will be used to run the boiler during the startup process for the digester. The propane line connection will be feeding the boiler only and measures will be taken to prevent propane from feeding the biogas line from the boiler to the gen-set. As the digester heats up and begins producing combustible biogas, the facility will switch over from the propane boiler to a biogas boiler. In the event the gen-set is down for any length of time the farm will be able to use the biogas boiler to provide heat for the digester.

Data logging is going to be done in one of two ways:

1) The control panels being provided may have the capabilities to perform the necessary data logging. This includes receiving signals from the power meter and two gas meters (one Modbus 485 signal, and two pulse or 4-20mA or Modbus 485) and logging time stamped data at 15 minute intervals. The data would then need to be made available to CDH Energy, the NYSERDA CHP Website Contractor, in a number of ways:
    - A nightly automated email to data_collection@cdhenergy.
    - A nightly automated upload to CDH’s FTP server.
    - If a static IP address can be provided, and the data made available online, CDH could set up automated processes to pull data on a nightly basis.

2) If the control panels do not have the capabilities required, CDH will provide an Obvius AcquiSuite data logger and panel. CDH will then terminate sensor wiring to the logger, and verify that accurate measurements are being received. The facility will be responsible to provide CDH with 110 V power, and either an internet or phone connection. The data logger will be connected to an uninterruptible power supply (UPS) to ensure the data logger retains its settings and data in the event of a power outage. The Farm will provide a static IP address that will be used by CDH Energy to communicate with the data logger.

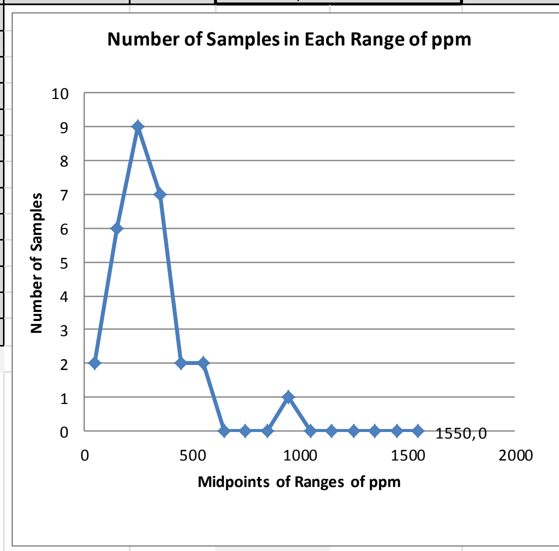
QA/QC Procedures for Documenting High Quality Gas Cleanup

Payment of this incentive (Capacity Payment #5) 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 NYSERDA. For this project the Landtec GA3000PLUS will be used to measure the H_2S concentrations. This system is in-line and can measure H_2S from 0-10,000 ppm. Readings of H_2S will be taken every 30 minutes. Calibration instruction as detailed in the GA3000 PLUS Gas Analyzer Operating Manual shall be followed to ensure accurate readings.

The following paragraph describes how daily test results can be used to document the ability of the equipment to achieve the required output level to receive the added incentive for the HQGCE. The individual who operates the ADG-to-Electricity system will measure hydrogen sulfide levels, both before and after the scrubber, on at least 25 days within a consecutive 30-day period during which the ADG systems is producing biogas at at least 75% of the design biogas power generation utilization rate of approximately 7,040 scf/hr and with CO_2 levels reaching 50% or lower. The pre and post scrubbing measurements are to determine the effectiveness of the installed scrubber system. 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 H_2S levels in the output of the HQGCE to be less than 400 ppmv. These samples can be an average of readings taken throughout the day. If influent concentrations exceed the GA3000 PLUS Gas Analyzer allowable range, Draeger tubes may be used to measure the H_2S concentrations before the scrubber.

The worksheet below will be used as a template for documenting the capabilities of the HQGCE. Biogas flow and H_2S input to and output from the HQGCE will be documented for each the 25 to 30 days that samples are taken. The Landtec, GA3000PLUS system has the capability to measure the CH_4 content of the gas. CH_4 content of the input gas will be measured for at least 7 of those days at intervals spread over the 30 days. If the percentage of cumulative samples with 399 ppm H_2S 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	Cumulative scf biogas generation input to gas cleanup	CO2 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		127,200										
1		254,400	40%	1,500	50			0 to 99	50	2	2	7%
2		381,600	39%	1,600	50			100 to 199	150	6	8	28%
3		508,800	38%	2,000	250			200 to 299	250	9	17	59%
4		636,000		1,600	250			300 to 399	350	7	24	83%
5		763,200		2,000	150			400 to 499	450	2	26	90%
6		890,400		1,100	150			500 to 599	550	2	28	97%
7		1,017,600		800	150			600 to 699	650	0	28	97%
8		1,144,800	38%	2,000	150			700 to 799	750	0	28	97%
9		1,272,000		1,100	250			800 to 899	850	0	28	97%
10		1,399,200		800	250			900 to 999	950	1	29	100%
11		1,526,400		2,000	250			1000 to 1099	1050	0	29	100%
12		1,653,600		1,600	150			1100 to 1199	1150	0	29	100%
13		1,780,800		2,000	150			1200 to 1299	1250	0	29	100%
14		1,908,000		1,100	250			1300 to 1399	1350	0	29	100%
15		2,035,200	42%	800	250			1400 to 1499	1450	0	29	100%
16		2,162,400		1,600	250			1500 or more	1550	0	29	100%
17		2,289,600		2,000	250					Total Samples	29	
18		2,416,800		1,100	350							
19		2,544,000		800	450							
20		2,671,200		2,000	350							
21		2,798,400		1,100	350							
22		2,925,600	33%	800	350							
23		3,052,800		1,600	350							
24		3,180,000		1,600	350							
25		3,307,200										
26		3,434,400		1,100	450							
27		3,561,600		800	350							
28		3,688,800		2,000	550							
29		3,816,000	33%	1,100	550							
30		3,943,200		800	950							
		5,300	38%	1,393	298	29						
		Total Biogas Generated in 30 Days Greater Than 5,280 scf/hr	Average CO2 Percentage Less than 50%	Average ppm H2S in Input Biogas	Average ppm of H2S Output Samples	Number of H2S samples						



Note: Design biogas power generation utilization rate is 7,040 scf/hr at 100% capacity. At 75% capacity, biogas power generation utilization rate would be 5,280 scf/hr.

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 weekly log of the cumulative power generation (kWh) from the Wattnode meter (**WG**) and gas flow (cf or ft^3) recorded by the Sage meters (**FG, FGF**) 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.ny.gov) 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, and
- RPS: Customer-Sited Tier Anaerobic Digester Gas-to-Electricity Program NYSERDA Incentive Program Reports.

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:

- a periodic email report summarizing system performance and the estimated incentive,
- an email report sent out if data is not received at the web site or does not pass the quality checks.

The website will automatically take the data collected from the data-logger and evaluate the quality of the data for each base time interval using range and relational checks. The range checks will be setup based on the expected ranges for the sensors (see Table 2).

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 incentive reports listed above. However, all hourly data is available from the NYSERDA CHP Website if the data quality flag of “Data Exists” is selected. 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.

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 propane or other fuel used for the engine/boiler. The Farm may use the NYSERDA Incentive Program Reports found on the CHP Website. Alternatively, they may provide their own summary of the data (using hourly CSV data downloaded from the Website or on-site sources) along with a narrative 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 readings of CO_2 concentration in the biogas gathered weekly will be used to estimate the average monthly Biogas Lower Heating Value using the following equation:

$$LHV_{biogas} = LHV_{methane} \cdot (F_{CH4})$$

where:

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

F_{CH4} - fraction of biogas that is CH_4 (average of readings for each month)

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 for the engine-generator at Spruce Haven Farm.

Appendices

Cut sheets and Manuals for:

Guascor, HGM-240, 1800 rpm Engine

Stamford, HCM534C2 Generator

Sage Metering Inc., Model SIP-05-10-STC-05-DIGGAS Mass Flow Meter

Sage Metering Inc., Model SIP-05-06-DC24-DIGGAS Mass Flow Meter

Pulse Output Wattnode Power Meter, Model WNA-3Y-480-P

Landtec, GA3000 PLUS Gas Analyzer

Gas

Speed	1,200/1,500/1,800 rpm
Generator frequency	50/60 Hz
Applicable gas types [2]	Natural gas, biogas, landfill gas, sewage gas, flare gas, other special gases
Minimum methane number [1]	75

Engine Parameters	English Units	Metric Units	HGM 240				HGM560					
Speed	rpm		1,500		1,800		1,200		1,500		1,800	
Engine power [2]	bhp	kWb	697	(520)	697	(520)	1,395	(1,040)	1,663	(1,240)	1,810	(1,350)
Cylinder arrangement			In Line 8				V16					
Mean effective pressure	psi	bar	252	(17.4)	210	(14.5)	268	(18.5)	256	(17.6)	232	(16.0)
Bore	inch	mm	5.98	(152)	5.98	(152)	6.30	(160)	6.30	(160)	6.30	(160)
Stroke	inch	mm	6.50	(165)	6.50	(165)	6.89	(175)	6.89	(175)	6.89	(175)
Displacement	cu.in	Litres	1,460	(24.0)	1,460	(24.0)	3,436	(56.3)	3,436	(56.3)	3,436	(56.3)
Mean piston speed	in/s	m/s	325	(8.3)	390	(9.9)	276	(7.0)	344	(8.8)	413	(10.5)
Compression ratio			11.8 : 1				11.9 : 1					
Combustion air mass flow [2]	lbs/hr	kg/h	4,828	(2,190)	5,736	(2,602)	11,025	(5,001)	13,470	(6,110)	14,233	(6,456)
Packaged ventilation air flow [3]	scfm	m^3/h	21,424	(36,400)	21,424	(36,400)	42,849	(72,800)	51,089	(86,800)	55,621	(94,500)
Engine coolant capacity [4]	gal.	Litres	21	(80)	21	(80)	69	(260)	69	(260)	69	(260)
Lube oil capacity [4]	gal.	Litres	45	(170)	45	(170)	106	(400)	106	(400)	106	(400)
Lube oil consumption [5]	lbs/bhp.hr	g/kWh	0.00058	(0.35)	0.00058	(0.35)	0.00033	(0.20)	0.00033	(0.20)	0.00033	(0.20)
Energy Balance												
Generator efficiency [6]	%	%	96.6		96.6		96.8		97.1		96.9	
Electrical power [6] [7]	kWe	kW	502		502		1,007		1,204		1,308	
Jacket (HT) water heat	Btu x 1,000/hr	kW	850.2	(249)	713.6	(209)	1,724.3	(505)	2,134.0	(625)	2,045.2	(599)
Oil (HT) cooler water heat	Btu x 1,000/hr		*	*	*	*	392.7	(115)	464.4	(136)	491.7	(144)
Intercooler (LT) water heat	Btu x 1,000/hr	kW	280.0	(82)	344.9	(101)	194.6	(57)	276.6	(81)	273.2	(80)
Exhaust heat – cooled to 120 °C	Btu x 1,000/hr	kW	846.8	(248)	1,068.7	(313)	1,635.5	(479)	1,990.6	(583)	2,581.3	(756)
Engine radiation heat	Btu x 1,000/hr	kW	95.6	(28)	136.6	(40)	218.5	(64)	221.9	(65)	280.0	(82)
Generator radiation heat	Btu x 1,000/hr	kW	60.4	(18)	60.4	(18)	113.6	(33)	122.8	(36)	142.9	(42)
Fuel consumption	Btu x 1,000/hr	kW	4,083.6	(1,196)	4,319.2	(1,265)	8,252.7	(2,417)	9,976.9	(2,922)	10,973.9	(3,214)
Mechanical efficiency	%		43.5		41.1		43.0		42.4		42.0	
Electrical efficiency	%		42.0		39.7		41.7		41.2		40.7	
Thermal efficiency	%		48.4		49.2		43.1		44.1		44.6	
Total efficiency	%		90.4		89.0		84.7		85.3		85.4	
System Parameters												
Jacket (HT) water temperature max.	°F	°C	194	(90)	194	(90)	194	(90)	194	(90)	194	(90)
Jacket (HT) water flow rate min.	gpm	L/hr	198	(45)	198	(45)	242	(55)	308	(70)	352	(80)
Intercooler stages			Single				Double					
Intercooler (LT) coolant temperature max.	°F	°C	131	(55)	131	(55)	131	(55)	131	(55)	131	(55)
Intercooler (LT) coolant flow rate min.	gpm	L/hr	97/132	22/30	97/132	22/30	53/132	12/30	92/132	21/30	110/132	25/30
Exhaust manifold type			Dry				Dry					
Exhaust temperature	°F	°C	860	(460)	901	(483)	768	(409)	766	(408)	883	(473)
Exhaust mass flow wet	lbs/hr	kg/h	5,027	(2,280)	5,941	(2,695)	11,416	(5,178)	13,955	(6,330)	14,753	(6,692)
Exhaust backpressure max.	psi	mbar	0.65	(45)	0.65	(45)	0.65	(45)	0.65	(45)	0.65	(45)
Maximum pressure loss in front of air cleaner	psi	mbar	0.073	(5)	0.073	(5)	0.073	(5)	0.073	(5)	0.073	(5)
Fuel pressure range	psi	mbar	0.73 - 3.48 (50 - 240)				0.73 - 3.48 (50 - 240)					
Starter battery 2x12 V, capacity required	Ampere-hour		280				280					
Emissions												
NOx	g/bhp.hr		< 1.1		< 1		< 2		< 1.1		< 2	
CO	g/bhp.hr		< 2.2		< 2.2		< 2.2		< 2.2		< 2.2	
THC (in C1base)	g/bhp.hr		< 3.5		< 3.5		< 3.5		< 3.5		< 3.5	
NMHC (in C1 base)	g/bhp.hr		< 0.7		< 0.7		< 0.7		< 0.7		< 0.7	

1) For other MN consult Dresser-Rand
2) Engine performance data acc. to ISO 3046/1 (LHV 38,500 KJ/mn3 - 970 Btu SCF) for performance on alternate gases consult the engineering team
3) Assumes intake air flow at delta T = 5°C including combustion air
4) Not Including pipes and heat exchangers
5) Mean lube oil consumption between maintenance steps
6) At 60 Hz, U = 0.48 kV, power factor = 1
7) At 50 Hz, U = 0.4 kV, power factor = 1
8) With a tolerance of + 5 %
9) Lower emission engines are available; consult Dresser-Rand for performance data
* Heat included with the jacket water heat

- Data is for continuous rating, at sea level, and at an ambient temperature of 77°F (25°C)
- Data for special gas and dual gas operation available on request
- The values given in this data sheet are for information purposes only and not binding

Dimensions and other data

Engine Dimensions	English Units	Metric Units	SFGLD 180		SFGLD 240		SFGLD 360		SFGLD 480		SFGLD 560/ SFGM 560		HGM 240		HGM 560	
Width	in.	mm	37,205	(945)	37,205	(945)	53,858	(1,368)	53,858	(1,368)	61,024	(1,550)	80,078	(2,034)	70,354	(1,787)
Length	in.	mm	79,528	(2,020)	102,835	(2,612)	103,819	(2,637)	123,740	(3,143)	118,110	(3,000)	123,819	(3,145)	134,213	(3,409)
Height	in.	mm	57,441	(1,459)	57,441	(1,459)	68,425	(1,738)	68,425	(1,738)	86,614	(2,200)	61,063	(1,551)	85,236	(2,165)
Dry weight genset	lb	kg	5,952	(2,700)	7,716	(3,500)	9,259	(4,200)	12,015	(5,450)	12,787	(5,800)	9,259	(4,200)	16,535	(7,500)

Genset Dimensions (60 Hz)	English Units	Metric Units	SFGLD 180		SFGLD 240		SFGLD 360		SFGLD 480		SFGLD 560/ SFGM 560		HGM 240		HGM 560	
Width	in.	mm	47,244	(1,200)	50,000	(1,270)	65,512	(1,664)	65,512	(1,664)	65,709	(1,669)	80,039	(2,033)	72,756	(1,848)
Length	in.	mm	119,055	(3,024)	144,016	(3,658)	150,787	(3,830)	173,071	(4,396)	183,819	(4,669)	154,330	(3,920)	222,362	(5,648)
Height	in.	mm	72,677	(1,846)	75,354	(1,914)	83,937	(2,132)	85,984	(2,184)	85,669	(2,176)	62,323	(1,583)	91,299	(2,319)
Dry weight genset	lb	kg	8,818	(4,00)	10,891	(4,940)	15,939	(7,230)	20,338	(9,225)	22,046	(10,000)	12,500	(5,670)	25,871	(11,735)

Noise emissions* 60 Hz (1,200 rpm)

Engine Noise dB(A)	HZ (Frec. Band)	SFGLD 180			SFGLD 240			SFGLD 360			SFGLD 480			SFGLD 560		SFGM 560		HGM 240		HGM 560		
		1,200	1,500	1,800	1,200	1,500	1,800	1,200	1,500	1,800	1,200	1,500	1,800	1,200	1,500	1,500	1,800	1,500	1,800	1,200	1,500	1,800
	125	--	--	--	59	72	70	--	70	--	66	73	70	71	76	76	73	69	67	71	73	70
	250	70	73	76	73	82	86	69	81	74	70	83	84	79	92	92	87	74	77	77	83	84
	500	82	83	88	79	87	84	76	86	90	76	88	84	81	89	89	85	83	80	79	85	82
	1,000	84	87	91	85	90	89	82	88	85	81	90	88	83	89	89	87	89	88	81	88	86
	2,000	81	84	87	83	89	87	83	86	87	80	89	89	84	89	89	91	93	91	88	92	92
	4,000	76	79	83	77	86	83	79	80	82	73	82	83	79	85	85	86	90	87	83	89	88
	LpA, å dB(A)	**88**	**90**	**94**	**88**	**95**	**94**	**87**	**92**	**93**	**85**	**95**	**93**	**89**	**97**	**97**	**95**	**96**	**94**	**90**	**96**	**95**

Exhaust Noise dB(A)	HZ	SFGLD 180			SFGLD 240			SFGLD 360			SFGLD 480			SFGLD 560		SFGM 560		HGM 240		HGM 560		
	63	94	97	99	96	99	101	96	100	102	94	98	99	98	102	102	103	100	102	99	102	103
	125	106	118	128	109	121	131	109	121	131	111	124	127	109	121	121	125	121	131	109	122	125
	250	106	124	128	113	127	131	113	126	131	112	125	114	112	125	125	135	129	133	115	128	136
	500	112	113	120	115	116	123	115	119	126	119	124	130	117	122	122	127	116	122	116	122	127
	1,000	108	112	115	111	115	118	112	117	119	116	121	123	113	118	118	120	116	119	114	119	121
	2,000	109	110	112	113	114	116	113	115	116	117	119	119	113	115	115	116	115	117	114	117	117
	4,000	109	106	105	112	109	108	114	110	110	116	111	112	114	109	109	112	112	110	116	112	113
	LpA, å dB(A)	**117**	**126**	**132**	**120**	**128**	**135**	**121**	**129**	**135**	**124**	**130**	**136**	**121**	**129**	**129**	**136**	**130**	**136**	**122**	**130**	**137**

Notes: Data obtained according to ISO 9614-2 • Data obtained @ 1 m from engine according to UNE-EN ISO-11203:1996 • Maximum data standard deviations = ± 4 dB(A)

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Form 85245

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GAS ENGINES AND GENSETS

1,200/1,500/1,800 rpm

Guascor®

Gas

Speed	1,200/1,500/1,800 rpm
Generator frequency	50/60 Hz
Applicable gas types [2]	Natural gas, biogas, landfill gas, sewage gas, flare gas, other special gases
Minimum methane number [1]	75

Engine Parameters	English Units	Metric Units	SFGLD 180						SFGLD 240					
Speed	rpm		1,200		1,500		1,800		1,200		1,500		1,800	
Engine power [2]	bhp	kWb	338	(252)	422	(315)	469	(350)	449	(335)	562	(419)	607	(453)
Cylinder arrangement			In Line 6						In Line 8					
Mean effective pressure	psi	bar	203	(14.0)	203	(14.0)	188	(13.0)	203	(14.0)	203	(14.0)	183	(12.6)
Bore	inch	mm	5.98	(152)	5.98	(152)	5.98	(152)	5.98	(152)	5.98	(152)	5.98	(152)
Stroke	inch	mm	6.50	(165)	6.50	(165)	6.50	(165)	6.50	(165)	6.50	(165)	6.50	(165)
Displacement	cu.in	Litres	1,095	(18.0)	1,095	(18.0)	1,095	(18.0)	1,460	(24.0)	1,460	(24.0)	1,460	(24.0)
Mean piston speed	in/s	m/s	260	(6.6)	325	(8.3)	390	(9.9)	260	(6.6)	325	(8.3)	390	(9.9)
Compression ratio			11.6:1						11.6:1					
Combustion air mass flow [2]	lbs/hr	kg/h	2,813	(1,276)	3,486	(1,581)	3,869	(1,755)	3,497	(1,586)	4,581	(2,078)	4,581	(2,078)
Packaged ventilation air flow [3]	scfm	m^3/h	10,383	(17,640)	12,978	(22,050)	14,420	(24,500)	13,802	(23,450)	17,263	(29,330)	18,664	(31,710)
Engine coolant capacity [4]	gal.	Litres	13	(50)	13	(50)	13	(50)	16	(60)	16	(60)	16	(60)
Lube oil capacity [4]	gal.	Litres	19	(70)	19	(70)	19	(70)	25	(95)	25	(95)	25	(95)
Lube oil consumption [5]	lbs/bhp.hr	g/kWh	0.00058	(0.35)	0.00058	(0.35)	0.00058	(0.35)	0.00058	(0.35)	0.00058	(0.35)	0.00058	(0.35)
Energy Balance														
Generator efficiency [6]	%	%	96.1		96.4		96.1		96.2		96.6		96.2	
Electrical power [6] [7]	kWe	kW	242		304		336		322		405		436	
Jacket (HT) water heat	Btu x 1,000/hr	kW	495.1	(145)	652.2	(191)	689.7	(202)	764.8	(224)	904.8	(265)	1,089.2	(319)
Oil (HT) cooler water heat	Btu x 1,000/hr		116.1	(34)	116.1	(34)	126.3	(37)	140.0	(41)	157.1	(46)	181.0	(53)
Intercooler (LT) water heat	Btu x 1,000/hr	kW	129.7	(38)	136.6	(40)	215.1	(63)	153.6	(45)	204.9	(60)	235.6	(69)
Exhaust heat – cooled to 120 °C	Btu x 1,000/hr	kW	331.2	(97)	450.7	(132)	566.8	(166)	495.1	(145)	604.4	(177)	710.2	(208)
Engine radiation heat	Btu x 1,000/hr	kW	37.6	(11)	54.6	(16)	54.6	(16)	51.2	(15)	71.7	(21)	71.7	(21)
Generator radiation heat	Btu x 1,000/hr	kW	33.6	(10)	38.7	(11)	46.6	(14)	43.5	(13)	48.6	(14)	58.8	(17)
Fuel consumption	Btu x 1,000/hr	kW	2,106.7	(617)	2,656.4	(778)	3,035.4	(889)	2,919.3	(855)	3,595.4	(1,053)	4,059.7	(1,189)
Mechanical efficiency	%		40.8		40.5		39.4		39.2		39.8		38.1	
Electrical efficiency	%		39.2		39.0		37.8		37.7		38.4		36.7	
Thermal efficiency	%		45.4		46.7		48.5		48.4		47.7		50.1	
Total efficiency	%		84.6		85.7		86.3		86.1		86.1		86.8	
System Parameters														
Jacket (HT) water temperature max.	°F	°C	194	(90)	194	(90)	194	(90)	194	(90)	194	(90)	194	(90)
Jacket (HT) water flow rate min.	gpm	L/hr	88	(20)	110	(25)	132	(30)	110	(25)	132	(30)	176	(40)
Intercooler stages			Single						Single					
Intercooler (LT) coolant temperature max.	°F	°C	131	(55)	131	(55)	131	(55)	131	(55)	131	(55)	131	(55)
Intercooler (LT) coolant flow rate min.	gpm	L/hr	66/132	15/30	66/132	15/30	88/132	20/30	66/132	15/30	88/132	20/30	110/132	25/30
Exhaust manifold type			Wet						Wet					
Exhaust temperature	°F	°C	662	(350)	702	(372)	761	(405)	743	(395)	709	(376)	788	(420)
Exhaust mass flow wet	lbs/hr	kg/h	2,912	(1,321)	3,611	(1,638)	4,012	(1,820)	3,635	(1,649)	4,751	(2,155)	4,775	(2,166)
Exhaust back-pressure max.	psi	mbar	0.65	(45)	0.65	(45)	0.65	(45)	0.65	(45)	0.65	(45)	0.65	(45)
Maximum pressure loss in front of air cleaner	psi	mbar	0.073	(5)	0.073	(5)	0.073	(5)	0.073	(5)	0.073	(5)	0.073	(5)
Fuel pressure range	psi	mbar	0.73 - 3.48 (50 - 240)						0.73 - 3.48 (50 - 240)					
Starter battery 2x12 V, capacity required	Ampere-hour		280						280					
Emissions														
NOx	g/bhp.hr		< 2		< 1.1		< 2		< 2		< 1.1		< 2	
CO	g/bhp.hr		< 1.8		< 1.8		< 1.8		< 1.8		< 1.8		< 1.8	
THC (in C1base)	g/bhp.hr		< 3.5		< 3.5		< 3.5		< 3.5		< 3.5		< 3.5	
NMHC (in C1 base)	g/bhp.hr		< 0.7		< 0.7		< 0.7		< 0.7		< 0.7		< 0.7	

1) For other MN consult Dresser-Rand
2) Engine performance data acc. to ISO 3046/1 (LHV 38,500 KJ/mn3 - 970 Btu SCF) for performance on alternate gases consult the engineering team
3) Assumes intake air flow at delta T = 5°C including combustion air
4) Not Including pipes and heat exchangers
5) Mean lube oil consumption between maintenance steps
6) At 60 Hz, U = 0.48 kV, power factor = 1
7) At 50 Hz, U = 0.4 kV, power factor = 1
8) With a tolerance of + 5 %
9) Lower emission engines are available; consult Dresser-Rand for performance data
* Heat included with the jacket water heat

- Data is for continuous rating, at sea level, and at an ambient temperature of 77°F (25°C)
- Data for special gas and dual gas operation available on request
- The values given in this data sheet are for information purposes only and not binding

Gas

Speed	1,200/1,500/1,800 rpm
Generator frequency	50/60 Hz
Applicable gas types [2]	Natural gas, biogas, landfill gas, sewage gas, flare gas, other special gases
Minimum methane number [1]	75

Engine Parameters	English Units	Metric Units	SFGLD 360						SFGLD 480					
Speed	rpm		1,200		1,500		1,800		1,200		1,500		1,800	
Engine power [2]	bhp	kWb	675	(503)	845	(630)	939	(700)	898	(670)	1,124	(838)	1,215	(906)
Cylinder arrangement			V12						V16					
Mean effective pressure	psi	bar	203	(14.0)	203	(14.0)	188	(13.0)	203	(14.0)	203	(14.0)	183	(12.6)
Bore	inch	mm	5.98	(152)	5.98	(152)	5.98	(152)	5.98	(152)	5.98	(152)	5.98	(152)
Stroke	inch	mm	6.50	(165)	6.50	(165)	6.50	(165)	6.50	(165)	6.50	(165)	6.50	(165)
Displacement	cu.in	Litres	2,191	(35.9)	2,191	(35.9)	2,191	(35.9)	2,921	(47.9)	2,921	(47.9)	2,921	(47.9)
Mean piston speed	in/s	m/s	260	(6.6)	325	(8.3)	390	(9.9)	260	(6.6)	325	(8.3)	390	(9.9)
Compression ratio			11.6:1						11.6:1					
Combustion air mass flow [2]	lbs/hr	kg/h	5,340	(2,422)	7,035	(3,191)	7,670	(3,479)	7,260	(3,293)	9,178	(4,163)	9,515	(4,316)
Packaged ventilation air flow [3]	scfm	m^3/h	20,724	(35,210)	25,956	(44,100)	28,840	(49,000)	27,604	(46,900)	34,526	(58,660)	37,328	(63,420)
Engine coolant capacity [4]	gal.	Litres	48	(180)	48	(180)	48	(180)	53	(200)	53	(200)	53	(200)
Lube oil capacity [4]	gal.	Litres	40	(150)	40	(150)	40	(150)	52	(195)	52	(195)	52	(195)
Lube oil consumption [5]	lbs/bhp.hr	g/kWh	0.00058	(0.35)	0.00058	(0.35)	0.00058	(0.35)	0.00058	(0.35)	0.00058	(0.35)	0.00058	(0.35)
Energy Balance														
Generator efficiency [6]	%	%	96.7		96.7		96.6		96.8		97		96.5	
Electrical power [6] [7]	kWe	kW	486		609		676		649		813		874	
Jacket (HT) water heat	Btu x 1,000/hr	kW	1,256.5	(368)	1,533.1	(449)	1,683.3	(493)	1,772.1	(519)	2,062.3	(604)	2,455.0	(719)
Oil (HT) cooler water heat	Btu x 1,000/hr		221.9	(65)	239.0	(70)	269.7	(79)	259.5	(76)	300.5	(88)	303.9	(89)
Intercooler (LT) water heat	Btu x 1,000/hr	kW	88.8	(26)	99.0	(29)	129.7	(38)	112.7	(33)	160.5	(47)	167.3	(49)
Exhaust heat – cooled to 120 °C	Btu x 1,000/hr	kW	641.9	(188)	901.4	(264)	1,109.7	(325)	1,017.5	(298)	1,215.5	(356)	1,570.6	(460)
Engine radiation heat	Btu x 1,000/hr	kW	58.0	(17)	92.2	(27)	99.0	(29)	68.3	(20)	112.7	(33)	99.0	(29)
Generator radiation heat	Btu x 1,000/hr	kW	56.7	(17)	71.0	(21)	81.3	(24)	73.2	(21)	85.8	(25)	108.3	(32)
Fuel consumption	Btu x 1,000/hr	kW	4,244.1	(1,243)	5,360.6	(1,570)	6,057.2	(1,774)	5,872.8	(1,720)	7,160.0	(2,097)	8,153.6	(2,388)
Mechanical efficiency	%		40.5		40.1		39.5		39.0		40.0		37.9	
Electrical efficiency	%		39.1		38.8		38.1		37.7		38.8		36.6	
Thermal efficiency	%		46.8		47.3		48.3		49.4		48.0		51.4	
Total efficiency	%		86.0		86.1		86.4		87.1		86.8		88.0	
System Parameters														
Jacket (HT) water temperature max.	°F	°C	194	(90)	194	(90)	194	(90)	194	(90)	194	(90)	194	(90)
Jacket (HT) water flow rate min.	gpm	L/hr	176	(40)	220	(50)	264	(60)	220	(50)	264	(60)	352	(80)
Intercooler stages			Double						Double					
Intercooler (LT) coolant temperature max.	°F	°C	131	(55)	131	(55)	131	(55)	131	(55)	131	(55)	131	(55)
Intercooler (LT) coolant flow rate min.	gpm	L/hr	66/132	15/30	101/132	23/30	110/132	25/30	79/132	18/30	101/132	23/30	110/132	25/30
Exhaust manifold type			Wet						Wet					
Exhaust temperature	°F	°C	667	(353)	698	(370)	756	(402)	739	(393)	712	(378)	824	(440)
Exhaust mass flow wet	lbs/hr	kg/h	5,542	(2,514)	7,291	(3,307)	7,956	(3,609)	7,538	(3,419)	9,517	(4,317)	9,899	(4,490)
Exhaust backpressure max.	psi	mbar	0.65	(45)	0.65	(45)	0.65	(45)	0.65	(45)	0.65	(45)	0.65	(45)
Maximum pressure loss in front of air cleaner	psi	mbar	0.073	(5)	0.073	(5)	0.073	(5)	0.073	(5)	0.073	(5)	0.073	(5)
Fuel pressure range	psi	mbar	0.73 - 3.48 (50 - 240)						0.73 - 3.48 (50 - 240)					
Starter battery 2x12 V, capacity required	Ampere-hour		280						280					
Emissions														
NOx	g/bhp.hr		< 2		< 1.1		< 2		< 2		< 1.1		< 2	
CO	g/bhp.hr		< 1.8		< 1.8		< 1.8		< 1.8		< 1.8		< 1.8	
THC (in C1base)	g/bhp.hr		< 3.5		< 3.5		< 3.5		< 3.5		< 3.5		< 3.5	
NMHC (in C1 base)	g/bhp.hr		< 0.7		< 0.7		< 0.7		< 0.7		< 0.7		< 0.7	

1) For other MN consult Dresser-Rand
2) Engine performance data acc. to ISO 3046/1 (LHV 38,500 KJ/mn3 - 970 Btu SCF) for performance on alternate gases consult the engineering team
3) Assumes intake air flow at delta T = 5°C including combustion air
4) Not Including pipes and heat exchangers
5) Mean lube oil consumption between maintenance steps
6) At 60 Hz, U = 0.48 kV, power factor = 1
7) At 50 Hz, U = 0.4 kV, power factor = 1
8) With a tolerance of + 5 %
9) Lower emission engines are available; consult Dresser-Rand for performance data
* Heat included with the jacket water heat

- Data is for continuous rating, at sea level, and at an ambient temperature of 77°F (25°C)
- Data for special gas and dual gas operation available on request
- The values given in this data sheet are for information purposes only and not binding

Gas

Speed	1,200/1,500/1,800 rpm
Generator frequency	50/60 Hz
Applicable gas types [2]	Natural gas, biogas, landfill gas, sewage gas, flare gas, other special gases
Minimum methane number [1]	75

Engine Parameters	English Units	Metric Units	SFGLD560				SFGM 560			
Speed	rpm		1,200		1,500		1,500		1,800	
Engine power [2]	bhp	kWb	1,057	(788)	1,321	(985)	1,415	(1,055)	1,475	(1,100)
Cylinder arrangement			V16				V16			
Mean effective pressure	psi	bar	203	(14.0)	203	(14.0)	217	(15.0)	189	(13.0)
Bore	inch	mm	6.30	(160)	6.30	(160)	6.30	(160)	6.30	(160)
Stroke	inch	mm	6.89	(175)	6.89	(175)	6.89	(175)	6.89	(175)
Displacement	cu.in	Litres	3,436	(56.3)	3,436	(56.3)	3,436	(56.3)	3,436	(56.3)
Mean piston speed	in/s	m/s	276	(7.0)	344	(8.8)	344	(8.8)	413	(10.5)
Compression ratio			11.6 : 1				12.3 : 1		12.3 : 1	
Combustion air mass flow [2]	lbs/hr	kg/h	8,274	(3,753)	10,816	(4,906)	10,986	(4,983)	11,021	(4,999)
Packaged ventilation air flow [3]	scfm	m^3/h	32,466	(55,160)	40,582	(68,950)	43,467	(73,850)	45,321	(77,000)
Engine coolant capacity [4]	gal.	Litres	53	(200)	53	(200)	53	(200)	53	(200)
Lube oil capacity [4]	gal.	Litres	61	(232)	61	(232)	61	(232)	61	(232)
Lube oil consumption [5]	lbs/bhp.hr	g/kWh	0.00033	(0.20)	0.00033	(0.20)	0.00033	(0.20)	0.00033	(0.20)
Energy Balance										
Generator efficiency [6]	%	%	96.7		97.2		97.2		96.8	
Electrical power [6] [7]	kWe	kW	762		957		1025		1065	
Jacket (HT) water heat	Btu x 1,000/hr	kW	1,946.2	(570)	2,420.8	(709)	1,789.2	(524)	2,014.5	(590)
Oil (HT) cooler water heat	Btu x 1,000/hr		293.6	(86)	341.4	(100)	392.7	(115)	341.4	(100)
Intercooler (LT) water heat	Btu x 1,000/hr	kW	133.2	(39)	170.7	(50)	218.5	(64)	239.0	(70)
Exhaust heat – cooled to 120 °C	Btu x 1,000/hr	kW	1,038.0	(304)	1,444.3	(423)	2,123.8	(622)	2,338.9	(685)
Engine radiation heat	Btu x 1,000/hr	kW	109.3	(32)	119.5	(35)	170.7	(50)	184.4	(54)
Generator radiation heat	Btu x 1,000/hr	kW	88.8	(26)	94.2	(28)	100.9	(30)	120.2	(35)
Fuel consumption	Btu x 1,000/hr	kW	6,613.7	(1,937)	8,385.8	(2,456)	8,833.1	(2,587)	9,413.6	(2,757)
Mechanical efficiency	%		40.7		40.1		40.8		39.9	
Electrical efficiency	%		39.3		39.0		39.6		38.6	
Thermal efficiency	%		47.1		48.1		46.8		48.8	
Total efficiency	%		86.5		87.1		86.4		87.4	
System Parameters										
Jacket (HT) water temperature max.	°F	°C	194	(90)	194	(90)	194	(90)	194	(90)
Jacket (HT) water flow rate min.	gpm	L/hr	264	(60)	308	(70)	308	(70)	330	(75)
Intercooler stages			Double				Double			
Intercooler (LT) coolant temperature max.	°F	°C	131	(55)	131	(55)	131	(55)	131	(55)
Intercooler (LT) coolant flow rate min.	gpm	L/hr	75/132	17/30	110/132	25/30	110/132	25/30	110/132	25/30
Exhaust manifold type			Dry				Dry			
Exhaust temperature	°F	°C	687	(364)	716	(380)	925	(496)	990	(532)
Exhaust mass flow wet	lbs/hr	kg/h	8,587	(3,895)	11,213	(5,086)	11,404	(5,173)	11,466	(5,201)
Exhaust backpressure max.	psi	mbar	0.65	(45)	0.65	(45)	0.65	(45)	0.65	(45)
Maximum pressure loss in front of air cleaner	psi	mbar	0.073	(5)	0.073	(5)	0.073	(5)	0.073	(5)
Fuel pressure range	psi	mbar	0.73 - 3.48 (50 - 240)				0.73 - 3.48 (50 - 240)			
Starter battery 2x12 V, capacity required	Ampere-hour		280				280			
Emissions										
NOx	g/bhp.hr		< 2		< 1.1		< 1.1		< 2	
CO	g/bhp.hr		< 1.8		< 1.8		< 2.2		< 2.2	
THC (in C1base)	g/bhp.hr		< 3.5		< 3.5		< 3.5		< 3.5	
NMHC (in C1 base)	g/bhp.hr		< 0.7		< 0.7		< 0.7		< 0.7	

1) For other MN consult Dresser-Rand
2) Engine performance data acc. to ISO 3046/1 (LHV 38,500 KJ/mn3 - 970 Btu SCF) for performance on alternate gases consult the engineering team
3) Assumes intake air flow at delta T = 5°C including combustion air
4) Not Including pipes and heat exchangers
5) Mean lube oil consumption between maintenance steps
6) At 60 Hz, U = 0.48 kV, power factor = 1
7) At 50 Hz, U = 0.4 kV, power factor = 1
8) With a tolerance of + 5 %
9) Lower emission engines are available; consult Dresser-Rand for performance data
* Heat included with the jacket water heat

- Data is for continuous rating, at sea level, and at an ambient temperature of 77°F (25°C)
- Data for special gas and dual gas operation available on request
- The values given in this data sheet are for information purposes only and not binding

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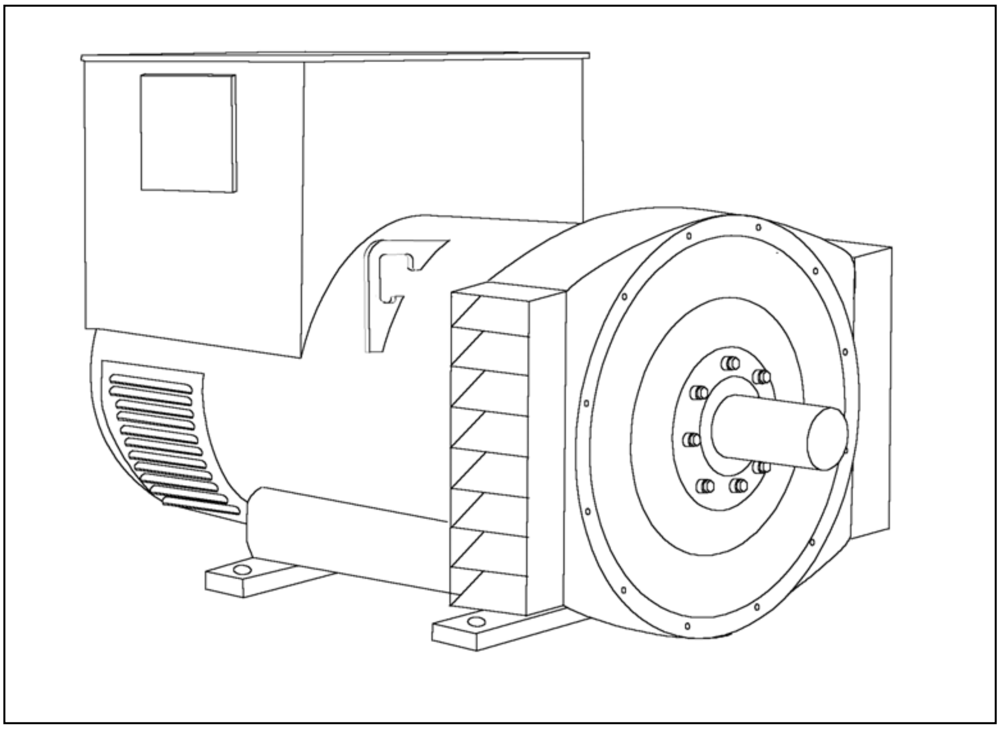
HCM534E - Technical Data Sheet



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SPECIFICATIONS & OPTIONS

STANDARDS

Marine generators may be certified to Lloyds, DnV, Bureau Veritas, ABS, Germanischer-Lloyd or RINA.
Other standards and certifications can be considered on request.

VOLTAGE REGULATORS

MX341 AVR - STANDARD

This sophisticated Automatic Voltage Regulator (AVR) is incorporated into the Stamford Permanent Magnet Generator (PMG) control system, and is standard on marine generators of this type.
The PMG provides power via the AVR to the main exciter, giving a source of constant excitation power independent of generator output. The main exciter output is then fed to the main rotor, through a full wave bridge, protected by a surge suppressor. The AVR has in-built protection against sustained over-excitation, caused by internal or external faults. This de-excites the machine after a minimum of 5 seconds.
An engine relief load acceptance feature can enable full load to be applied to the generator in a single step.
If three-phase sensing is required with the PMG system the MX321 AVR must be used.
We recommend three-phase sensing for applications with greatly unbalanced or highly non-linear loads.

MX321 AVR

The most sophisticated of all our AVRs combines all the features of the MX341 with, additionally, three-phase rms sensing, for improved regulation and performance.
Over voltage protection is built-in and short circuit current level adjustments is an optional facility.

WINDINGS & ELECTRICAL PERFORMANCE

All generator stators are wound to 2/3 pitch. This eliminates triplen (3rd, 9th, 15th …) harmonics on the voltage waveform and is found to be the optimum design for trouble-free supply of non-linear loads. The 2/3 pitch design avoids excessive neutral currents sometimes seen with higher winding pitches, when in parallel with the mains. A fully connected damper winding reduces oscillations during paralleling. This winding, with the 2/3 pitch and carefully selected pole and tooth designs, ensures very low waveform distortion.

TERMINALS & TERMINAL BOX

Standard generators are 3-phase reconnectable with 12 ends brought out to the terminals, which are mounted on a cover at the non-drive end of the generator. A sheet steel terminal box contains the AVR and provides ample space for the customers' wiring and gland arrangements. It has removable panels for easy access.

SHAFT & KEYS

All generator rotors are dynamically balanced to better than BS6861:Part 1 Grade 2.5 for minimum vibration in operation. Two bearing generators are balanced with a half key.

INSULATION/IMPREGNATION

The insulation system is class 'H'.
All wound components are impregnated with materials and processes designed specifically to provide the high build required for static windings and the high mechanical strength required for rotating components.

QUALITY ASSURANCE

Generators are manufactured using production procedures having a quality assurance level to BS EN ISO 9001.

The stated voltage regulation may not be maintained in the presence of certain radio transmitted signals. Any change in performance will fall within the limits of Criteria 'B' of EN 61000-6-2:2001. At no time will the steady-state voltage regulation exceed 2%.

NB Continuous development of our products entitles us to change specification details without notice, therefore they must not be regarded as binding.

Front cover drawing typical of product range.

HCM534E

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WINDING 311

CONTROL SYSTEM	SEPARATELY EXCITED BY P.M.G.		
A.V.R.	MX321	MX341	
VOLTAGE REGULATION	± 0.5 %	± 1.0 %	With 4% ENGINE GOVERNING
SUSTAINED SHORT CIRCUIT	REFER TO SHORT CIRCUIT DECREMENT CURVES (page 7)		

INSULATION SYSTEM	CLASS H
PROTECTION	IP23
RATED POWER FACTOR	0.8
STATOR WINDING	DOUBLE LAYER LAP
WINDING PITCH	TWO THIRDS
WINDING LEADS	12
STATOR WDG. RESISTANCE	0.0043 Ohms PER PHASE AT 22°C SERIES STAR CONNECTED
ROTOR WDG. RESISTANCE	1.96 Ohms at 22°C
EXCITER STATOR RESISTANCE	17 Ohms at 22°C
EXCITER ROTOR RESISTANCE	0.092 Ohms PER PHASE AT 22°C
R.F.I. SUPPRESSION	BS EN 61000-6-2 & BS EN 61000-6-4,VDE 0875G, VDE 0875N. refer to factory for others
WAVEFORM DISTORTION	NO LOAD < 1.5% NON-DISTORTING BALANCED LINEAR LOAD < 5.0%
MAXIMUM OVERSPEED	2250 Rev/Min
BEARING DRIVE END	BALL. 6220 (ISO)
BEARING NON-DRIVE END	BALL. 6314 (ISO)

	1 BEARING	2 BEARING
WEIGHT COMP. GENERATOR	1543 kg	1535 kg
WEIGHT WOUND STATOR	722 kg	722 kg
WEIGHT WOUND ROTOR	617 kg	588 kg
WR² INERTIA	8.9828 kgm^2	8.7049 kgm^2
SHIPPING WEIGHTS in a crate	1635 kg	1625 kg
PACKING CRATE SIZE	166 x 87 x 124(cm)	166 x 87 x 124(cm)

	50 Hz				60 Hz			
TELEPHONE INTERFERENCE	THF<2%				TIF<50			
COOLING AIR	1.035 m³/sec 2202 cfm				1.312 m³/sec 2780 cfm			
VOLTAGE SERIES STAR	380/220	400/231	415/240	440/254	416/240	440/254	460/266	480/277
VOLTAGE PARALLEL STAR	190/110	200/115	208/120	220/127	208/120	220/127	230/133	240/138
VOLTAGE SERIES DELTA	220/110	230/115	240/120	254/127	240/120	254/127	266/133	277/138
kVA BASE RATING FOR REACTANCE VALUES	530	530	530	530	606	625	638	650
Xd DIR. AXIS SYNCHRONOUS	2.77	2.50	2.32	2.07	3.14	2.89	2.71	2.53
X'd DIR. AXIS TRANSIENT	0.15	0.13	0.12	0.11	0.15	0.14	0.13	0.12
X''d DIR. AXIS SUBTRANSIENT	0.11	0.10	0.09	0.08	0.11	0.10	0.10	0.09
Xq QUAD. AXIS REACTANCE	2.16	1.95	1.81	1.61	2.51	2.31	2.16	2.02
X''q QUAD. AXIS SUBTRANSIENT	0.23	0.21	0.19	0.18	0.30	0.28	0.26	0.24
X_L LEAKAGE REACTANCE	0.05	0.04	0.04	0.04	0.05	0.05	0.04	0.04
X_2 NEGATIVE SEQUENCE	0.16	0.14	0.13	0.11	0.20	0.19	0.17	0.16
X_0 ZERO SEQUENCE	0.07	0.07	0.06	0.05	0.09	0.08	0.08	0.07

REACTANCES ARE SATURATED — VALUES ARE PER UNIT AT RATING AND VOLTAGE INDICATED

T'd TRANSIENT TIME CONST.	0.08s
T''d SUB-TRANSTIME CONST.	0.012s
T'do O.C. FIELD TIME CONST.	2.5s
Ta ARMATURE TIME CONST.	0.019s
SHORT CIRCUIT RATIO	1/Xd

50 Hz

HCM534E

Winding 311

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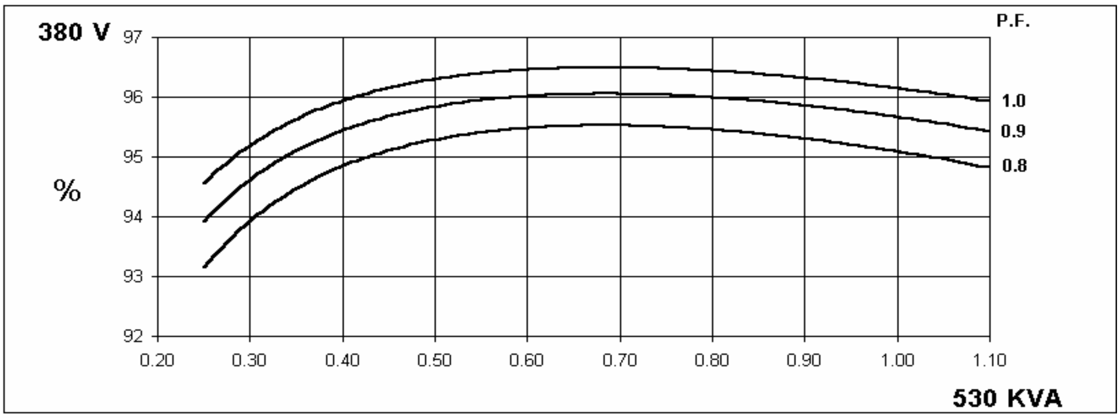
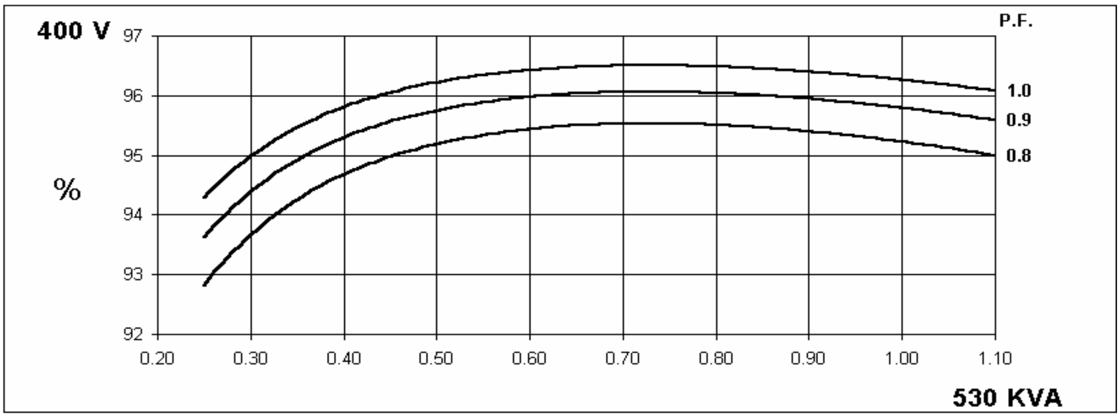
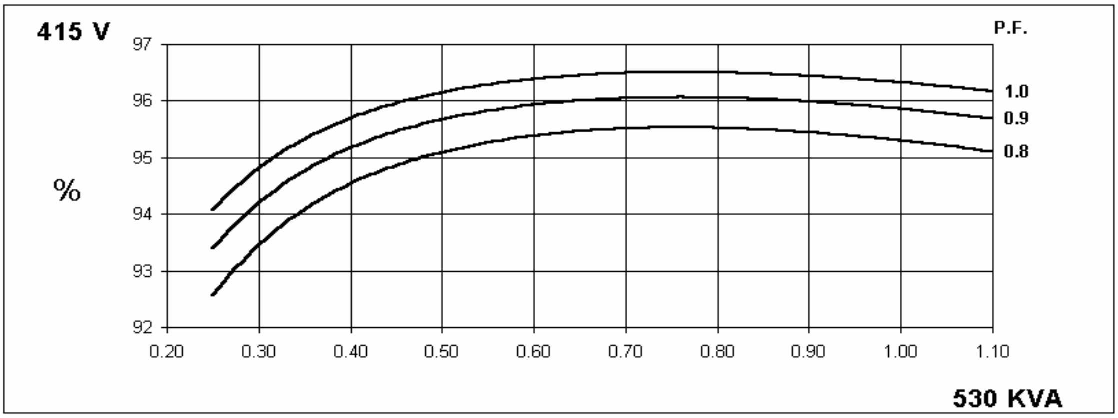
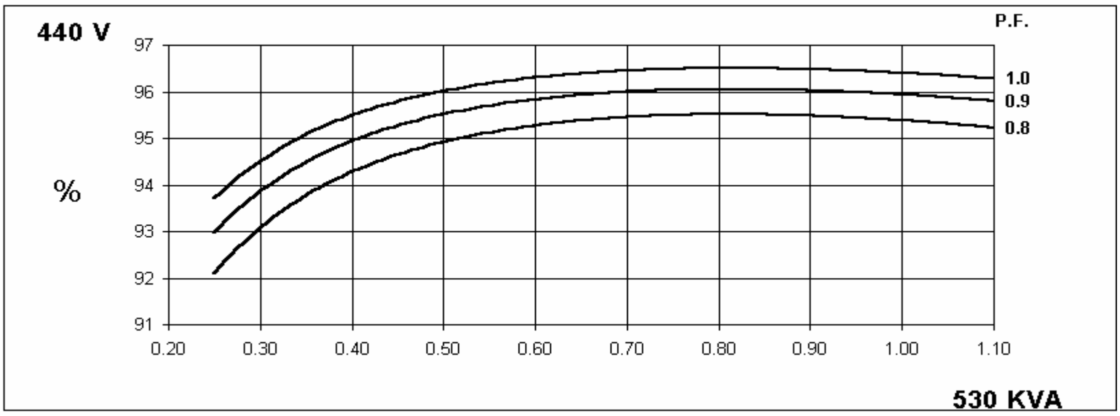
THREE PHASE EFFICIENCY CURVES









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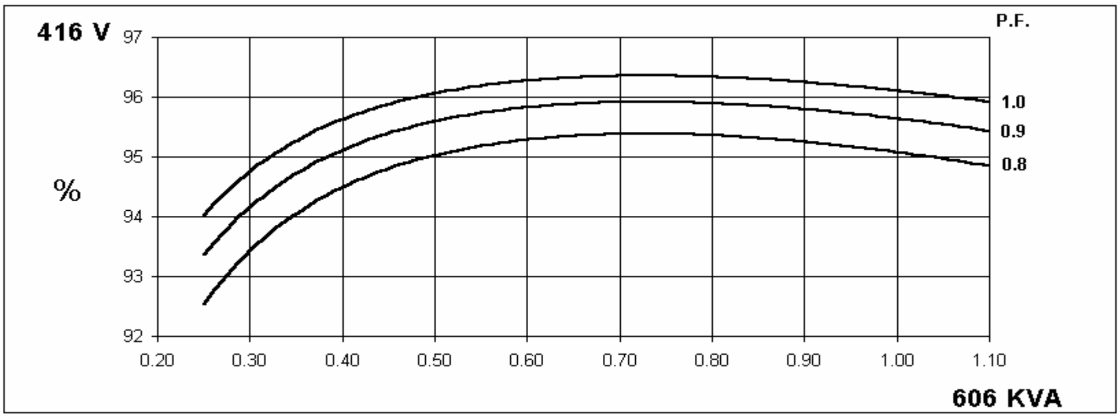
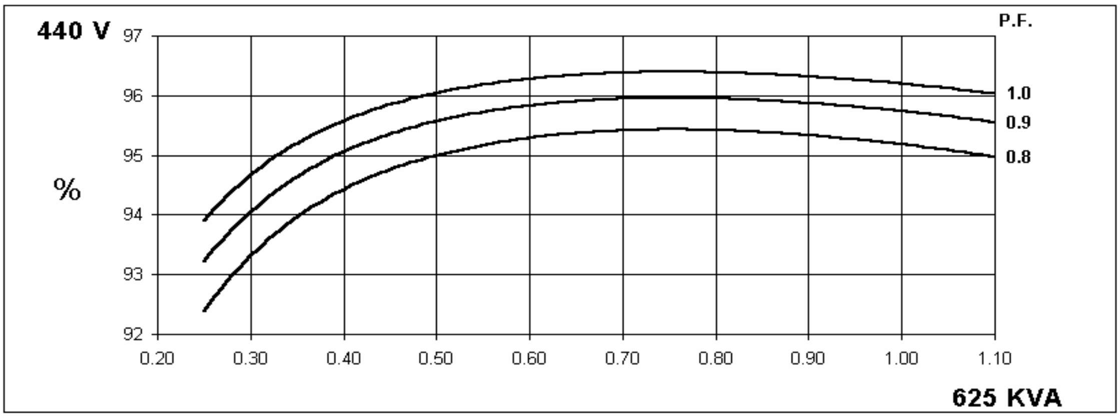
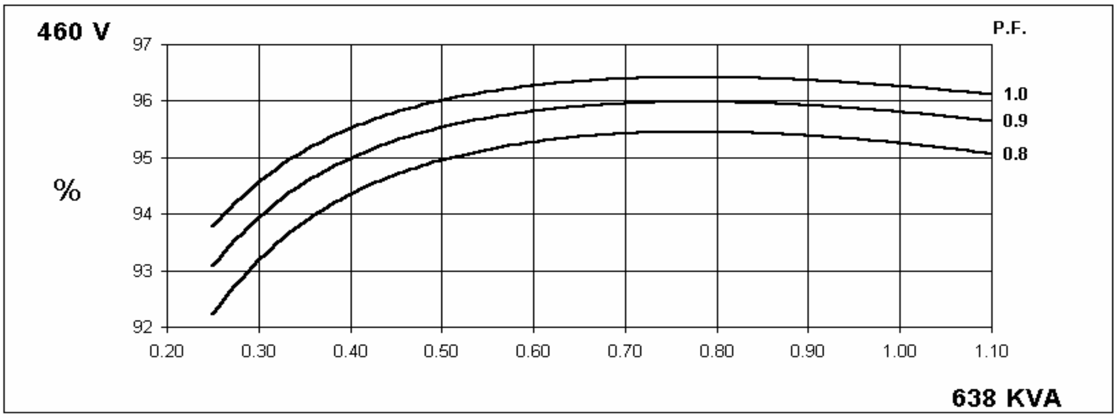
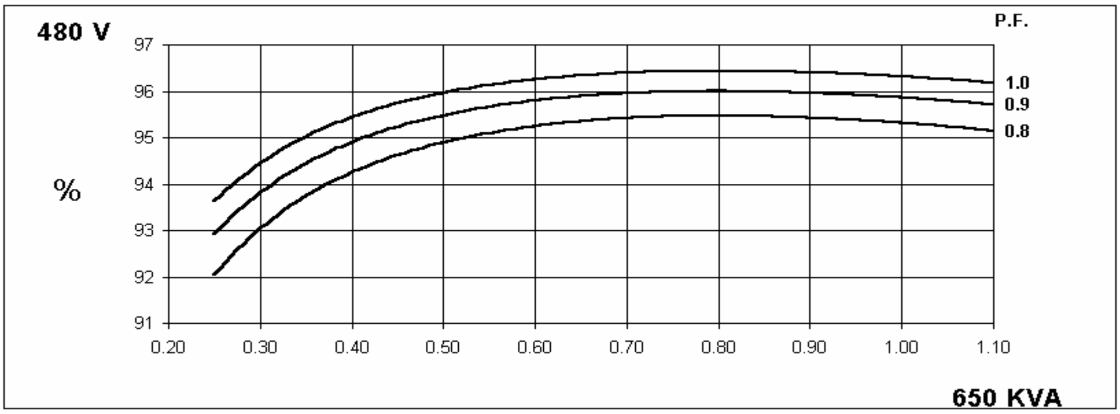
Winding 311

THREE PHASE EFFICIENCY CURVES









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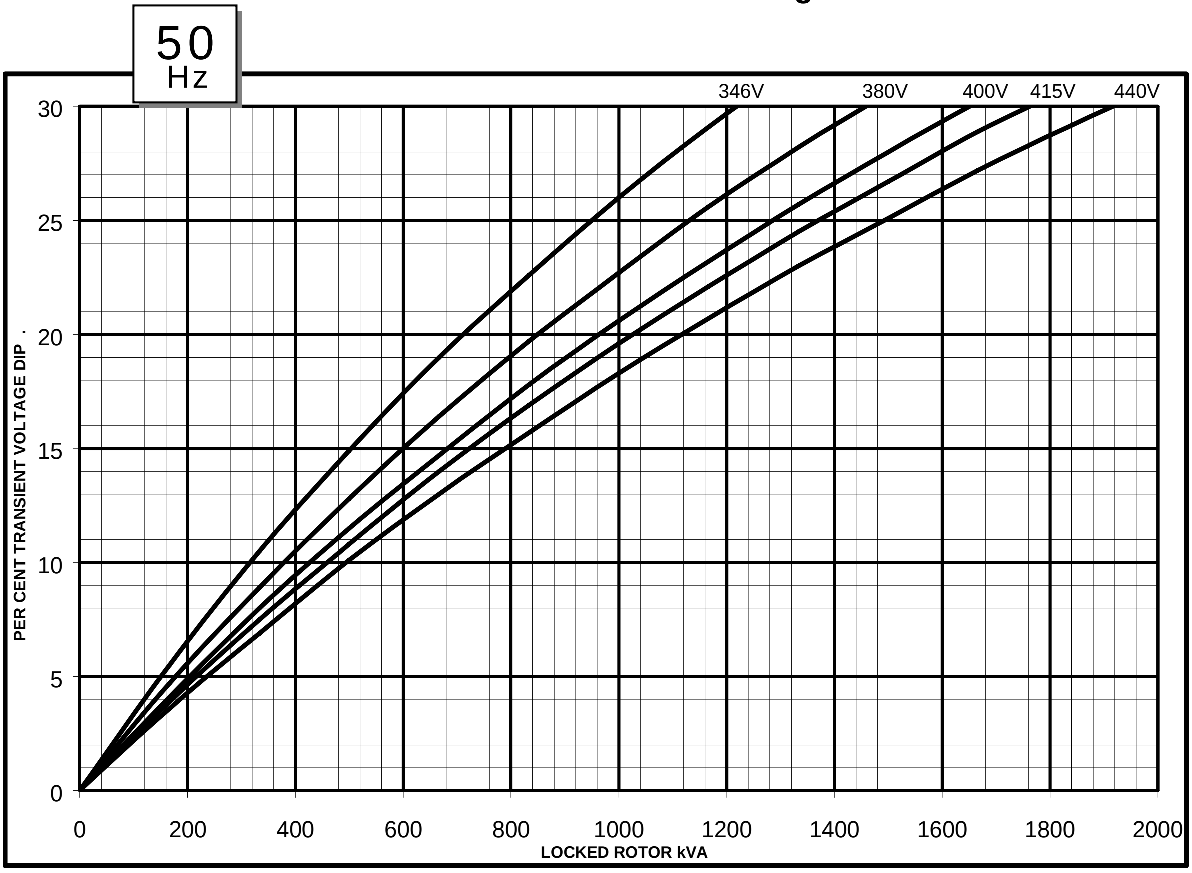
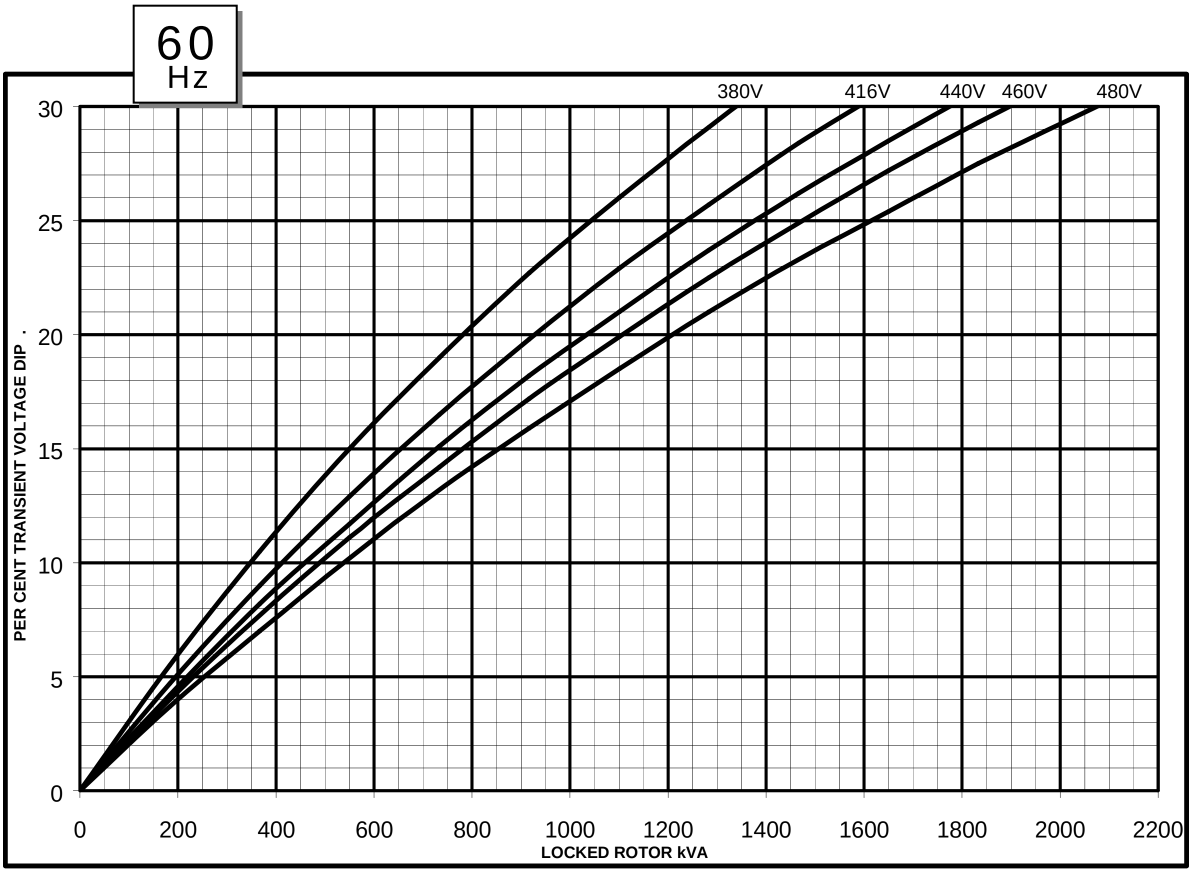
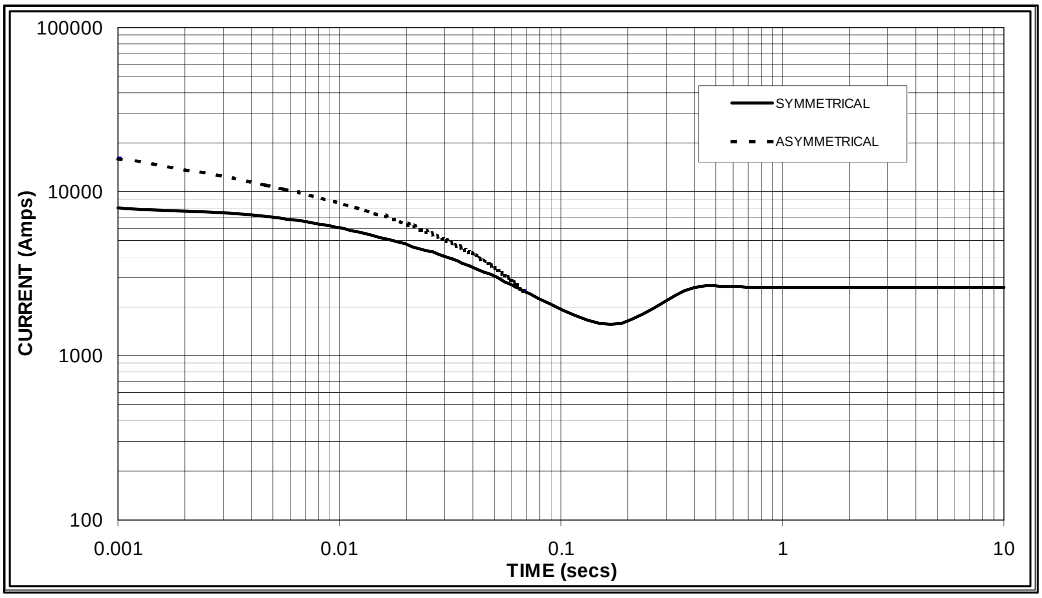
Locked Rotor Motor Starting Curve





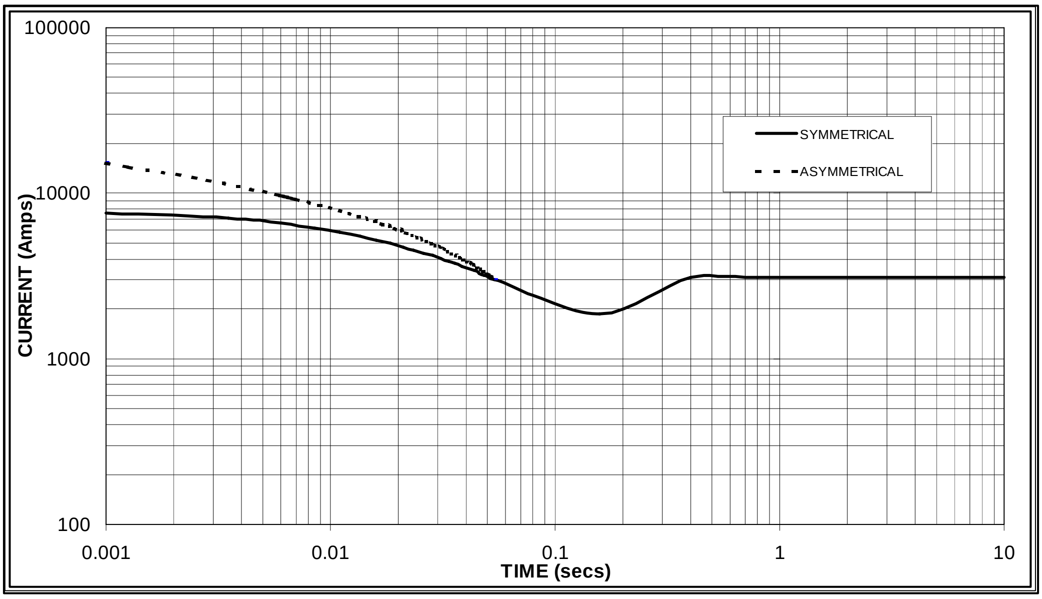
Three-phase Short Circuit Decrement Curve. No-load Excitation at Rated Speed Based on star (wye) connection.

50 Hz



Sustained Short Circuit = 2,600 Amps

60 Hz



Sustained Short Circuit = 3,100 Amps

Note 1

The following multiplication factors should be used to adjust the values from curve between time 0.001 seconds and the minimum current point in respect of nominal operating voltage :

50Hz		60Hz	
Voltage	Factor	Voltage	Factor
380v	X 1.00	416v	X 1.00
400v	X 1.06	440v	X 1.06
415v	X 1.09	460v	X 1.12
440v	X 1.12	480v	X 1.20

The sustained current value is constant irrespective of voltage level

Note 2

The following multiplication factor should be used to convert the values calculated in accordance with NOTE 1 to those applicable to the various types of short circuit :

	3-phase	2-phase L-L	1-phase L-N
Instantaneous	x 1.00	x 0.87	x 1.30
Minimum	x 1.00	x 1.80	x 3.20
Sustained	x 1.00	x 1.50	x 2.50
Max. sustained duration	10 sec.	5 sec.	2 sec.

All other times are unchanged

Note 3

Curves are drawn for Star (Wye) connected machines. For other connection the following multipliers should be applied to current values as shown :

Parallel Star = Curve current value X 2

Series Delta = Curve current value X 1.732 Note 3

HCM534E

STAMFORD

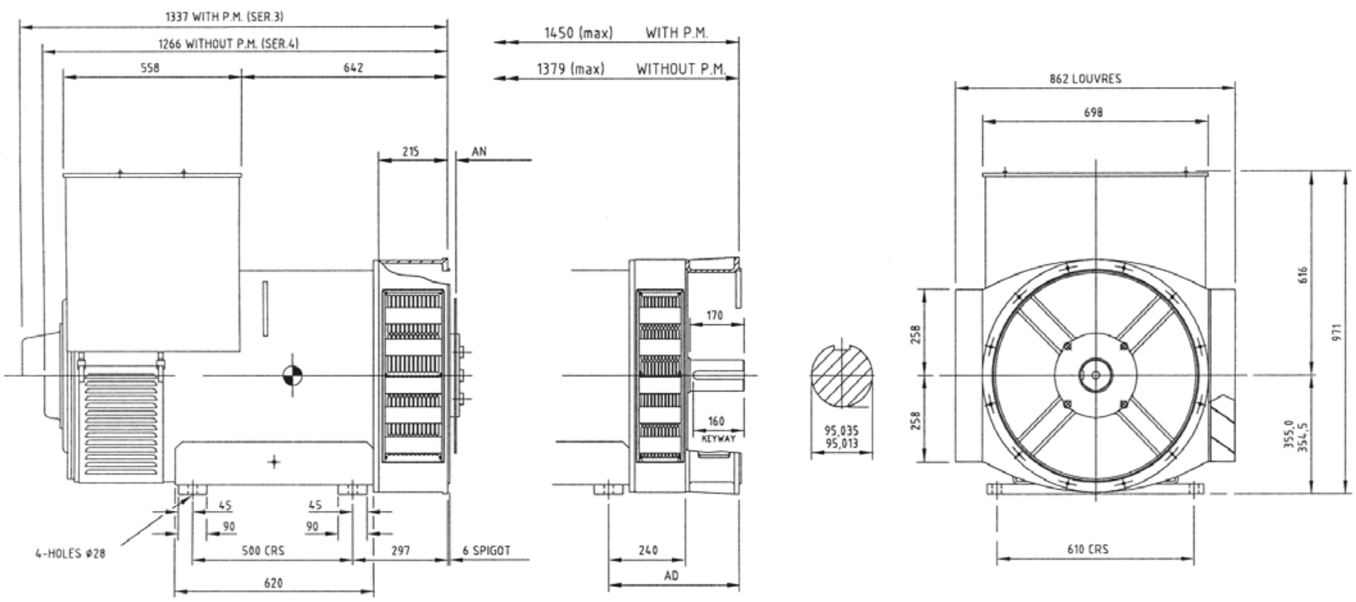
Winding 311 / 0.8 Power Factor

RATINGS

Class - Temp Rise	Cont. E - 65/50°C				Cont. B - 70/50°C				Cont. F - 90/50°C				Cont. H - 110/50°C			
50 Hz Series Star (V)	380	400	415	440	380	400	415	440	380	400	415	440	380	400	415	440
Parallel Star (V)	190	200	208	220	190	200	208	220	190	200	208	220	190	200	208	220
Series Delta (V)	220	230	240	254	220	230	240	254	220	230	240	254	220	230	240	254
kVA	395	410	420	420	415	430	440	440	475	490	505	505	530	530	530	530
kW	316	328	336	336	332	344	352	352	380	392	404	404	424	424	424	424
Efficiency (%)	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.3	95.4	95.4	95.4	95.1	95.2	95.3	95.4
kW Input	331	343	352	352	348	360	369	369	399	411	423	423	446	445	445	444

60 Hz Series Star (V)	416	440	460	480	416	440	460	480	416	440	460	480	416	440	460	480
Parallel Star (V)	208	220	230	240	208	220	230	240	208	220	230	240	208	220	230	240
Delta (V)	240	254	266	277	240	254	266	277	240	254	266	277	240	254	266	277
kVA	470	490	495	505	495	515	520	530	563	588	594	606	606	625	638	650
kW	376	392	396	404	396	412	416	424	450	470	475	485	485	500	510	520
Efficiency (%)	95.4	95.4	95.5	95.5	95.3	95.4	95.4	95.5	95.2	95.3	95.4	95.4	95.1	95.2	95.3	95.3
kW Input	394	411	415	423	416	432	436	444	473	494	498	508	510	525	536	546

DIMENSIONS



COUPLING DISC	AN
SAE 14	25,4
SAE 18	15,87
SAE 21	0

ADAPTOR	AD
SAE 00	410
SAE 0	410
SAE 1/2	390
SAE 1	390

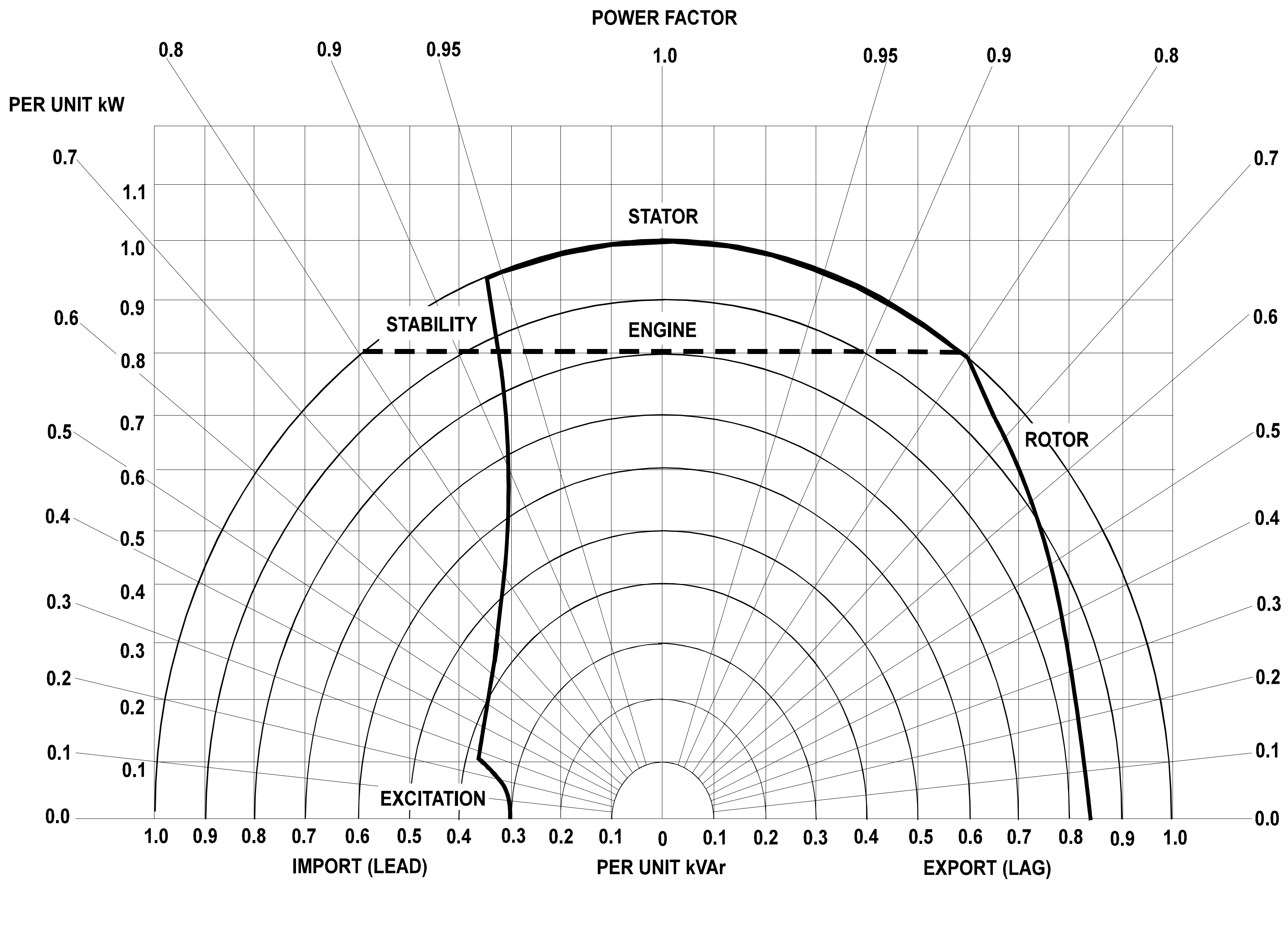
STAMFORD
Barnack Road • Stamford • Lincolnshire • PE9 2NB
Tel: 00 44 (0)1780 484000 • Fax: 00 44 (0)1780 484100

NEWAGE INTERNATIONAL

AC GENERATOR FRAME HC534E

TYPICAL OPERATING CHART

480 Volts 3 PHASE 60 Hz 1800 REV/MIN WINDING 311



1 PER UNIT = 750 kVA

APPLICATION DATA SHEET NUMBER HC534E/311/60/NA/5/480 Volts

ISSUE a

DATE 1-Jul-04

SAGE THERMAL GAS MASS FLOW METER

Operations and Instruction Manual

For Industrial Style Models SIP and SRP (SAGE PRIME™)

Make the Wise Choice.
Choose Sage Flow Meters.

SAGE METERING, INC.
8 Harris Court, D1
Monterey, CA 93940
1-866-677-SAGE (7243)
Tel 831-242-2030
Fax 831-655-4965
www.sagemetering.com

Table of Contents

continued on next page

Welcome

We are pleased that you have purchased a Sage Metering Mass Flow Meter for your requirement. We hope that you are satisfied with the performance, operation and design of our highly precise, NIST traceable Thermal Gas Mass Flow Meter.

Sage Metering is your source for monitoring,measuring and controlling the gas mass flow in your industrial process. Our high performance, NIST traceable, thermal mass flow meters will help increase productivity, reduce energy costs, and maximize product yields.With over 120 years of combined experience in delivering quality in-line and insertion thermal mass flow meters for a wide variety of industrial needs, the Sage Metering management team is dedicated to providing you with the performance and customer support that you deserve. Sage Thermal Mass Flow Meters are designed for high performance mass flow measurement of flow rate and consumption of gases such as natural gas, air, oxygen, digester gas, landfill gas and other gases and gas mixes.

Sage Meters measure mass flow directly — there is no need for ancillary instrumentation such as temperature or pressure transmitters. Furthermore, our instruments have exceptional signal sensitivity, have no moving parts, require little if any maintenance, have negligible pressure drop and have a rangeability of at least 100 to 1 and as high as 1000 to 1. Sage Flow Meters can measure and control the mass flow rate and consumption of air, oxygen, natural gas, nitrogen, digester gas, biogas, flare gas, hydrogen, argon, carbon dioxide and other gases and gas mixes.

Sage Prime is the latest addition to our family of high performance Thermal Mass Flow Meters. It features a bright new graphical display of Flow Rate,Total and Temperature, robust industrial enclosure, and easy to access power and output terminals. Sage Prime has a new dual-compartment windowed explosion proof enclosure featuring a very high contrast photo-emissive OLED display.The rear compartment, which is separated from the electronics, has large, easy to access and well marked terminals, for ease of customer wiring. It is powered by 24 VDC (15 VDC optional, or 115/230 VAC).The power dissipation is under 2.5 watts (e.g. under 100 ma at 24 VDC) for the DC version.

Please let us know if we can assist you in any way with your Sage Meter, or if you have any questions about its installation, operation, or features. Simply phone us at 866-677-SAGE (7243), or visit our website at www.sagemetering.com to contact a factory representative in your area. (To access this manual on the website, enter in passcode 7243737 when prompted.)

Sincerely,

Robert Steinberg
President

Section A

GETTING STARTED

Getting Started

UNPACKING YOUR SAGE METER

Your Sage flow meter is a sensitive, yet rugged, precision built electronic instrument. Upon delivery, care should be taken when opening the shipping container and removing your meter. The meter should be inspected for any damage that may have occurred during transit. If damage is found, please contact the carrier immediately to place a claim for damaged goods. The contents of the container should be checked against the packing list for any discrepancies. If there are any questions as to the contents or configuration of the equipment including calibration ranges, or, mounting hardware, contact Sage Metering as soon as possible. Please save shipping container and packaging materials (including PVC tube probe protector on Sage Insertion Flow Meters) in case the unit needs to be returned for any reason.

MAINTENANCE

Sage thermal mass flow meters essentially require little or no maintenance. While the sensing element is somewhat resistant to dirt and particulate build up, it may become necessary to clean it from time to time if mounted in extremely dirty environments. NOTE: ALWAYS DISABLE THE TRANSMITTER POWER SUPPLY PRIOR TO ANY CLEANING OR MAINTENANCE. A simple blast of compressed air may be sufficient; or a detergent or appropriate non-corrosive solvent for removing the buildup may be required. A soft brush can be used to gently clean the sensing element's surface, using caution to avoid damaging the RTDs. If any disassembly is necessary, contact Sage Metering, Inc. for instructions. **In general, it is recommended that your Sage Thermal Mass Flow Meter be returned to the factory if cleaning, repair, or recalibration is needed. This is usually the most cost-effective and reliable alternative.**

CALIBRATION

Sage Prime has continuous diagnostics. The raw calibration milliwats (mw) is always displayed in the upper left hand corner of the meter's display. At any time, you can check this reading at a "no flow" condition and compare the reading to the original reported "zero flow" value noted on the last line of your meter's Certificate of Conformance. This method helps validate the meter's performance, and depending on your company's quality control procedures, may eliminate, or at least postpone the need for annual factory calibrations. See "Sensor Functionality and Zero Calibration Self Check" on page 37.

CAUTION cable glands shipped with unit are for shipping purposes only.
Remove shipping cable glands before installing.

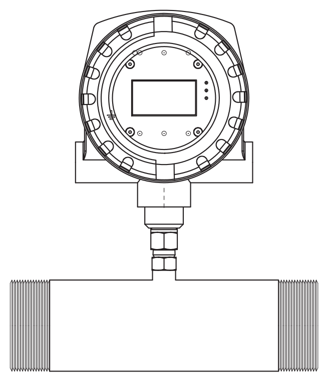
INSTALLATION AND MOUNTING

- Check the Certificate of Conformance included with your Sage Thermal Mass Flow Meter for system pressure, temperature, gas composition, power input, and signal output.
- Check the installation. Choose the longest straight-run section of pipe available to allow a uniform, well-developed flow profile. Allow for a minimum ten (10) diameters (15 preferred) straight-run upstream of the sensors and five (5) diameters straight-run downstream of the sensors. Avoid, if possible, installations immediately downstream of bends, fans, nozzles, heaters, or anything else installed in the line that may cause non-uniform flow profiles and swirls which can result in signal output errors (refer to "Probe Insertion Guideline Drawing" on page 13).
- Check the orientation: Standard calibration flow direction is left to right when facing the flow meter. Gas flow direction is marked with an arrow on in-line flow meters; UPSTREAM is marked on insertion probes.
- Hook up the system per the wiring diagram provided with your Sage flow meter. Double check that wiring for the proper power and signal connections are correct.
- Check that all plumbing and electrical hook-ups are in accordance with OSHA, NFPA, and all other safety requirements.
- **For Remote Style Meters (SRP), be sure that the Remote Electronics is matched with the ransmitter (Probe or Flow Body). There will be Metal Serial Number Tags on both ends. Do not mismatch the serial numbers of the Remote Electronics and the Transmitter, or calibration errors will occur.**

IN-LINE FLOW METER APPLICATION

In-line mounting styles are available through Sage Metering, Inc. in sizes from 1/4" pipe through 4" pipe. Threaded male NPT ends are standard up to 2-1/2"; ANSI 150lb flanged ends are standard for 3" and 4" models. Contact the factory if optional end mounting styles are required. Pipe sizes in excess of 4" require the insertion style mass flow meter.

The inline style flow meter assembly flow section is typically specified to match the user's flow conduit and is plumbed directly in the flow line by threading, flanging, welding, etc. DO NOT USE REDUCERS. It includes the sensing element (a self-heated flow sensor and a temperature/reference sensor) mounted directly in the specified flow section for exposure to the process gas; a sensor drive circuit; microprocessor meter board, and transmitter enclosure.



LOCATING PROPER WIRING DIAGRAM

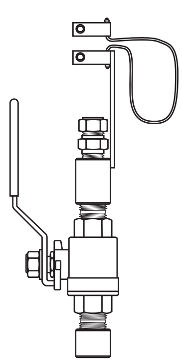
1) Look at the sticker on your meter. The first three digits describe the basic model that you have. Refer to the appropriate page numbers below for your wiring diagram
2) SIP: See page 16
3) SRP: See page 17 for input/output terminals; see page 18 (Junction Box Wiring Terminals for Remote Style Meters)

WIRING

Remove the rear cap and follow diagram on page 16 (SIP) and page 17 (SRP). **CAUTION: Do not open display side!**

SAGE VALVE ASSEMBLY OPERATION

Valve assemblies (SVA05) are an optional mounting hardware available through Sage Metering Inc. They allow the removal of insertion-style meters for service, cleaning, re-calibration, relocation, etc. without the need to "shut-down" your process. The probe insertion depth is adjustable to permit sensor to be located at center to optimize measurement accuracy. (Refer to PROBE INSERTION GUIDELINE DRAWING and CHART.) The ball valve will seal off leaks of the process gas at the point of insertion after the probe assembly has been removed. The assembly includes a valve, threadolet, compression fitting with Teflon ferrule, a cable restraint, and a collar clamp.



NOTE: Detailed Drawing is shown on page 30.

A threaded half coupling (3/4" FNPT)properly sized to accommodate the isolation valve retractor assembly must be fitted to the pipe/duct to which the insertion probe will be inserted. Direct threading together (or with necessary bushings) of the retractor assembly may be required. In other cases, the threadolet must be welded in place and a clearance hole must be drilled through the pipe/ duct to accept the probe assembly. **If the pipe/duct is under pressure during installation, a hot tap drill (not available through Sage Metering) may be required.**

COMPRESSION FITTING

A bored through tube fitting, properly sized to accommodate an insertion probe's particular OD, can be provided by the user or purchased as an option from Sage Metering. Prior to installation, a clearance hole to accommodate the insertion probe assembly must be drilled in the pipe/duct. A fitting (1/2" FNPT) is then welded in place or threaded into the half-threadolet which has been welded to the pipe/duct. The probe insertion depth is adjustable to permit sensor to be located at center, to optimize measurement accuracy. (Refer to PROBE INSERTION GUIDELINE DRAWING and CHART, pages 13 &14.)

INSTALLATION INSTRUCTIONS

1. Insert tubing into the tube fitting.
2. Make sure that the tubing is positioned properly per the PROBE INSERTION GUIDELINE DRAWING AND CHART, pages 13 &14.
3. **Due to the variations of tubing diameters, a common starting point is desirable. Therefore, tighten the nut until the tubing will not turn by hand or move axially in the fitting.**
4. Scribe the nut at the 6 o'clock position.
5. While holding fitting body steady, tighten the nut 1¼ turns to the 9 o'clock position.

Insert the probe shaft tubing into the compression fitting to the position indicted in the Probe Insertion guidelines.

Mark the nut at the 6 o'clock position.

While holding the fitting body steady, tighten the nut one and one-quarter turns to the 9 o'clock position.

Probe Insertion Guideline Drawing[1]

INSERTION FLOW METER APPLICATION

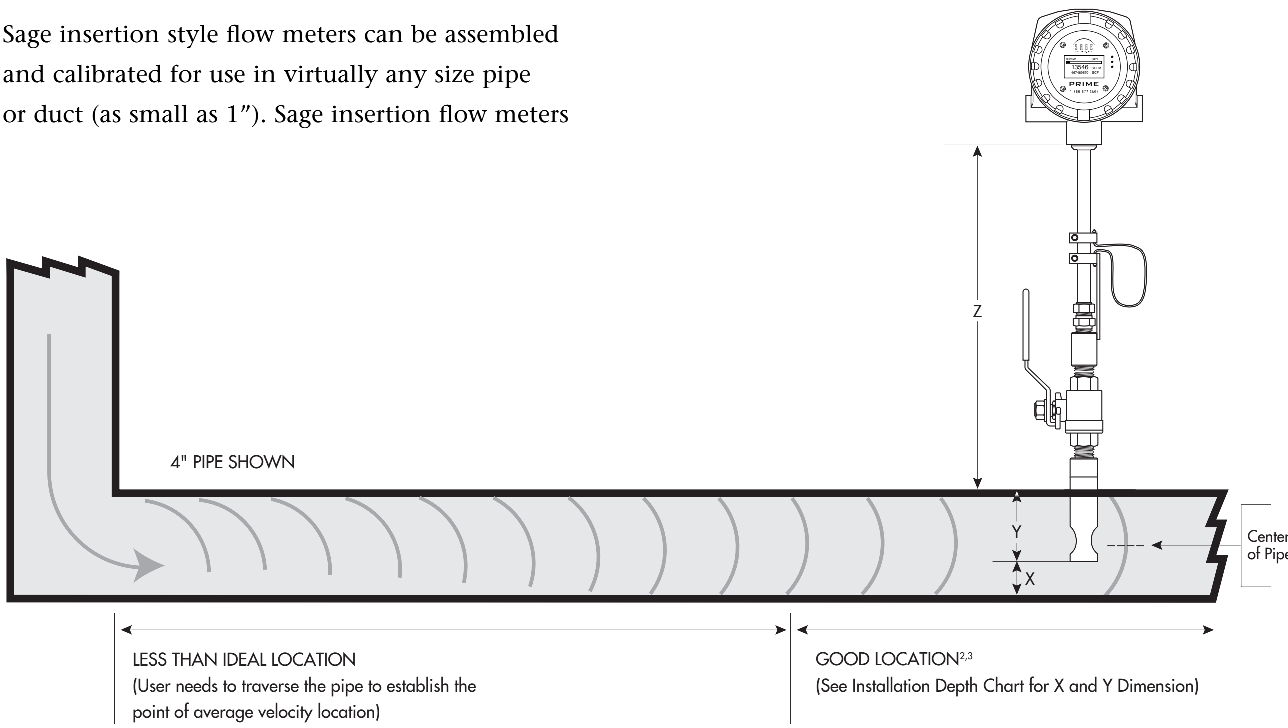
Straight Run Requirements. Choose the longest straight run section of pipe available to allow a uniform, well developed flow profile. Allow for a minimum of 10 diameters straight run (15 preferred) upstream of the sensors, and 5 down stream to minimize flow profile inaccuracies.

Insertion styles are available through Sage Metering, Inc. with a standard 1/2" OD probe support assembly; 3/4" is also available. Standard probe lengths are 6", 12", 15", 18", 24", 30", 36" and 48". A common method of mounting the probe assembly through a pipe wall or duct is with a compression fitting. A Sage valve assembly is useful and highly recommended. Flange mounting is optionally available.

Sage insertion style flow meters can be assembled and calibrated for use in virtually any size pipe or duct (as small as 1”). Sage insertion flow meters include a probe assembly that supports the sensing element (a self-heated flow sensor and a temperature/reference sensor); a sensor drive circuit; microprocessor meter board, and transmitter enclosure. The probe assembly must be inserted into the correct position in the process gas flow conduit to allow the gas to flow through the sensor “window” across the sensor element. The “sensing point” or active part of the sensor (0.5" from the end of the probe) should be positioned as follows:

INSTALLATION DEPTH

The center of the pipe (assuming a well developed turbulent flow profile) is fairly flat, and easy to locate. See “Installation Depth Chart” on next page to determine proper insertion depth.



1. SIP Industrial Meter shown in drawing.
2. Probe should be inserted per Installation Depth Chart (see following pages), so sensors are in the center of the pipe.
3. The portion of the probe that remains outside of the pipe, is simply the factory ordered probe length (i.e. “-15” = 15 inches) minus the “Y” dimension.

Installation Depth Chart

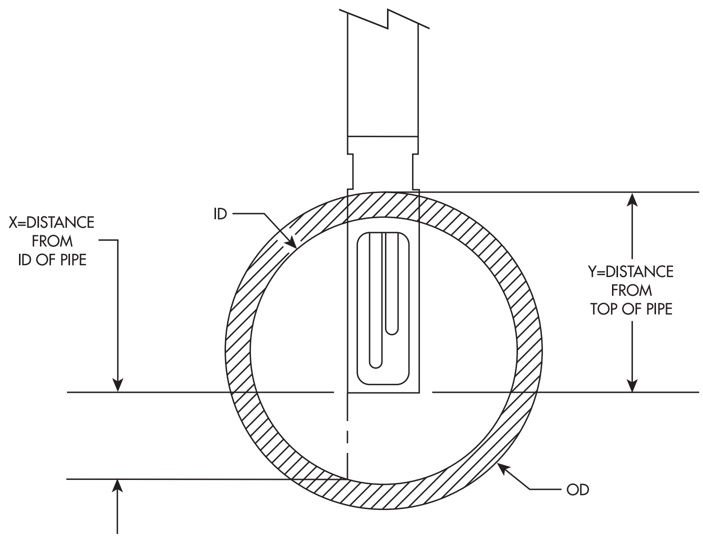
METHODS FOR PROBE INSERTION TO PIPE CENTER

METHOD 1

Using charts below, select pipe size (column 1), determine X. Insert probe until the end touches the bottom of the pipe (ID), mark probe as it exits top of fitting. Lift probe distance "X" and tighten compression fitting.

METHOD 2

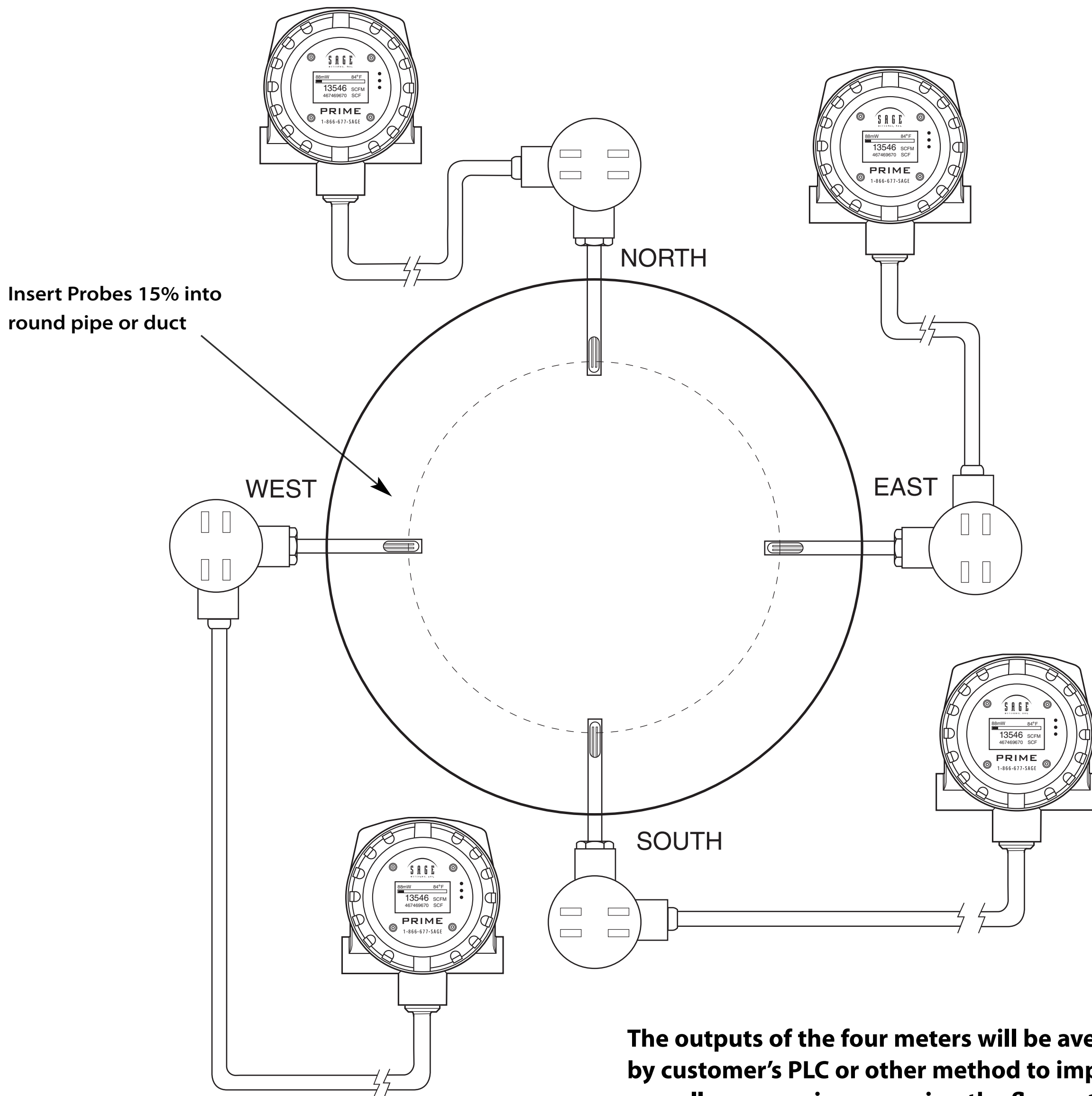
Using charts below, select pipe size (column 1), determine Y. Subtract Y from the factory supplied probe length. That difference should be outside of the pipe, and is measured from the bottom of the probe weld to pipe OD.



SCHEDULE 40 PIPE					
PIPE SIZE	OD	ID	X	Y	PIPE AREA
1"	CONSULT FACTORY				
1.5"	1.900	1.610	.20"	1.56"	0.0141
2"	2.375	2.067	.40"	1.82"	0.0233
2.5"	2.875	2.469	.60"	2.07"	0.0332
3"	3.500	3.068	.90"	2.38"	0.0513
4"	4.500	4.026	1.40"	2.86"	0.0884
6"	6.625	6.065	2.40"	3.95"	0.2006
8"	8.625	7.981	3.40"	4.90"	0.3474
10"	10.750	10.020	4.40"	6.00"	0.5476
12"	12.750	11.938	5.50"	7.00"	0.7773
14"	14.000	13.124	6.00"	7.50"	0.9394
16"	16.000	15.000	7.00"	8.60"	1.2272
18"	18.000	16.876	8.00"	9.60"	1.5533
24"	24.000	22.625	10.75"	12.60"	2.7919

SCHEDULE 80 PIPE					
PIPE SIZE	OD	ID	X	Y	PIPE AREA
1"	CONSULT FACTORY				
1.5"	1.900	1.500	.15"	1.56"	0.0123
2"	2.375	1.939	.35"	1.82"	0.0205
2.5"	2.875	2.323	.55"	2.07"	0.0294
3"	3.500	2.900	.80"	2.38"	0.0459
4"	4.500	3.826	1.30"	2.86"	0.0798
6"	6.625	5.761	2.25"	3.95"	0.1810
8"	8.625	7.625	3.25"	4.90"	0.3171
10"	10.750	9.750	4.25"	6.00"	0.5185
12"	12.750	11.374	5.13"	7.00"	0.7056
14"	14.000	12.500	5.70"	7.50"	0.8522
16"	16.000	14.312	6.60"	8.60"	1.1172
18"	18.000	16.124	7.50"	9.60"	1.4180
24"	24.000	21.562	10.25"	12.60"	2.5357

Configuration for Utilizing Four (4) Sage Insertion Mass Flow Meters for Large Round Pipes or Ducts Larger than 36" to Minimize Effects of Varying Flow Profiles

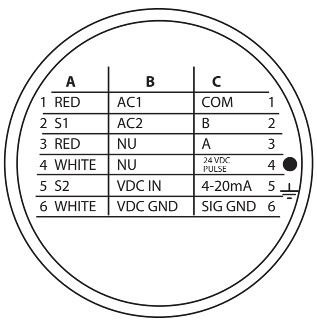


NOTE: Each Probe is mounted in the centroid (geometric center) of each quadrant. By averaging the outputs of all four probes, better accuracy is achieved.

The outputs of the four meters will be averaged by customer's PLC or other method to improve overall accuracy in measuring the flow rate. (For medium sized round pipes [18" to 36"], two meters, on the opposite side of the same diameter, may be sufficient [insert parallel to an upstream 90 degree bend for optimal benefit.]) Note, in this configuration, each sensor needs to be averaged. A K-factor (menu 304) of 1.22 is required in each meter to correct for this averaging method of insertion. Alternately, put a 1.22 factor in your PLC.

Prime Integral Terminals

INSIDE COVER VIEW

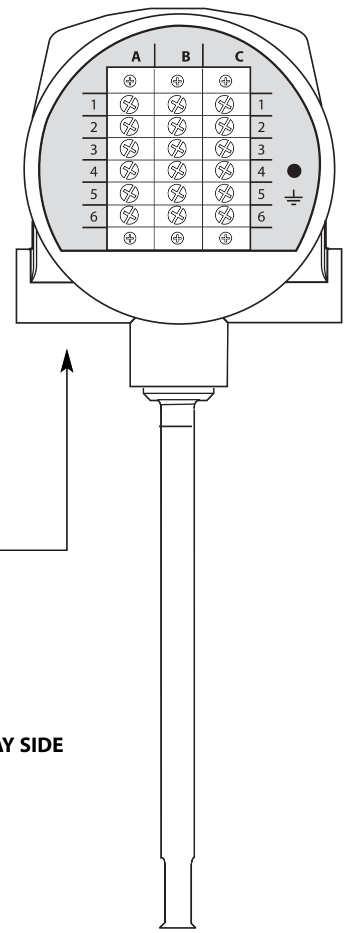


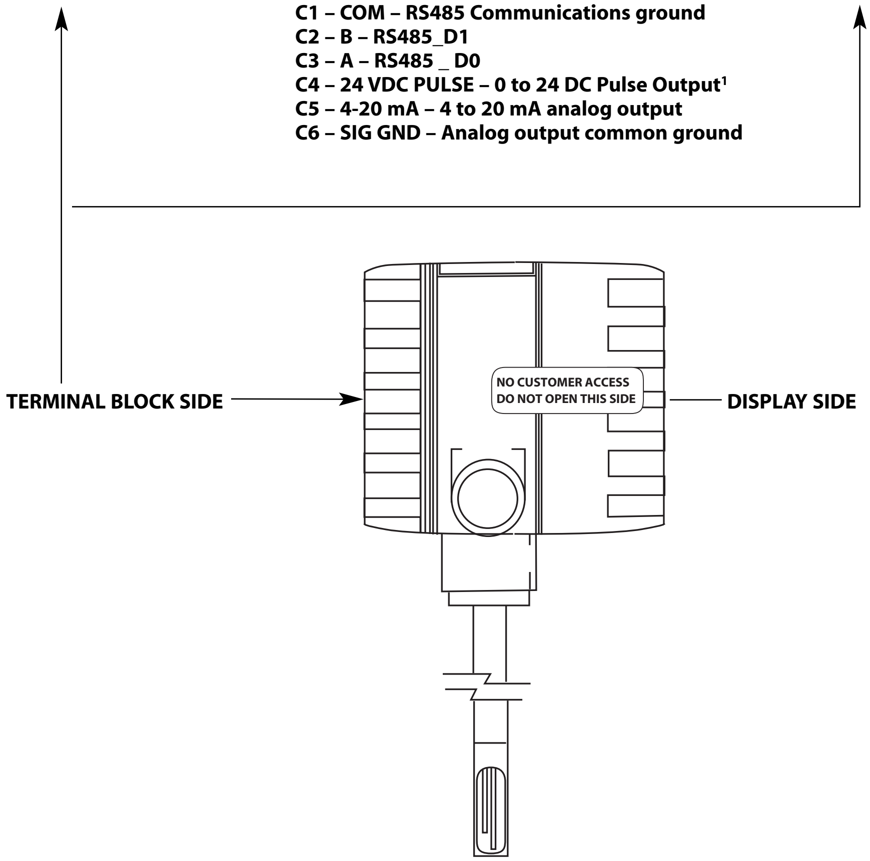
A1 – RED – Velocity Sensor wire (heated element)
A2 – no wire
A3 – RED – Velocity Sensor wire (heated element)
A4 – WHITE – Temperature Sensor wire
A5 – no wire
A6 – WHITE – Temperature Sensor wire

B1 – AC1 – AC Voltage
B2 – AC2 – AC Voltage
B3 – NU – Not Used
B4 – NU – Not Used
B5 – VDC IN – Voltage DC – postive (+)
B6 – VDC GND – Voltage DC – ground (–)

C1 – COM – RS485 Communications ground
C2 – B – RS485_D1
C3 – A – RS485 _ D0
C4 – 24 VDC PULSE – 0 to 24 DC Pulse Output[1]
C5 – 4-20 mA – 4 to 20 mA analog output
C6 – SIG GND – Analog output common ground

INSIDE BODY VIEW

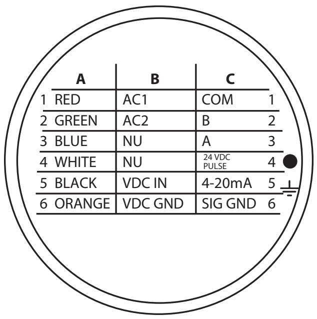




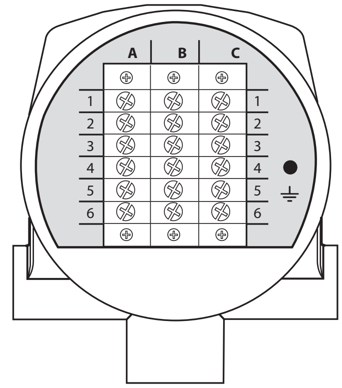
1 Pulse Width is Fixed at 500 msec. The minimum standard cubic feet per pulse (SCF per pulse) is a Valve of 0.0125 X Full Scale (FS). Full Scale in SCFM units. In summary SCF per Pulse ≥0.0125 X FS. Note: FS in units of SCFM

Prime Remote Terminals

INSIDE COVER VIEW



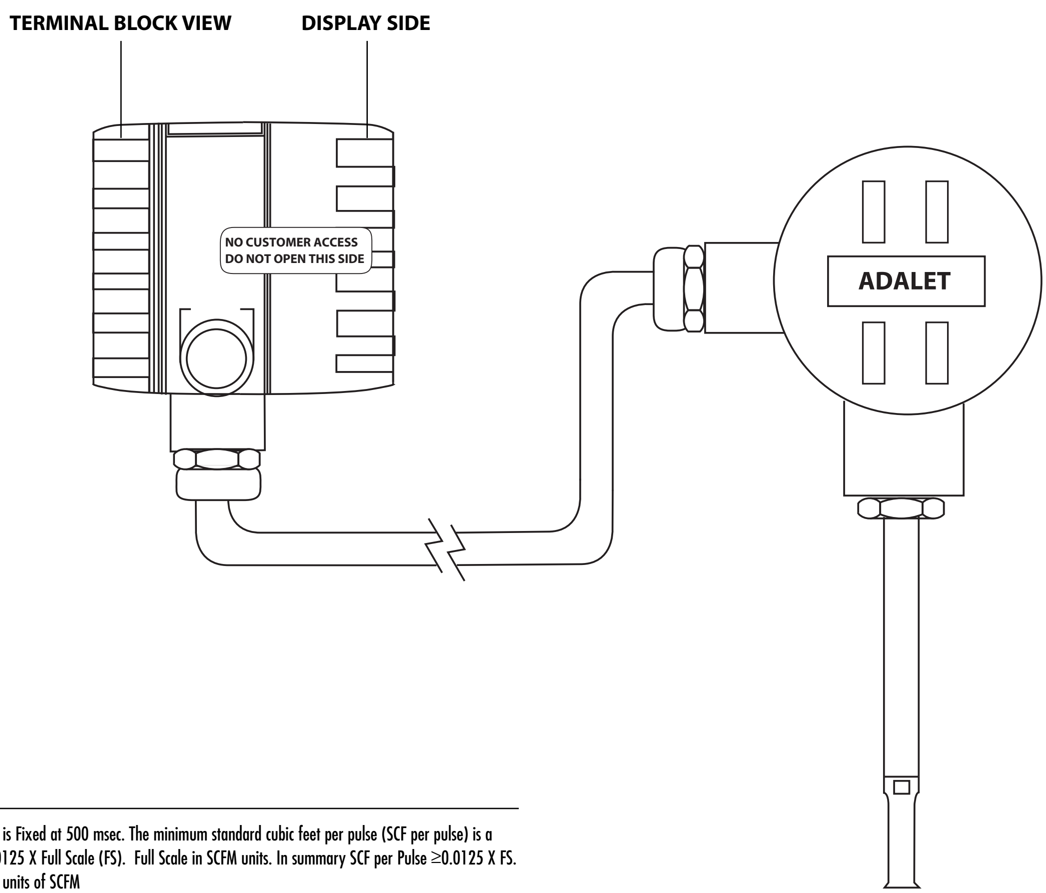
INSIDE BODY VIEW



A1 – RED – Velocity Sensor wire (heated element)
A2 – GREEN – sense wire
A3 – BLUE – Velocity Sensor wire (heated element)
A4 – WHITE – Temperature Sensor wire
A5 – BLACK – sense wire
A6 – ORANGE – Temperature Sensor wire

B1 – AC1 – AC Voltage
B2 – AC2 – AC Voltage
B3 – NU – Not Used
B4 – NU – Not Used
B5 – VDC IN – Voltage DC – postive (+)
B6 – VDC GND – Voltage DC – ground (–)

C1 – COM – RS485 Communications ground
C2 – B – RS485_D1
C3 – A – RS485 _ D0
C4 – 24 VDC PULSE – 0 to 24 DC Pulse Output[1]
C5 – 4-20 mA – 4 to 20 mA analog output
C6 – SIG GND – Analog output common ground

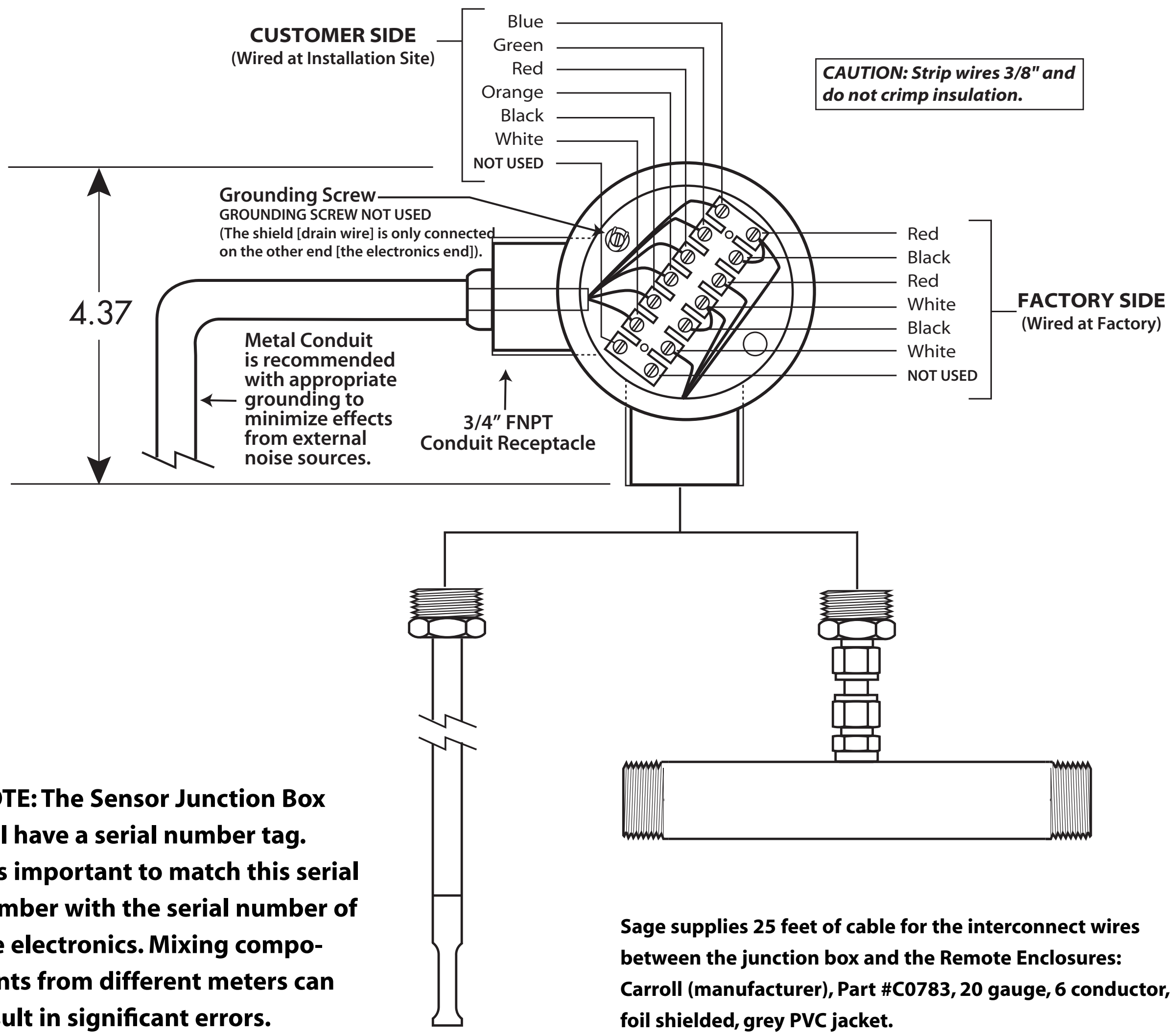


1 Pulse Width is Fixed at 500 msec. The minimum standard cubic feet per pulse (SCF per pulse) is a Valve of 0.0125 X Full Scale (FS). Full Scale in SCFM units. In summary SCF per Pulse $\geq$0.0125 X FS. Note: FS in units of SCFM

Junction Box Wiring Terminals for Remote Style Meters

(THERE ARE NO ELECTRONICS INSIDE JUNCTION BOX)

SEE THE FOLLOWING PAGE FOR THE OTHER END OF THE REMOTE WIRING HOOKUP (the electronics side).



NOTE: The Sensor Junction Box will have a serial number tag. It is important to match this serial number with the serial number of the electronics. Mixing components from different meters can result in significant errors.

Sage supplies 25 feet of cable for the interconnect wires between the junction box and the Remote Enclosures: Carroll (manufacturer), Part #C0783, 20 gauge, 6 conductor, foil shielded, grey PVC jacket.

Section B

STYLES AND FEATURES

Styles and Features

"SAGE PRIME™" HIGH PERFORMANCE, COST EFFECTIVE INDUSTRIAL THERMAL MASS FLOW METER FOR GASES

Sage Prime is the latest addition to our family of high performance Thermal Mass Flow Meters. It features a bright new graphical display of Flow Rate,Total and Temperature, robust industrial enclosure, and easy to access power and output terminals. Sage Prime has a new dual-compartment windowed explosion proof enclosure featuring a very high contrast photo-emissive OLED display.The rear compartment, which is separated from the electronics, has large, easyto- access and well marked terminals, for ease of customer wiring. It is powered by 24 VDC (15 VDC optional, or 115/230 VAC).The power dissipation is under 2.5 watts (e.g. under 100 ma at 24 VDC) for the DC version.

The Sage Prime Flow Meter is offered in the Integral Style (standard) or Remote Style (with lead length compensation up to 1000 feet) with explosion proof enclosures with your choice of Probe or Flow Body depending on your pipe size. It has a 4-20 ma output as well as a Pulsed Output of Totalized Flow (solid state [sourcing] transistor drive). In addition, Sage Prime supports full Modbus® compliant RS485 RTU communications.

THERMAL MASS FLOW METERS

Sage Metering is your source for monitoring,measuring and controlling the gas mass flow in your industrial process. Our high performance, NIST traceable, thermal mass flow meters will help increase productivity, reduce energy costs, and maximize product yields.With over 120 years of combined experience in delivering quality in-line and insertion thermal mass flow meters for a wide variety of industrial needs, the Sage Metering management team is dedicated to providing you with the performance and customer support that you deserve.

Sage Thermal Mass Flow Meters are designed for high performance mass flow measurement of flow rate and consumption of gases such as natural gas, air, oxygen, digester gas, landfill gas and other gases and gas mixes.

Sage Metering has distinguished itself by offering a higher standard—our mass flow meter output is unaffected by even large process temperature variations, and our digital electronics is impervious to external analog noise. Fast response, high resolution, and ultra sensitivity are features that are at the heart of every Sage Thermal Mass Flow Meter. See Sage Metering product brochure for additional information and product benefits, or contact us at 866-677-7243 for application assistance.

HOW DOES THERMAL MASS FLOW MEASUREMENT BENEFIT YOU?

- Direct Mass Flow—No need for separate temperature or pressure transmitters
- High Accuracy and Repeatability—Precision measurement and optimal control of your process
- Rangeable over at least a range of 100 to 1 and as high as 1000 to 1
- Low-End Sensitivity—Detects leaks, and measures as low as 5 SFPM!
- Negligible Pressure Drop—Will not impede the flow nor waste energy
- No Moving Parts—Eliminates costly bearing replacements, and prevents undetected accuracy shifts
- Dirt Insensitive—Provides sustained performance
- Low cost of ownership

continued on next page

WHAT ARE THE BENEFITS THAT SAGE PRIME THERMAL MASS FLOW METERS OFFER YOU?

- Powerful state-of-the-art microprocessor technology designed for high performance mass flow measurement, at a low cost-of-ownership
- Rugged, user-friendly packaging with easy terminal access
- Proprietary digital sensor drive circuit provides enhanced signal stability and is unaffected by process temperature and pressure changes
- Low power dissipation, under 2.5 Watts (e.g. under 100 ma at 24 VDC)
- High contrast photo-emissive OLED display with numerical Flow Rate, Total and Temperature, as well as Graphical Flow Indicator
- Displays calibration milliwatts (mw) for ongoing diagnostics
- Remote Style has Lead-Length Compensation. Remote electronics up to 1000 ft from probe, and the Junction Box has no electronics
- Modbus® compliant RS485 RTU communications
- Ease of installation, and convenient mounting hardware
- Flow conditioning built in to In-line flow meters (3/4" and up)

Sage PRIME™ Industrial Flow Meter Specifications

SIP SERIES

Sage Prime™ is a thermal dispersion type of Flow Meter, utilizing the constant temperature difference method of measuring Gas Mass Flow Rate. It contains two reference grade platinum RTD sensors clad in a protective 316 SS sheath. It features direct Mass Flow for gases, wide rangeability, low pressure drop, very low end sensitivity, and no moving parts.

The Prime is microprocessor based, does not have any potentiometers, and has Modbus® RS485 RTU communications. It is powered by 24 VDC (15 VDC optional, or 115/230 VAC).The power dissipation is under 2.5 watts (e.g. under 100 ma at 24 VDC) for the DC version.The power and output terminals are in a separate compartment for ease of installation.

The enclosure is an Explosion Proof,NEMA 4X,windowed, dual compartment enclosure with display.The display is a high contrast photoemissive OLED display, and it displays Mass Flow Rate,Totalized Flow and Temperature as well as a graphical representation of Flow Rate in a horizontal bar graph format. In addition, the calibration milliwatts (mw) is continuously displayed, providing ongoing diagnostics.

Outputs include a 4-20 ma signal (ground based) proportional to Mass Flow Rate, and Pulsed Outputs of Totalized Flow (24VDC solid state [sourcing] transistor drive) , as well as Modbus® compliant RS485 RTU communications.

SRP SERIES[1]

The Flow Element (Integral and Remote, Insertion Style) consists of a 1/2"OD probe (3/4" optional) with lengths up to 36" long (typically 15" long) suitable for insertion into the center of a process pipe. Mounting hardware choices (such as Isolation Valve Assemblies, Compression Fittings, and Flange Mounts) are optionally available.

The Flow Element (Integral and Remote, In-line Style) consists of a choice of 316 Stainless Steel Schedule 40 Flow Bodies sized from 1/4" x 6" long to 4"x 12" long.Male NPT ends are standard,with flanged ends, tube, or butt weld optionally available. Note 3"and 4" Flow Bodies have flanged ends as standard.

Calibration is NIST traceable, and covers a wide variety of gas calibrations. Sage Prime™ can measure gas flow up to 500ºF (-40ºF to 350ºF standard, 500ºF optional) at pressures up to 500 PSIG (1000 PSIG , optional).

Calibration Self Check: Flow Meter has built in diagnostics-a display of the calibration milliwatts (mw) can be used to check the sensor's operation by being compared to the original reported "zero flow" value noted on last line of meter's Certificate of Conformance.

Accuracy is +/- 0.5% of Full Scale +/- 1% of reading with a turn-down of up to 1000 to 1.Higher accuracy available with lower turndown (contact Sage). Repeatability of 0.2%.The Flow Meter is Sage Metering, Inc. SIP Series (Integral Style) or SRP (Remote Style),with the trade name Sage Prime™.

1 On the Remote Styles, the Flow Element's Junction Box is Explosion Proof (Class 1, Div 1, Groups B, C, D), and does not have any electronics - only a wiring terminal block.The Flow Element will be connected to the Electronics by 25 feet of lead-length compensated cable.The cable (6-conductor) can be lengthened or shortened without affecting accuracy (max loop resistance 10 ohms, over 1000 feet).

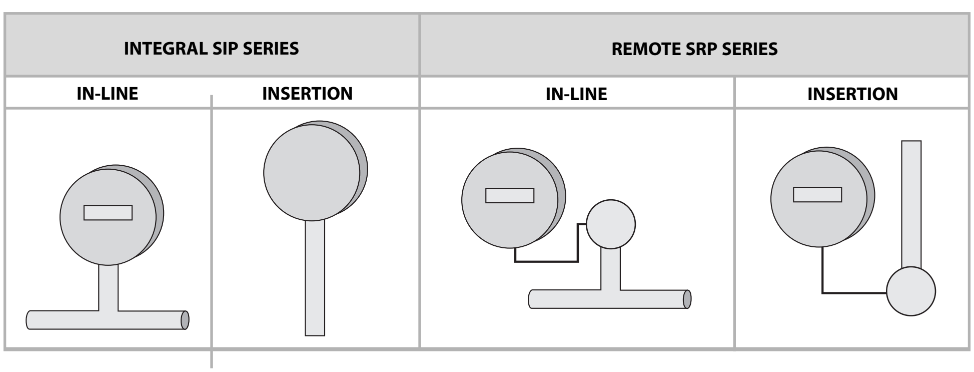
Principle of Operation of the Thermal Mass Flow Meter

Sage Thermal Mass Flow Meters have two sensors constructed of reference grade platinum windings (RTDs). The two RTDs are clad in a protective 316SS sheath and are driven by a proprietary sensor drive circuit. One of the sensors is self-heated (flow sensor), and the other sensor (temperature/reference sensor) measures the gas temperature. The pair is referred to as the sensing element, and is either installed in a probe as an Insertion style, or inserted into a pipe section as an In-Line style flow meter.

As gas flows by the flow sensor, the gas molecules carry heat away from the surface, and the sensor cools down as it loses energy. The sensor drive circuit replenishes the lost energy by heating the flow sensor until it is a constant temperature differential above the reference sensor. The electrical power required to maintain a constant temperature differential is directly proportional to the gas mass flow rate and is linearized to be the output signal of the meter.

It is essential that this constant temperature differential be maintained, even if there are wide fluctuations in gas temperature. It is the “job” of the Sage proprietary sensor drive circuit to maintain the differential, whether or not the gas temperature changes, or however quickly molecules cool off the flow sensor. It is also necessary to properly calibrate the device with the actual gas (or close equivalent with certain gases), in the Sage National Institute of Standards certified (NIST) calibration facility. By accomplishing these two critical objectives, the Sage meters provide an extremely repeatable (0.2% of full scale) and accurate output directly proportional to the mass flow rate of the gas being measured.

BASIC SAGE PRIME™ INDUSTRIAL FLOW METER STYLES



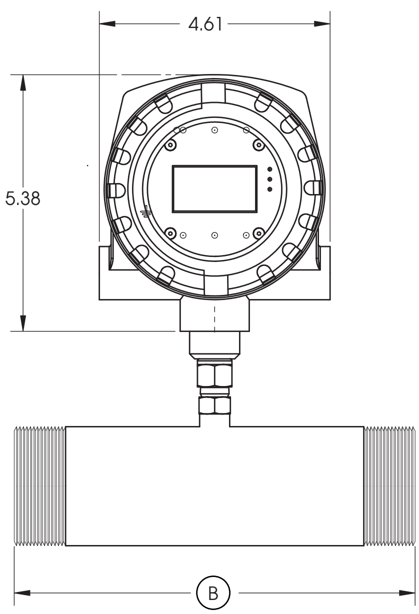
Section C

DRAWINGS

SIP Series Integral Style Industrial Mass Flow Meters

IN-LINE STYLE[1,4]

NEMA 4X Enclosure. 150#, 300#, or 600# flanged ends are optionally available.

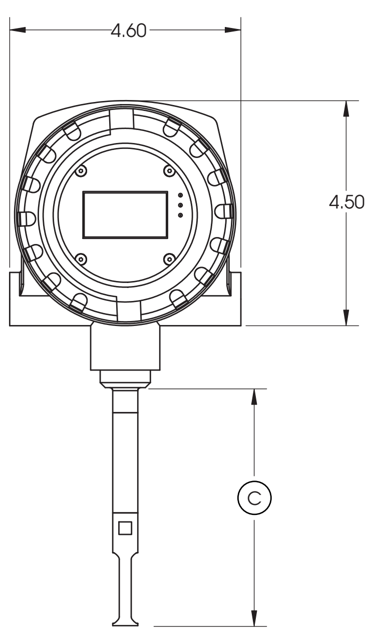


IN-LINE METER DIMENSIONS
Pipe Size x Flow Body Length (B)[3]
1/4" x 6"
3/8" x 6"
1/2" x 7"
3/4" x 7"
1" x 8"
1-1/14" x 10"
1-1/2" x 12"
2" x 12"
2-1/2" x 12"
3" x 12"
4" x 12"

Depth: DC Enclosure depth is 4.35"
AC Enclosure depth is 5.35"

INSERTION STYLE[2,4]

NEMA 4X Enclosure. 150#, 300#, or 600# flanged mounting is optionally available. Available probe lengths (C) are 6", 12", 15", 18", 24", 30", 36" or 48".



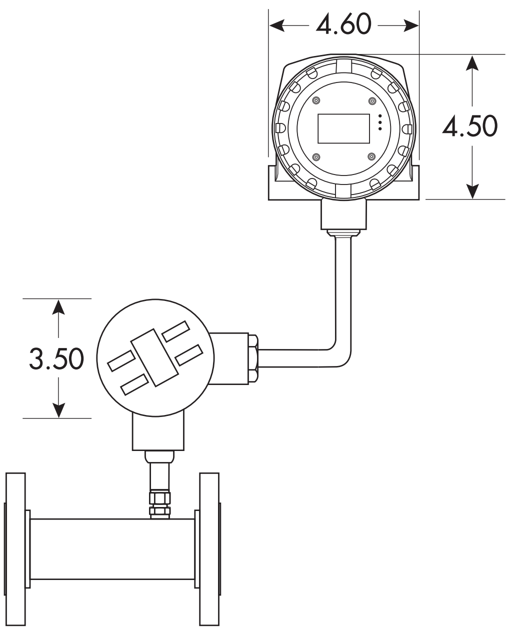
1 NPT Fittings standard
2 Flanged Mounting available for high pressure operation
3 Flow Conditioning built in to Flow Meter Pipe Sizes 3/4" and up. Contact Sage for optional 1/4" tube flow body.
4 Meter has two 1/2" NPT access holes.

SRP Series Remote Style Industrial Mass Flow Meters

IN-LINE STYLE[1,3]

In-line style has not been CSA approved for hazardous area

NEMA 4X Enclosure. 150#, 300#, or 600# flanged ends are optionally available. (1" Flow Body shown)



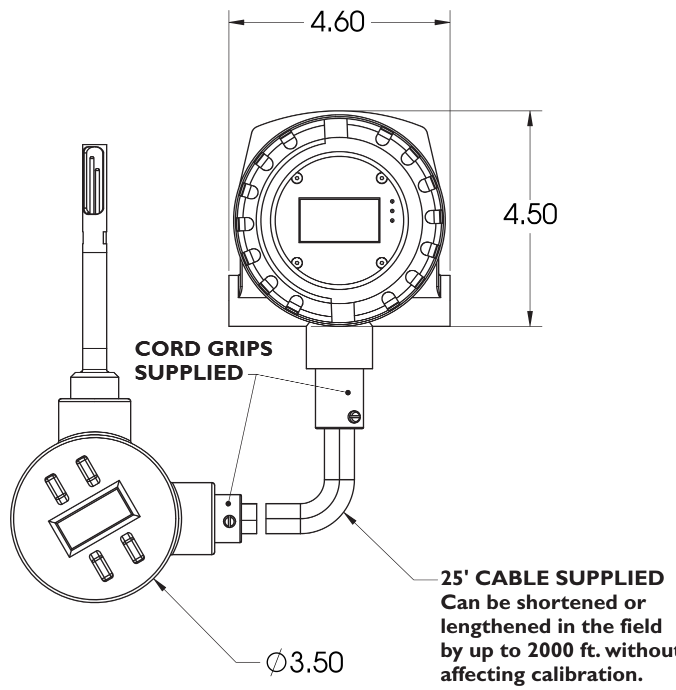
1 Cord Grips shown have 1/2" NPT access holes.

2 See Chart on page 31.

INSERTION STYLE[2,4]

This enclosure not rated for hazardous area environments

NEMA 4X Enclosure. 150#, 300#, or 600# flanged mounting is optionally available. Available probe lengths (C) are 6", 12", 15", 18", 24", 30", 36" or 48".



1 NPT Fittings standard

2 Flanged Mounting available for high pressure operation

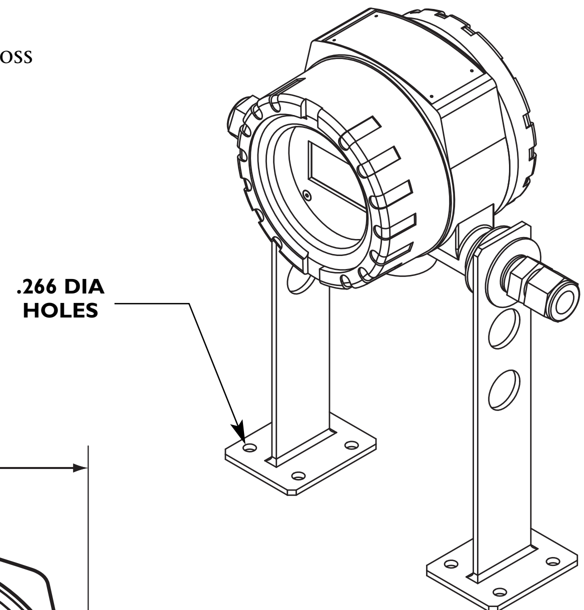
3 Flow Conditioning built in to Flow Meter Pipe Sizes 3/4" and up. Contact Sage for optional 1/4" tube flow body.

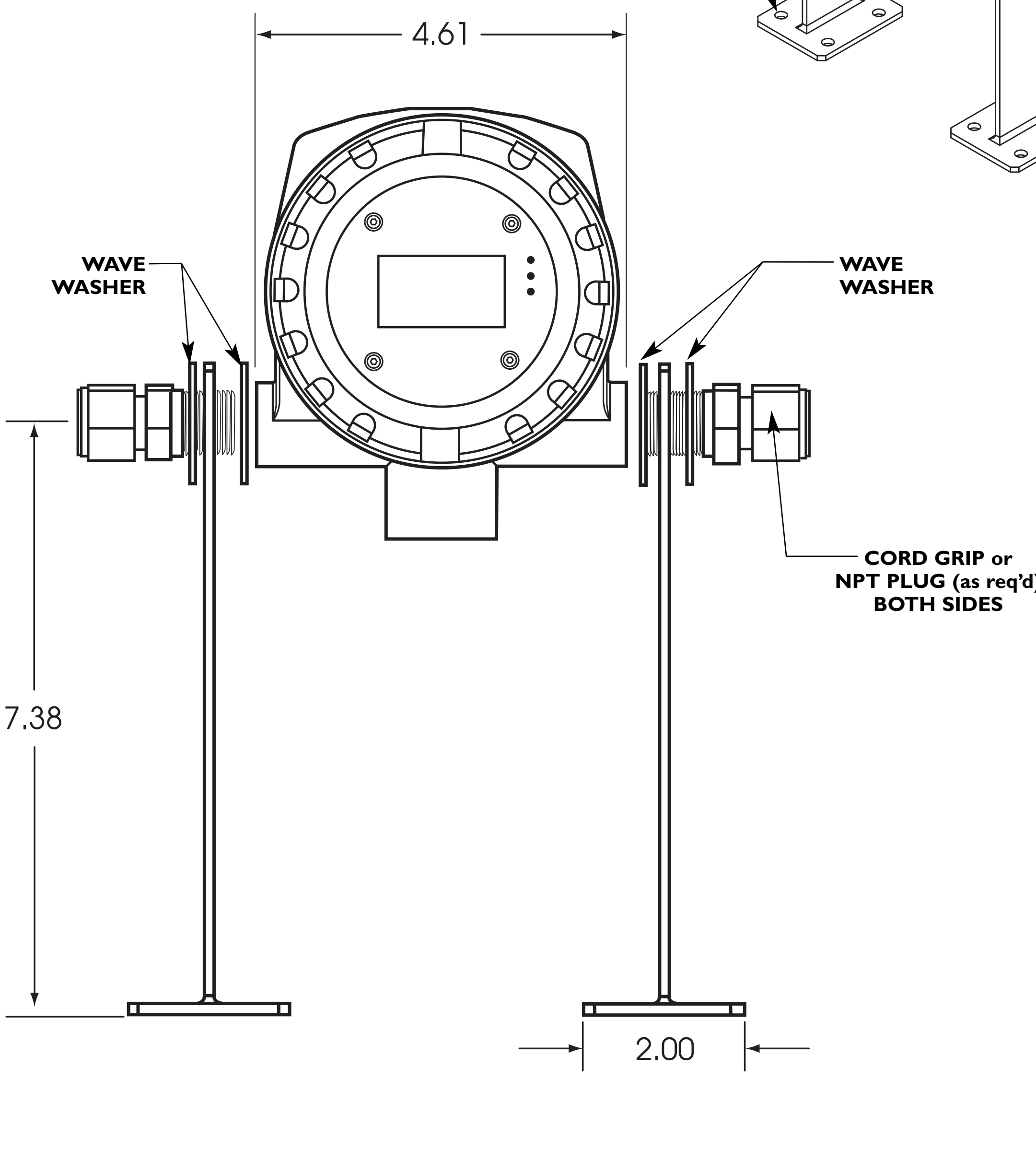
4 Meter has two 1/2" NPT access holes.

Sage Prime Remote Bracket Layout

MOUNTING OPTIONS

1. Overhead with U-bolts (customer supplied) across pipe on each leg
2. Vertically, as shown
3. Horizontally

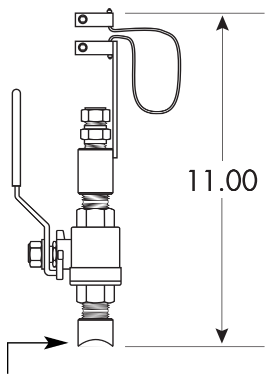




Mounting Hardware[3]

SVA SERIES ISOLATION VALVE ASSEMBLY FOR INSERTION METERS[4]

Used for pressures to 650 psig[1] (shown for use with 1/2" diameter insertion meters). 150# or 300# flanged mounting is optionally available. Available sizes are 1/2" x 3/4" NPT (shown) and 3/4" x 1" NPT.

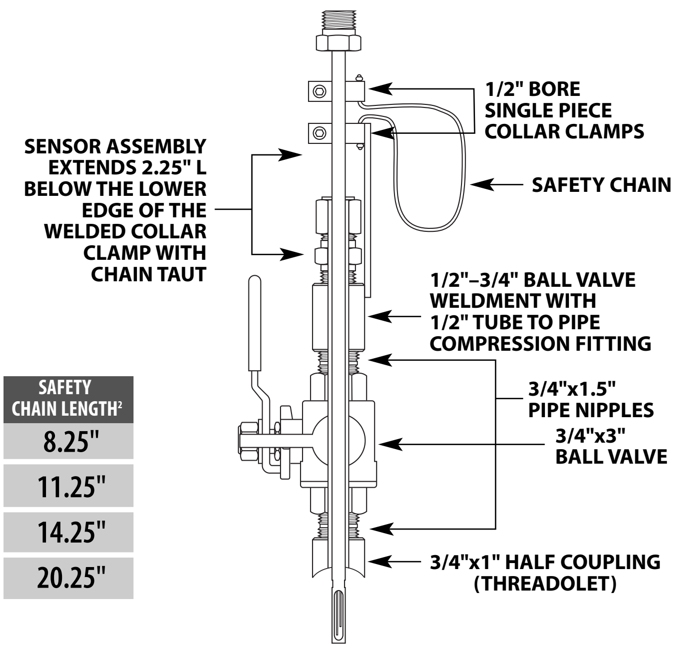


NOTE: User needs to weld a 3/4" female threadolet (of appropriate radius) to mate with existing pipe after a 3/4" hole has been drilled in pipe. The 3/4" Male Coupling of the Sage Isolation Valve Assembly will thread into the user's 3/4" threadolet.

PROBE LENGTH (with sensor)	SAFETY CHAIN LENGTH[2]
12"	8.25"
15"	11.25"
18"	14.25"
24"	20.25"

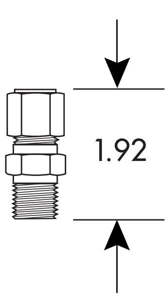
SVA SERIES ISOLATION VALVE ASSEMBLY DETAIL

Cut away view of probe inserted through isolation ball valve assembly.

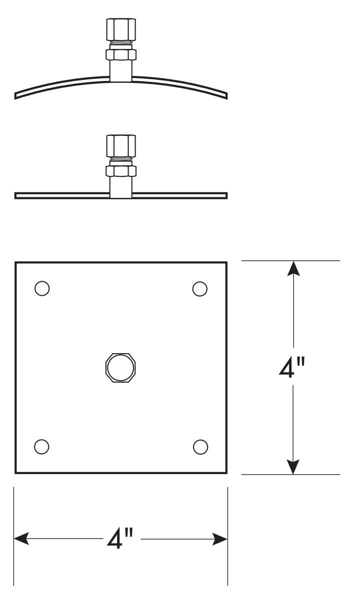


STCF SERIES TEFLON FERRULE COMPRESSION FITTING

1/2" tube x 1/2" pipe fitting (shown, not to scale), is used for low pressure insertion applications to 125 psig (Stainless Steel Ferrule optional for higher pressure applications – up to 225 psig). Also available in 3/4" tube x 3/4" pipe size.

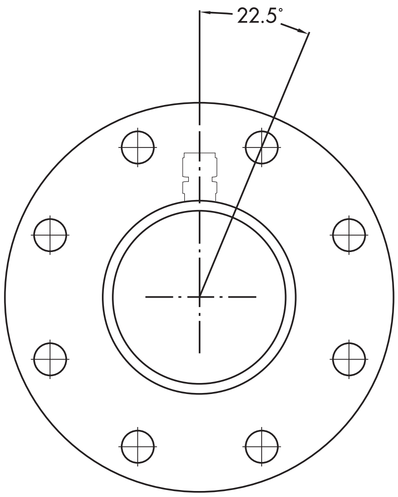


MOUNTING PLATE FOR THIN WALLED DUCTS (INCLUDES STCF05 COMPRESSION FITTING)

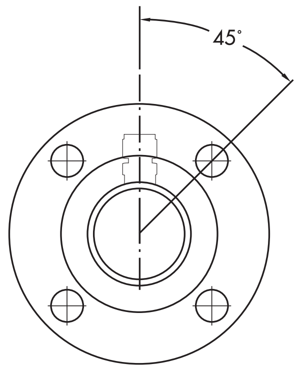


1 At 650 psig, force exerted on 1/2" diameter probe is approx. 125 psig
2 Safety chain is designed to prevent probe from accidentally escaping from assembly during removal from pressurized pipe
3 Insertion meters can have optional flanged mounting (generally used for high pressure or very hot gases). This adaptation is not shown. Consult factory for details.
4 Maximum gas temperature, 200F, unless high temperature models ordered.

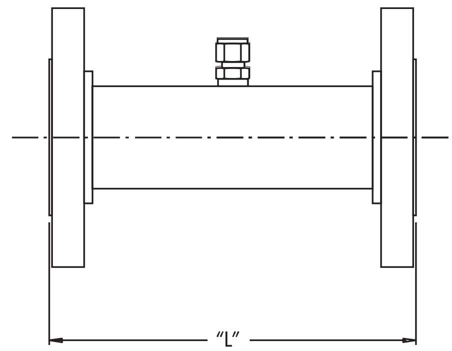
Flanged Ends



Flanges for 3½" pipe sizes and up, have 8 bolt holes



Flanges for 3" pipe sizes and smaller have 4 bolt holes



LENGTH "L" SAME AS NON-FLANGED METER (See table on page 39. For example, 1"x8" flow body has an 8" length. The length will be the same whether an NPT flow body, or whether a flanged. If a flanged flow body, the 8" dimension will be a Face-to-Face dimension.)

Section D

DIAGNOSTICS

Common Diagnostics

SYMPTOM: Meter reading zero continuously, or full scale continuously, or temperature reading is abnormally low (hundreds of degees below zero).

POSSIBLE CAUSES/SUGGESTED CORRECTIVE ACTION:

a) It is likely that a wire is loose. But in rare cases, a sensor could fail (i.e., if a standard sensor, HT01 or HT02 sensor exceeds a process temperature of 500˚F.

b) Check for continuity to be sure the wiring is making good contact at the terminals of the Junction Box. (See the note on the Junction Box drawing on page 17 requiring that the wires be stripped 3/8" and that the insulation is not interfering with the contact.) (An Ohm Meter can be placed between the Electronics end of the wire and the Sensor side [the left side] of the Junction Box to assure of continuity and good contact.)

c) Also, to verify that the electronics is not mixed up with the sensors, the serial number will come up upon power up, right after Initializing on the Display. If the serial number doesn't agree with the Junction Box labels, that would effect calibration (in other words, sensors and electronics are a matched pair—mixing them up will cause false readings). Also metal Serial Number Tags are fastened to both the electronics as well as the Junction Box. They must have identical Serial numbers.

d) To check if a sensor has failed on a remote style meter, it is easy to use the Junction Box to do so. You must Power Down (shut off power), but you do not need to remove the probe from the pipe. Refer to page 17.

e) An Ohm Meter is required to check across the sensor leads of the Flow Sensor. Look at the drawing of the Junction Box. Disconnect the red wires on the Factory Side to isolate and measure the resistance. If the reading is infinity or a short, it means that sensor is burned out.

f) Now check the Temperature Sensor. Disconnect the white wires on the Factory Side to isolate and measure the resistance. If you have infinity or a short, it means that sensor is burned out. **Note:** *Normally the sensors will read approximately 110 ohms at 70˚ F. At higher temperatures they should read a higher resistance, but both sensors should have a similar value.*

g) On integral style meters (SIP), there is no Junction Box. In that case, refer to the Circuit Board Wiring drawing on page 18 and check the sensor on the SDB Terminal. Remove the appropriate wires first (red pair for flow, then white pair for temperature). Measure their resistance. If reading infinity or short, it means that sensor is burned out.

SYMPTOM: Meter Railing (Pegging) or Reading High

POSSIBLE CAUSES/SUGGESTED CORRECTIVE ACTION:

a) Possibly caused by water droplets hitting the sensor (which generally causes output to spike; but if droplets are near continuous, output may rail).

b) Poor Wiring.

c) A downstream valve too close to the meter (flow may be reflecting back).

d) Possible jet effect if upstream pipe is smaller than meter flow body or if valve is too close upstream) to meter.

e) Not following Probe Insertion Guideline.

f) Sensor may be contaminated. Remove probe, wipe off or clean with a solvent. Reinsert.

g) Insufficient straight run (i.e. flow profile is disturbed, causing errors).

h) Using a different gas or gas mix than the meter was specified and calibrated for.

i) If a Remote Style Meter (SRP), be sure Serial Numbers of Probe and Remote Electronics are identical (if not, errors in calibration are inevitable). To confirm, verify that Junction Box Serial Number Tag has identical Serial Numbers to Tag on Remote Enclosure.

j) If sensor is not aligned properly, with Upstream" mark facing upstream, rotation greater than ± 5 degrees may cause change in reading (greater than ± 5 degrees and less than ± 20 degrees causes meter to over-report; a greater rotation actually blocks the sensor, and causes meter to under-report).

k) Meter may appear to be reading high if user is comparing Sage flow meter readings (SCFM) to an uncorrected volumetric device (ACFM). For example, at constant volume, a decrease in gas temperature will increase the mass flow (SCFM). That is completely normal.

SYMPTOM: Reading Low
POSSIBLE CAUSES:

a) Poor flow profile Upstream (insufficient upstream straight run).

b) Insufficient power supply—most products require minimum 100 mA.

c) Excessive load on the 4-20 mA .

d) To check if problem is due to 4-20 mA output device, temporarily remove device, and observe if display reads as expected (if so, see "c").

e) Not following Probe Insertion Guideline.

f) Sensor may be contaminated. Remove probe, wipe off or clean with a solvent. Reinsert.

g) Using a different gas or gas mix than the meter was specified and calibrated for.

h) If a Remote Style Meter (SRP), be sure Serial Numbers of Probe and Remote Electronics are identical (if not, errors in calibration are inevitable). To confirm, verify that Junction Box Serial Number Tag has identical Serial Numbers to Tag on Remote Enclosure.

i) If sensor is not aligned properly, with "Upstream" mark facing upstream, rotation greater than ± 5 degrees may cause change in reading (greater than ± 5 degrees and less than ± 20 degrees causes meter to over-report; a greater rotation actually blocks the sensor, and causes meter to under-report).

j) Meter may appear to be reading low if user is comparing Sage flow meter readings (SCFM) to an uncorrected volumetric device (ACFM). For example, at constant volume, an increase in gas temperature will lower the mass flow (SCFM). That is completely normal.

k) On most models, the Totalizer will not start counting for 10 seconds after power up so any flow data will not be accumulated during this time.

SYMPTOM: Totalizer can take up to 10 seconds to update its reading when flow meter is first powered up, or a channel is changed.
CORRECTIVE ACTION: None. This slight delay is completely normal.

SYMPTOM: Display does not have power
POSSIBLE CAUSE: Mis-wiring

Sensor Functionality and Zero Calibration Self Check

(USE KEPAD, NOT LAPTOP)

1. Verify that meter has no gas flow[1]
   Close appropriate valves in the process to have a "no flow" condition so you can check the "live zero" mw output of the actual gas (it should be checked at the same pressure as noted on Certificate of Conformance). Optionally, do an Ambient Air check by removing probe and covering up sensor by capping the sensor with a plastic bag or other means of preventing flow
2. Observe the raw milliwatts (mw) on the top of the meter's display. Check the observed reading (after a few minutes of "no flow" stabilization) against the last line(s) of your Meter's Certificate of Conformance
3. A value within about 3 milliwatts of the original Factory value (assuming the same gas is checked at same pressure) strongly suggests that the meter is still in calibration, and that the sensor does not need to be cleaned

1 Sage "zeros" the meter in a horizontal pipe. If you have a vertical pipe, mW will be slightly lower at zero.

Section E

WARRANTIES AND SERVICE WORK

Warranties and Service Work

LIMITED WARRANTY

Sage Metering's products are warranted against faulty materials or workmanship for one year from the date of shipment from the factory. Sage's obligation is limited to repair, or at its sole option, replacement of products and components which, upon verification by Sage at our factory in Monterey, California, prove to be defective. Sage shall not be liable for installation charges, for expenses of Buyer for repairs or replacement, for damages from delay or loss of use, or other indirect or consequential damages of any kind. This warranty is extended only to Sage products properly used and properly installed for the particular application for which intended and quoted; and does not cover water damage due to improper use of cord grips or removal of protective caps; and does not cover Sage products which have been altered without Sage authorization or which have been subjected to unusual physical or electrical stress. Sage makes no other warranty, express or implied, and assumes no liability that goods sold to any purchaser are fit for any particular purpose. Transportation charges for materials shipped to the factory for warranty repair are to be paid by the shipper. Sage will return items repaired or replaced under warranty prepaid. NOTE: No items will be returned for warranty repair without prior written authorization from Sage Metering, Inc.

Sage does not warranty damage due to corrosion.

CANCELLATION / RETURN POLICY

Cancellation or Return: After issuance of a purchase order (by phone, mail, e-mail or fax) or a credit card order (by phone, mail, e-mail or fax), there will be a cancellation fee for any cancelled order. Cancellations must be in writing (by mail, e-mail or fax):

1) If credit card order or non-credit card order is cancelled within 7 days of issuance of purchase order or date order was placed (which ever is earlier), there will be a 10% cancellation fee.
2) If credit card order or non-credit card order is cancelled after 7 days, but prior to shipment, there will be a 20% cancellation fee. (If order is cancelled due to late delivery, the cancellation fee will be waived. Late delivery is defined as shipping a meter 7 days or later than the delivery date acknowledged by Sage Metering at time of placing order).
3) If a credit card customer decides to return the equipment after shipment for credit, credit will not be issued if equipment is damaged or if equipment is returned after four (4) months of shipment. If equipment is not damaged, then equipment can be returned after issuance of a Return Meter Authorization (RMA) by Sage. **Returned package must be insured by customer and must reference proper RMA# on outside of package,** or package may be rejected (i.e., package will be returned unopened). Credit Card customers will be charged a 30% re-stocking fee (70% balance will be credited back). Customer is responsible for return shipping charges and any damage if improperly packaged.

continued on next page

4) If a non-credit card customer decides to return the equipment after shipment for credit, credit will not be issued if equipment is damaged or if equipment is returned after 1 month of shipment, unless authorized by a representative at Sage Metering, Inc. The Sage representative will issue a Return Material Authorization (RMA) at that time and will advise of the restocking fee. **Returned package must be insured by customer and must reference proper RMA# on outside of package**, or package may be rejected (i.e., package will be returned unopened). Customer is responsible for return shipping charges and any damage if improperly packaged.

RETURNING YOUR SAGE METER

A Return Material Authorization Number (RMA#) must be obtained prior to returning any equipment to Sage Metering for any reason. RMA#s may be obtained by calling Sage Metering at 866-677-7243 or 831-242-2030 between 8:00 am and 5:00 pm Monday through Friday.

A Sage RMA Form (see page 44) must be filled out and included with the meter being returned to Sage Metering.

A purchase order is required prior to an RMA being issued. Most repairs or recalibrations can be quoted over the phone. For equipment that must be evaluated, an Evaluation purchase order in the amount of $150 is required. Once an evaluation is completed and a quote has been issued, you can choose to proceed with the work or have the unit returned with only the evaluation and freight fee billed.

In accordance with the "Right to Know Act" and applicable US Department of Transportation (DOT) regulations, Sage Metering will not accept delivery of equipment that has been contaminated without written evidence of decontamination, and has instituted the following Return/Repair conditions. Strict adherence to these conditions is required. Returned equipment that does not conform to the requirements listed below will not be processed. If Sage Metering finds evidence of contamination, we may, at our option, have the unit returned at your expense. For your reference, the requirements for packaging and labeling hazardous substances are listed in DOT regulations 49 CFR 172, 178, and 179.

1. The equipment must be completely cleaned and decontaminated prior to shipment to Sage Metering. This decontamination includes the sensor, probe, electronics and enclosures internally and externally. All packaging must be clean and free from contamination.
2. A Material Safety Data Sheet (MSDS) is required for all process fluids and gases that have been in contact with the equipment. This includes fluids or gases used in cleaning the equipment. A Decontamination Statement is also required for each meter returned using a different gas or fluid. Both the MSDS and the Decontamination Statement are to be attached to the OUTSIDE of the shipping container. If both documents are not attached, you will be called, and the equipment sent back to you at your expense.
3. The decontamination Statement must include the following required information
   - A. A list of all chemicals and process fluids used in the equipment, including decontamination fluids or gases.
   - B. The model and serial number of the equipment being returned.
   - C. A company officer or other authorized person's signature on the statement.

Return Shipping Address:

Sage Metering, Inc.
8 Harris Court, Building D1
Monterey, CA 93940

RETURN MATERIAL AUTHORIZATION

RMA # ______________________

RETURN CUSTOMER INFORMATION

Customer's Name ______________________ Fax # ______________________

Customer's Contact Name ______________________ Phone # ______________________

Email Address ______________________

CUSTOMER'S RETURN ADDRESS

Bill to: ______________________ Ship to: ______________________

RETURN PRODUCT INFORMATION

Model No. ______________________ Serial No(s). ______________________

TEMP: MIN ____________ NORMAL ____________ MAX ____________

PRESSURE: MIN ____________ NORMAL ____________ MAX ____________

GAS ______________________

REASON FOR RETURN / DESCRIPTION OF SYMPTOMS

(All non-warranty repairs could be subject to a minimum evaluation charge)

Recommended steps to be used to duplicate problem/symptoms ______________________

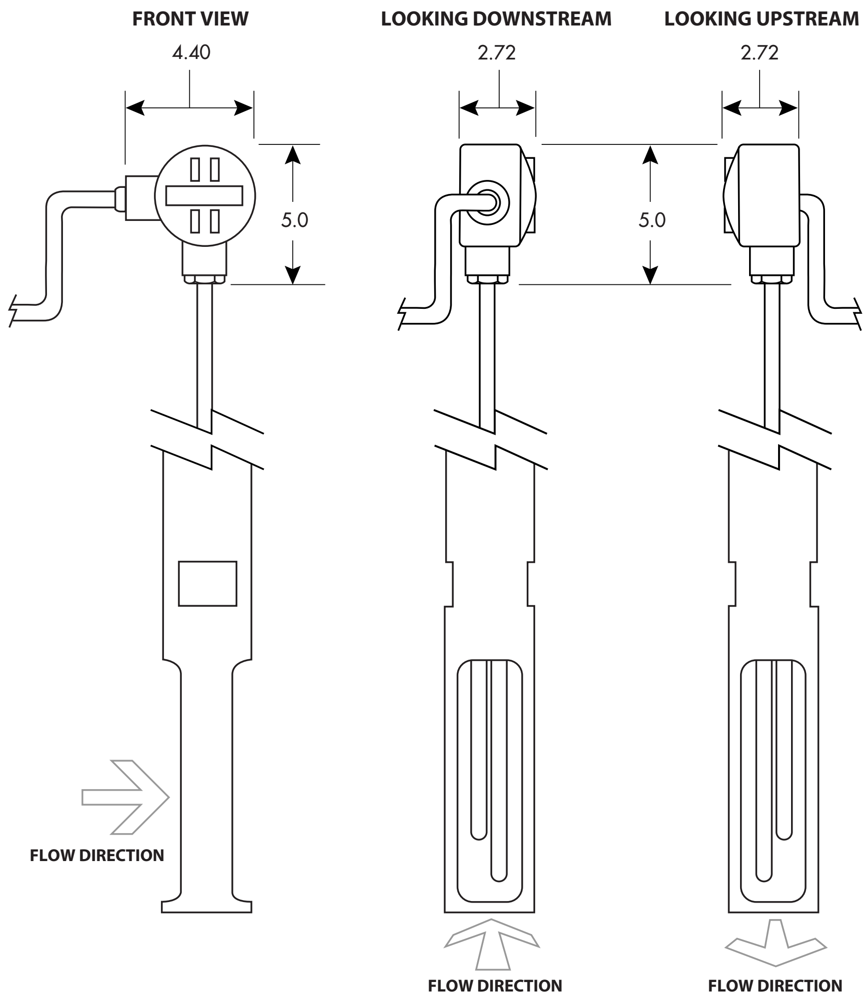
Sage Metering Technical Contact ______________________

SAGE METERING, INC.
8 Harris Court, Building D-1 / Monterey, California 93940
PHONE: 831-242-2030 / FAX: 831-655-4965

Section F

APPENDIX

J-Box and Upstream Orientation



What is a Thermal Mass Flow Meter?

- What is a Thermal Mass Flow Meter? It is a meter that directly measures the gas mass flow based on the principle of conductive and convective heat transfer.

- All Meters have probes (Insertion Style) or Flow Bodies (In-Line Style) that support a pair of sensors, which are in contact with the gas.

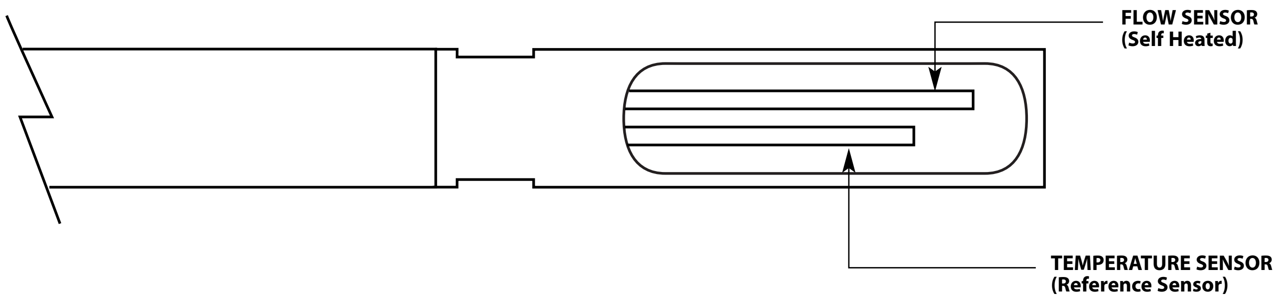
- The sensors are RTDs, which are resistance temperature detectors. They consist of highly stable reference-grade platinum windings. In fact, we use the same material that is used as Platinum Resistance Standards at the NIST.

- The RTDs are clad in a protective 316 SS sheath for industrial environments.

- One of the RTDs [See Diagram below] is self-heated by the circuitry and serves as the flow sensor. The other RTD acts as a reference sensor, and measures the gas temperature. Essentially it is used for temperature compensation.

- The Sage proprietary sensor drive circuitry maintains a constant overheat between the flow sensor and the reference sensor. As gas flows by the heated sensor (flow sensor), the molecules of flowing gas carry heat away from this sensor, and the sensor cools down as it loses energy. The circuit equilibrium is disturbed, and momentarily the temperature difference between the heated sensor and the reference sensor has changed. The circuit will automatically (within 1 second) replace this lost energy by heating up the flow sensor so the overheat temperature is restored.

- The current required to maintain this overheat represents the mass flow signal. There is no need for external temperature or pressure devices.



Continental Control Systems LLC

Pulse Output WattNode®

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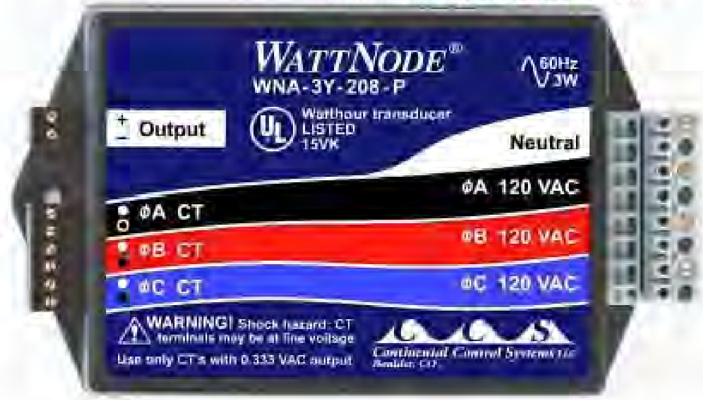
*Compact,
Low-Cost
kWh
Transducer/Submeter
True RMS*



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The Pulse Output WattNode® is a true RMS AC watt-hour transducer with pulse output (solid state relay closure) proportional to kWh consumed. The WattNode provides accurate measurement at low cost to meet your needs for sub-metering, energy management, and performance contracting applications.

Easy installation saves you time and money. The WattNode is small enough to fit entirely within a standard electrical panel and the screw terminals unplug for easy wiring.

The complete Pulse Output family measures 1, 2, or 3 phases in 2, 3, or 4 wire configurations. With voltage ratings from 120 to 600 VAC and current transformer (CT) ratings from 5 to 3000 amps, there is a WattNode combination to meet your AC power measurement requirements.

Accuracy of the WattNode is 0.5% of reading over a wide range of power factor and harmonic content. The WattNode measures true RMS power even with leading or lagging power factor and chopped or distorted waveforms. This makes the WattNode ideas for monitoring motors and pumps controlled by variable speed drives.

To assure reliability and accuracy, each WattNode is tested and calibrated by a custom, automated production system. A key part of the production system is a NIST traceable, precision voltage source that establishes the high accuracy associated with the WattNode. To assure the initial calibration accuracy is maintained, the WattNode has been designed with fixed, precision resistors, not potentiometers, in its measurement circuit.

Our safe CTs, with integral burden resistors, produce a voltage proportional to the load current. At rated current the voltage is only 0.333 VAC. Split core CTs quickly install on existing wiring and solid core CTs can prevent tampering. Bus bar CTs are available in a variety of standard sizes, plus custom designs up to 10" x 10" (254mm x 254mm) and 4000A.

The optional LCD module remotely displays energy in WH, kWh, or MWH; or power in W or kW. To protect the kWh total you can disable the front panel reset button and use a wired remote reset. The eight digit panel mount display runs for four years on a single replaceable battery.

- **Pulse output** - Compatible with energy management systems and data loggers.
- **Small size** - Can be installed in existing service panels or junction boxes.
- **Uses safe CTs** - Integral burden resistor limits the output to low voltage.
- **Line powered** - No external supply required.
- **Detachable terminal blocks** - Easy to install and remove.

- **UL Listed** - Designed and tested for safety.

SPECIFICATIONS

Measurement Configurations

- Single phase: 2 or 3 wire
- Three phase: 4 wire
- Three phase: 3 wire

Electrical

- Line powered
- FCC Class A
- Operating Voltage Range: ±20% of nominal
- Power Line Frequency: 50 or 60 Hz
- CT Input: 0 - 0.5 VAC operating, 3 VAC maximum

Pulse Output

- Square-Wave output: 50% duty cycle
- Optoisolator (phototransistor) output handles up to 50 mA at 3-35 VDC
- Fully isolated to withstand 2500 volts

Frequencies at Full Scale Power

WattNode Model	Frequency
WNA-1P-240-P	2.667 Hz
WNA-3Y-xxx-P	4.000 Hz
WNA-3D-xxx-P	2.667 Hz

Higher output frequencies are available. Call for more information.

TTL Output Option

- 0 - 5 volt TTL square-wave output - short circuit protected
- Fully isolated to withstand 1500 volts
- Specify with '-TTL' at end of model number

Accuracy

- 0.45% of reading + 0.05% of full scale through 25th harmonic

Environmental

- Operating Temperature: -30° to 60°C
- Humidity: Up to 90% RH (non-condensing)

Mechanical

Click on the image for a larger view.

- Enclosure: High impact, UL rated, ABS plastic
- Size: 143mm x 85mm x 32mm (5.63" x 3.34" x 1.25")
- Connectors: Euroblock style detachable screw terminals
  - Green: 12 - 22 AWG, 600 V
  - Black: 16 - 26 AWG, 300 V

Optional LCD Display

- Display: Eight digits, each 0.43" high
- Units: Power in W or kW, Energy in WH, kWh or MWH
- Reset: Remote wire and configurable front panel button
- Enclosure: Panel mount box, 75mm x 40mm x 38.5mm (2.95" x 1.57" x 1.52")

- Battery: Lithium 2/3 A, replace every four years
- Backlit versions available
- See our **LCD Display Page**.

Models and Pricing

Price List

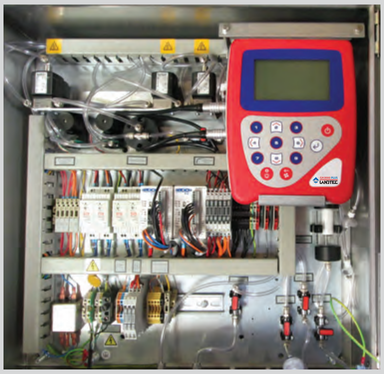
List prices for 1 piece quantities. Call for pricing on larger quantities. Effective January 1, 2009.

Model	VAC Phase to Neutral	VAC Phase to Phase	Phases	Wires	Price
WNA-1P-240-P	120	240	1	2 or 3	$170
WNA-3Y-208-P	120	208-240	3	4	$195
WNA-3Y-400-P	230	400	3	4	$195
WNA-3Y-480-P	277	480	3	4	$195
WNA-3Y-600-P	347	600	3	4	$210
WNA-3D-240-P	N/A	208-240	3	3	$195
WNA-3D-480-P	N/A	480	3	3	$210

The delta models, WNA-3D-xxx-P, are used only when neutral is not present.

Datasheet, Manuals and Application Notes

- Download a **datasheet** (PDF)
- Download or view the Manual: **PulseWnManual.pdf**
- See a list of **Application Notes**
- View scale factor tables **Pulses per kilowatt-hour** and **Watt-hours per pulse**.



GA3000 PLUS

FIXED GAS ANALYZER

Features

- CH_4, CO_2, O_2 measurement
- Multiple H_2S ranges
- Modbus communication
- 4-20mA outputs for each gas
- Alarm relays (user configurable)
- User replaceable H_2S sensor
- IP54 rated weather-proof enclosure

Key Benefits

- Limited training required
- Low cost of ownership
- Calibration accredited to ISO 17025
- Quick and easy installation
- Compact, self-contained system
- Gas conditioning included as standard
- Zero service downtime – "Hot Swap" capability
- Field-proven, industry-standard equipment
- Simple user calibration

Technical Specifications

General Specifications

Number of Sampling Points	1-3
Gasses To Be Monitored	CH_4, CO_2, O_2, $H2_S$ (optional)
Reading Intervals	Continuous For CH_4, CO_2, & O_2 Configurable For H_2S Operating
Operating Temperature Range	32°F to 122°F

Gas Ranges

Gases Measured	CH_4 & CO_2	By dual wavelength infrared cell with reference channel			
	O_2	By internal electrochemical cell			
	H_2S	By internal electrochemical cell			
Ranges	CH_4	0 - 70% to specification, 0 - 100% reading			
	CO_2	0 - 60% to specification, 0 - 100% reading			
	O_2	0 - 25%			
	H_2S	0 - 50ppm, 0-200ppm, 0-500ppm, 0-5000ppm			
Typical Accuracy	Gas	0-5% vol	5-15% vol	15%-FS	FS
	CH_4	± 0.5% (vol)	± 1.0% (vol)	± 2.0% (vol)	70%
	CO_2	± 0.5% (vol)	± 1.0% (vol)	± 2.0% (vol)	60%
	O_2	± 1.0% (vol)	± 1.0% (vol)	± 1.0% (vol)	25%
	H_2S	0-50ppm	± 1.5% FS		
	H_2S	0-200ppm	± 1.5% FS		
	H_2S	0-500ppm	± 2.0% FS		
	H_2S	0-5000ppm	± 100ppm or ±5% of reading (if greater)		
Response Time, T90	CH_4	≤20 seconds	H2S (0-50ppm)	≤30 seconds	
	CO_2	≤20 seconds	H2S (0-200ppm)	≤35 seconds	
	O_2	≤20 seconds	H2S (0-500ppm)	≤35 seconds	
			H2S (0-5000ppm)	≤40 seconds	
Oxygen Cell Lifetime	Approximately 3 years in air				
H_2S Cell Lifetime	Approximately 2 years in air				

Power

Power Supply	110 - 230 VAC 50/60 Hz
Consumption	0.1 A ± 5%
Instrument Backup Memory	Lithium Manganese Backup Battery For Memory Retention

Pump

Flow	300 ml/min typically
Flow-Fail Point	-100 in. H_2O Vacuum
Maximum Vacuum Restart	-100 in. H_2O

Communications

Output Channels	Up to four 4-20mA output channels plus Modbus digital output
Alarm Notifications	2 user-definable alarms can be triggered when above or below a set value, recovery values can also be defined. (Alarm option only available on single sample systems)
Relay Outputs	Single pole changeover 6A 250V relay volt free.

Physical

Weight	80 lbs
Size	25" x 24" x 8"
Enclosure	Painted Steel 600 x 600 x 210, IP54

Associations

SWANA MEMBER

ISWA International Solid Waste Association

The Climate Registry

American biogas Council MEMBER

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