MEASUREMENT AND VERIFICATION PLAN

FOR

DG/CHP SYSTEM
AT
BETH ISRAEL KINGS HIGHWAY DIVISION
ECOSYSTEM ENERGY

As Built December 21, 2012

Submitted to:

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

Submitted by:

CDH Energy Corp.
PO Box 641
2695 Bingley Rd
Cazenovia, NY 13035
(315) 655-1063
www.cdhenergy.com

Project Team:

NYSERDA Project Manager:

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518-862-1090 ext 3492

Applicant:

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Beth Israel Medical Center
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New York, NY 10019

Developer:

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New York, NY 10119
Tel (212) 786-7613
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NYSERDA QC Contractor:

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Modern Energy Technologies (as sub-contractor to CDH Energy)
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john@modernenergyllc.com

NYSERDA M&V Contractor:

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PO Box 641
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1. Introduction

Ecosystem is in the process of installing a combined heat and power (CHP) system at the Beth Israel Kings Highway Hospital in Brooklyn, NY. The proposed CHP system based on a Mann natural gas fueled reciprocating engine-generator set having an electrical rating of 250 kW. The site's electric demand is sufficient to keep the system operating at or near its rated capacity on a continuous basis. Heat would be recovered as hot water from both the engine jacket and exhaust at a supply temperature of 195°F. A heat exchanger will separate the engine coolant from the boiler return loop. Under design conditions the return water temperature would increase from 159 to 190°F at a flow rate of 87 GPM yielding a peak recovery rate of over 1.3 MMBtu/h. Any excess heat that is produced will be rejected through an external radiator. The CHP system is expected to operate at an annual efficiency of 79% (LHV) and achieve a 95% or better availability. It is intended the CHP system be installed in a weatherized container located on the roof of one of the site's buildings.

Peak operation of the CHP system will result in the following performance:

Gross electrical output:	250 kW
Parasitic electrical input (estimated):	-10 kW
Hot water output at 195°F:	1.3 MMBtu/h
Fuel input:	2.43 MMBtu/h LHV

Annually the system is anticipated to displace 2,021,860 kWh and displace 118,530 therms of gas through heat recovery. Annual fuel consumption is 224,180 therms.

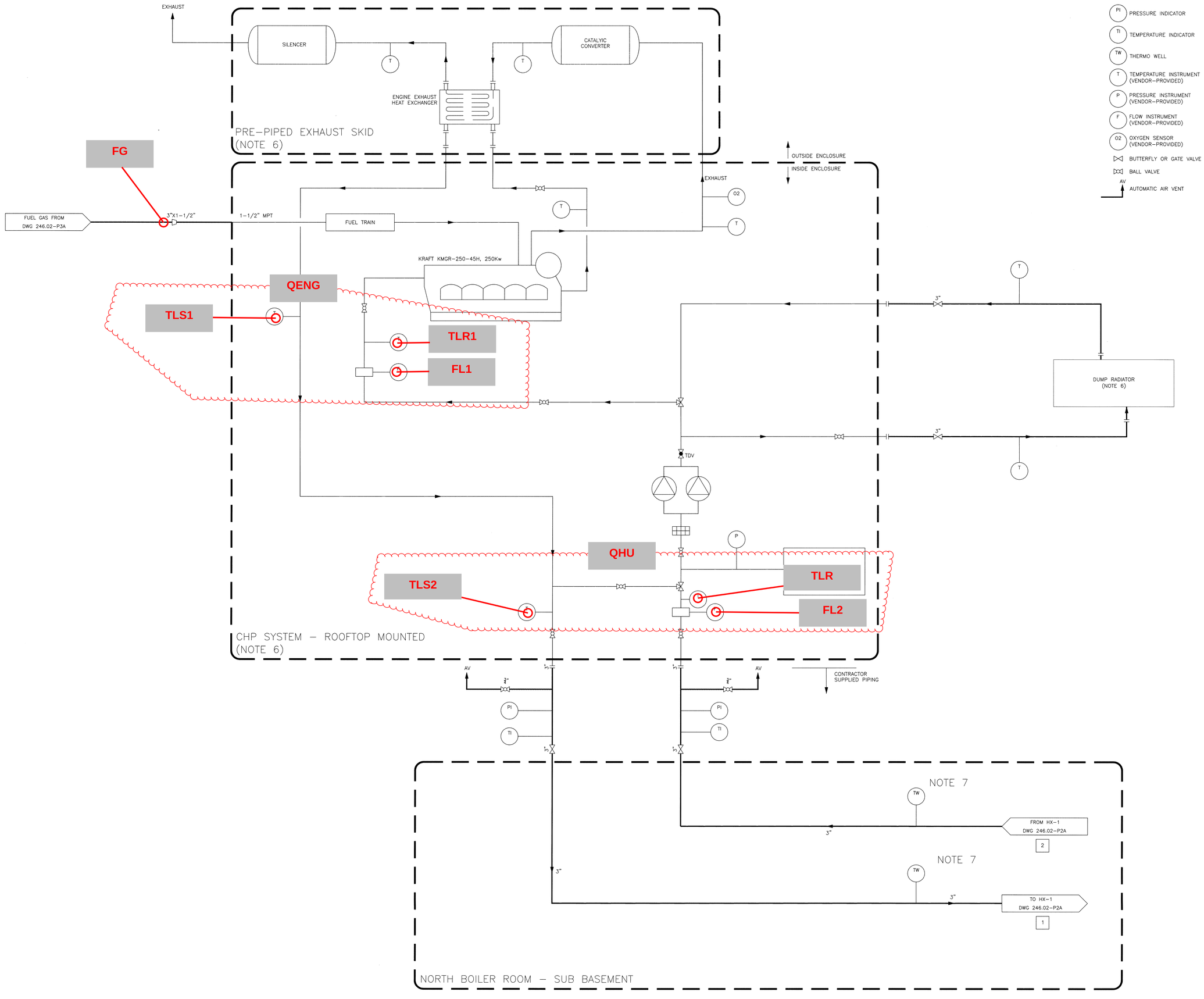
2. Instrumentation

In order to quantify the performance of the proposed CHP system, the CHP system fuel input, net electrical output, and useful thermal output must be measured. To capture these energy flows, an instrumentation plan was developed by CDH Energy and presented to the applicant, Ecosystem. The instrumentation plan covers the location and type of sensors necessary to provide the appropriate measurements of the energy flows of the system.

In accordance to the instrumentation plan, Ecosystem will supply the instrumentation listed Table 1 below for use in meeting the NYSERDA CHP program monitoring requirements.

Table 1. Instrumentation Supplied By Ecosystem & Kraft Power for CHP Analysis

Data Point	Description	Units	Sensor	Signal Type	Primary Signal Type
WGgross	Generator #1 Electrical Output (Gross)	kW/kWh	CompAP InteliSys RTU	Modbus RTU	Modbus RTU
WPAR	Parasitic Load Electrical Consumption - Panel PPH	kWh	OSI/Flexcore GH-008E with 100:5 A secondary CTs	Modbus RTU	Pulse (20 Wh/pulse)
FG	Combined Generator Fuel Input	CF	Utility Pulse Meter	Modbus RTU	Pulse
QENG	Total Engine Heat Ouptut	Mbtu	Data Industrial Model 340	Modbus RTU	Pulse (1e5 Btu/pulse)
FL1	Primary Glycol Loop Flow Rate	GPM	Data Industrial Series 228	Modbus RTU	Frequency
TLS1	Primary Glycol Loop Supply Temperature	deg F	10k Type II Thermistor	Modbus RTU	Resistance
TLR1	Primary Glycol Loop Return Temperature Dowstream of Dump Radiator	deg F	10k Type II Thermistor	Modbus RTU	Resistance
QHU	Total Useful Heat Recovery	Mbtu	Data Industrial Model 340	Modbus RTU	Pulse (1e5 Btu/pulse)
FL2	Secondary Glycol Loop	GPM	Data Industrial Series 228	Modbus RTU	Frequency
TLS2	Secondary Glycol Loop Supply Temperature (To Building)	deg F	10k Type II Thermistor	Modbus RTU	Resistance
TLR2	Secondary Glycol Loop Return Temperature (From Building)	deg F	10k Type II Thermistor	Modbus RTU	Resistance
WT	Total Facility Energy / Power	kW/kWh	CompAP InteliSys RTU	Modbus RTU	Modbus RTU
TAO	Ambient Temperature	deg F	10k Type II Thermistor	Modbus RTU	Resistance



NOTES:

1. CONTRACTOR SHALL PROVIDE DRAINS AND VENTS AT ALL LOW AND HIGH POINTS, RESPECTIVELY FOR TESTING, STARTUP AND COMMISSIONING. ALL DRAINS AND VENTS SHALL BE VALVED AND CAPPED IN ACCORDANCE WITH PIPE SPECIFICATION.
2. CONTRACTOR SHALL PROVIDE ISOLATION VALVES FOR ALL INSTRUMENT PRESSURE TAPS. ISOLATION VALVES SHALL CONFORM TO PIPE SPECIFICATION.
3. CONTRACTOR SHALL ENSURE ALL VALVES, INSTRUMENTS AND EQUIPMENT ARE ACCESSIBLE FOR MAINTENANCE.
4. SEE DRAWING 246.02-M400A FOR MECHANICAL EQUIPMENT SCHEDULE.
5. SEE SECTIONS 232114,230523 AND 230519 FOR HYDRONIC PIPING, VALVE AND INSTRUMENT SPECIFICATIONS.
6. PROVIDED BY KRAFT ENERGY SYSTEM, INSTALLED BY CONTRACTOR.
7. PROVIDED BY OTHERS, INSTALLED BY CONTRACTOR.

DWG. No. REV. BY DATE	DESCRIPTION	CHECKED BY PROJECT MANAGER LEAD ENGINEER
1 MTH 8/1/11	ISSUED FOR CONSTRUCTION	

WALDRON
ENGINEERING OF NEW YORK, P.C.
NEW YORK, N.Y.
www.waldron.com

	NAME	DATE
DRAWN BY	MTH	2/28/2011

CAD FILE NAME: 246.02-P1A.DWG

W.E&C DRAWING No.: 246.02-P1A-1

CLIENT
ecosystem
11 Penn Plaza, Fifth Floor
New York,NY 10001

DRAWING TITLE
Beth Israel Medical Center
Kings Highway Division

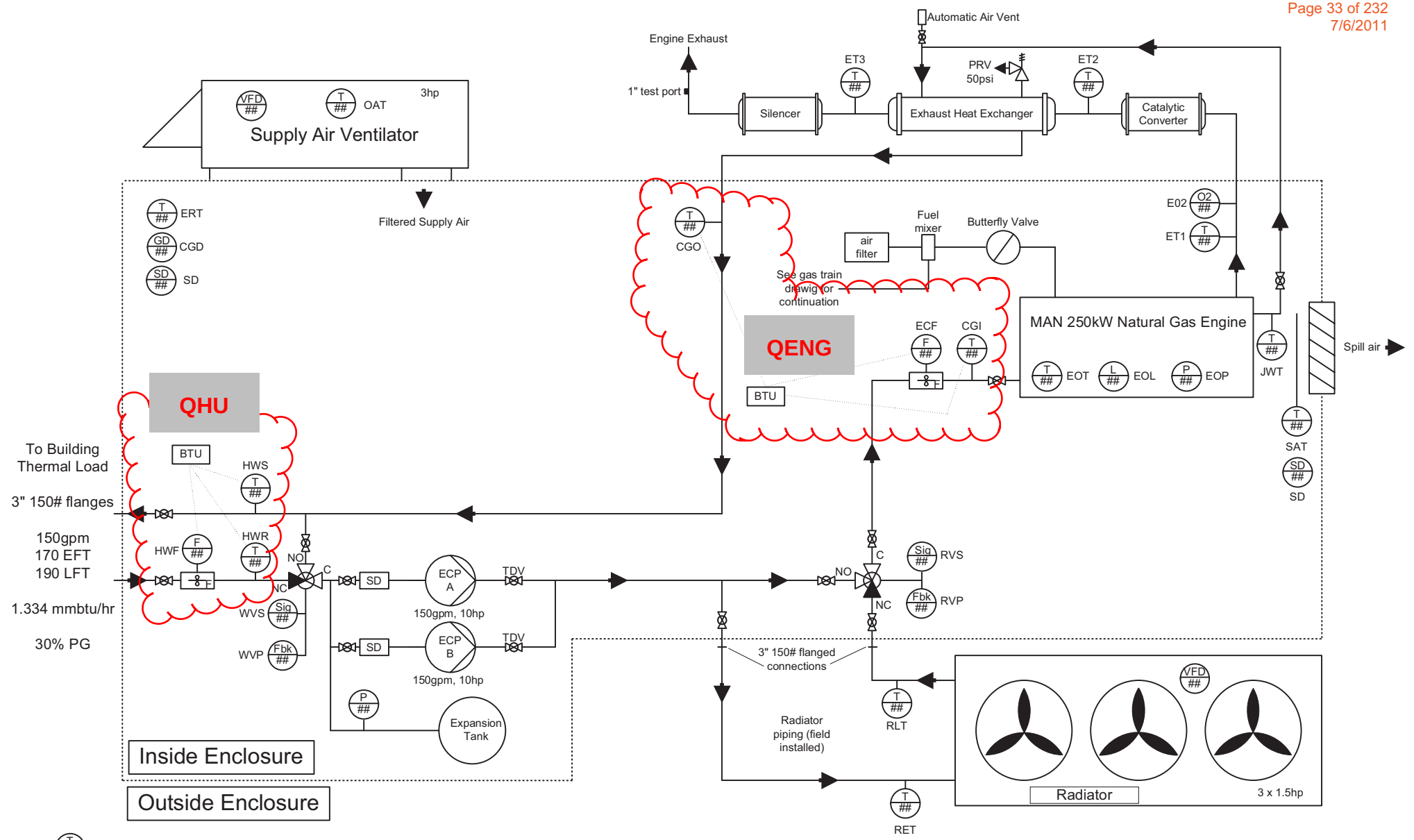
ENERGY CONSERVATION PROJECT

CHP SYSTEM DIAGRAM

SEAL: STATE OF NEW YORK, RICHARD D. LETOURNEAU, 78619, LICENSED PROFESSIONAL ENGINEER
SIGNATURE
DATE

DWG No. M-001.00

SHEET No. 1 OF 1



T ## Temperature
P ## Pressure
F ## Flow
CG ## Combustible Gas
L ## Level
VFD ## Variable Frequency Drive
O2 ## Oxygen Sensor
SD ## Smoke Detector

CHP P&ID

250kW Induction CHP System

Kraft Energy Systems
37-C North Grand Blvd
Brentwood, NY 11717
phone 631-650-0228 fax 631-389-2466
e-mail sbellone@kraftpower.com

Job Name/Number
Beth Israel Medical Center

REV 2
29 JUN 2011

PI PRESSURE INDICATOR

PS PRESSURE SWITCH

TI TEMPERATURE INDICATOR

LUBRICATED PLUG VALVE

CHECK VALVE

STRAINER

NOTES:

1. CONTRACTOR SHALL PROVIDE ¾" DRAINS AND VENTS AT ALL LOW AND HIGH POINTS RESPECTIVELY FOR TESTING, STARTUP AND COMMISSIONING. ALL DRAINS AND VENTS SHALL BE VALVED AND CAPPED IN ACCORDANCE WITH APPLICABLE PIPE SPECIFICATION.
2. CONTRACTOR SHALL PROVIDE ½" ISOLATION VALVES FOR ALL INSTRUMENT PRESSURE TAPS. ISOLATION VALVES SHALL CONFORM TO APPLICABLE PIPE SPECIFICATION.
3. CONTRACTOR SHALL ENSURE ALL VALVES, INSTRUMENTS AND EQUIPMENT ARE ACCESSIBLE FOR MAINTENANCE.
4. ALL GAS PIPING AND COMPONENTS SHALL BE INSTALLED IN STRICT ACCORDANCE WITH THE NEW YORK CITY FUEL GAS CODE (LATEST EDITION).

TO COGEN UNIT
13" WC FUEL GAS
TO DWG 246.02-P1A

PI TI 3" 3/4" 3"

ROOF

3"

3RD FLOOR

2ND FLOOR

1ST FLOOR

BASEMENT

METERING ROOM

CUT AND CAP PIPING TO EXISTING BOILER PILOTS

1 1/4" 1 1/4" X 3/4" 3/4" X 1"

EXISTING PILOT GAS METER

Utility Gas Meter Outside at Ground Level

FG

NATIONAL GRID GAS SERVICE

MINIMUM GUARANTEED PRESSURE = 4" WG

CONNECT TO EXISTING 4" GAS SERVICE

NEW GAS METER COORDINATE WITH NATIONAL GRID

4"

PS

4" 4" X 3" 4" X 2" 2" 1-1/2" X 2"

EXISTING ROOTS METER #5236634

4 X 3 3 X 4

NORTH BOILER ROOM

One time power reading on gas booster

PI PI P-002

P-001 EXISTING GAS BOOSTER

CONNECT TO EXISTING 4" GAS LINE

EXISTING BOILERS TO BE REMOVED BY OTHERS

B1 3.35 MMBTU/HR INPUT

B2 3.35 MMBTU/HR INPUT

B-1 2.3 MMBTU/HR INPUT

B-2 2.3 MMBTU/HR INPUT

B-3 2.3 MMBTU/HR INPUT

HB-1 0.63 MMBTU/HR INPUT

SUB-BASEMENT

REV. No.	REV. BY	DATE	DESCRIPTION	CHECKED BY
1	MTH	8/1/11	ISSUED FOR CONSTRUCTION	PROJECT MANAGER / LEAD ENGINEER

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	NAME	DATE
DRAWN BY	MTH	2/28/2011

CAD FILE NAME
246.02-P3A.DWG

W.E&C DRAWING No.
246.02-P3A-1

CLIENT
ecosystem
11 Penn Plaza, Fifth Floor
New York,NY 10001

DRAWING TITLE
Beth Israel Medical Center
Kings Highway Division

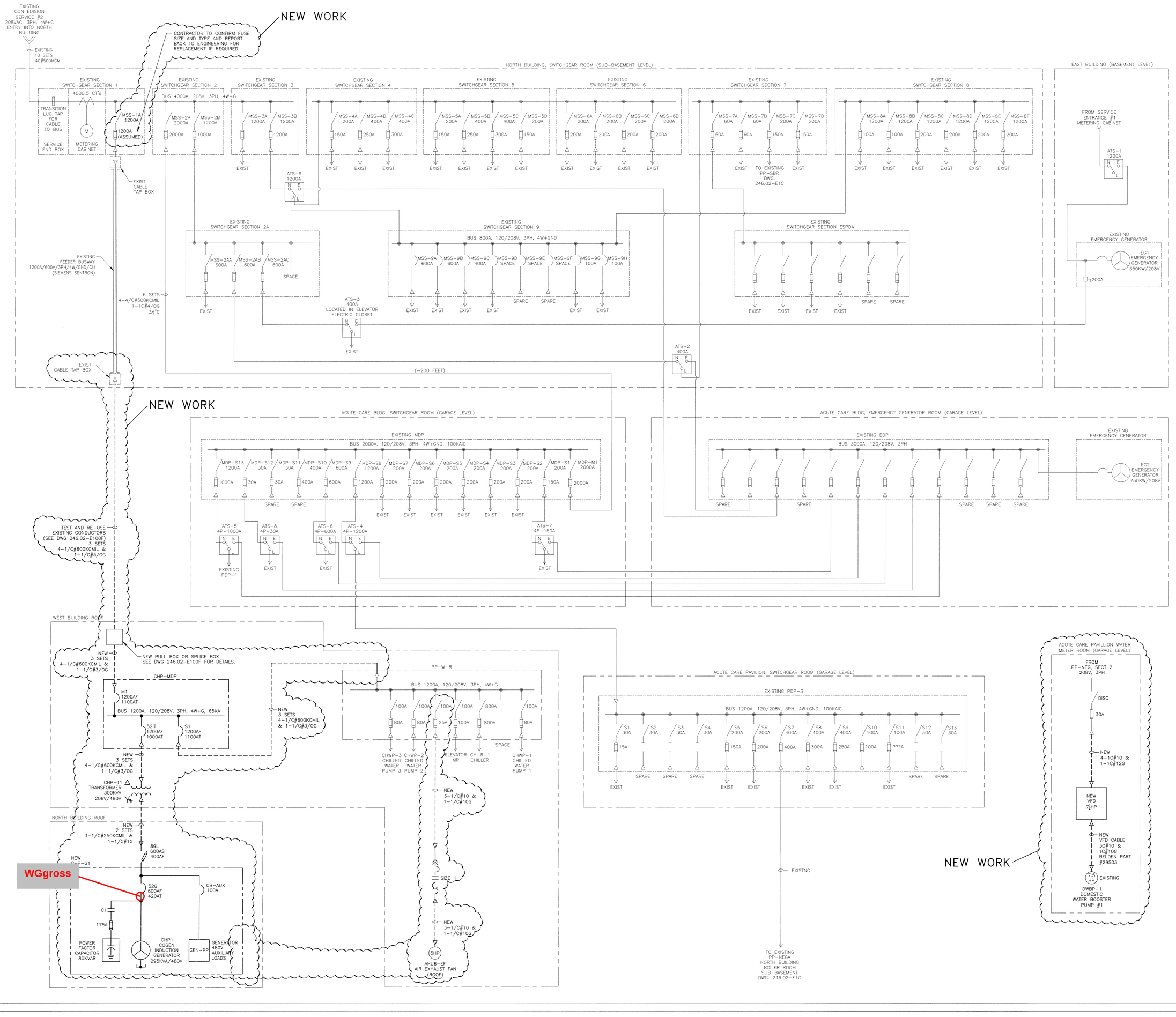
ENERGY CONSERVATION PROJECT

GAS RISER DIAGRAM

SEAL
STATE OF NEW YORK
MARC O LETOURNEAU
76519
LICENSED PROFESSIONAL ENGINEER
SIGNATURE DATE

DWG No.
M-003.00

SHEET No.
1 OF 1



GENERAL NOTES

1. THIS DRAWING BASED ON EXISTING CONDITIONS DRAWINGS PROVIDED BY CLIENT. SEE REFERENCE DRAWINGS BELOW.

2. FOR ORIGINAL MDP (NORMAL) PANEL SCHEDULE SEE DWG NO. NE-200 BY NORTHGATE ELECTRIC CORPORATION DATED 7-30-01.

3. THIS INSTALL IS IN ACCORDANCE WITH CON ED APPLICATION AND DESIGN MANUAL No. 4, SECTION EO-2115, REVISION 8, DRAWING NUMBER 2 (LOW TENSION INDUCTION GENERATORS - ALTERNATE ARRANGEMENT)

4. FOR ADDITIONAL NOTES SEE ELECTRICAL DRAWING 246.02-E0A AND MECHANICAL DRAWING 246.02-M100A.

REFERENCE DRAWINGS

1. FOR ELECTRICAL SEE DWG 246.02-E0A.

2. FOR MECHANICAL SEE DWG 246.02-M100A.

CLIENT REFERENCE DRAWINGS

1. BETH ISRAEL DRAWING "EXISTING SINGLE LINE ELECTRICAL DISTRIBUTION RISER", DWG. NO. E-5, DATED 3-6-97 (BY JANSEN & ROGAN CONSULTING ENGINEERS).

2. BETH ISRAEL DRAWING "ONE LINE DIAGRAM AS-BUILT", DWG. NO. NE-500, DATED 7-30-01 (NORTHGATE ELECTRIC CORPORATION).

3. BETH ISRAEL DRAWING, "SINGLE LINE DIAGRAM EMERGENCY POWER SERVICE UPGRADE, NORTH AND EAST BUILDINGS", DWG. NO. SLD, DATED 7-13-2004 (BY POWER SYSTEMS SOLUTIONS).

REV. No.	REV. BY	DATE	DESCRIPTION	CHECKED BY PROJECT MANAGER	LEAD ENGINEER
1	JBC	8/1/11	ISSUED FOR CONSTRUCTION		

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NEW YORK, N.Y.
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	NAME	DATE
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CAD FILE NAME: 246.02-E1A-1.dwg

W.E&C DRAWING No.: 246.02-E1A-1

CLIENT
ecosystem
11 Penn Plaza, Fifth Floor
New York,NY 10001

DRAWING TITLE
Beth Israel Medical Center
Kings Highway Division

ENERGY CONSERVATION PROJECT

POWER ONE LINE DIAGRAM
NORTH & ACUTE CARE BLDGS

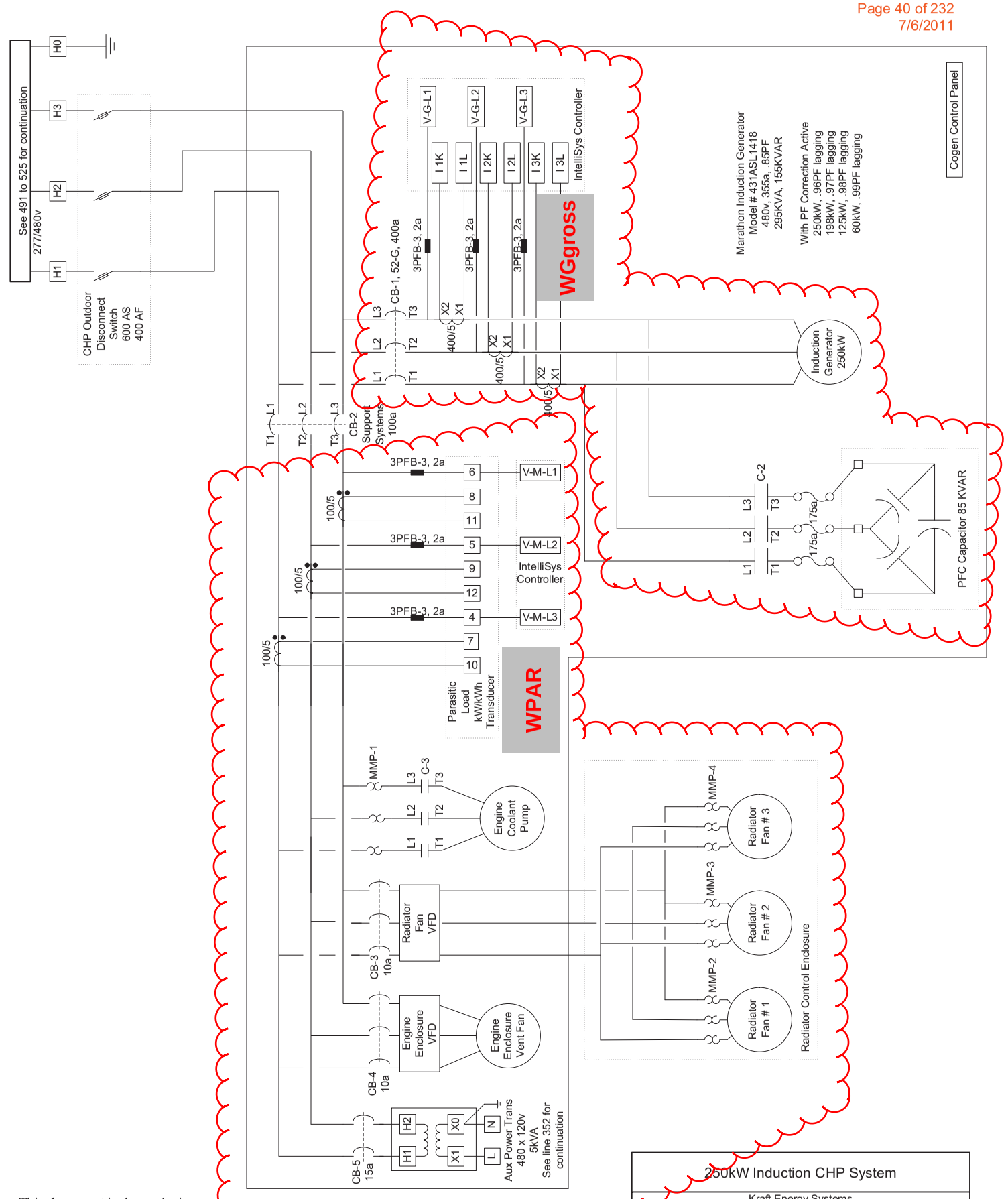
SEAL

SIGNATURE

DATE

DWG No.: E-103.00

SHEET No.: 1 OF 1



Main Electric Service
3 Line, Part B

250kW Induction CHP System

Kraft Energy Systems
37-C North Grand Blvd
Brentwood, NY 11717
phone 631-650-0228 fax 631-389-2466
e-mail sbellone@kraftpower.com

Job Name/Number
Beth Israel Medical Center

REV 2
29 JUN 2011

Readings for the installed instrumentation will be recorded by an Obvius Acqusuite data logger provided and installed by CDH Energy. All sensors are polled once per second by the engine controller RTU. The same data are made available to the data logger using a MODBUS RTU data stream using an RS-485 connection. The data logger will sample all sensors approximately once per second and record one-minute totals (of pulse or digital sensors) or averages (of analog sensors). The one minute readings of heat recovery temperatures and flows will be used to provide an accurate calculation of heat transfer on the heat recovery loops. In addition, the integrated heat transfer totals from the two BTU meters are available for comparison to computation from the fundamental temperature and flow readings.

Based on the number of monitored data points (20), the logger will have sufficient memory to store 30-days of data if communications with the logger are interrupted. The data will be downloaded from the datalogger once per day via an internet connection provided by the site/applicant. The data will loaded into a database, checked for validity, and posted on the NYSERDA web site.

In addition to the data points identified for energy analysis and CHP system performance calculation, several diagnostic data points are also collected off the PLC. Table 2 displays the full data stream collected from the engine controller PLC.

Table 2. Full Data Point List Collected from PLC – Including Diagnostic Points

No.	CDH Data Point	CDH Description	Units	Modbus Register #	Modbus Register Name	Data Type	Multiplier	Data Label on Submital PID Drawing
1	FL1	Primary Glycol Loop Flow Rate	GPM	40018	Eng Cool Flow	INT16	1	ECF
2	FL2	Secondary Glycol Loop Flow (Building Loop)	GPM	40019	ThermLoadFlow	INT16	1	HWF
3	WPAR_kW	Parasitic Load Power Consumption	kW	40024	Parasitic Load	INT16	1	n/a
4	TLR1	Primary Glycol Loop Return Temperature Dowstream of Dump Radiator	deg F	40025	CHP Inlet Temp	INT16	0.1	CGI
5	TJWS	Primary Glycol Loop Supply Temperature Leaving Jacket	deg F	40027	EngCoolTmp	INT16	0.1	JWT
6	TLS1	Primary Glycol Loop Supply Temperature	deg F	40028	CHP Out Tmp	INT16	0.1	CGO
7	WT_kW	Total Facility Utility Import Power	kW	40030	Utility Load	INT16	1	n/a
8	TLR2	Secondary Glycol Loop Return Temperature (From Building)	deg F	40032	HHW from Bldg	INT16	0.1	HWR
9	TLS2	Secondary Glycol Loop Supply Temperature (To Building)	deg F	40033	HHW to Bldg	INT16	0.1	HWS
10	VP_W	Valve Position Primary/Secondary Loop Mixing	%	40034	Warmup TCV Pos	INT16	1	WVP
11	VP_R	Valve Position Radiator Loop	%	40035	Rad TCV Pos	INT16	1	RVP
12	TRE	Radiator Entering Temperature	deg F	40036	Rad EWT	INT16	0.1	RET
13	TRL	Radiator Leaving Temperature	deg F	40037	Rad LWT	INT16	0.1	RLT
14	TAO	Ambient Temperature	deg F	40038	Outside Temp	INT16	0.1	OAT
15	WG_kW	Generator #1 Power Output (Gross)	kW	40264	Act Power	INT16	1	n/a
16	WG	Generator #1 Energy Output (Gross)	kWh	43578 (MSB) 43579 (LSB)	kWhours	INT32 (2-reg)	1	n/a
17	WPAR_kWh	Parasitic Load Energy Consumption	kWh	43712 (MSB) 43713 (LSB)	kWh consumed	UINT32 (2-reg)	0.01	n/a
18	QENG	Total Engine Heat Output	1e5 Btu	43714 (MSB) 43715 (LSB)	BTU Produced	UINT32 (2-reg)	0.00001	n/a
19	QU	Total Useful Heat Recovery	1e5 Btu	43716 (MSB) 43717 (LSB)	BTU Consumed	UINT32 (2-reg)	0.00001	n/a
20	FG	Combined Generator Fuel Input	CCF	43718 (MSB) 43719 (LSB)	Gas Consumed	UINT32 (2-reg)	1	n/a

Onsite Installation

Kraft Power has integrated the CDH Energy datalogger in the lower portion of the engine control cabinet. The engine control cabinet provides battery backed 24-VDC power for continuous logger operation.

Communications

The data logger will require a connection to the Internet. A dedicated internal static IP address has been provided by the facility, but the connection allows outbound traffic only. The logger can upload data every night to the CDH Energy servers, but we will not be able to access the logger for remote configuration purposes.

The logger has the following static IP address on the internal network at the hospital.

IP: 190.10.93.136
Netmask: 255.255.255.0
Gateway: 190.10.93.99
DNS #1: 192.168.254.3
DNS #2: 192.168.254.4

On Site Support

CDH Energy will interface with Kraft Power and Ecosystem for access to all areas necessary to complete the monitoring installation, as well as any return trips for verification of sensors or service to the monitoring system.

3. Data Analysis

The collected data will be used to determine the net power output of the system as well as the fuel conversion efficiency (FCE).

Table 3. Summary of Monitored Data Points Used for CHP Energy Balance and Analysis

Data Point	Description	Units
WGgross	Generator #1 Electrical Output (Gross)	kW/kWh
WPAR	Parasitic Load Electrical Consumption - Panel PPH	kWh
FG	Combined Generator Fuel Input	CF
QENG	Total Engine Heat Ouptut	Mbtu
FL1	Primary Glycol Loop Flow Rate	GPM
TLS1	Primary Glycol Loop Supply Temperature	deg F
TLR1	Primary Glycol Loop Return Temperature Dowstream of Dump Radiator	deg F
QHU	Total Useful Heat Recovery	Mbtu
FL2	Secondary Glycol Loop Flow (Building Loop)	GPM
TLS2	Secondary Glycol Loop Supply Temperature (To Building)	deg F
TLR2	Secondary Glycol Loop Return Temperature (From Building)	deg F
WT	Total Facility Energy / Power	kW/kWh
TAO	Ambient Temperature	deg F

Peak Demand or Peak kW

The peak electric output or demand for each power reading will be taken as the average kW in a fixed 15-minute interval (0:00, 0:15, 0:30, etc), or

$$\text{kW} = \sum_{15\text{min}} \frac{\text{kWh}}{\Delta t} = \sum_{15\text{min}} = \frac{\text{kWh per interval}}{0.25\,\text{h}}$$

Heat Recovery Rates

The heat recovery rates will be calculated offline based on the 1-minute data collected, and compared with the integrated heat transfer data provided by each BTU meter. The piping arrangement at this site results in measuring the total heat produced by the engine using one BTU meter, and the heat provided to the building using another BTU meter. The heat rejected by the dump radiator is calculated as the difference between the two meters.

The pulse output of the BTU meters is fairly coarse at 1,000,000 BTU/pulse. Therefore, heat transfer at heat BTU meter location will be calculated using the fundamental flow and temperature difference measurements also provided as part of the meter output stream.

The useful heat recovery (defined as heat transferred to the building loop) is calculated as:

Useful heat recovery (**QHU**) = K·Σ [FL2·(TLS2-TLR2)] / n

The total heat produced by the engine is calculated as:

Total heat produced (**QENG**) = K·Σ [FL1·(TLS1-TLR1)] / n

The total heat rejected by the dump radiator is calculated as:

Heat rejected by dump radiator (**QD**) = QENG – QHU

In addition to the heat transfer measurements, diagnostic data on the dump radiator entering and leaving temperatures, the radiator three-way mixing valve position, and radiator fan VSD speed are recorded.

The loop fluid is expected to be a glycol-water mixture. The factor K will be determined based on a periodic reading of the fluid properties with a refractometer to determine the glycol concentration. (K ~ 500 Btu/h-gpm-°F for pure water; ~480 for 20% glycol). 'n' is the number of scan intervals included in each recording interval (e.g., with 1 sec scans and 1-minute data, n=60).

Calculated Quantities

The net power output from the CHP system will be defined as the gross power from the engines minus the parasitic power. Note that for this particular site, WG represents the net power output from the engines, and therefore the measured parasitic power for the skid shall be subtracted at the time of calculation of the fuel conversion efficiency (FCE).

The fuel conversion efficiency of the CHP system, based on the lower heating value of the fuel, will be defined as:

$$FCE = \frac{QU + 3{,}413 \cdot (WG)}{0.9 \cdot HHV_{gas} \cdot FG}$$

where:
- QU - Useful heat recovery (Btu/h) (QHU)
- WG - Engine generator net output (kWh) (WGgross – WPAR)
- FG - Generator gas consumption (Std CF)
- HHV_{gas} - Higher heating value for natural gas (~1030 Btu per CF). Where 0.9 is the conversion factor between HHV and LHV

Only the net delivered power (WGgross - WPAR) is used in determining compliance with either the kWspc, kWp, or annual FCE of the project.

The FCE can be calculated for any time interval. When converting to daily, monthly, or annual values, the each value is summed and then the formula is applied:

$$FCE = \frac{\sum^{N} QU + 3{,}413 \cdot \sum^{N} (WG)}{0.9 \cdot HHV_{gas} \cdot \sum^{N} FG}$$

Where N is equal to the number of intervals in the period of interest.

Appendix A

Cut Sheets for Key Sensors and Instruments

Energy Information Made Obvius

PRODUCT DATASHEET

AcquiSuite - EMB

Data Acquisition Server

ACQUISUITE – EMB A8810

Obvius' AcquiSuite is an intelligent, flexible data acquisition server allowing users to collect energy data from meters and environmental sensors. Designed to connect to IP-based applications such as enterprise energy management, demand response and smart grid programs, the AcquiSuite server lets you connect thousands of energy points, benchmark energy usage and reduce energy costs.

EMBEDDED (OEM) SOLUTION

The compact EMB footprint and industrial temperature range (-30 to 70C) makes this a perfect solution for embedded applications. Reduce development time and speed up integration by collecting and distributing energy information directly from your equipment.

DATA COLLECTION

The AcquiSuite collects and logs data from connected (wired or wireless) devices based on user selected intervals. Data from downstream devices are time stamped and stored in non-volatile memory. This interval data is stored locally until the next scheduled upload or manual download. Using an Ethernet (LAN) connection you can push or pull data via HTTP, XML, FTP or any custom protocol utilizing our AcquiSuite Module to build your own application, including integrated cellular communication options.

INSTALLATION & FEATURES

No software is required. Easily access information through ANY web browser. There are several additional features including alarming, SNMP Traps, network configuration, wireless diagnostics, USB, security provisions and backlit LCD. Our integrated meter driver library is designed to speed up installation and lower integration costs through "plug-and-play" connectivity. Ask about our free commissioning software, Obvius Configuration Console (OCC).

COMPATIBILITY

The AcquiSuite is compatible with nearly any front-end software platform allowing customers to use a variety of reporting tools; whether it's a local server or an enterprise wide reporting suite. Obvius offers a free utility for automated .CSV file downloads or an affordable hosted solution for $195.00 annually (unlimited data storage).

PARTNERS

Obvius' outstanding integration and software partners supplement our products and services to ensure you receive the very best energy monitoring solution.

APPLICATIONS

- Measurement and verification (M&V)
- Reduce energy costs
- Access energy information from local or remote sites
- Benchmark building energy usage
- View "real time" performance data
- Track energy use and peak demand for Demand Response programs
- Monitor performance of critical systems (lighting, HVAC, PDUs, inverters, etc.)
- Alarm notification for data points above or below target levels (including SNMP Traps)
- Monitor renewable energy performance and production
- Push or pull meter data to energy dashboards, kiosks and software applications
- LEED / Energy Star certification

ABOUT OBVIUS

Obvius manufactures data acquisition and wireless connectivity products specifically for energy management. We deliver cost-effective, reliable hardware designed to speed up installation. Our products are based on an open architecture allowing our customers to collect and log energy information from virtually any meter or sensor. The ability to support multiple communication options provides remote access to all your energy information. Founded in 2003, Obvius is located in Hillsboro, Oregon. We serve a global clientele and continue to drive innovation by simplifying data collection.

SOLUTIONS

- Data Acquisition
- Wireless Communication
- Meters & Sensors
- Custom Packaged Solutions
- Integration & Software Partners

HEADQUARTERS

Hillsboro, Oregon

CONTACT US

sales@obvius.com

AcquiSuite A8810

Obvius helps customers collect and distribute energy information. Users can begin with one best-of-breed solution that solves a specific pain point, or incorporate several products and services that help reduce energy costs.

Specifications	
Processor	ARM9 embedded CPU
Operating System	Linux 2.6
Memory	32 MB RAM
Flash ROM	16 MB NOR Flash (expandable with USB memory device)
Interval Recording	1 to 60 minutes, user selectable (default 15 minutes)
LEDs	Ethernet, Modbus TX/RX, power, alarm
Console	2 x 16 LCD character, two push buttons
Power	
Power Supply	24VDC, 500mA
	*This unit is to be sourced by a Class 2 power supply with the following output: 24VDC, 500mA min not to exceed 8A
Isolation	RJ45 Ethernet and RS485 port are isolated to 1500VDC from the main board. (Power and USB non-isolated)
Communication	
Protocols	Modbus/RTU, Modbus/TCP, TCP/IP, PPP, HTTP/HTML, FTP, NTP, XML, SNMP-Trap
LAN	RJ45 10/100 Ethernet, full half duplex, auto polarity
USB	USB expansion port
Inputs	
Serial Port	RS-485 Modbus, supports up to 32 external devices (expandable)
Physical	
Weight	0.42lbs (0.19kg)
Size	4" x 4.25" x 2" (102mm x 108mm x 51mm)
Environment	
North America	-30 to 70C, 95% RH, non-condensing
Codes and Standards	
FCC CFR 47 Part 15, Class A, EN 61000, EN 61326, CE, UL61010 Recognized	
Additional Notes	
NEMA enclosures available upon request	
Manufactured in the USA	

Obvius
3300 NW 211th Terrace
Hillsboro, OR 97124

503 601 2099
866 204 8134 (USA only)
sales@obvius.com

Stride Industrial Ethernet Switches

5-Port Ethernet Switch - Plastic Case

STRIDE SlimLine Industrial Unmanaged Ethernet Switch, plastic case, -10 to +60 °C operating temperature range, five 10/100BaseT RJ45 Ethernet ports. Redundant power inputs with surge and spike protection, auto-crossover, DIN rail mounting. Supports Store and Forward wire speed switching and full-duplex with flow control. UL (cUL) listed and CE certified.

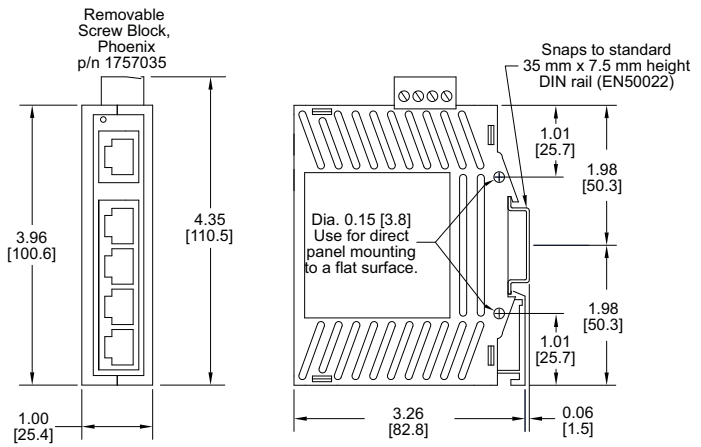
SE-SW5U

<--->

Dimensions

Inches [mm]

5 Port – SE-SW5U



ACT/LNK LED

This is the Yellow LED on models with a Yellow and a Green LED per RJ45 port.

ON (yellow) (not flashing)	Indicates that there is a proper Ethernet connection (Link) between the port and another Ethernet device, but no communications activity is detected.
ON (yellow) (flashing)	Indicates that there is a proper Ethernet connection (Link) between the port and another Ethernet device, and that there is communications activity.
OFF	Indicates that there is not a proper Ethernet connection (Link) between the port and another Ethernet device. Make sure the cable has been plugged securely into the ports at both ends.

Speed 10/100 LED

This is the Green LED on models with a Yellow and a Green LED per RJ45 port.

ON (green)	A 100 Mbps (100BaseT) connection is detected.
OFF	A 10 Mbps (10BaseT) connection is detected.

Specifications

The following are specifications relevant to the SE-SW5U 5-Port Ethernet Switch.

Input power (typical with all ports active at 100 Mbps)	2.0 W
Weight	4 oz (0.11 kg)
Power connector max. screw torque	5.0 lb-in (0.57 Nm)

Stride™ Industrial Ethernet Switches & Media Converters

General Specifications		
Ethernet switch type	Up to 9 ports	
Operating mode	Store and forward wire speed switching, non-blocking	
Devices supported	All IEEE 802.3 compliant devices are supported	
Standards	IEEE 802.3, 802.3u, 802.3x	
MAC addresses	1024 addresses	
Memory bandwidth	3.2 Gbps	
Latency for 10 Mbps ports	16 us + frame time (typical)	
Latency for 100 Mbps ports	5 us + frame time (typical)	
Power input	Redundant Input Terminals	
Input power (typical with all ports active at 100 Mbps)	SE-MC2U-ST SE-MC2U-SC SE-SW5U SE-SW5U-WT	2.0 W
	SE-SW5U-ST SE-SW5U-SC SE-SW5U-ST-WT SE-SW5U-SC-WT	3.0 W
	SE-SW8U SE-SW8U-WT	4.0 W
	SE-SW9U-ST SE-SW9U-SC SE-SW9U-ST-WT SE-SW9U-ST-WC	5.0 W
Input voltage	10-30 VDC (continuous) - Class 2 Power Supply	
Reverse power protection	Yes	
Transient protection	15,000 watts peak	
Spike protection	5,000 watts (10x for 10 uS)	
Ethernet isolation	1500 VRMS 1 minute	
Operating temperature range	SE-MC2U-ST SE-MC2U-SC SE-SW5U SE-SW8U SE-SW5U-ST SE-SW5U-SC SE-SW9U-ST SE-SW9U-SC	-10 to +60 °C (+14 to +140 °F), cold startup at -10 °C (+14 °F)
	SE-SW5U-WT SE-SW8U-WT SE-SW5U-ST-WT SE-SW5U-SC-WT SE-SW9U-ST-WT SE-SW9U-SC-WT	-40 to +85 °C (-40 to +185 °F), cold startup at -40 °C (-40 °F)
Storage temperature range	-40 to +85 °C (-40 to +185 °F)	
Humidity (non-condensing)	5 to 95% RH	
Environmental Air	No corrosive gasses permitted	
Vibration, shock & freefall	IEC68-2-6, -27, -32	
Agency Approvals	UL/cUL 508, CSA C22 per EN61010-1, UL/cUL 1604 (Class 1, Div. 2, Groups A, B, C, D), CSA C 22.2/213 9 per EN50021/EN60079-15 (Zone 2, Category 3), CE (ATEX)	
EMI emissions	FCC part 15, ICES-003, EN55022	
EMC immunity	IEC61326-1	
RoHS and WEEE	RoHS (Pb free) and WEEE compliant	
Environmental Air	For use in Pollution Degree 2 environment	

General Specifications Cont'd		
Packaging and protection	SE-MC2U-ST SE-MC2U-SC SE-SW5U SE-SW8U SE-SW5U-ST SE-SW5U-SC SE-SW9U-ST SE-SW9U-SC	UL94VO Lexan, IP30
	SE-SW5U-WT SE-SW8U-WT SE-SW5U-ST-WT SE-SW5U-SC-WT SE-SW9U-ST-WT SE-SW9U-SC-WT	Aluminum IP30
Dimensions (L x W x H)	See mechanical diagrams for details	

Copper RJ45 Ports: (10/100BaseT)	
10/100BaseT ports	Shielded RJ45
Protocols supported	All standard IEEE 802.3
Ethernet compliancy	IEEE 802.3, 802.3u, 802.3x
Auto-crossover	Yes, allows you to use straight-through or crossover wired cables
Auto-sensing operation	Yes, Full and half duplex
Auto-negotiating	Yes, 10BaseT and 100BaseT
Auto-polarity	Yes, on the TD and RD pair
Flow control	Automatic
Ethernet isolation	1500 VRMS 1 minute
Plug and play	Yes
Cable requirements	Twisted pair (Cat. 5 or better) (shielded recommended)
Max. cable distance	100 meters

Fiber Port: (100BaseFX multimode)	
100BaseFX ports	1
Fiber port mode	Multimode (mm)
Fiber port connector	ST – models SE-XXXX-ST and SE-XXXX-ST-WT SC – models SE-XXXX-SC and SE-XXXX-SC-WT
Optimal fiber cable	50/125 or 62.5/125 µm
Center wavelength	1300 nm
Multimode	Links up to 4 km typ.; 1300 nm; use with 50 or 62.5/125 um fiber > Transmitter power (dB): -21 min, -17 typ, -14 max > Receiver sensitivity (dB): -34 typ, -31 max
Nominal max. distance (full duplex)	4 km
Half and full duplex	Full duplex
Ethernet compliance	100BaseFX
Eye safety (laser)	IEC 60825-1, Class 1; FDA 21 CFR 1040.10 and 1040.11

Complete documentation

Documentation can be downloaded from www.automationdirect.com.

ComAp

New InteliSys NT

HIGH–END GEN–SET CONTROLLER

New Technology InteliSys is an expandable controller for both single and multiple gen-sets operating in standby or parallel modes, especially in CHP and other complex applications. Detachable construction (consisting of IS-NT-BB and IS-Display) allows easy installation with the potential for many different extension modules designed to suit individual customer requirements.

A built-in synchronizer and digital isochronous load sharer allow a total integrated solution for gen-sets in standby, island parallel or mains parallel. Native cooperation of up to 32 gen-sets is a standard feature.

InteliSys^{NT} supports many standard ECU types and is specially designed to easily integrate new ones.

A powerful graphic display with user-friendly controls allows any user whatever their ability to find the information they need. The display on the basic version is capable of displaying graphical languages (e.g. Chinese).

ComAp is able to offer customized firmware solutions.

Benefits

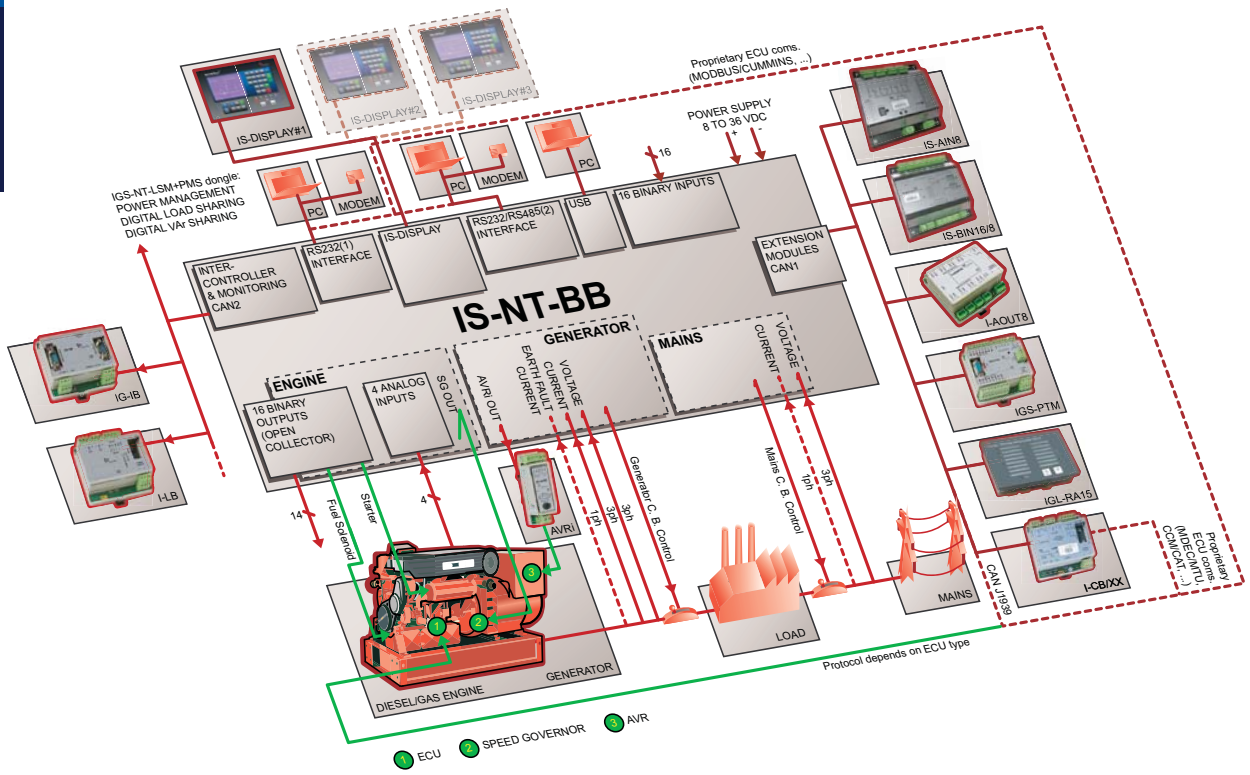
- Support of engines with ECU (Electronic Control Unit)
- Excellent configurability to match customers' needs exactly
- Complete integrated gen-set solution incorporating built-in PLC and signal sharing via CAN bus – minimum external components needed
- Many communication options – easy remote supervising and servicing
- Perfect price/performance ratio
- Gen-set performance log for easy problem tracing

Features

InteliSys^{NT}

- CHP support (programmable PID loops and other built-in PLC functions)
- Support of engines with ECU (J1939, ModBus and other proprietary interfaces); alarm codes displayed in text form
- Automatic synchronizing and power control (via speed governor or ECU)
- Baseload, Import/Export, TempByPower
- Peak shaving
- Voltage and PF control (AVR)
- Generator measurement: U, I, Hz, kW, kVAr, kVA, PF, kWh, kVAhr
- Mains measurement: U, I, Hz, kW, kVAr, PF
- Selectable measurement ranges for AC voltages and currents – 120 / 277 V, 0–1 / 0–5 A
- Inputs and outputs configurable for various customer needs
- 2× RS232/RS485 interface with ModBus protocol support; Analog/GSM/ISDN/CDMA modem communication support; SMS messages; ECU ModBus interface; secondary RS485 converter is isolated
- Event-based history (up to 1000 records) with customer-selectable list of stored values; RTC; statistic values
- Integrated PLC programmable functions
- Interface to remote display units (3× IS-Display)
- USB 2.0 slave interface
- Dimensions 284 × 180 mm (front panel)
- Sealed to IP65

New InteliSys NT
HIGH–END GEN–SET CONTROLLER



Integrated fixed and configurable protections

- 3 phase integrated generator protections (U + f)
- IDMT overcurrent + Shortcurrent protection
- Overload protection
- Reverse power protection
- Earth fault protection
- 3 phase integrated mains protections (U + f)
- Vector shift protection
- All binary/analog inputs free configurable for various protection types: HistRecOnly / Alarm Only / Warning / Off load / Slow stop / BreakerOpen&Cooldown / Shutdown / Mains protect / Sensor fail
- Additional 160 programmable protections configurable for any measured value to create customer-specific protections

Communication extension features

- **IG-IB**
- **I-LB**
- **I-CR**
- **InteliMonitor**
- **GenConfig**

Upgrade kit

- **IGS-NT-LSM+PMS dongle:** Enables multiple isolated parallel or multiple parallel with mains operation (with CAN bus)
  - Digital Load Sharing
  - Digital VAr Sharing
  - Optimizing number of running engines: Power management; kW, kVA or % load based

Extension modules

- up to 10× **IS-AIN8**
- up to 4× **IS-BIN16/8**
- up to 4× **I-AOUT8**
- up to 4× **IGS-PTM**
- **IGL-RA15**
- **I-CB**
- **IS-Display**

HW modification codes

- Order code IS-NT (LT) (Marine) – product that consists of two other products:
  - **IS-Display** (LT) (Marine) – local or remote display
  - **IS–NT–BB** (Marine) – Base Box; the unit without display for switchboard mounting

LT = Low Temperature; display equipped with heating foil for operation down to –30 °C
Marine = Type approved version for Marine

Power for mines

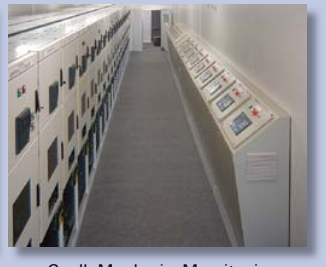
Contract Power Management Pty. Ltd. is one of Australia's largest Independent Power Producers owning and operating power stations in the range 5–15 MW for mining companies in Western Australia and overseas.

„We first chose InteliSys as the control system in 2004 and now we have five power stations utilizing these controllers. We have always liked the simplicity of operation and programming and this has saved us a lot of costs as there was no software engineering involved."

Brian Hall, *Electrical Manager*


Sally Malay, Australia


Tulawaka, Tanzania


Guelb Moghrein, Mauritania

WATT/WH or VAR/VAR HR TRANSDUCERS

WATT/WATTHOUR or VAR/VAR HOUR TRANSDUCER *MODEL* GH & VGH

ACCURATE TO 0.2% OF READING

FEATURES

- Accurate regardless of variations in voltage,current, power factor, or load.
- Available with 1, 2, 2 1/2, or 3 element configurations. Bi-directional Watt and Watthour outputs available. (GH) Bi-directional Var and Var Hour outputs available. (VGH)
- Accuracy maintained over wide temperature range, calibration traceable to **NIST**.

APPLICATIONS

- Integration into energy management systems, or a variety of sub-metering applications.
- Measurement using direct-connection, potential and/or current transformers.

SINGLE PHASE MODELS-INTEGRAL SENSOR (ONE ELEMENT)

INPUTS		F.S. WATTS or VARS	STANDARD GH- OR VGH- OUTPUTS				F.S. COUNTS /HOUR	WH RELAY OPTIONS (ADD SUFFIX)			
VOLTS	AMPS		+1mAdc	+10Vdc	4-20mA	4-12-20mA		"-T"	"-R"	"-H"	"-K"
0 to 150	0 to 1	100	103B	103D	103E	103EM	100	Relay is replaced with 5Vdc, TTL compatible pulse.	A second relay or pulse is provided to allow bi-directional measurement.	Form C (SPDT) solid state relay 0.1A	Form C (SPDT) solid state relay operating in "KYZ" format (50% duty cycle) 0.1A
	0 to 5	500	001B	001D	001E	001EM	500				
	0 to 10	1000	010B	010D	010E	010EM	1000				
	0 to 20	2000	019B	019D	019E	019EM	2000				
0 to 300	0 to 1	200	104B	104D	104E	104EM	200				
	0 to 5	1000	002B	002D	002E	002EM	1000				
	0 to 10	2000	011B	011D	011E	011EM	2000				
	0 to 20	4000	020B	020D	020E	020EM	4000				
0 to 600	0 to 1	500	105B	105D	105E	105EM	500				
	0 to 5	2000	003B	003D	003E	003EM	2000				
	0 to 10	4000	012B	012D	012E	012EM	4000				
	0 to 20	8000	021B	021D	021E	021EM	8000				

Highlighted models, (5A), can be used with current transformers.
To calculate unit scaling when using current or potential transformers, multiply the base unit scaling by the CT or PT ratio.

Example:
GH-001D used with 100:5 CTs.
CT ratio = 100/5 = 20
F.S. Watt input = 500W x 20 = 10,000W (10kW)
(0-10kW input = 0 - 10V output)
WH relay scaling = 1WH/Cnt x 20 = 20WH/cnt.

All std. units require 85-135Vac instrument power, (60 Hz.).
Optional 60Hz self-powered models-Add suffix "**-G**"
Optional 230Vac instrument power - Add suffix "**-22**"
Input voltage ranges limited to:
85-135 for 150V models
200-280 for 300V models
380-550 for 600V models

50 HERTZ MODELS
Self-powered units-Add suffix "**-50**" to part number.
Units requiring external instrument power:
120V, 50Hz-Add suffix "**-51**" to part number.
220V, 50Hz-Add suffix "**-52**" to part number.

Standard Relay is a Form A, SPST

ORDERING INFORMATION
Example: Single-Phase, 120V, 5A Input with +10Vdc Output Proportional to +500 Watts, TTL Pulse Output for Watthours, Each Pulse Proportional to 1.0 Watthour.
GH-001D-T

ORDERING INFORMATION
Example: Single-Phase, 120V, 5A Input with +10Vdc Output Proportional to +500 VAR's, Self-Powered, 1.0 VARhour per Relay Count.
VGH-001DG

CUSTOM WATT HOUR OR VAR HOUR COUNT RATES AVAILABLE - CONSULT FACTORY

THREE PHASE THREE WIRE MODELS-INTEGRAL SENSOR (TWO ELEMENT)

INPUTS		F.S. WATTS or VARS	STANDARD GH- OR VGH- OUTPUTS				F.S. COUNT PER HR	WH RELAY OPTIONS (ADD SUFFIX)			
VOLTS	AMPS		+1mAdc	+10Vdc	4-20mA	4-12-20mA		"-T"	"-R"	"-H"	"-K"
0 to 150	0 to 1	200	120B	120D	120E	120EM	200	Relay is replaced with 5Vdc, TTL compatible pulse.	A second relay or pulse is provided to allow bi-directional measurement.	Form C (SPDT) solid state relay 0.1A	Form C (SPDT) solid state relay operating in "KYZ" format (50% duty cycle) 0.1A
	0 to 5	1000	004B	004D	004E	004EM	1000				
	0 to 10	2000	013B	013D	013E	013EM	2000				
	0 to 20	4000	022B	022D	022E	022EM	4000				
0 to 300	0 to 1	400	121B	121D	121E	121EM	400				
	0 to 5	2000	005B	005D	005E	005EM	2000				
	0 to 10	4000	014B	014D	014E	014EM	4000				
	0 to 20	8000	023B	023D	023E	023EM	8000				
0 to 600	0 to 1	800	122B	122D	122E	122EM	800				
	0 to 5	4000	006B	006D	006E	006EM	4000				
	0 to 10	8000	015B	015D	015E	015EM	8000				
	0 to 20	16000	024B	024D	024E	024EM	1600				

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WATT/WH or VAR/VAR HR TRANSDUCERS

WATT/WATTHOUR or VAR/VAR HOUR TRANSDUCER *MODEL* GH & VGH

ACCURATE TO 0.2% OF READING

Utility Load

CHP Parasitic Loads

THREE PHASE FOUR WIRE MODELS-INTEGRAL SENSOR (THREE ELEMENT)

INPUTS		F.S. WATTS or VARS	STANDARD GH- OR VGH- OUTPUTS				F.S. COUNT PER HR	WH RELAY OPTIONS (ADD SUFFIX)			
VOLTS	AC AMPS		±1mAdc	±10Vdc	4-20mA	4-12-20mA		"-T"	"-R"	"-H"	"-K"
0 to 150 L-N	0 to 1	300	125B	125D	125E	125EM	300	Relay is replaced with 5Vdc, TTL compatible pulse.	A second relay or pulse is provided to allow bi-directional measurement.	Form C (SPDT) solid state relay 0.1A	Form C (SPDT) solid state relay operating in "KYZ" format (50% duty cycle) 0.1A
	0 to 5	1500	007B	007D	007E	007EM	1500				
	0 to 5	1500	7.5B	7.5D	7.5E	7.5EM	1500				
	0 to 10	3000	016B	016D	016E	016EM	3000				
	0 to 20	6000	025B	025D	025E	025EM	6000				
0 to 300 L-N	0 to 1	600	126B	126D	126E	126EM	600				
	0 to 5	3000	008B	008D	008E	008EM	3000				
	0 to 5	3000	8.5B	8.5D	8.5E	8.5EM	3000				
	0 to 10	6000	017B	017D	017E	017EM	6000				
	0 to 20	12000	026B	026D	026E	026EM	12000				

PART NUMBERS 7.5 AND 8.5 DENOTE 2 1/2 ELEMENT UNITS. Standard Relay is a Form A, SPST

Highlighted models, (5A), can be used with current transformers. To calculate unit scaling when using current or potential transformers, multiply the base unit scaling by the CT or PT ratio.

Example:
GH-001D used with 100:5 CTs.
CT ratio = 100/5 = 20
F.S. Watt input = 500W x 20 = 10,000W (10kW)
(0-10kW input = 0 - 10V output)
WH relay scaling = 1WH/Cnt x 20 = 20WH/cnt.
All std. units require 85-135Vac instrument power, (60 Hz.).
Optional 60Hz self-powered models-Add suffix "**-G**"
Optional 230Vac instrument power - Add suffix "**-22**"
Input voltage ranges limited to:
85-135 for 150V models
200-280 for 300V models
380-550 for 600V models

ORDERING INFORMATION

Example: Three-Phase, Four Wire 120V, 5A Input with ± 10Vdc Output Proportional to ± 1500 Vars, TTL Pulse Output for Var Hours, each Pulse Proportional to 1.0 Var Hour.
VGH-007D-T

50 HERTZ MODELS
Self-powered units-Add suffix "**-50**" to part number.
Units requiring external instrument power:
120V, 50Hz-Add suffix "**-51**" to part number.
220V, 50Hz-Add suffix "**-52**" to part number.

CUSTOM WATT HOUR OR VAR HOUR COUNT RATES AVAILABLE - CONSULT FACTORY

SPECIFICATIONS

INPUT

Voltage ..... See Tables
Current ..... See Tables
Frequency Range ..... GH ..... 58-62Hz .... VGH 60Hz
Optional 50Hz ..... GH ..... 48-52Hz .... VGH 50Hz
Power Factor ..... Any
Burden
Voltage 0.1VA/phase
Current 0.28VA/phase
Overload
Voltage (cont.) ..... 150V Range 175V
300V Range 350V
600V Range 600V
Current (cont.) ..... 5A Range ..... 2 X F.S.
10A Range ..... 2 X F.S.
20A Range ..... F.S.
Transient ..... All Ranges
50A ..... 10 sec./hr.
250A ..... 1 sec./hr.
Dielectric Test....(Input/Output/Case) ..... 1800Vac (RMS)
Surge ..... Withstands IEEE SWC test

OUTPUT

VGH ..... + = Lagging/ - = Leading
ACCURACY ..... ± 0.2% Rdg. ..... ± 0.05% F.S.
Includes combined effects of voltage, current, load and power factor
Relay ..... Form A (SPST, N.O.) 120Vac, 0.5A
Contact closure duration ..... 200 milliseconds
Option T ..... Pulse ..... 5V TTL Compatible Pulse
Pulse duration ..... 200 milliseconds
Option H ..... Form C (SPDT) 120Vac, 0.1A
Contact closure duration ..... 200 milliseconds
Option K ..... Form C (KYZ) 120Vac, 0.1A
Contact closure duration ..... 50% duty cycle
Analog Output Ripple ..... < 0.5% F.S.
Output Loading (Ohms)
±1mA 0-10K
±10Vdc ..... 2K min.
4-20mA 0-500
Response Time....(99%) ..... <400 milliseconds
Field Adjustable Cal. ..... ± 2% min.
Temperature Effect....(-20°C to +60°C) ..... +0.005%/°C
Operating Humidity ..... 0-95% non-condensing
Instrument Power (std.) 95-135Vac, 60Hz, 7.5VA
"**-22**" Option ..... 230Vac, 50/60Hz, ±10%

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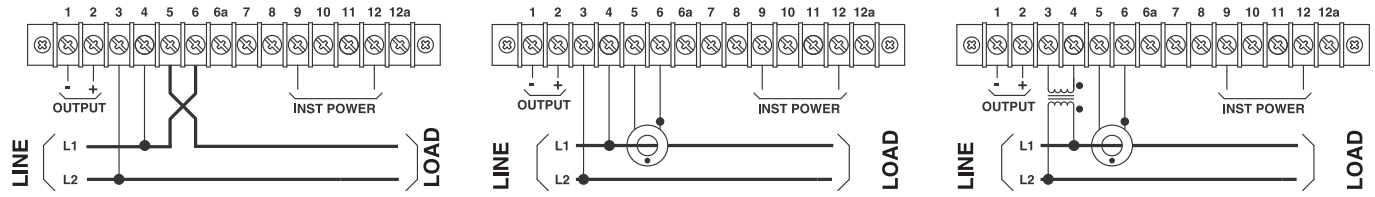
WATT/WH or VAR/VAR HR TRANSDUCERS

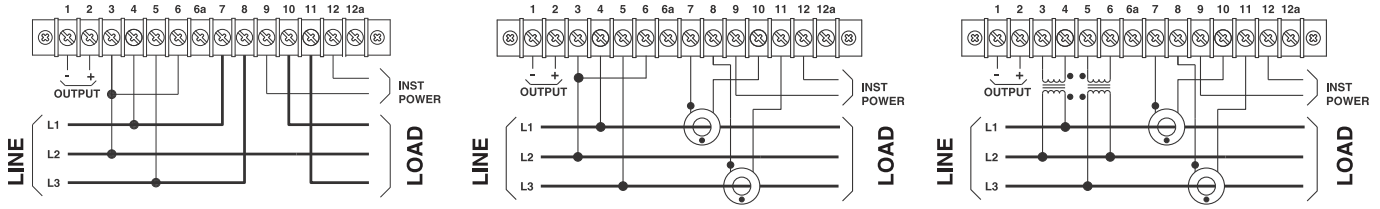
CONNECTION DIAGRAMS — MODEL GH & VGH

SINGLE PHASE CONNECTIONS (ONE ELEMENT)



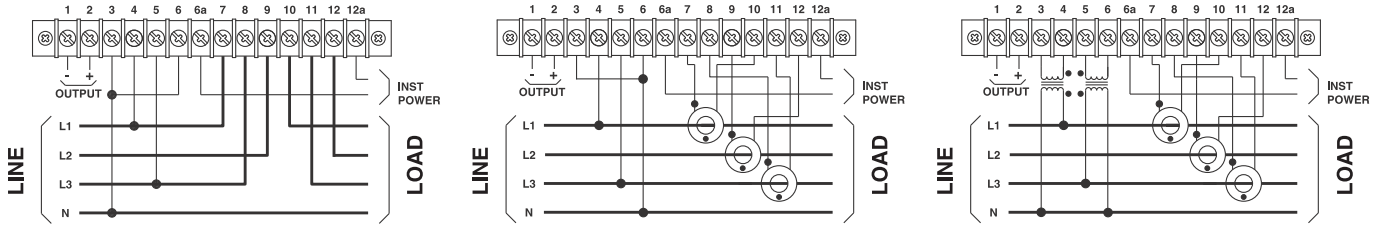
DIRECT CONNECTION | USING ONLY CURRENT TRANSFORMERS | USING CURRENT & POTENTIAL TRANSFORMERS

THREE-PHASE,THREE-WIRE CONNECTIONS (TWO ELEMENT)



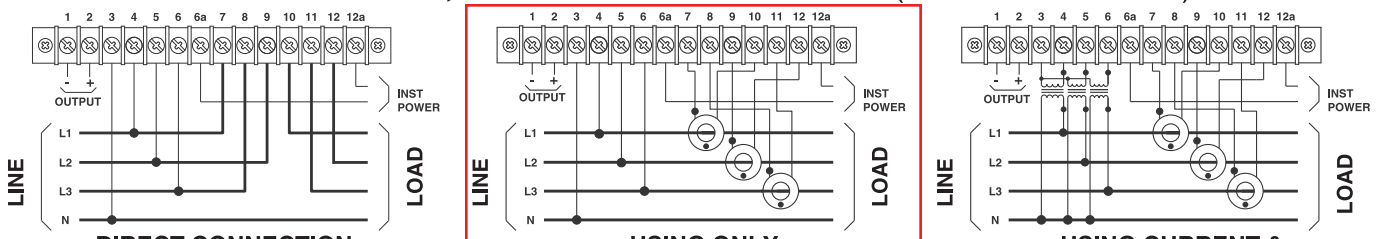
DIRECT CONNECTION | USING ONLY CURRENT TRANSFORMERS | USING CURRENT & POTENTIAL TRANSFORMERS

THREE-PHASE,FOUR-WIRE CONNECTIONS (2 1/2 ELEMENT)



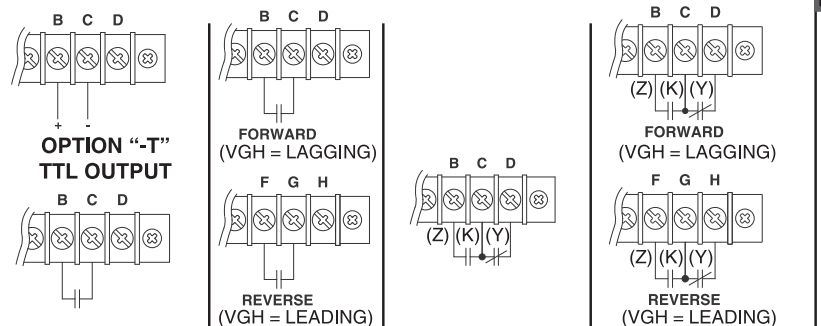
DIRECT CONNECTION | USING ONLY CURRENT TRANSFORMERS | USING CURRENT & POTENTIAL TRANSFORMERS

THREE-PHASE,FOUR-WIRE CONNECTIONS (THREE ELEMENT)



DIRECT CONNECTION | USING ONLY CURRENT TRANSFORMERS | USING CURRENT & POTENTIAL TRANSFORMERS

WATTHOUR OR VARHOUR OUTPUT CONNECTIONS



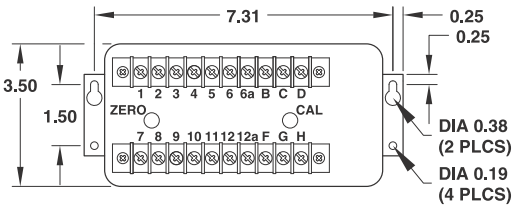
STANDARD OUTPUT SPST RELAY (VGH = LAGGING)

OPTION "R" BI-DIRECTIONAL SPST RELAY

OPTION "H" OR "K" SPDT RELAY

OPTION "RH" OR "RK" SPDT RELAY

CASE DIMENSIONS



CASE HEIGHT 5.88"
1PH 2W 2.9 LBS
3PH 3W 3.3 LBS
3PH 4W 3.8 LBS

All Dimensions In Inches

FLEX-CORE
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CURRENT TRANSFORMERS

METERING CLASS CURRENT TRANSFORMERS

MODELS 191-194-195

ACCURATE TO 0.3%

FEATURES

- For use with Watt, Var, Watt/Var, Watt/Watt-Hour Transducers, Meters and Relays
- Meets ANSI specifications for sub-metering applications.
- UL Recognized.

SPECIFICATIONS

Frequency ..... 25 to 400 Hz.
Insulation Class ..... 600 Volts
Impulse Level ..... 10KV, Full Wave
Terminals ... Brass studs No. 8-32 UNC with one flat washer, lockwasher and regular nut.
Mounting Bracket ..... P/N 0221B00777
*Approved for Revenue Metering by Industry Canada T-196

600V CLASS


191


194


195

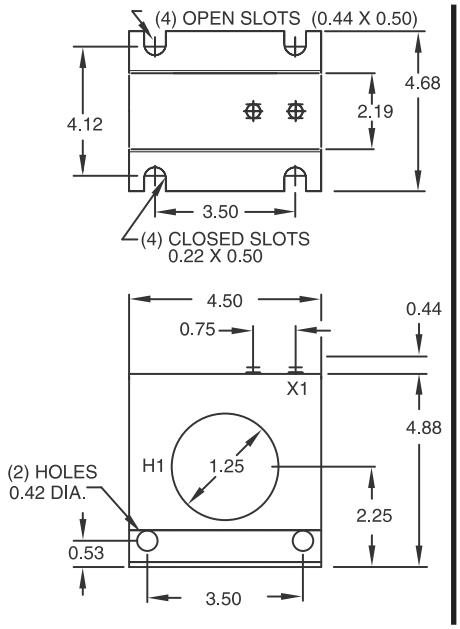
E93779 LR89403

CURRENT RATIO	MODEL NUMBER	WEIGHT (LBS)	ANSI METERING CLASS ACCURACY (60 HZ.)					RELAY CLASS	SECONDARY WINDING RESISTANCE (OHMS @ 75°C)	CONTINUOUS THERMAL RATING FACTOR	
			B 0.1	B 0.2	B 0.5	B 0.9	B 1.8			@30°C	@55°C
100:5	**191-101**	5.5	0.6	0.6	2.4	4.8	-	-	0.034	2.0	2.0
150:5	**191-151**	5.5	0.3	0.3	1.2	1.2	2.4	C10	0.051	2.0	2.0
200:5	**191-201**	5.5	0.3	0.3	0.6	1.2	2.4	C10	0.068	2.0	2.0
250:5	**191-251**	5.5	0.3	0.3	0.3	0.6	1.2	C20	0.085	2.0	1.5
300:5	**191-301**	5.5	0.3	0.3	0.3	0.3	0.6	C20	0.126	2.5	1.33
400:5	**191-401**	5.5	0.3	0.3	0.3	0.3	0.6	C20	0.189	1.5	1.0
	194-401*	3.5	0.3	0.3	0.3	0.6	1.2	C10	0.104	2.0	1.5
500:5	**194-501***	3.5	0.3	0.3	0.3	0.3	0.6	C10	0.133	1.5	1.0
	195-501	2.25	0.3	0.3	0.3	0.6	1.2	-	0.105	2.0	1.5
600:5	**194-601***	3.5	0.3	0.3	0.3	0.3	0.6	C10	0.180	1.5	1.0
	195-601	2.25	0.3	0.3	0.3	0.6	0.6	-	0.151	1.5	1.33
800:5	**194-801***	3.5	0.3	0.3	0.3	0.3	0.3	C10	0.302	1.0	0.8
	195-801	2.25	0.3	0.3	0.3	0.6	0.6	-	0.265	1.0	0.8
1000:5	**194-102***	3.5	0.3	0.3	0.3	0.3	0.3	-	0.354	1.0	0.8
	195-102	2.25	0.3	0.3	0.3	0.3	0.6	-	0.209	1.0	0.8
1200:5	**194-122***	3.5	0.3	0.3	0.3	0.3	0.3	-	0.424	1.0	0.8
	195-122	2.25	0.3	0.3	0.3	0.3	0.6	-	0.301	1.0	0.6
1500:5	**194-152***	3.5	0.3	0.3	0.3	0.3	0.3	-	0.531	1.0	0.8
	195-152	2.25	0.3	0.3	0.3	0.3	0.3	-	0.471	1.0	1.0
1600:5	**195-162**	2.25	0.3	0.3	0.3	0.3	0.3	-	0.502	1.0	1.0
2000:5	**195-202**	2.25	0.3	0.3	0.3	0.3	0.3	-	0.782	0.6	0.6

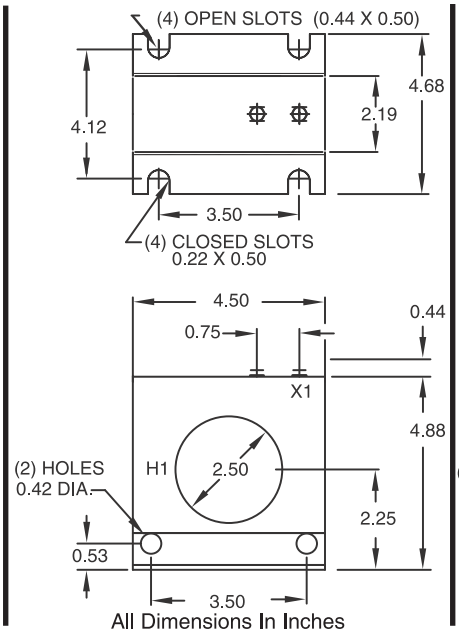
Parasitic Load kW/kWh Transducer

Generator

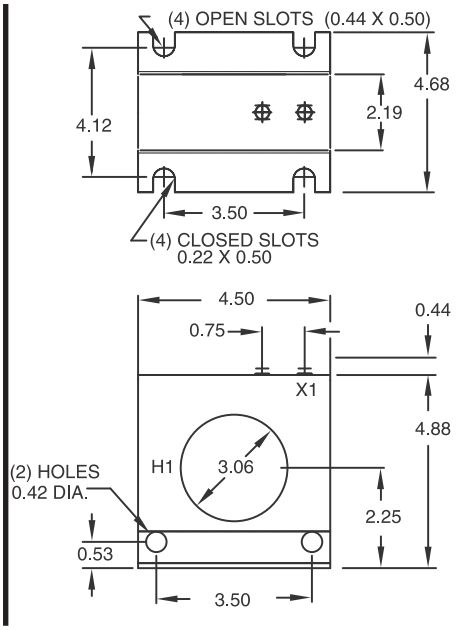
MODEL 191



MODEL 194



MODEL 195



All Dimensions In Inches

FLEX-CORE®
Div. Morlan & Associates, Inc.
6625 McVey Blvd. Columbus, Ohio 43235

WWW.FLEX-CORE.COM
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PHONE (614) 889-6152
TECH. ASSISTANCE (614) 876-8308
FAX # (614) 876-8538

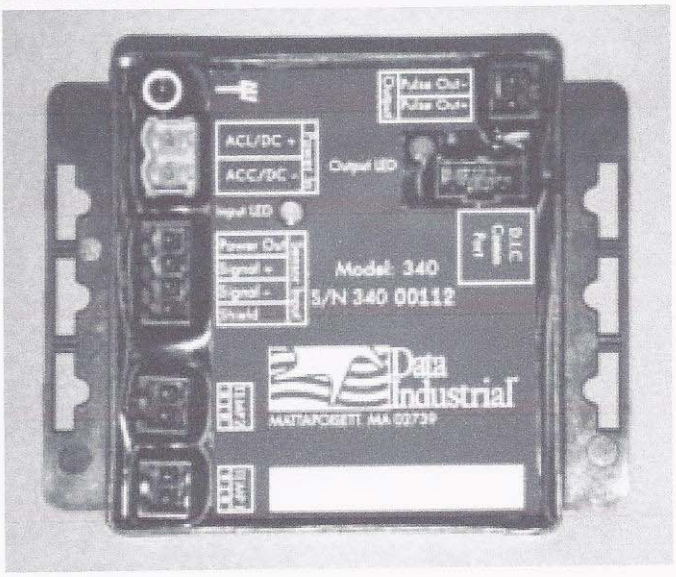
Data Industrial®

Model 340 Btu Transmitter

The Data Industrial Series 340 Btu transmitter is an economical, compact device for sub-metering applications.

The 340 calculates thermal energy by measuring liquid flow in a closed pipe system and measuring temperature at the inlet and outlet points. The 340 requires two 10 kΩ thermistors for temperature input. The flow input may be provided by any Data Industrial sensor and many other pulse or sine wave signal flow sensors.

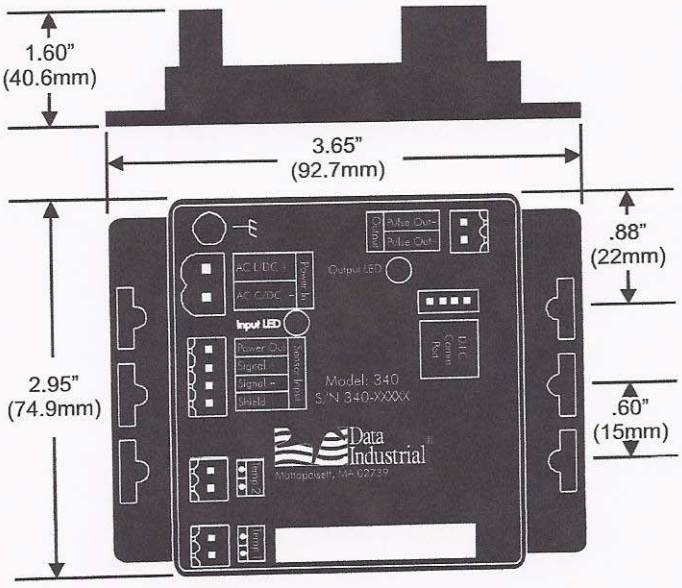
The onboard microcontroller and digital circuitry make precise measurements and produce accurate drift-free outputs. The 340 is programmed using Data Industrial's Windows® based software and a Data Industrial A301 programming cable. Calibration information for the flow sensor, units of measurement and output scaling may be downloaded prior to installation or in the field. While the unit is connected to a PC or laptop computer, real-time flow rate, flow total, both temperature readings, energy rate and energy total are available.



Series 340 Ordering Matrix

	EXAMPLE:	340	-	xx
SERIES				
Btu Transmitter		340		
OPTIONS				
Transmitter Only				00
W / Metal Enclosure				02
W / Plastic Enclosure				03
W / DIN Rail Mounting Clips				04

Transmitter Only



The Series 340 transmitter features two LED's to verify input and output signals.

The standard output for the Series 340 is an isolated solid state switch closure that is user programmed for units of energy. The output pulse width is adjustable from 50 mS to 5 seconds.

The Series 340 Btu transmitter operates on AC or DC power supplies ranging from 12 to 24 volts.

The compact cast epoxy body measures 3.65"(93mm) x 2.95"(75mm) and can be easily mounted on panels, DIN rails or enclosures.

Specifications

Power
Power supply options:
12-24 VAC
12-24 VDC
Current Draw:
60 mA @ 12 VDC

Flow Sensor Input
All sensors:
Excitation voltage 3 wire sensors:
7.9 – 11.4 VDC 270Ω source impedance
Pulse type sensors:
Signal amplitude:
2.5 VDC threshold
Signal limits:
Vin < 35V (DC or AC peak)
Frequency:
0-10kHz
Pull-up:
2 kΩ
Sine Wave Sensors:
Signal amplitude:
10 mV p-p threshold
Signal limits:
Vin < 35V (DC or AC peak)
Frequency:
0-10kHz

Temperature Sensor Input
2 required:
10 kΩ thermistor, 2 wire, type II, 10 kΩ @ 25°C

Pulse Output
Pulse Width:
Programmable from 50 mS to 5 Sec in 50mS increments
Pulse frequency:
Max of 10Hz @ 50mS pulse width programmable to scaling requirements of connected device
Opto-isolated solid state switch
Operating Voltage range:
0 - ±60V (DC or AC peak)
Closed(on) state:
Load Current - 700mA max. over operating temperature range
On-resistance - 700mΩ max. over operating temperature range
Open(off) state – leakage @ 70°C
<1μA @ 60V (DC or AC peak)

Operating Temperature
-29° C to +70° C
-20° F to +158° F

Storage Temperature
-40° C to +85° C
-40° F to +185° F

Weight
4.8 oz. With headers installed

SENSOR CALIBRATION

Data Industrial
Use "K" and "offset" provided in sensor owner's manual

Other Sensors
Check with factory

UNITS OF MEASURE

Flow measurement
Rate:
gpm, gph, l/sec, l/min, l/hr, ft3/sec, ft3/min, ft3/hr, m3/sec, m3/min, m3/hr
Total:
gallons, liters, cubic feet, cubic meters

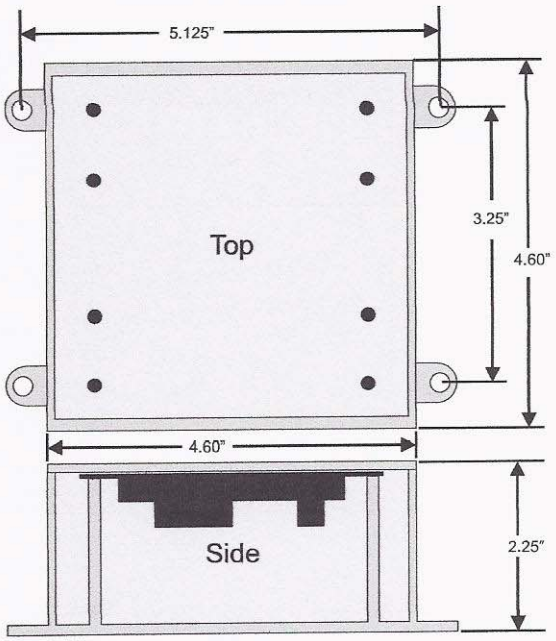
Energy measurement
Rate
kBtu/min, kBtu/hr, kW, MW, hp, tons
Total
Btu, kBtu, MBtu, kWh, MWh, kJ, MJ

Temperature Units
Fahrenheit, Centigrade

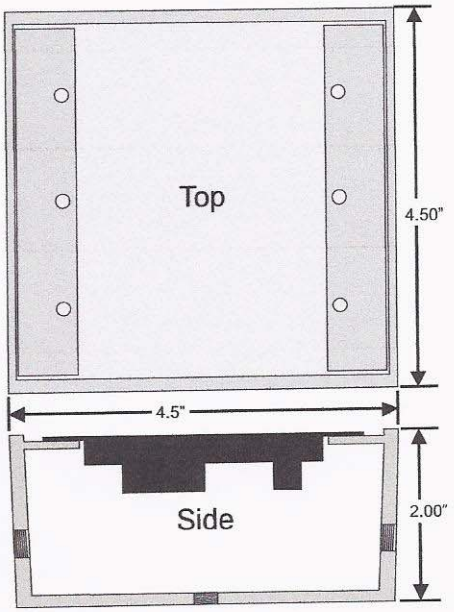
PROGRAMMING
Requires PC or laptop running Windows® 9x, ME, NT, 2000, XP

Data Industrial A-340 programming kit containing software and A301 programming cable

Plastic Enclosure Dimensions



Metal Enclosure Dimensions



Data Industrial®

Series 228 Metallic Tee Flow Sensors

The Data Industrial Series 228 flow sensors feature a six bladed impeller design with a proprietary non-magnetic sensing mechanism. The forward swept impeller shape provides higher, more consistent torque than four bladed impeller designs and is less prone to be fouled by water borne debris. The forward curved shape coupled with the absence of magnetic drag provides improved operation and repeatability even at lower flow rates. This is especially true where the impeller is exposed to metallic or rust particles found in steel or iron pipes. As the liquid flow turns the impeller, a low impedance square wave signal is transmitted with a frequency proportional to the flow rate. The signal can travel up to 2000' between the flow sensor and the display unit without the need for amplification. All sensors except irrigation versions are supplied with 20' of 2-conductor 20 AWG shielded U.L. type PTLC 105°C cable.

Series 228 Tee Sensors

The tee mounted flow sensors consist of a standard 220BR or 220SS mounted in a 2" or 2.5" tee.

Model 228B - brass/bronze sensor mounted in a bronze tee.

Model 228CB - brass/bronze sensor mounted in a cast iron tee.

Model 228CS - stainless steel sensor mounted in a cast iron tee.

Model 228SS - stainless steel sensor mounted in a stainless steel tee.

228 Series Metal Tee Sensors Ordering Matrix (2" to 2½")

	Example:	2	28	BR	20	0	5	-	0	2	1	1
STYLE												
Tee Mounted Insert Sensor (2" and 2.5" only)			28									
MATERIAL												
Brass/Bronze				BR								
Stainless Steel (2" and 2.5" only)				SS								
Tee - Carbon Steel Sensor Brass				CB								
Tee - Carbon Steel Sensor Stainless Steel				CS								
Size												
2"					20							
2.5"					25							
Electronics Housing												
PPS						0						
ELECTRONICS												
Magnetic							2					
FM/CSA Approved							4					
Standard							5					
IR-Irrigation							6					
O-RING												
Viton®									0			
FPDM									1			
Buna N									8			
SHAFT												
Zirconia Ceramic										0		
Hastalloy C										1		
Tungsten Carbide										2		
Titanium										3		
Monel										5		
316 Stainless Steel										6		
Tantalum										7		
IMPELLER												
Nylon											1	
Tefzel®											2	
BEARING												
Pennlon												1
Tefzel®												2
Teflon®												3

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CE FM APPROVED CSA® Exia

Data Industrial Corporation, 11 Industrial Drive, P.O. Box 740, Mattapoisett, MA 02739, Telephone: (508) 758-6390 Fax: (508) 758-4057
web site: www.dataindustrial.com email: sales@dataindustrial.com

Specifications

Wetted Materials (except tees)
— See Ordering Matrix

Sensor Sleeve and Hex Adapter for 228BR and 228CB
— Sleeve: Admiralty Brass, UNS C44300; Hex Adapter: Valve Bronze, UNS C83600

Sensor Sleeve and Hex Adapter for 228SS and 228CS
— 300 Series Stainless Steel

Tee for 228BR
— Cast Bronze, Class 125 Per ASME B16.15, and Copper Coupling

Tee for 228SS
— Cast 316 Stainless, Class 150

Tee for 228CB and 228CS
— Cast Iron, Class 125 Per ASME B16.4

Temperature Ratings
— Standard Version:
221°F (105°C) continuous service
— Irrigation Version:
150°F (66°C) continuous service
— High Temperature Version:
285°F (140.6°C) continuous service
305°F (150°C) peak temperature
(limited duration)

Pressure

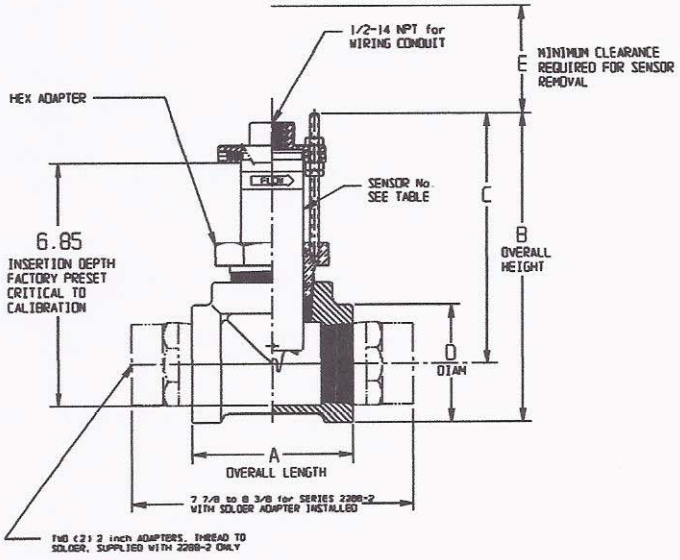
	At 100°F	At 300°F
228B	200 psi	165 psi
228CB	175 psi	140 psi
220SS	400 psi	325 psi

Recommended Design Flow Range
— 0.5 to 30 ft/sec

Accuracy
— ± 1.0% of full scale over recommended design flow range

Repeatability
— ± 0.3% of full scale over recommended design flow range

Linearity
— ± 0.2% of full scale over recommended design flow range



NOTE- DIMENSIONS "B" AND "C" MAY VARY +/- 1/4 inch, DEPENDING UPON MAKE-UP ON PIPE THREADS.

228CB-2.5	SEE MATRIX	71881T	2.5-8	4.88	9	7	4	6
228B-2.5	SEE MATRIX	71883T	2.5-8	4.75	8.78	7	3.56	6
228SS-2	SEE MATRIX	711338T	2-11.5	4.5	6.38	6.88	3	6
228CS-2	SEE MATRIX	71876T	2-11.5	4.5	8.57	6.88	3.38	6
228CB-2	SEE MATRIX	71876T	2-11.5	4.5	8.57	6.88	3.38	6
228B-2	SEE MATRIX	71879T	2-11.5	4.25	8.35	6.88	2.94	6
SERIES No COMPLETE	SENSOR No.	TEE No.	NPT	A	B	C	D	E

Transducer Excitation
— Quiescent current 600uA@8VDC to 35VDC max.
— Quiescent voltage (V_{high})
Supply Voltage -(600uA*Supply impedance)
— ON State (V_{Low}) Max. 1.2VDC@40mA current limit (15Ω + 0.7VDC)

Electrical Cable for Standard Sensor Electronics
— 20 feet of 2-conductor 20 AWG shielded U.L. type PTLC wire provided for connection to display or analog transmitter unit. Rated to 105°C. May be extended to a maximum of 2000 feet with similar cable and insulation appropriate for application.

Electrical Cable for IR Sensor Electronics
— 48 inches of U.L. Style 116666 copper solid AWG 18 wire w/direct burial insulation. Rated to 105°C.

Appendix B

Monitoring Installation Details

Site Visits

Date	Actions
March 13, 2012	Initial site visit by CDH Energy. Draft monitoring plan developed.
August 20, 2012	Data logger installation visit. Logger connected to MODBUS network, programmed, and data collection begins.
December 20, 2012	Data logger readings verified/calibrated.

Description of Monitored Data Points and Schematics

The data logger operates as a MODBUS master, polling the engine controller RTU once per second and recording 1-minute data records. The engine controller is configured as MODBUS device #1. MODBUS register location and data type are subject to the PLC constraints.

Table 1. Monitored Data Point on PLC Modbus

No.	CDH Data Point	CDH Description	Units	Modbus Register #	Modbus Register Name	Data Type	Multiplier	Data Label on Submital PID Drawing
1	FL1	Primary Glycol Loop Flow Rate	GPM	40018	Eng Cool Flow	INT16	1	ECF
2	FL2	Secondary Glycol Loop Flow (Building Loop)	GPM	40019	ThermLoadFlow	INT16	1	HWF
3	WPAR_kW	Parasitic Load Power Consumption	kW	40024	Parasitic Load	INT16	1	n/a
4	TLR1	Primary Glycol Loop Return Temperature Dowstream of Dump Radiator	deg F	40025	CHP Inlet Temp	INT16	0.1	CGI
5	TJWS	Primary Glycol Loop Supply Temperature Leaving Jacket	deg F	40027	EngCoolTmp	INT16	0.1	JWT
6	TLS1	Primary Glycol Loop Supply Temperature	deg F	40028	CHP Out Tmp	INT16	0.1	CGO
7	WT_kW	Total Facility Utility Import Power	kW	40030	Utility Load	INT16	1	n/a
8	TLR2	Secondary Glycol Loop Return Temperature (From Building)	deg F	40032	HHW from Bldg	INT16	0.1	HWR
9	TLS2	Secondary Glycol Loop Supply Temperature (To Building)	deg F	40033	HHW to Bldg	INT16	0.1	HWS
10	VP_W	Valve Position Primary/Secondary Loop Mixing	%	40034	Warmup TCV Pos	INT16	1	WVP
11	VP_R	Valve Position Radiator Loop	%	40035	Rad TCV Pos	INT16	1	RVP
12	TRE	Radiator Entering Temperature	deg F	40036	Rad EWT	INT16	0.1	RET
13	TRL	Radiator Leaving Temperature	deg F	40037	Rad LWT	INT16	0.1	RLT
14	TAO	Ambient Temperature	deg F	40038	Outside Temp	INT16	0.1	OAT
15	WG_kW	Generator #1 Power Output (Gross)	kW	40264	Act Power	INT16	1	n/a
16	WG	Generator #1 Energy Output (Gross)	kWh	43578 (MSB) 43579 (LSB)	kWhours	INT32 (2-reg)	1	n/a
17	WPAR_kWh	Parasitic Load Energy Consumption	kWh	43712 (MSB) 43713 (LSB)	kWh consumed	UINT32 (2-reg)	0.01	n/a
18	QENG	Total Engine Heat Output	1e5 Btu	43714 (MSB) 43715 (LSB)	BTU Produced	UINT32 (2-reg)	0.00001	n/a
19	QU	Total Useful Heat Recovery	1e5 Btu	43716 (MSB) 43717 (LSB)	BTU Consumed	UINT32 (2-reg)	0.00001	n/a
20	FG	Combined Generator Fuel Input	CCF	43718 (MSB) 43719 (LSB)	Gas Consumed	UINT32 (2-reg)	1	n/a

Modbus Device Template Editor

Template: **BethIsrael_PLC**

Point List

Point	Name	Units	Register	Type	Byte Order	Slope	Offset	I
0	Eng Cool Flow	GPM	40018	INT16	none	1		
1	ThermLoadFlow	GPM	40019	INT16	none	1		
2	Parasitic Load	kW	40024	INT16	none	1		
3	CHP Inlet Temp	deg F	40025	INT16	none	0.1		
4	EngCoolTmp	deg F	40027	INT16	none	0.1		
5	CHP Out Tmp	deg F	40028	INT16	none	0.1		
6	Utility Load	kW	40030	INT16	none	1		
7	HHW from Bldg	deg F	40032	INT16	none	0.1		
8	HHW to Bldg	deg F	40033	INT16	none	0.1		
9	Warmup TCV Pos	%	40034	INT16	none	1		
10	Rad TCV Pos	%	40035	INT16	none	1		
11	Rad EWT	deg F	40036	INT16	none	0.1		
12	Rad LWT	deg F	40037	INT16	none	0.1		
13	Outside Temp	deg F	40038	INT16	none	0.1		
14	Generator Act Power	kW	40264	INT16	none	1		
15	Generator kWhours	kWh	43578	INT32	none	1		
16	Parasitic kWh Consumed	kWh	43712	UINT32	none	0.01		
17	Engine BTU Produced	1e5 BTU	43714	UINT32	none	0.00001		
18	Building BTU Consumed	1e5 BTU	43716	UINT32	none	0.00001		
19	Engine Gas Consumed	CCF	43718	UINT32	none	1		
20	SAV Speed	%	40040	INT16	none	1		
21	Rad Speed	%	40041	INT16	none	1		
22	ECP Speed	%	40042	INT16	none	1		

Save Cancel

BethIsrael_PLC

Device Address: 1
Device Type: BethIsrael_PLC
Status: Ok

Function	Current Reading	Low Alarm	High A
Eng Cool Flow	0 GPM	0.000 GPM	0.000
ThermLoadFlow	0 GPM	0.000 GPM	0.000
Parasitic Load	0 kW	0.000 kW	0.000
CHP Inlet Temp	144.900 deg F	0.000 deg F	0.000
EngCoolTmp	143.800 deg F	0.000 deg F	0.000
CHP Out Tmp	146.900 deg F	0.000 deg F	0.000
Utility Load	442.000 kW	0.000 kW	0.000
HHW from Bldg	145.100 deg F	0.000 deg F	0.000
HHW to Bldg	145.800 deg F	0.000 deg F	0.000
Warmup TCV Pos	0 %	0.000 %	0.000
Rad TCV Pos	0 %	0.000 %	0.000
Rad EWT	86.400 deg F	0.000 deg F	0.000
Rad LWT	85.300 deg F	0.000 deg F	0.000
Outside Temp	84.000 deg F	0.000 deg F	0.000
Generator Act Power	0 kW	0.000 kW	0.000
Generator kWhours	11.000 kWh	0.000 kWh	0.000
Parasitic kWh Consumed	4.450 kWh	0.000 kWh	0.000
Engine BTU Produced	0.207 1e5 BTU	0.000 1e5 BTU	0.000
Building BTU Consumed	0.000 1e5 BTU	0.000 1e5 BTU	0.000
Engine Gas Consumed	0 CCF	0.000 CCF	0.000
SAV Speed	0 %	0.000 %	0.000
Rad Speed	0 %	0.000 %	0.000
ECP Speed	invalid	0.000 %	0.000

Configure Done

obvius®
3300 NW 211th Terrace, Hillsboro, OR 97124
Ph: +1-503-601-2099 Fax: +1-503-601-6878

The only data logger connections are the RS-485 MODBUS connection, 24 VDC power, and an Ethernet connection (Figure 1). The logger is mounted on a section of DIN rail alongside a 24 VDC powered switch located in the lower portion of the engine controller cabinet (Figure 1).

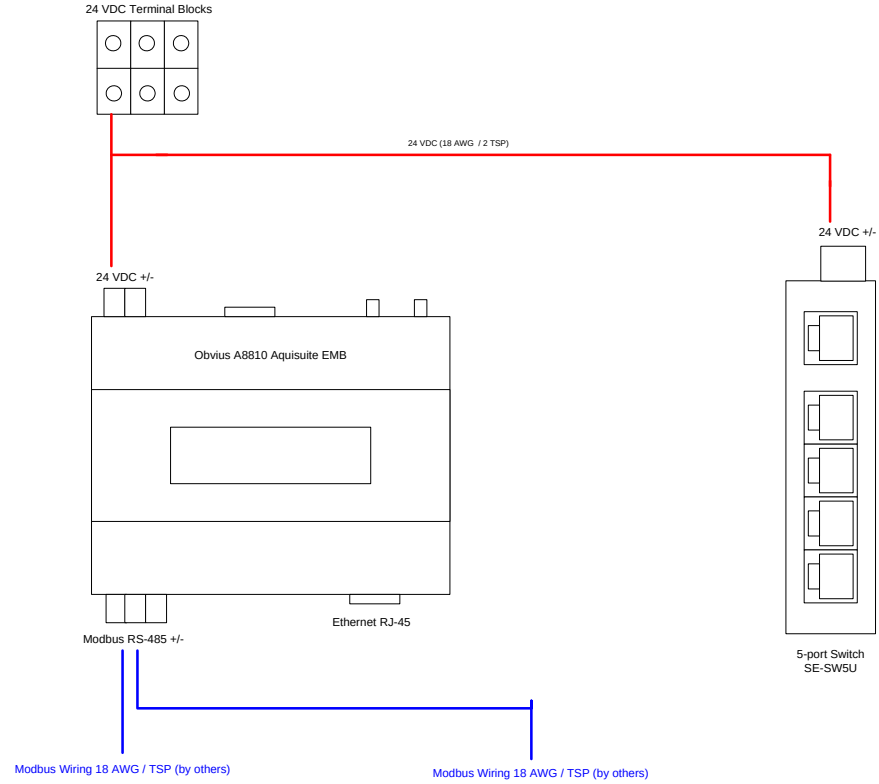


Figure 1. Data Logger Wiring Diagram

Figure 2. Data Logger Installation

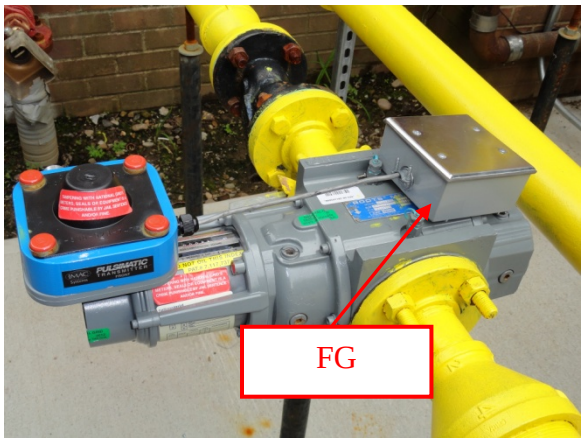
Photos of Installed Sensors and Equipment

Mann 250 kW Engine Generator

Engine Loop Pumps, Building Loop Valves (Right) and Radiator Valves (Left)

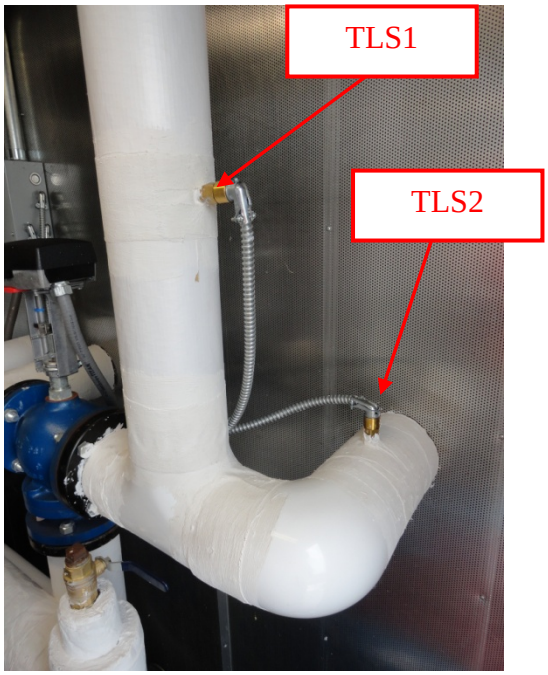
CHP Container and Dump Radiator On Rooftop

Generator Disconnect and CTs, Parasitic Power Transducer

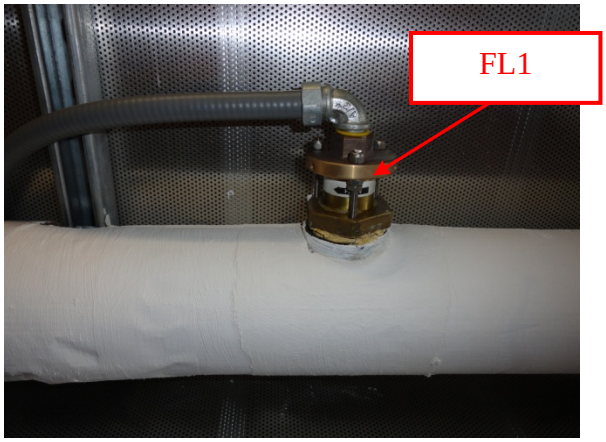


Gas Booster Compressor (430 W added to WPAR)

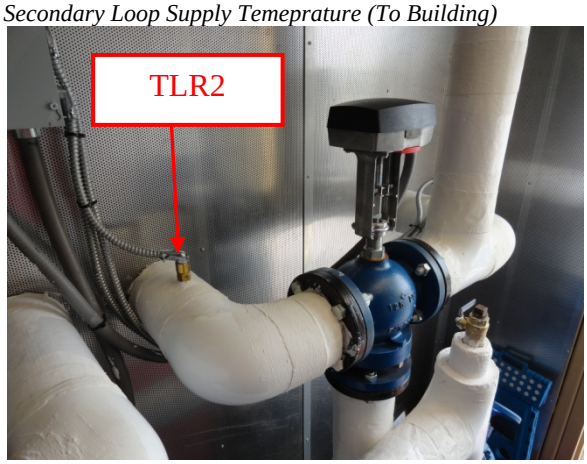
Primary Loop Return Temeprature (To CHP)



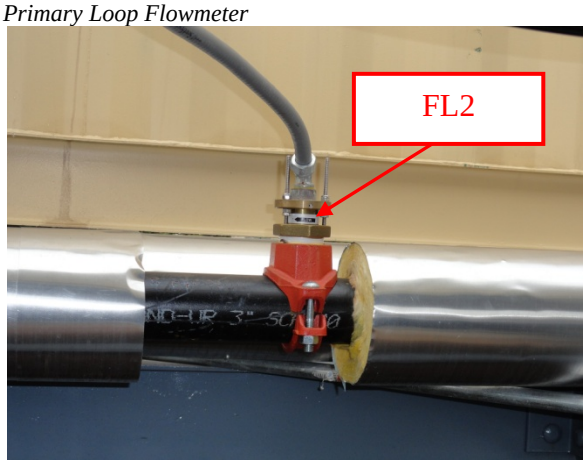
Primary Loop Supply Temeprature (From CHP)
Secondary Loop Supply Temeprature (To Building)



Primary Loop Flowmeter



Secondary Loop Retun Temeprature (From Building)



Secondary Loop Flowmeter (From Building)

Ultrasonic Flowmeter Verification of FL2

Ultrasonic Flowmeter Verification of FL1

FL1 Flowmeter Reading (Typ of FL2 also)

Net Power Verification Location Leaving Skid (WG_{net})

Beth Israel Data Logger Verification Dec 20, 2012

Note: Engine at full load: 253 kW gross

Gas Readings (FG)

	Time	Meter (CF)	Time	DAS (CCF)
Reading 1	12:05	6,884,858	11:53	3,538
Reading 2	12:20	6,885,532	12:40	3,559
Difference	0:15	674	0:47	21
	Rate (CFH)	**2,696**		**2,681**

Efficiency and Heat Balance Calcs

Electrical Eff Calc (LHV)	
WG_{gross}	253.0 kW
WG_{gross}	863.5 MBtu/h
FG (LHV)	2,499.2 MBtu/h
Elec Eff	**34.6% MBtu/h**

FCE Calc (LHV) Field Measurements	
WG_{net}	247.6 kW
WG_{net}	845.0 MBtu/h
QU	1,201.5 MBtu/h
FG (LHV)	2,499.2 MBtu/h
FCE (LHV)	**81.9% MBtu/h**

FCE Calc (LHV) (Data Logger)	
WG_{net}	245.6 kW
WG_{net}	838.1 MBtu/h
QU	1,303.7 MBtu/h
FG (LHV)	2,680.9 MBtu/h
FCE (LHV)	**79.9% MBtu/h**

Heat Balance (HHV)	
WG_{gross}	253.0 kW
WG_{gross}	863.5 MBtu/h
QU	1,201.5 MBtu/h
QENG	1,339.2 MBtu/h
QD	137.7 MBtu/h
FG (HHV)	2,761.3 MBtu/h
FCE (HHV)	**79.8% MBtu/h**

Note: FCE (HHV) based on gross power and gross thermal QENG

Power Readings (WG, WPAR)

	DAS (WG_{gross}) (kW)	DAS (WG_{par}) (kW)	DAS (WG_{net}) (kW)	Fluke 39 (kW)	Fluke 39 (amps)	(Volts)
WG_{net}	253	7	246	248	350 / 352 / 363	480 VAC
WG_{net}	253	7	246	248	352 / 352 / 357	480 VAC
$WPAR_{booster}$				0.43	7.7	120 VAC

Note: Booster assumed to be constant load, added to parasitic in database

Temperature Readings (TLS2, TLR2) (To/From Building)

	DAS (F)	Fluke (F)	Difference (F)
TLS2	184.5	180.3	4.2
TLS2	185.0	179.2	5.8
TLR2	167.7	162.4	5.3

Note: Surface mount verification compared to sensor in well. Carbon steel pipe.
Average supply difference 5.0 F
Average return difference 5.3 F
Total temp delta error 0.3 F

Temperature Readings (TLS1, TLR1) (To/From Engine)

	DAS (F)	Fluke (F)	Difference (F)
TLS1	187.5	180.3	7.2
TLR1	168.7	161.7	7.0

Note: Surface mount verification compared to sensor in well. Carbon steel pipe.
Average supply difference 7.2 F
Average return difference 7.0 F
Total temp delta error 0.2 F

Temperature Readings (TRE, TRL) (To/From Radiator)

	DAS (F)	Fluke (F)	Difference (F)
TLS1	50.9	51.1	-0.2
TLR1	50.1	51.1	-1.0

Note: Surface mount verification compared to sensor in well. Copper header.
No flow in radiator, so no adjustment made at this time.

Flow Readings (FL2) (Secondary Loop to Building)

Settings:	3-inch Carbon Steel Schedule 40
	3.5-inch diameter
	0.216-inch wall thickness
	2.490-inch transducer spacing (set with micrometer)
	Fluid: Water (less than 50% glycol)

DAS (GPM)	Portaflow (GPM)	Difference (GPM)
157	150	7
157	147	10
158	149	9

Note: Radiator circuit off, so FL2 = FL1. Average difference 8.66 GPM
Average flow ratio adjustment 0.944

Flow Readings (FL1) (Primary Loop to Engine)

Settings:	3-inch Carbon Steel Schedule 40
	3.5-inch diameter
	0.216-inch wall thickness
	2.490-inch transducer spacing (set with micrometer)
	Fluid: Water (less than 50% glycol)

DAS (GPM)	Portaflow (GPM)	Difference (GPM)
158	150	8
159	151	8

Note: Radiator circuit off, so FL2 = FL1.
Average difference 8.0 GPM
Average flow ratio adjustment 0.949