Monitoring and Analysis Plan for Aegis AGEN-75 CHP System at the 300 E 40th St Manhattan, NY – The Churchill

This document describes the measurements, sensors, and data logging equipment proposed to quantify the performance of the Aegis AGEN-75 based CHP system installed at The Churchill Building in New York, NY (Figure 1). The CHP system consists of two Aegis AGEN-75 75-kW engine generators systems that produce electricity and hot water for domestic hot water, space heating, and pool heating.

Figure 1. 300 E 40 Street – The Churchill

Description of CHP System

The two 75-kW engine generators are located in the sub-cellar level of the building. Also located in the sub-cellar adjacent to the CHP units is a heat exchanger (HX) coupling the heat recovery loop to the North Wing space heating hot water loop, and an isolation HX for the high-rise heat recovery loop piping serving the thermal loads on upper floors of the building. The high-rise heat recovery loop continues to the second floor where an HX couples the heat recovery loop with the second floor domestic hot water (DHW) system. The high-rise heat recovery loop then continues upward to the 32nd floor, where two HXs couple the heat recovery loop to the 32nd floor DHW system and to the 32nd floor pool-water-heating (PWH) piping. The high-rise heat recovery loop piping continues to the upper roof level, where a final HX couples the loop to a separate dump radiator loop for rejection of any excess heat to the atmosphere.

CHP Unit #1

CHP Unit #2

Figure 2. CHP Units

DHW System Upgrades

In addition to the CHP units and heat recovery loop piping installed, the upgrades to two DHW systems in the building are being incorporated into this project. The DHW systems consist of two existing steam driven hot water generators (size unknown). Aegis is adding four 300-gallon hot water storage tanks and a duplex circulating pump on the DHW load side at each HX location on the 2nd and 32nd floors. In addition, a pump is being added to circulate return DHW from the building piping systems into the new storage tank system.

Description of Monitored Data Points

Table 1 lists the monitored points required to characterize the performance of the CHP system. Each point is accompanied by the respective sensor and engineering unit measured.

Table 1. Data Point List

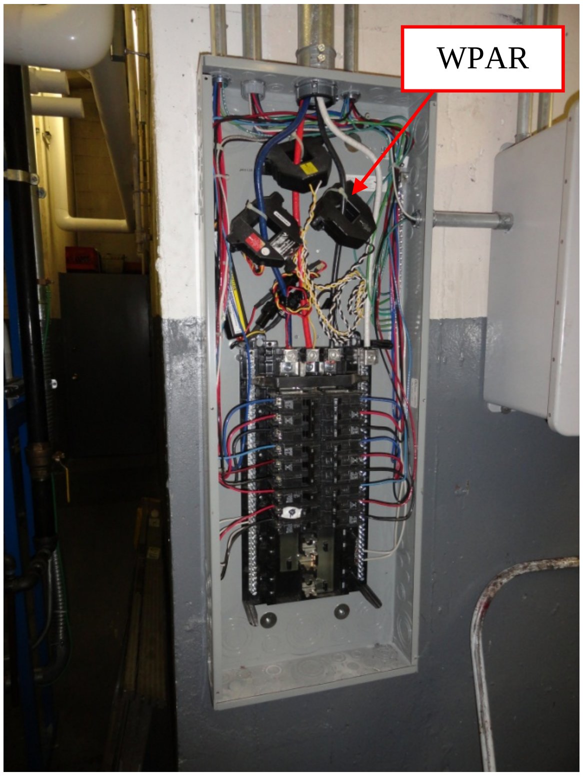
No.	Data Point	Description	Units	Sensor	Output	Notes
1	WT	Total Facility Power	kW/kWh	Veris E50 C2 with MV Rope CTs	Modbus/Pulse	Installed at service entrance
2	WG	Generator Power	kW/kWh	Veris H8035-0400-3	Modbus	Installed at CHP disconnect
3	WPAR	Parasitic Power - All CCPs	kW/kWh	Veris H8035-0300-2	Modbus	Installed at parasitic breaker panel
4	FG	Generator Gas Use	CF	Utility pulse output from billing meter	Pulse	Con-Ed pulse demark
5	QT	CHP Loop 1 Heat Transfer (Total Heat Output)	Mbtu	Badger 380 BTU meter	Modbus	Installed in basement, powered from data logger
6	TLS1	CHP Loop 1 Supply Temperature (Total Heat Output)	deg F		Modbus	
7	TLR1	CHP Loop 1 Return Temperature (Total Heat Output)	deg F		Modbus	
8	FL1	CHP Loop 1 Flowrate (Total Heat Output)	GPM		Modbus	
9	QD	Heat Transfer Dump Radiator	Mbtu	Badger 380 BTU meter	Modbus	Installed at 34th Floor powered from local power supply
10	TLS2	CHP Loop 2 Temperature Before Dump Radiator	deg F		Modbus	
11	TLR2	CHP Loop 2 Temperature After Dump Radiator	deg F		Modbus	
12	FL2	CHP Loop 2 Flowrate	GPM		Modbus	
13	IEP	Ejector Pump Current (non-CHP load)	amps	Veris H921 Current CT	4-20 mA	Installed at parasitic breaker panel

Power Meters (WT, WG, WPAR)

Aegis is providing a power meter to monitor the entire facility energy consumption (**WT**) on the incoming bus section from the utility service. The recommended facility meter is a Veris E50 C2 using rope CTs. The E50 meter will provide a modbus data connection to the data logger for continuous reporting of facility demand (kW) and accumulated energy consumption (kWh).

Aegis is providing a power meter to monitor the combined output of the two CHP units. The recommended generator power meter (**WG**) is a Veris H8035-400, which provides a modbus data connection to the data logger for continuous reporting of system power (kW) and accumulated produced energy (kWh).

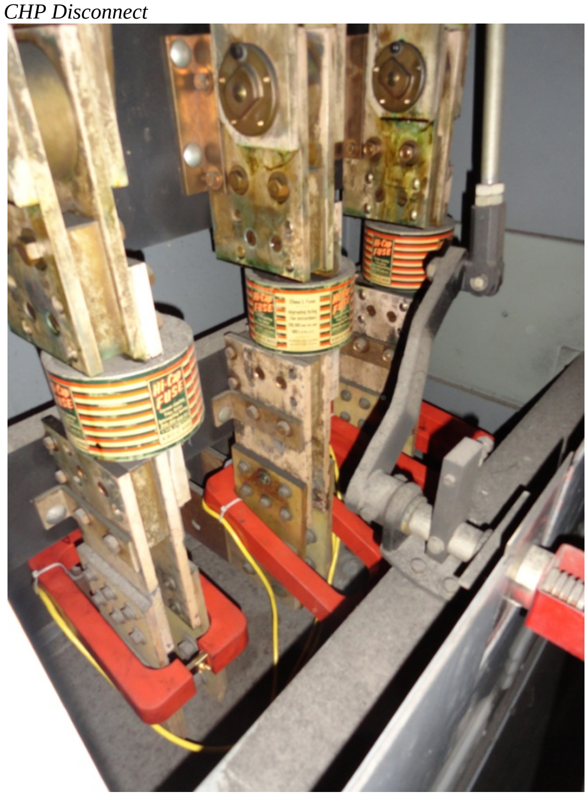
Parasitic power loads (**WPAR**) for the system, typically from additional circulating pumps and the dump radiator fans, are located in Cogen Control Panels (CCPs) located at each mechanical tie-in location. A single power transducer captures the energy for all CCPs at the parasitic load breaker panel. The recommend power transducer for each location is a Veris H8035-300-2. This power transducer will provide a modbus data connection for continuous reporting of parasitic load power (kW) and accumulated energy consumption (kWh). The current for the ejector pumps (**IEP**) (a non-CHP related load) will be monitored and subtracted from the parasitic energy consumption.



Parasitic Power Panel

CHP Disconnect

Building Main Switchgear



Facility CT Location (to be installed above reverse power protection CTs)

Figure 3. Power Transducers

All power transducers need two sets of #20/2-conductor twisted shielded pair (or one set of #20/4-conductor twisted shielded pair) pulled between each meter and the data logger. All daisy chain connections shall be made at the data logger panel.

Locations of the power metering equipment are shown on the one line diagram in Figure 4. Locations for the parasitic load power transducers are not shown.

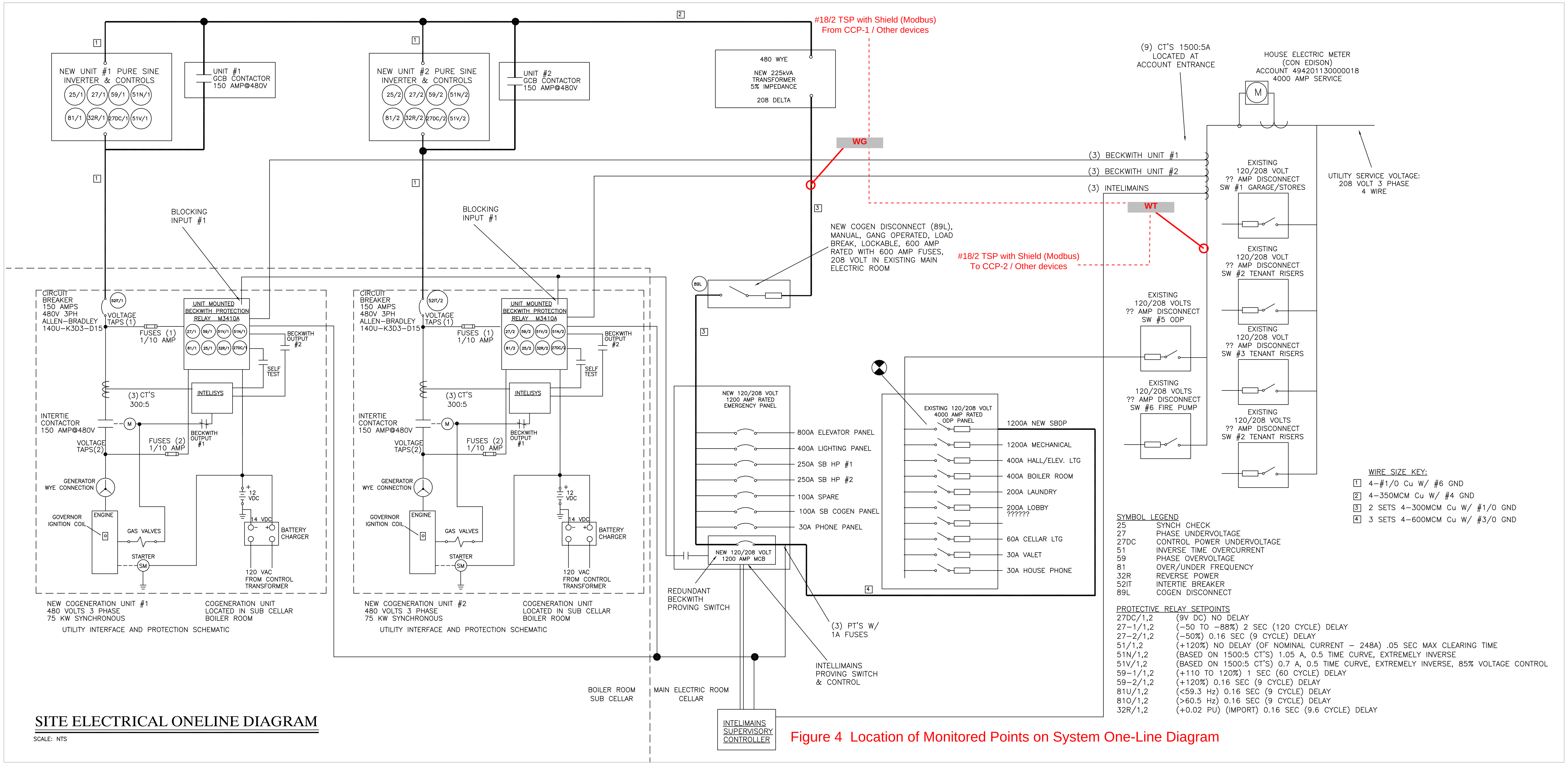
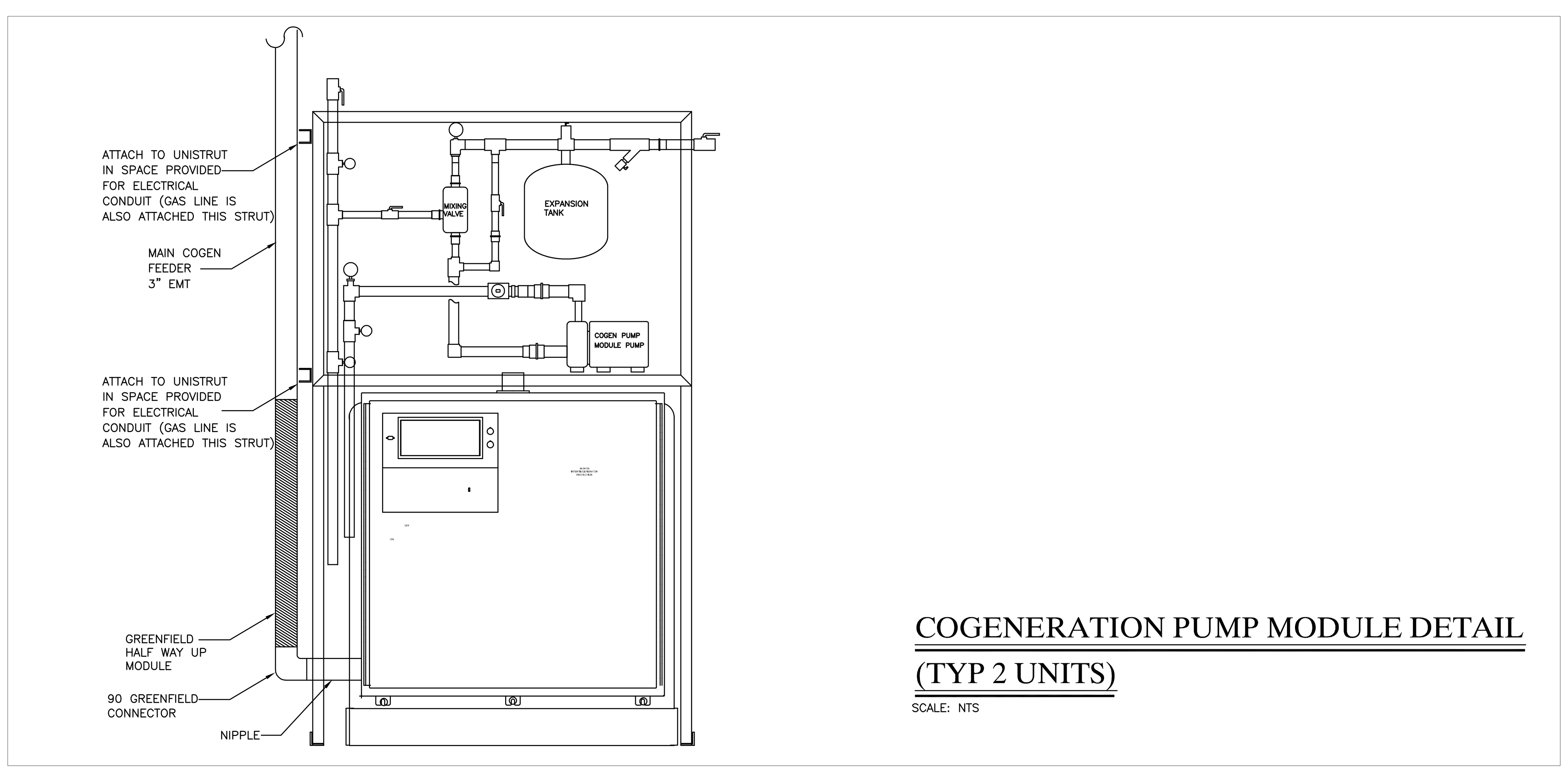
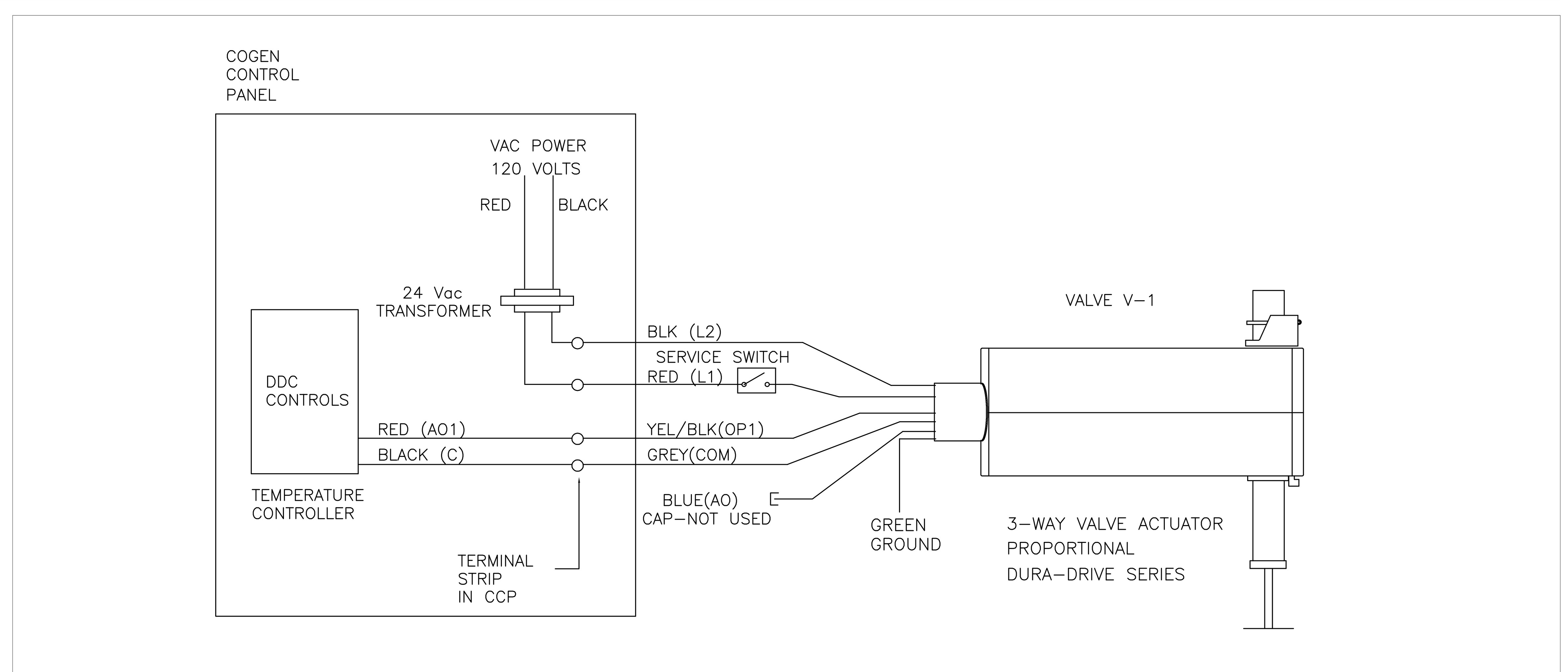


Figure 4 Location of Monitored Points on System One-Line Diagram



COGENERATION PUMP MODULE DETAIL (TYP 2 UNITS)

SCALE: NTS



THREE WAY MODULATING VALVE WIRING DETAIL

FOR VALVES V-1,2,4,5,7,8. VALVE 3,6 USE ONLY RED & BLACK WIRE.
SCALE: NTS

NOTES:

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Natural Gas Flow (FG)

The natural gas meter for the CHP system is located in the sub-cellar level in a metering room. The CHP system gas consumption (**FG**) will be read using a utility supplied pulse interface that provides a dry-contact switch closure for a fixed volume of gas (typically 100 CF/pulse).

The gas meter pulse output requires a dedicated twisted pair signal wire back to the data logger panel location in the sub-cellar.

Locations of the gas metering equipment are shown on the piping diagram in Figure 5.

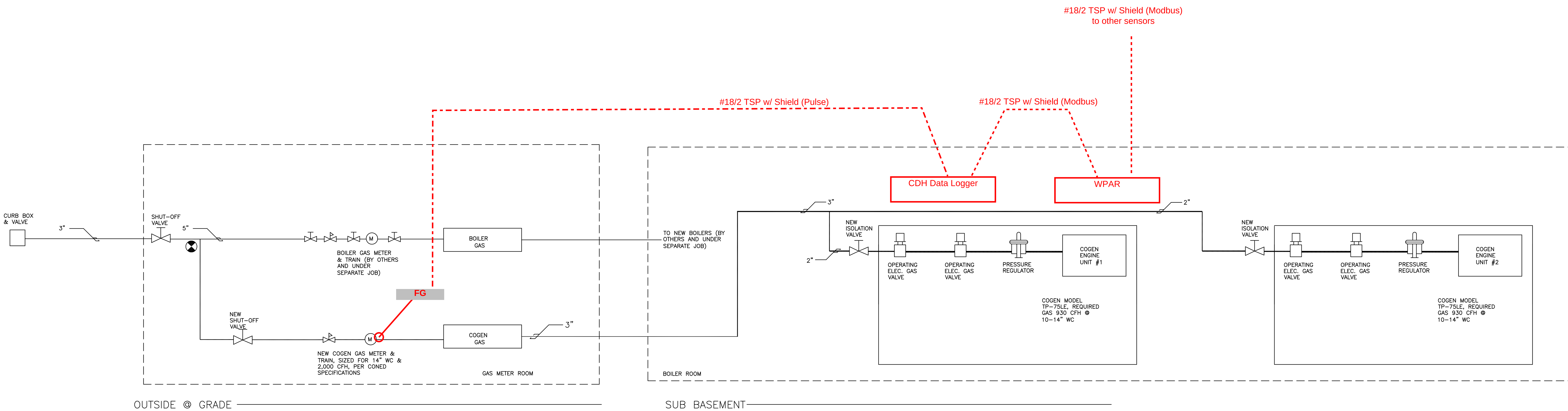

Figure 5 Location of Monitored Points on System Gas Piping Diagram

GAS RISER DIAGRAM

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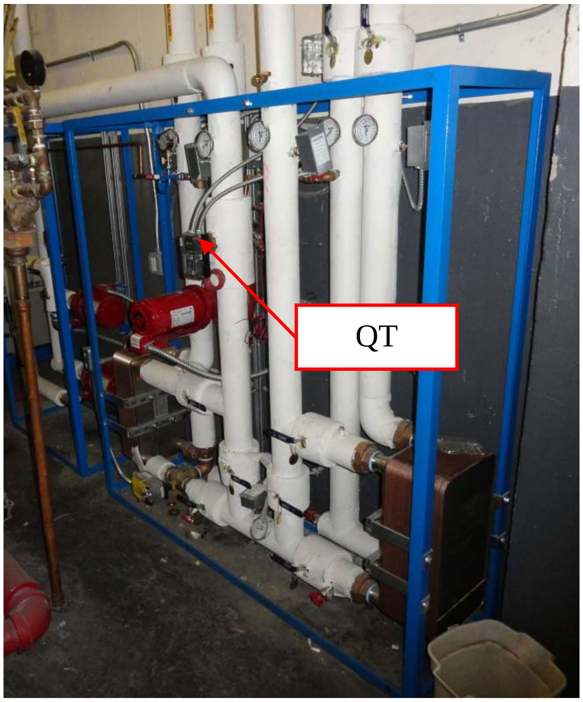
Heat Recovery Calculations (QT, TLS1, TLR1, FL1, QD, TLS2, TLR2, FL2)

The recovered heat from the CHP system is measured using two Badger 380 Btu meters. The Badger meter provides not only an integrated heat transfer measurement using its two onboard temperature sensors and flow meter, but also the temperature and flow readings used to compute the BTU value. Recording the flows and temperatures simultaneously with the BTU data allows for diagnosis of deviations in the heat transfer values beyond what the BTU data can provide alone.

The first Badger BTU meter records the total heat output from the CHP units (**QT**) to the heat recovery loop, which is then transferred to either the space heating HX, or to the loads on the high-rise heat transfer loop. The second Badger BTU meter records the unused heat recovery (**QD**), recorded across the dump radiator HX. The difference between the two heat recovery readings (**QT – QD**) is the total useful heat provided by the CHP system.

The total heat output meter (**QT**) will be powered by the data logger unit (+/- 24 VDC), using a separate pair of #20/2 wires, which need to be pulled from the meter to the data logger. The dumped heat meter (**QD**) will be powered by the 24 VAC transformer located at the Cogen Control Panel on the 34th floor.



Low Rise Loop HX and BTU Meter (QT)

Dump Radiator HX and BTU Meter (QD)

Dump Radiator

Figure 6. BTU Meter Locations and Equipment

The total plant output meter (**QT**) needs two sets of #20/2-conductor twisted shielded pair (or one set of #20/4-conductor twisted shielded pair) pulled between the meter and the data logger. The dumped heat meter (**QD**) needs one set of #20/2-conductor twisted shielded pair pulled between the meter and the data logger, as this meter will be the last meter in the daisy chain connection.

Locations of the thermal metering equipment are shown on the piping diagram in Figure 7.

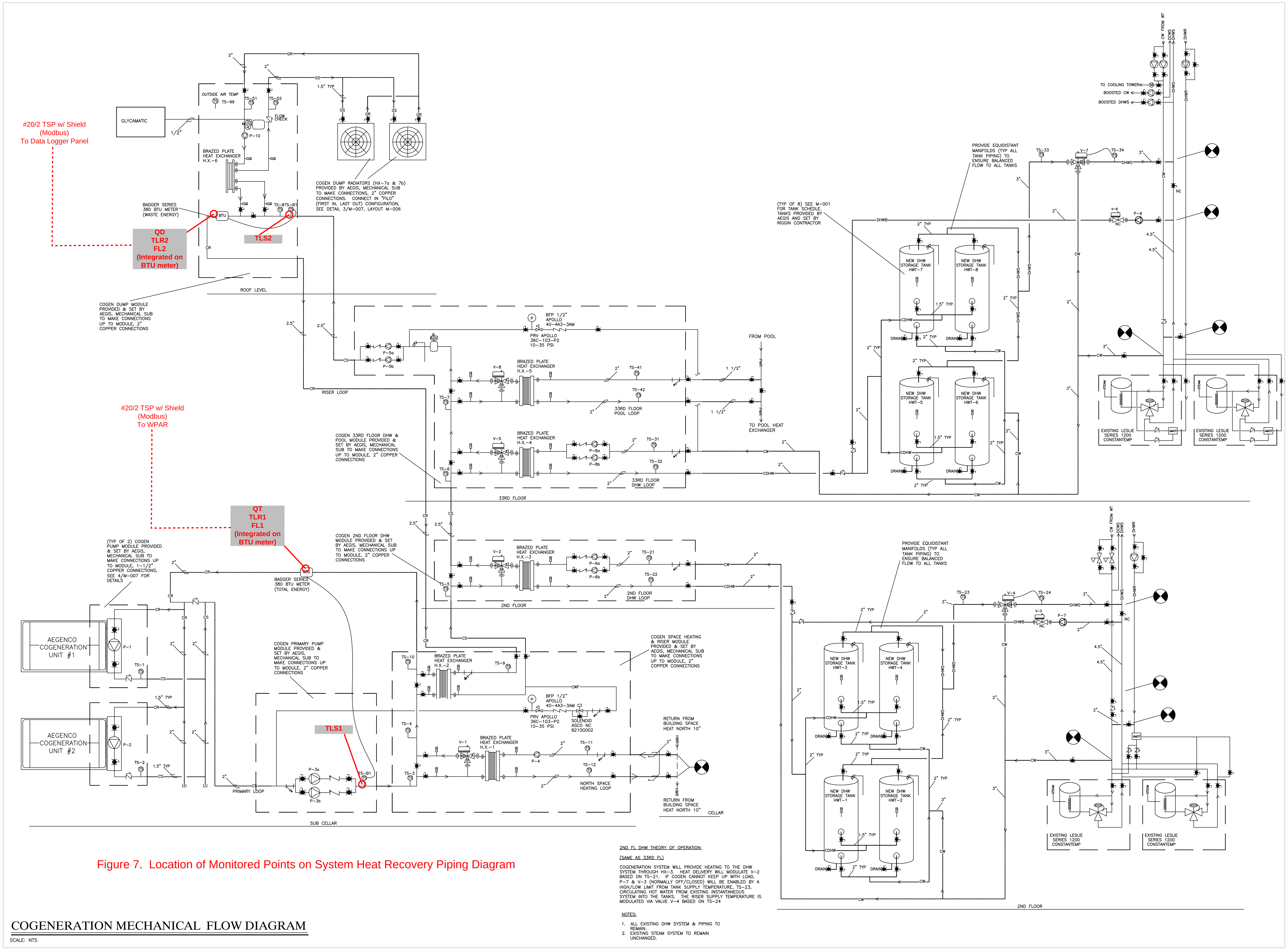


Figure 7. Location of Monitored Points on System Heat Recovery Piping Diagram

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Data Logger Location and Communication

The data logger will be installed adjacent to the Aegis parasitic load panel in the sub-cellar level, and will utilize a port on the router (DHCP or Static IP to be provided by Aegis). Inside the Aegis communication panel is a 110 VAC outlet that will be utilized for datalogger power.

The modbus communication loop will be configured for the following modbus slave address on each device.

Table 2. Modbus Communication Loop Device Numbers

Data Point	Sensor	Modbus Device Number
WT	Veris E50 C2 with MV Rope CTs	1
WG	Veris H8035-0400-3	2
WPAR	Veris H8035-0300-3	3
QT	Badger 380 #1 (Heat Recovery Loop)	4
QD	Badger 380 #2 (Dumped Heat Recovery Loop)	5

The modbus communication loop is shown schematically in Figure 8. Wire pull locations and number of conductors are shown on Figure 9 through **Error! Reference source not found.**.

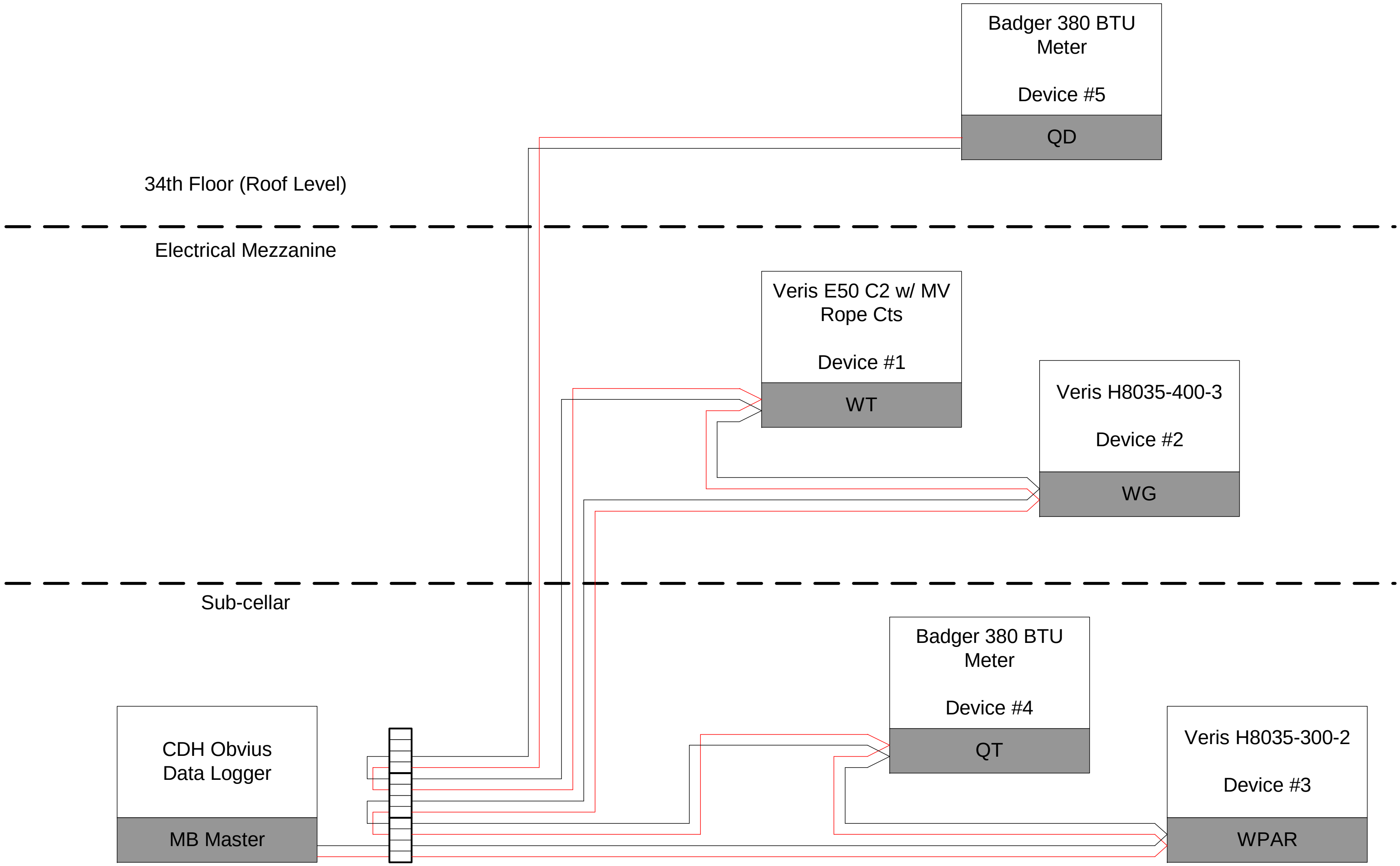
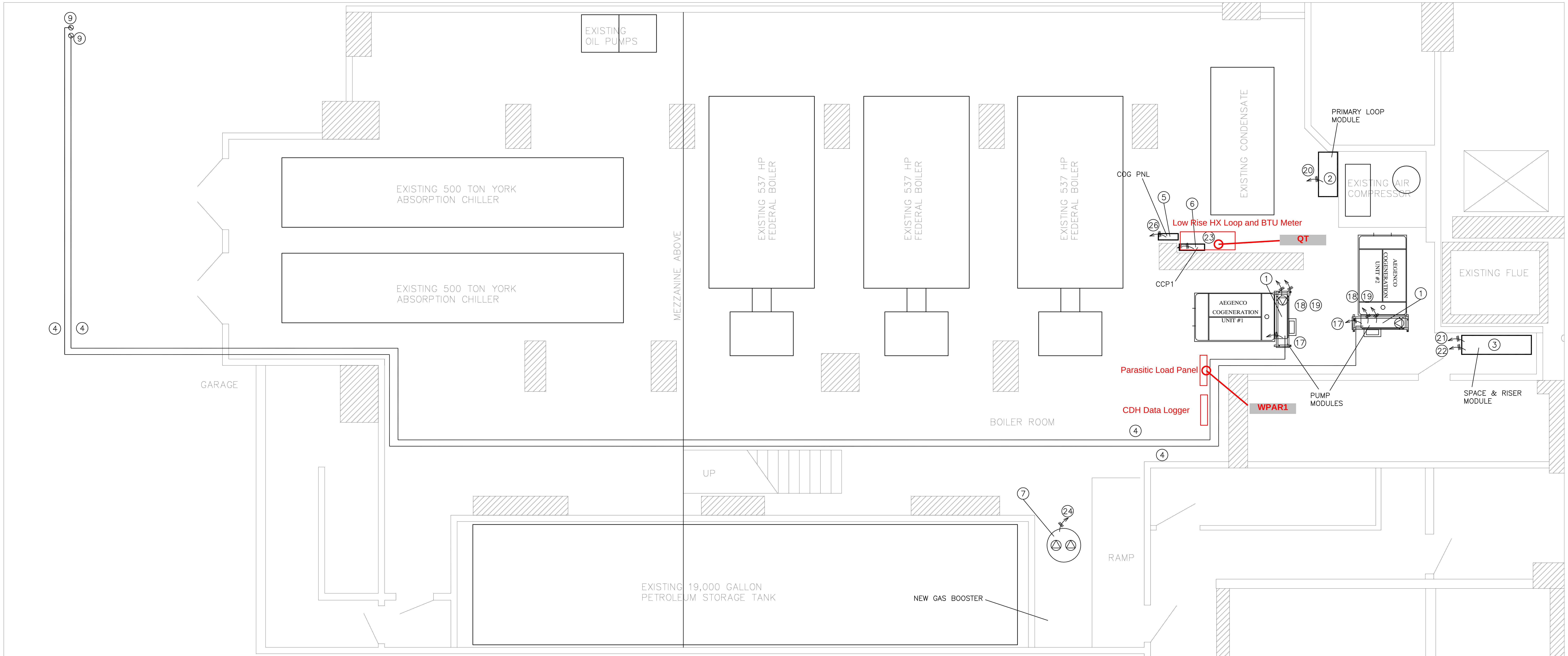


Figure 8. Modbus Communication Loop Configuration



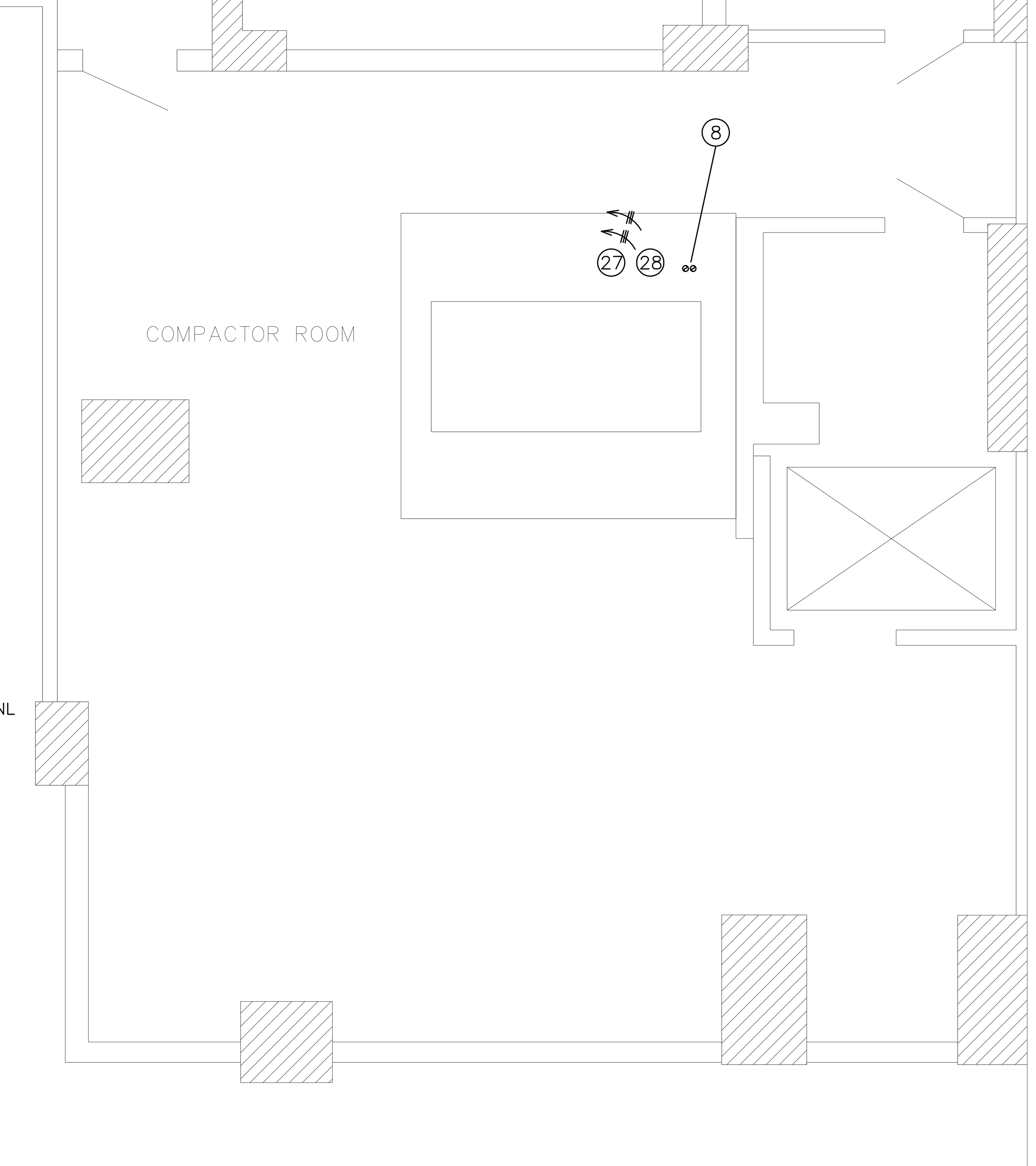


Figure 9. Physical Location of Monitoring Equipment - Sub Cellar

NOTES:

(1) (2 PLACES) PUMP MODULE PROVIDED AND SET BY AEGIS, ELECTRICAL CONTRACTOR TO MAKE UP CONNECTIONS TO MODULE

(2) PRIMARY PUMP MODULE PROVIDED BY AEGIS, ELECTRICAL CONTRACTOR TO MAKE UP CONNECTIONS TO MODULE

(3) SPACE HEAT & RISER MODULE PROVIDED BY AEGIS, ELECTRICAL CONTRACTOR TO MAKE UP CONNECTIONS TO MODULE

(4) (2 PLACES) COGEN MAIN FEEDER, (4) #1/0 COPPER WITH #6 GROUND IN 1.5" CONDUIT.

(5) S&I NEW 208V, 3ϕ, 100 AMP PANEL FOR COGEN LOADS, POWER FROM NEW STANDBY PANEL.

(6) COGEN CONTROL PANEL #1 (CCP1), 24x36x8" WITH DDC MOUNTED BELOW, DDC POWERED FROM CCP1 120 VOLT POWER

(7) COGEN GAS BOOSTER, PROVIDED BY AEGIS, ELECTRICAL CONTRACTOR TO MAKE UP CONNECTIONS TO MODULE

(8) INSTALL (2) 3/4" EMT RISERS FROM SB TO ROOF, BEHIND MECHANICAL PIPING IN COMPACTOR ROOMS. ONE FOR LINE VOLTAGE, ONE FOR LOW VOLTAGE. CORE DRILLING BY MECHANICAL CONTRACTOR. USE CABLE SUPPORTS EVERY 8 FLOORS.

(9) (2 PLACES) CORE DRILL & RUN COGEN MAIN FEEDER UP THROUGH FLOOR INTO MAIN ELECTRICAL ROOM, SEE CONTINUATION ON SHEET E-002

(10) PROVIDED BY OWNER, 3) CAT5 COMMUNICATIONS LINES TO SUB CELLAR FOR COGEN, DDC, AND BTU METERING

* USE 3/4" EMT MINIMUM FOR ALL RUNS, KEEP SEPARATE CONTROL AND LINE VOLTAGE WIRE.

* ELECTRICIAN RESPONSIBLE FOR FIRE STOPPING ALL PENETRATIONS. ALL FIRE STOPPING MUST USE APPROVED SYSTEMS AND METHODS AND MUST MEET OR EXCEED 2 HR RATING

(11) - (16) NOT USED.

(17) (2 PLACES) TO INVERTER FROM COGEN
LOW VOLTAGE
CONTROL OUTPUTS
15) #18/2 SHIELDED
CONTROL INPUTS
15) #18/2 SHIELDED

(18) (2 PLACES) TO CCP1 FROM COGEN
HIGH VOLTAGE
FAN F-1 (OR F-2)
2) #12 WITH GROUND AND SERVICE SWITCH
PUMP P-1 (OR P-2)
3) #12 W/ GROUND AND 3 POLE TOGGLE SWITCH

(19) (2 PLACES) TO CCP1 FROM COGEN
LOW VOLTAGE
COGEN KW OUT
1) #18/2 SHIELDED 1115 & 1116 IN COGEN
COGEN S/S
2) #18 717-523 IN COGEN
COGEN ALARM
2) #18 621-622 IN COGEN
COGEN RUN STATUS
2) #18 534-535 IN COGEN
CO ALARM
2) #18 BI15-523 IN COGEN
COGEN TURNDOWN
1) #18/2 1136-1137 IN COGEN
TS-1 (OR TS-2)
1) #18/2 SHIELDED

(20) TO CCP1 FROM PRIMARY MODULE
HIGH VOLTAGE
PUMP P-3a
3) #12 W/ GROUND AND 3 POLE TOGGLE SWITCH
PUMP P-3b
3) #12 W/ GROUND AND 3 POLE TOGGLE SWITCH

(21) TO CCP1 FROM HTG/RISER MODULE
HIGH VOLTAGE
PUMP P-4
3) #12 W/ GROUND AND 3 POLE TOGGLE SWITCH
DUPLEX OUTLET
2) #12 W/ GROUND

(22) TO CCP1 FROM HTG/RISER MODULE
LOW VOLTAGE
VALVE V-1
2) #18 W/ SERVICE SW
1) #18/2 SHIELDED
TS-3,4,9,10,11,12
6) #18/2 SHIELDED
CFW CUTOFF SOLENOID
2) #18

(23) TO SUB PANEL FROM CCP1
3) #10 W/ GROUND
1) 3P 30 AMP CB
2) #12 W/ GROUND
1) 1P 20 AMP CB

(24) TO COGEN SUB PANEL FROM EJECTORS
EP-1 (3 HP)
3) #12 W/ GROUND
1) 1P 20 AMP CB
EP-2 (3 HP)
3) #12 W/ GROUND
1) 1P 20 AMP CB

(25) NOT USED

(26) TO SBDP (CELLAR) PANEL FROM SUB PNL
4) #3 W/ #8 GROUND
1) 3P 100 AMP CB

(27) TO CCP1 FROM RISER
LOW VOLTAGE
MODBUS CABLE
2) #18/2 SHIELDED TWISTED
LON CABLE (PROVIDED BY AEGIS)
2) CABLES
CAT5e CABLE
2) CABLES
ELEVATOR CONTROLS
4) #18/2

(28) TO SUB PANEL FROM RISER
HIGH VOLTAGE
CCP2 FROM 2ND FL
4) #10 W/GROUND
1) 3P 20 AMP CB
CCP3 FROM 33RD FL
4) #10 W/ GROUND
1) 3P 20 AMP CB

NORTH

COGENERATION ELECTRICAL LAYOUT - SUB CELLAR
PARTIAL PLAN

SCALE: 1/4" = 1' 0"

NOTES:

FOR:
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ELECTRICAL LAYOUT
SUB CELLAR

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NOTES:

(1) NEW SBDP, PROVIDED BY ELECTRICIAN, SEE SCHEDULE FOR DETAILS.

(2) NEW 208 VOLT, 600 AMP RATED COGEN DISCONNECT (89L) WITH 600 AMP FUSES. MANUAL, GANG OPERATED, VISIBLE BREAK, LOCKABLE, PROVIDED BY ELECTRICIAN.

(3) NEW 225 kVA 277/480Y TO 120/208Δ TRANSFORMER, 5% IMPEDANCE, PROVIDED BY ELECTRICIAN.

(4) (2 PLACES) NEW 150A, 480V, ENCLOSED MOTORIZED CIRCUIT BREAKER WITH PROVING SWITCH, PROVIDED BY ELECTRICIAN

(5) (2 PLACES) NEW AEGENCO INVERTER PROVIDED & SET BY AEGIS.

(6) NOT USED.

(7) REPLACE 800A ELEVATOR SOCKET IN ODP WITH 1200 AMP MOTOR CONTROLLED CIRCUIT BREAKER FOR NEW SBDP.

(8) CONNECT NEW HOUSE PUMP #3 (25 HP) PUMP AND MOTOR STARTER PANEL, PROVIDED BY OWNER.

(9) (3 LINES) REROUTE ELEVATOR, HOUSE LIGHTING, AND PHONE SYSTEM CIRCUITS TO NEW SBDP FROM EXISTING ODP.

(10) (2 PLACES) COGEN FEEDER FROM PARKING GARAGE BELOW, SEE CONTINUATION ON SHEET E-001.

(11)-(12) NOT USED.

(13) TO INVERTERS FROM CT'S (INSTALL ON SW#5 OUTPUT) 18) #12 W/ GND

(14) NOT USED

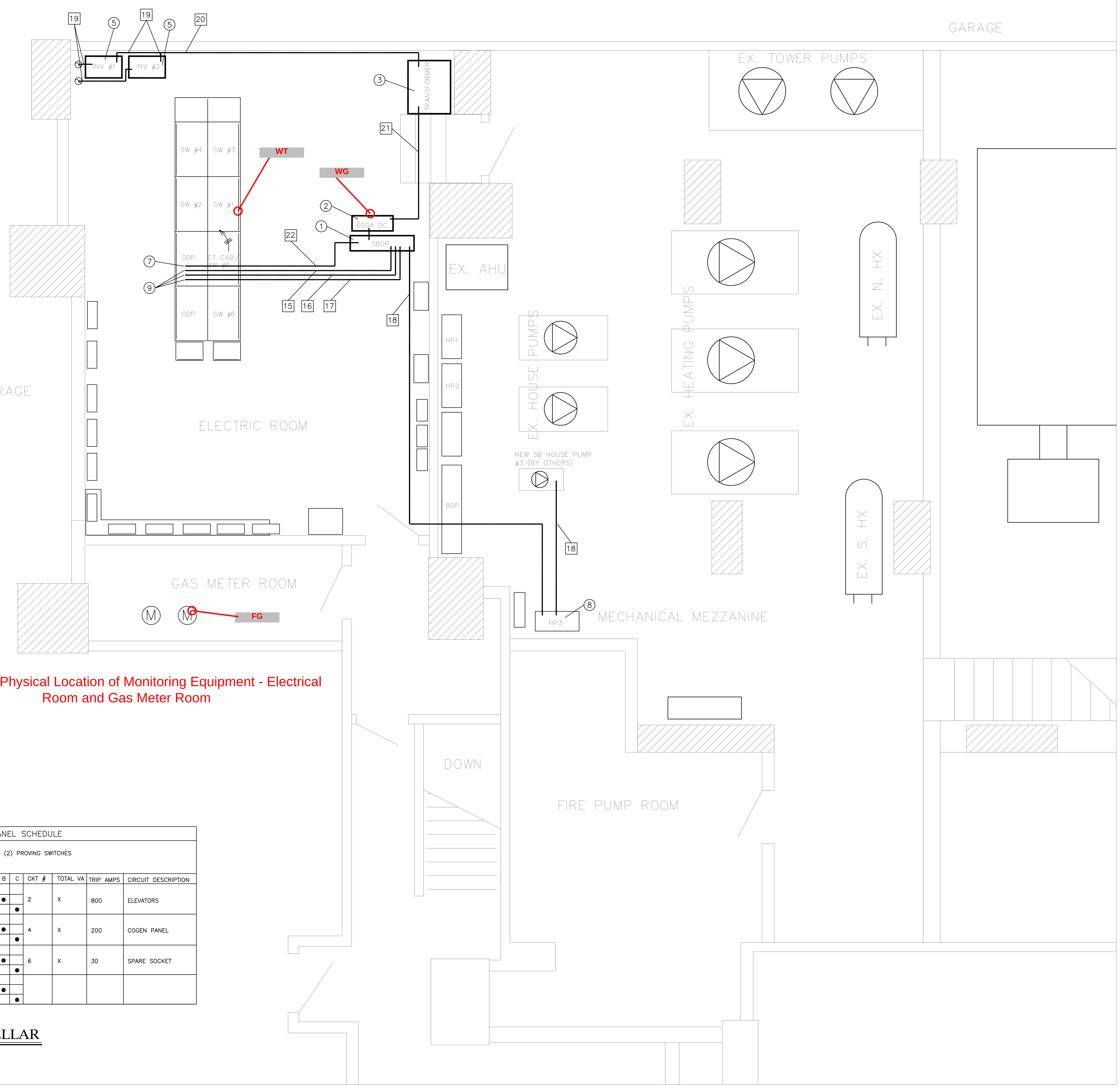

Figure 10. Physical Location of Monitoring Equipment - Electrical Room and Gas Meter Room

WIRE SIZE KEY:

[15] ELEVATOR PANEL 2 SETS 4-500MCM Cu W/ #1/0 GND

[16] LIGHTING PANEL 4-500MCM Cu W/ #2 GND

[17] PHONE SYSTEM 4-#10 Cu W/ #10 GND

[18] HOUSE PUMP #3 3-#2 Cu W/ #8 GND

[19] SINGLE 480V COGEN FEEDERS 4-#1/0 Cu W/ #6 GND

[20] COMBINED 480V COGEN 4-300MCM Cu W/ #4 GND

[21] 208V COGEN FEEDER 2 SETS 4-300MCM Cu W/ #1/0 GND

[22] SBDP FEEDER 3 SETS 4-600MCM Cu W/ #3/0 GND

NEW SBDP PANEL SCHEDULE

VOLTAGE: 120/208V, 3ϕ, 4W
MAINS: 1200 AMP MOTORIZED CIRCUIT BREAKER 65000 AIC W/ (2) PROVING SWITCHES
(3) SETS OF (4) #600MCM Cu, (1)#3/0 Cu G IN (3) 3"c
MOUNTING: SURFACE

CIRCUIT DESCRIPTION	TRIP AMPS	TOTAL VA	CKT #	A	B	C	CKT #	TOTAL VA	TRIP AMPS	CIRCUIT DESCRIPTION
HALLWAY & ELEV LTG	400	X	1	●	●	●	2	X	800	ELEVATORS
HOUSE PUMP #3	100	X	3	●	●	●	4	X	200	COGEN PANEL
SPARE SOCKET	100	X	5	●	●	●	6	X	30	SPARE SOCKET
PHONE SYSTEM 2P 208V	30	X	7	●	●	●				

NORTH

COGENERATION ELECTRICAL LAYOUT - CELLAR

PARTIAL PLAN

SCALE: 3/8" = 1' 0"

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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).

Peak Demand or Peak kW

The peak electric output or demand for each power reading will be taken as the average kW in a 1-minute interval, or

$$kW = \frac{kWh}{\Delta t} = \frac{kWh\ per\ interval}{1/60\ h}$$

Heat Recovery Rates

The heat recovery rates will be calculated based on the 1-minute data recorded by the data logger. The piping arrangement at this site requires for separate heat rates to be determined with four temperature sensors and two flow readings:

Useful heat recovery (**QHU**) = K·Σ [FL1·(TLS1-TLR1)] / n - K·Σ [FL2·(TLS2-TLR2)] / n
Useful heat recovery (**QHU**) = QT – QD (Both From BTU Meters)

Dumped heat recovery (**QHD**) = K·Σ [FL2·(TLS2-TLR2)] / n
Dumped heat recovery (**QHD**) = QD (From BTU Meter)

The loop fluid is expected to be glycol water mixture, (K ~ 480 Btu/h-gpm-°F). 'n' is the number of scan intervals included in each recording interval (e.g., with 1-minute data, n=60).

Parasitic Loads

The parasitic electric loads on this system consists of 14 circulation pumps (four pumps are redundant) and two dump radiator fans.

Parasitic Energy (**WPAR**) = ΣWPAR / n

Calculated Quantities

The net power output from the CHP system will be defined as the power from the engine generators minus the parasitic power.

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

$$FCE = \frac{QHU \cdot \Delta t + 3.412 \cdot (WG - WPAR)}{LHV_{gas} \cdot FG}$$

where:	QHU	-	Useful heat recovery (Btu/h)
	WG	-	Engine generator gross output (kWh) (WG1+WG2)
	WPAR	-	Parasitic energy (kWh)
	FG	-	Generator gas consumption (Std CF)
	Δt	-	1/60 for 1-minute data
	LHV_{gas}	-	Lower heating value for natural gas (~920 Btu per CF).
Where			
			0.9 is the conversion factor between HHV and LHV

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

$$FCE = \frac{\sum^{N} QHU \cdot \Delta t + 3.412 \cdot \sum^{N} (WG - WPAR)}{LHV_{gas} \cdot \sum^{N} FG}$$

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

Data Logging Equipment

The data logging system will be based around the Obvius AquiSuite A8812 data logger. The logger has eight analog or digital inputs on the main board, and monitoring capabilities can be extended using expansion boards. The primary sensor connection configuration for the logger is a two-wire twisted pair network, that reduces the number of low voltage sensor wire runs. The logger has 32 MB of onboard RAM for data retention. The logger is equipped with both a 10/100 LAN port and an analog phone modem for remote data retrieval.

Obvius AcquiSuite

Figure 11. Obvious AcquiSuite Data Logger

Each night we poll the logger via a network connection, and collect the data recorded across the day. Data are automatically loaded into the database system here at CDH Energy, where a number of automated data verification routines will identify any suspect data. Verification routines will consist of range checks, where the data are compared to a preset range of value, and data exceeding these values will be flagged; and/or relational checks, where the data are compared to the operational state of the unit for validity, such as “Are the engines consuming gas while producing power?” Data that fails the verification routines will be checked manually by CDH personnel on a daily basis, and corrupt data will be removed from the database. We will endeavor to address data collection issues such as data logging hardware or sensor failures within 48-hours of the failure being identified.

All data collected will be converted to hourly data in a comma delimited CSV format consistent with the requirements for inclusion into the NYSERDA integrated data system website.

All sensors are scanned on the order of once per second, and these samples will be combined into 1-minute averages (for analog data) and totals (for digital data). The logger has sufficient memory to hold up to 30-days of data without overwriting the logger memory.

All data logging equipment is installed in a fiberglass NEMA Type 1 enclosure to be mounted inside the cellar mechanical room, near the existing Aegis control panel, providing 110 VAC and internet connectivity.

Other Monitoring Requirements

The data logger will require a connection to the Internet. A dedicated static IP address is desired, but not required. If a dynamic IP address is used, the logger will upload data every night to the CDH Energy servers, but we will not be able to access the logger for remote configuration purposes.

All low voltage signal wiring will not be installed in conduit. Cable runs will be neat and secured to existing conduit.

Sensor Selection

Cut sheets for the data logging equipment and sensors are attached.

Sensor Verification

To be performed at monitoring system installation.

System Energy Flows

System energy and thermal flows documented in data analysis section.

Data Collection Status

To be provided at monitoring system commissioning.

APPENDIX A – Data Logger and Sensor Cut Sheets

A8812 AcquiSuite DR™ Data Acquisition Server

Description

Obvius, the leader in cost effective data acquisition and wireless metering solutions introduces the all-new A8812-x AcquiSuite DR™ data acquisition server, providing high performance and low cost for:

- Demand response programs
- Benchmarking building operations performance
- Verification of energy savings and utility costs
- Cost allocation to departments or tenants
- Internet based supervisory control outputs

The system combines the flexibility of choosing LAN, modem or cellular communication paths with the lowest total installed cost for logging building data such as:

- Electrical, gas and water usage and costs
- Indoor and outdoor temperatures
- Pressure, humidity, CO_2
- Industry standard pulse or analog inputs

AcquiSuite™ brings "plug and play" capability to the data acquisition market, dramatically reducing the time and training required to put a typical building on line. In most applications, the installation can be done by the building engineer or contractor in less than 2 hours. The system automatically detects and configures Modbus devices in just seconds reducing installation time and costs.

Applications

- Demand response program control and reporting
- Cost allocation to tenants and third parties
- Measurement & verification of energy savings
- Data center branch circuit monitoring
- Monitoring performance of building systems (e.g., chillers, boilers, fans)

Easy installation saves time and money

- Simple "plug and play" connectivity to standard Modbus meters minimizes installation time and costs
- "Flex" I/O inputs provide easy connections for analog, pulse and resistance sensors
- Integrated relay outputs allow supervisory control from any location for load shedding or local generation
- Integrated web server provides setup and configuration using any industry standard web browser (i.e., Netscape™ or Internet Explorer™)

AcquiSuite Framework lets users add Modbus devices

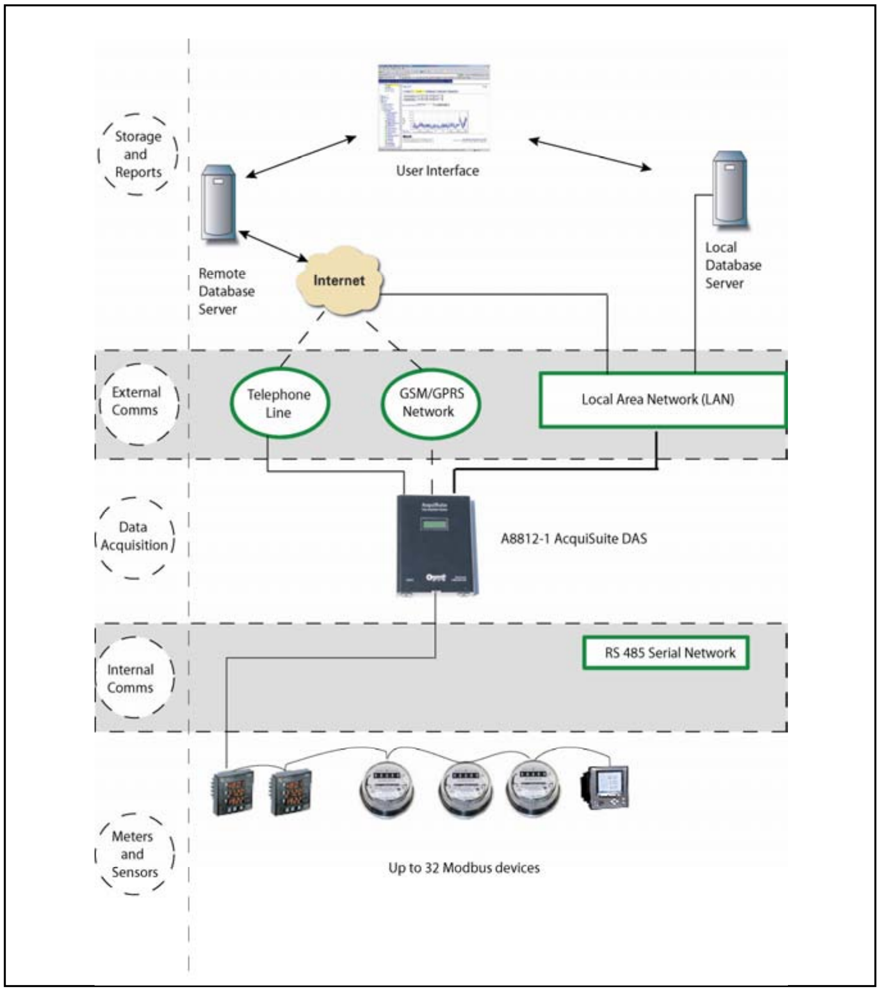
- Allows users a simple means to add Modbus devices not supported by AcquiSuite plug and play drivers
- Driver templates can be stored and shared with multiple AcquiSuites
- Simple web-based interface makes the process easy

Internet display of key building parameters

- Buildingmanageronline.com™ allows authorized users to see building performance data in an easy to use graphical format
- BMO site provides storage, display and downloads of historical data in a secure SQL database
- Users can be notified of alarm conditions in any or all monitored points
- Open protocols provide connectivity to any energy management or building automation software

Flexible communications and wireless connectivity

- All data is stored at the site in nonvolatile memory, insuring protection of valuable information in the event of power loss
- Optional on-board ModHopper (R9120-x) for wireless RS 485 communications (consult factory)
- A8812-1 provides two communication options: Local Area Network (LAN) or phone line
- A8812-GSM replaces the standard phone modem with a GSM/GPRS modem for cellular data transfer



SPECIFICATIONS

Processor	Main processor: ARM 9 ; I/O co-processor: ARM 7
Operating System	Linux 2.6
Flash ROM	16 MB NOR Flash (expandable with USB memory device)
Memory	32 MB RAM
LED	8x pulse input, 4 modem activity, Modbus TX/RX, power status
Console	2 x 16 LCD character, two buttons
LAN	10/100, Auto crossover detection
Modem (phone)	V.34 bis, 33,600 bps **(Part number A8812-1)**
Modem (cellular)	GSM/GPRS Class10, 85 kbps **(Part number A8812-GSM)**
Protocols	Modbus/RTU, Modbus/TCP, TCP/IP, PPP, HTTP/HTML, FTP,SNMP, SMTP, XML
Power Supply	24 VDC, included
Serial Port	RS-485 Modbus
Approvals	CE; FCC Part 15, Class A
USB port	USB memory expansion port
Power Requirement	110-120VAC
Interval recording	User selectable 1-60 minutes. Default 15 minute interval.
Outputs	2x, Dry contact 30 VDC, 150 mA max
Inputs	8x, user selectable:

- 0-10 V - Min/Max/Ave/Instantaneous
- 4-20 mA - Min/Max/Ave/Instantaneous
- Pulse- Consumption, Rate
- Resistance - Min/Max/Ave/Instantaneous
- Runtime - Runtime, Status

CE

VERIS INDUSTRIES

Enhanced Power and Energy Meter

Versatile Energy Monitoring Solution

E5x

5 Year Warranty

APPLICATIONS

- Energy monitoring in building automation systems
- Renewable energy
- Energy management
- Commercial submetering
- Industrial monitoring
- Cost allocation

FEATURES

All Models: A compact solution for panelboard monitoring

- DIN rail mounting option...easy installation
- ANSI 12.20 0.5% accuracy, IEC 62053-22 Class 0.5S...great for cost allocation
- Real energy output and phase loss alarm output on E50Bx and E5xCx models...one device serves multiple applications
- 90-600 VAC...application versatility with fewer models to stock
- Bright backlit LCD...easy visibility in dark enclosures
- Data logging capability (E5xC3 and E50H5)...safeguard during power failures
- Compatible with CTs from 5A to 32000A...wide range of service types
- User-enabled password protection...protect from tampering
- System integration via Modbus (E5xCx) or BACnet MS/TP (E50H5)...convenient compatibility with existing systems
- Native BACnet MS/TP support with serial rates up to 115.2 kbaud (E50H5)

E51 Models: An essential solution for Solar and other renewable energy applications

- Bi-directional metering (4-quadrant)...allows net metering
- Data logging capability (E51C3)...ensures long term data retrieval
- CSI approved
- Includes SunSpec compliant common and meter register blocks

DESCRIPTION

The **E5x Series** DIN Rail Meter combines exceptional performance and easy installation to deliver a cost-effective solution for power monitoring applications. The E5x can be installed on standard DIN rail or surface mounted as needed. Pulse output and phase alarms provide additional versatility. The Modbus and BACnet output options offer added flexibility for system integration. The data logging capability (E5xC3 and E50H5) protects data in the event of a power failure. Modbus, pulse output, and phase alarms are all provided to suit a wide variety of applications.

Additional pulse inputs on E50H5 provide an easy way to incorporate simple flow sensors to track gas, water, steam, or other energy forms using a BACnet system in addition to full monitoring of electrical energy.

The E51 models add a bi-directional monitoring feature designed expressly for renewable energy applications, allowing measurement of power imported from the utility grid as well as power exported from the renewable energy source (e.g. solar panels). In this way, a facility administrator track all energy data, ensuring accuracy in billing and crediting.

SPECIFICATIONS

Inputs:	
Control Power, AC	50/60 Hz; 5VA max.; 90V min.; UL Maximums: 600V_{L-L} (347V_{L-N}); CE Maximums: 300V_{L-N} (520V_{L-L})
Control Power, DC	3W max.; UL and CE: 125 to 300VDC (external DC current limiting required)
Voltage Input	UL: 90 V_{L-N} to 600 V_{L-L}; CE: 90 V_{L-N} to 300 V_{L-L}
Current Input	
Scaling	5 A to 32,000 A
Input Range	0 to 0.333 V or 0 to 1 V (selectable)
Pulse Inputs (E50H5 only)	Two sets of contact inputs to pulse accumulators
Accuracy:	
Real Power and Energy	0.5% (ANSI C12.20, IEC 62053-22 Class 0.5S)
Outputs:	
All Models (except E50H5)	Real Energy Pulse: N.O. static; Alarm contacts: N.C. static
E50Bx	Reactive energy pulse 30 VAC/DC
E5xCx	RS-485 2-wire Modbus RTU (1200 baud to 38.4 kbaud)
E50H5	RS-485 2-wire BACnet MS/TP (9600 baud to 115.2 kbaud)
Mechanical:	
Mounting	DIN Rail or 3-point screw mount
Environmental:	
Operating Temperature Range	-30° to 70°C (-22° to 158°F)
Storage Temperature Range	-40° to 85°C (-40° to 185°F)
Humidity Range	<95% RH noncondensing

UL listed, CE, California CSI Solar, ANSI C12.20

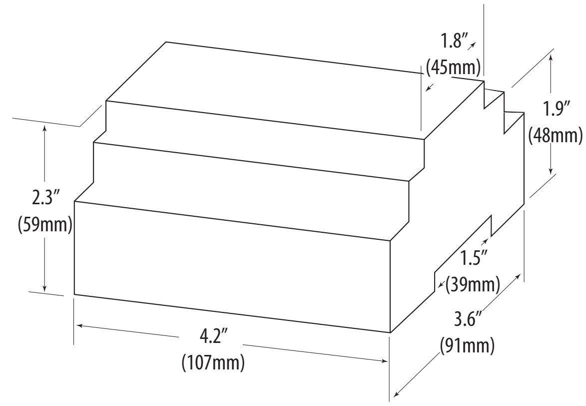
ORDERING INFORMATION

SunSpec alliance
E51 only

E51 only

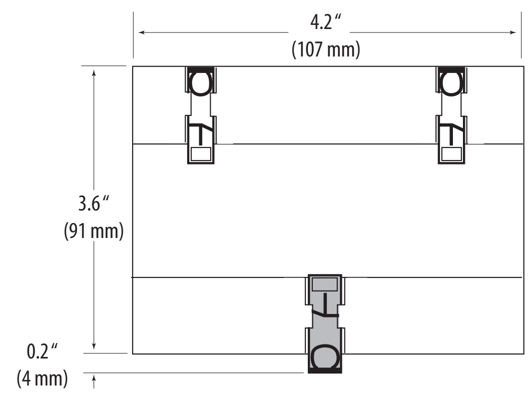
	E50B1	E50C2	E50C3	E50H5	E51C2	E51C3
Measurement Capability - Full Data Set						
Bi-directional Energy Measurements					●	●
Power (3-phase total and per phase) - Real (kW), Reactive (kVAR), and Apparent (kVA)	●	●	●	●	●	●
Power Factor: 3-phase average and per phase	●	●	●	●	●	●
Present Power Demand - Real (kW), Reactive (kVAR), and Apparent (kVA)	●	●	●	●	●	●
Import and Export totals of Present Power Demand - Real (kW), Reactive (kVAR), and Apparent (kVA)					●	●
Peak Power Demand - Real (kW), Reactive (kVAR), and Apparent (kVA)	●	●	●	●	●	●
Current: (3-phase average and per phase)	●	●	●	●	●	●
Voltage - Line-Line and Line-Neutral: (3-phase average and per phase)	●	●	●	●	●	●
Frequency	●	●	●	●	●	●
Accumulated Energy - Real (kWh), Reactive (kVARh), and Apparent (kVAh)	●	●	●	●		
Import and Export Accumulators of Real and Apparent Energy					●	●
Reactive Energy Accumulators by Quadrant (3-phase total and per phase)					●	●
Configurable Demand Subinterval	●	●	●	●	●	●
Demand Interval Configuration: Fixed or Rolling Block	●	●	●	●	●	●
Demand Interval Configuration: External Sync to Comms		●	●	●	●	●
Data Logging (store up to 60 days at 15-minute interval):						
Data Logging - 10 16-Bit Configurable (can include Date/Time) Data Buffers			●			●
Data Logging - 3 Timestamped 32-Bit Configurable Data Buffers				●		
Outputs:						
Alarm Output (N.C.)	●	●	●		●	●
1 Pulse Output (N.O.)		●	●		●	●
2 Pulse Outputs (N.O.)	●					
RS-485 Serial (Modbus RTU Protocol)		●	●		●	●
RS-485 Serial (BACnet MS/TP Protocol)				●		
Inputs:						
2 Pulse Contact Accumulator Inputs				●		

DIMENSIONAL DRAWING

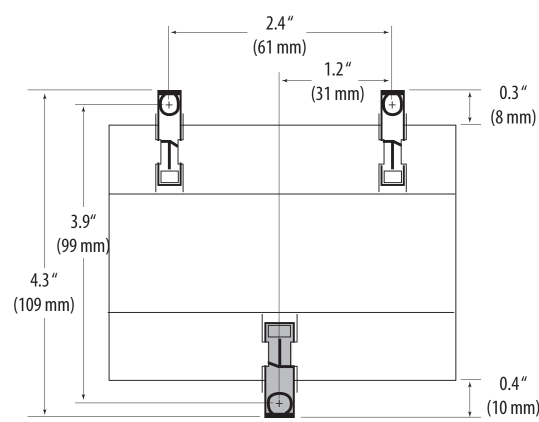


MOUNTING DIAGRAMS

DIN Mount Configuration



Wall Mount Configutation



ACCESSORIES

NEMA4 enclosure (AE010) with locking mechanism (AE011) (pictured)
Fuse Kits with hi-interrupt capability AC Fuses (AH02, AH03, AH04)
Split-core and solid-core CTs (H681x, UCT, SCT)
Replacement mounting clips (AE004)
DIN Rail (AV01)
DIN Rail Stop Clips (AV02)
Terminating Resistor (AH22)

VERIS INDUSTRIES

Enercept® Networked Power Transducers (Modbus® RTU)

Integral Monitoring Solution Eliminates The Need For Separate Enclosures

APPLICATIONS

- Energy managing & performance contracting
- Monitoring for commercial tenants
- Activity-based costing in commercial and industrial facilities
- Real-time power monitoring

FEATURES

The world's most cost-effective power transducer

- Monitor energy parameters (kW, kWh, kVAR, PF, Amps, Volts) at up to 63 locations on a single RS-485 network...greatly reduces wiring time and cost
- Fast split-core installation eliminates the need to remove conductors...saves time and labor
- Precision electronics and current transformers in a single package...reduces the number of installed components...huge labor savings
- Smart electronics eliminate CT orientation concerns...fast trouble-free installation

High accuracy

- ±1% total system accuracy, (10% to 100% of CT rating)

H8035

U.S. Patent No. 6,373,238

5 Year Warranty

DESCRIPTION

The **Enercept H8035/8036** are innovative three-phase networked (Modbus RTU) power transducers that combine measurement electronics and high accuracy industrial grade CTs in a single package. The need for external electrical enclosures is eliminated, greatly reducing installation time and cost.

There are two application-specific platforms to choose from. The Basic Enercept energy transducers (H8035) are ideal for applications where only kW and kWh are required. The Enercept Enhanced power transducers (H8036) output 26 variables including kW, kWh, volts, amps, and power factor, making them ideal for monitoring and diagnostics.

Color-coordination between voltage leads and CTs makes phase matching easy. Additionally, the Enercept automatically detects and compensates for phase reversal, eliminating the concern of CT load orientation. Up to 63 Enercepts can be daisy-chained on a single RS-485 network.

POWER/ENERGY MONITORING

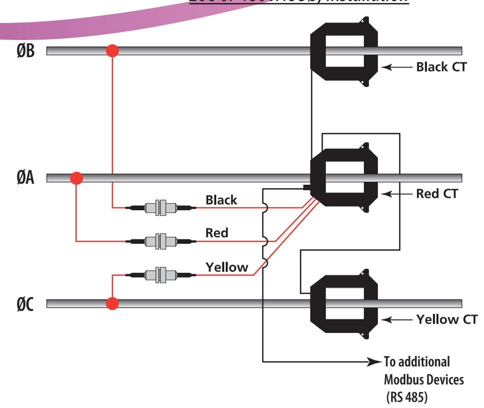
SPECIFICATIONS

Inputs:	
Voltage Input	208 to 480VAC, 50/60 Hz RMS †(††)
Current Input	Up to 2400A continuous per phase †
Accuracy:	
System Accuracy	±1% of reading from 10% to 100% of the rated current of the CTs, accomplished by matching the CTs with electronics and calibrating them as a system
Outputs:	
Type	Modbus RTU**(*)
Baud Rate	9600, 8N1 format
Connection	RS-485, 2-wire + shield
Environmental:	
Operating Temperature Range	0° to 60°C (32° F to 140°F), 50°C (122°F) for 2400A
Humidity Range	0 - 95% non-condensing

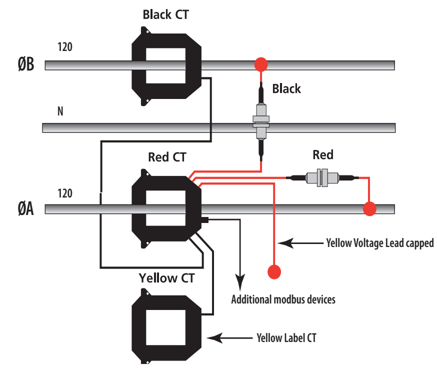
UL, approved for California CSI Solar applications (check the CSI Solar website for model numbers)
*** Detailed protocol specifications are available at: http://www.veris.com/modbus*
** Other protocols available. Please consult factory.*
† Contact factory to interface for voltages above 480VAC or current above 2400 Amps.
†† Do not apply 600V Class current transformers to circuits having a phase-to-phase voltage greater than 600V, unless adequate additional insulation is applied between the primary conductor and the current transformers. Veris assumes no responsibility for damage of equipment or personal injury caused by products operated on circuits above their published ratings.

APPLICATION/WIRING EXAMPLES

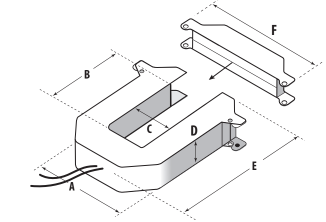
208 or 480VAC 3Ø, Installation



240VAC 1Ø, 3-Wire Installation

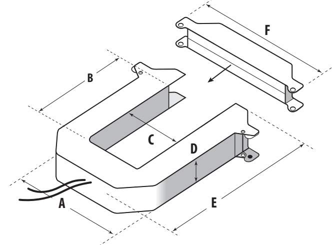


DIMENSIONAL DRAWINGS



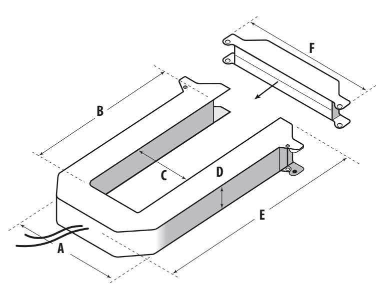
SMALL
100/300 Amp

A = 3.8" (96 mm)
B = 1.2" (30 mm)
C = 1.3" (31 mm)
D = 1.2" (30 mm)
E = 4.0" (100 mm)
F = 4.8" (121 mm)



MEDIUM
400/800 Amp

A = 4.9" (125 mm)
B = 2.9" (73 mm)
C = 2.5" (62 mm)
D = 1.2" (30 mm)
E = 5.2" (132 mm)
F = 5.9" (151 mm)



LARGE
800/1600/2400 Amp

A = 4.9" (125 mm)
B = 5.5" (139 mm)
C = 2.5" (62 mm)
D = 1.2" (30 mm)
E = 7.9" (201 mm)
F = 6.0" (151 mm)

DATA OUTPUTS

H8035
kWh
kW

H8036
kWh, Consumption
kW, Real Power
kVAR, Reactive Power
kVA, Apparent Power
Power Factor
Average Real Power
Minimum Real Power
Maximum Real Power
Voltage, L-L
Voltage, L-N*
Amps, Average Current
kW, Real Power ØA*
kW, Real Power ØB*
kW, Real Power ØC*

** Based on derived neutral voltage.*

POWER/ENERGY MONITORING

ORDERING INFORMATION

LISTED 44XJ UL 508 E212445

Modbus Basic Power Transducers*

MODEL	MAX. AMPS	CT SIZE
H8035-0100-2	100	SMALL
H8035-0300-2	300	SMALL
H8035-0400-3	400	MEDIUM
H8035-0800-3	800	MEDIUM
H8035-0800-4	800	LARGE
H8035-1600-4	1600	LARGE
H8035-2400-4	2400	LARGE

**H8035 models work with H8920-5 LON nodes*

Modbus Enhanced Data Stream Power Transducers*

MODEL	MAX. AMPS	CT SIZE
H8036-0100-2	100	SMALL
H8036-0300-2	300	SMALL
H8036-0400-3	400	MEDIUM
H8036-0800-3	800	MEDIUM
H8036-0800-4	800	LARGE
H8036-1600-4	1600	LARGE
H8036-2400-4	2400	LARGE

**H8036 models work with H8920-1 LON nodes*

ACCESSORIES

CT Mounting brackets (AH06)
H8920 Series LON nodes

Badger Meter

Series 380 Impeller
380CS/HS

OVERVIEW

The Badger Meter Series 380 Btu Systems provide a low cost system for metering cold or hot systems. The 380CS/HS can accurately measure flow and temperature differential to compute energy. Utilizing either BACnet or Modbus RS-485 communications protocols or a scaled pulse output, the Btu Meter can interface with many existing control systems.

The rugged design incorporates an impeller flow sensor and two temperature probes. One temperature probe is conveniently mounted directly in the flow sensor tee. The second temperature probe is placed on either the supply or the return line depending on ease of installation for the application. These minimal connections help simplify installation and save time.

The main advantage of the Series 380 Btu meters is the cost savings over other systems offered on the market today. The integration of flow and temperature sensors provide a single solution for metering. With this system it will be possible to meter energy where it hasn't been cost effective before.

Commissioning of this meter can be completed in the field via a computer connection. Setup includes energy measurement units, measurement method, communication protocol, pulse output control, fluid density, and specific heat parameters.

RS-485 Configuration

All Series 380 Btu meters are equipped with BACnet and Modbus protocols as a standard feature. The protocol of choice can be selected and setup in the field at the users discretion. These common protocols allow for quick and easy commissioning while gaining valuable application data beyond energy total. Information such as Flow Rate, Flow Total, Energy Rate, Energy Total, Temp 1, Temp 2, and Delta T can all be transmitted on the RS-485 connection.

Scaled Pulse Output

If the RS-485 is not required for the application, a simple scaled pulse output is available. This output would represent energy total and can be set in various units of measure. This output is an open drain scaled pulse output that is compatible with a variety of PLCs, counters and also the Badger Meter 350 wireless system. This ensures the unit is easily compatible with most inputs.

MECHANICAL

Mass — Less than 13 lbs.

ELECTRICAL

Inputs
- Power: 12-35 VDC; 12-28 VAC
- Communication: Modbus RTU; BACnet MSTP

Output
- Scaled Pulse: Open drain; 0.01 Hz min. to 100 Hz max.

MATERIALS

Housing	Polycarbonate
Flow Sensor	PEEK
Potting Material	Polyurethane
Tee Material	Brass

SENSOR BODY SIZES

Tee Sizes 3/4", 1", 1 1/4", 1 1/2", and 2"

ENVIRONMENTAL

Fluid Temp.	-4°F to 140°F (-20°C to 60°C) - chilled 40°F to 260°F (4°C to 125°C) - hot
Ambient Temp.	-4°F to 149°F (-20°C to 65°C)

ACCURACY

± 2% of flow rate within flow range
± 0.5% repeatability
RTD meets IEC751 Class B

FLOW RANGE

1 - 15ft./sec

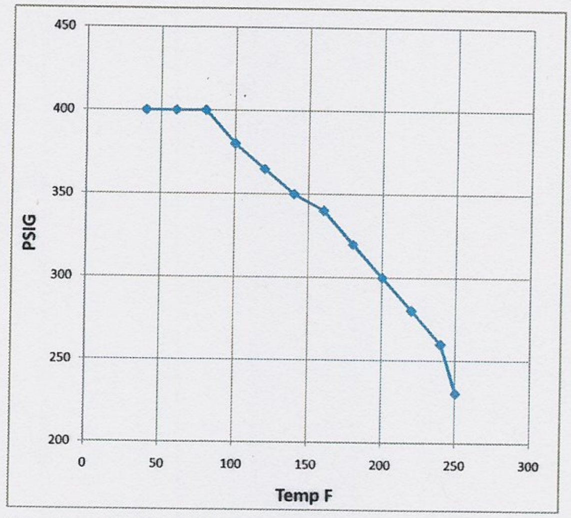
Diameter (Inches)	380 Btu Meter Flow Range (GPM)		
0.75	1.65	to	24.69
1	2.70	to	40.48
1.25	4.66	to	69.93
1.5	6.35	to	95.18
2	10.49	to	157.34

This chart is based on ASME/ANSI B36.10 Welded and Seamless Wrought Steel Pipe and ASME/ANSI B36.19 Stainless Steel Pipe

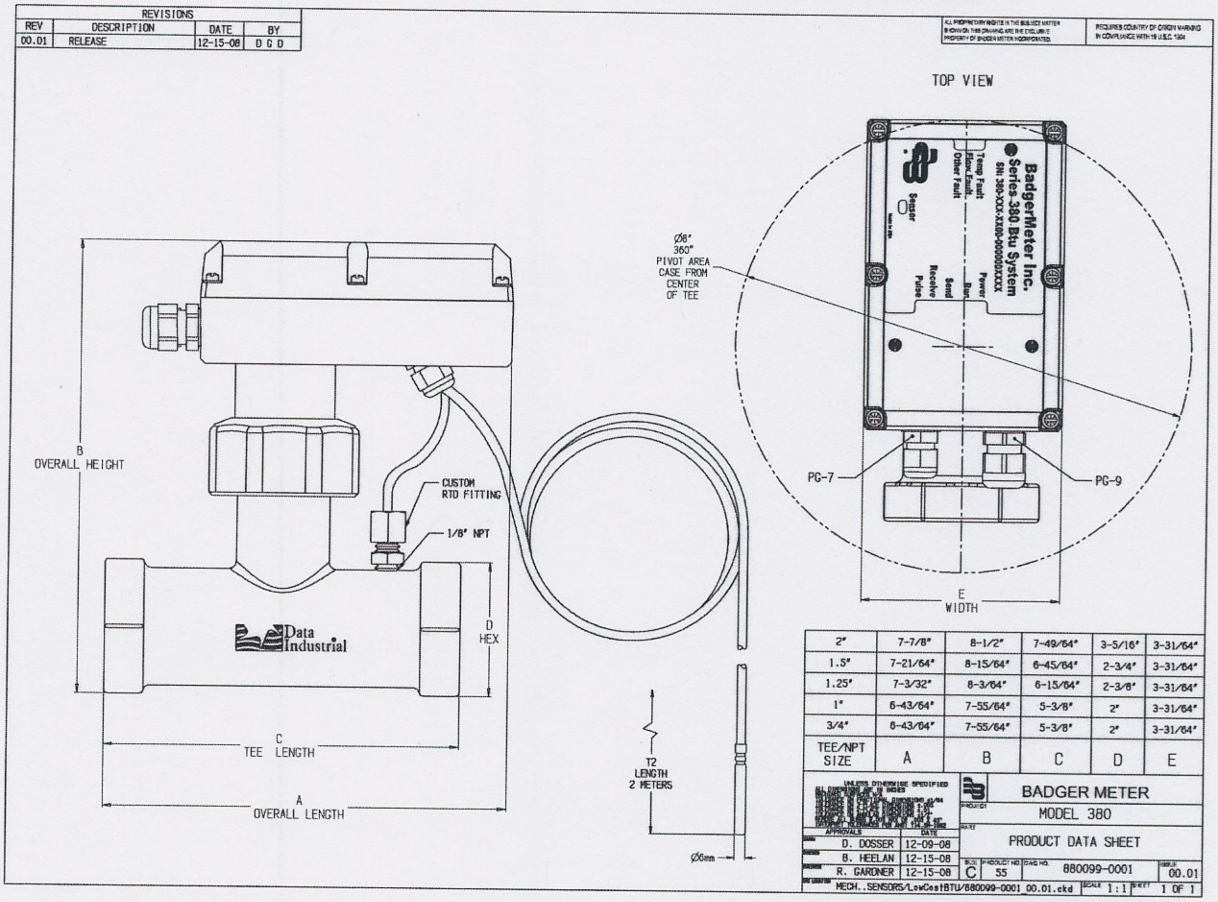
Badger® Series 380 BTU System Ordering Matrix

380 | 0 | 7 | 0 | 0 | 0 | - | 1 | 2 | 0 | 0

Type	
CS - Cold Service	0
HS - Hot Service	1
Size	
0.75"	07
1"	10
1.25"	12
1.5"	15
2"	20
Electronic Housing	
Polycarbonate	0
Output	
Scaled Pulse and RS-485 (Modbus and BACnet)	0
Display	
N/A	0
O-Ring	
EPDM (CS - Cold Service)	1
Aflas® (HS - Hot Service)	2
Shaft	
Tungsten Carbide [Standard]	2
Impeller	
Stainless Steel	0
Bearing	
Torlon® (CS - Cold Service)	0
Ketron® (HS - Hot Service)	2



*Max. Temp. 250ºF 230 PSIG
Unit can be used to -20ºF @ 400 PSIG



TEE/NPT SIZE	A	B	C	D	E
2"	7-7/8"	8-1/2"	7-49/64"	3-5/16"	3-31/64"
1.5"	7-21/64"	8-15/64"	6-45/64"	2-3/4"	3-31/64"
1.25"	7-3/32"	8-3/64"	6-15/64"	2-3/8"	3-31/64"
1"	6-43/64"	7-55/64"	5-3/8"	2"	3-31/64"
3/4"	6-43/64"	7-55/64"	5-3/8"	2"	3-31/64"

Data Industrial®

Please see our website at www.badgermeter.com for specific contacts.

Due to continuous research, product improvements and enhancements, Badger Meter reserves the right to change product or system specifications without notice, except to the extent an outstanding contractual obligation exists.

Badger Meter | P.O. Box 245036, Milwaukee, Wisconsin 53224-9536
800-876-3837 | infocentral@badgermeter.com | www.badgermeter.com

APPENDIX B – Data Logger Wiring Diagrams

Instrumentation, Wiring Schematic, and Installation Details

Site Visits

September 27, 2012	Initial site visit and rough in of data logger equipment

Description of Monitored Data Points and Schematics

Table B-1 lists the monitored points installed at the site.

Table B-1. Monitored Data Point List

No.	Data Point	Description	Units	Sensor	Output	Notes
1	WT	Total Facility Power	kW/kWh	Veris E50 C2 with MV Rope CTs	Modbus/Pulse	Installed at service entrance
2	WG	Generator Power	kW/kWh	Veris H8035-0400-3	Modbus	Installed at CHP disconnect
3	WPAR	Parasitic Power - All CCPs	kW/kWh	Veris H8035-0300-2	Modbus	Installed at parasitic breaker panel
4	FG	Generator Gas Use	CF	Utility pulse output from billing meter	Pulse	Con-Ed pulse demark
5	QT	CHP Loop 1 Heat Transfer (Total Heat Output)	Mbtu	Badger 380 BTU meter	Modbus	Installed in basement, powered from data logger
6	TLS1	CHP Loop 1 Supply Temperature (Total Heat Output)	deg F		Modbus	
7	TLR1	CHP Loop 1 Return Temperature (Total Heat Output)	deg F		Modbus	
8	FL1	CHP Loop 1 Flowrate (Total Heat Output)	GPM		Modbus	
9	QD	Heat Transfer Dump Radiator	Mbtu	Badger 380 BTU meter	Modbus	Installed at 34th Floor powered from local power supply
10	TLS2	CHP Loop 2 Temperature Before Dump Radiator	deg F		Modbus	
11	TLR2	CHP Loop 2 Temperature After Dump Radiator	deg F		Modbus	
12	FL2	CHP Loop 2 Flowrate	GPM		Modbus	
13	IEP	Ejector Pump Current (non-CHP load)	amps	Veris H921 Current CT	4-20 mA	Installed at parasitic breaker panel

Figure B-1 displays the data logger termination diagram.

Obvius Acquisite A8812 -1 Data Logger
Input Terminals

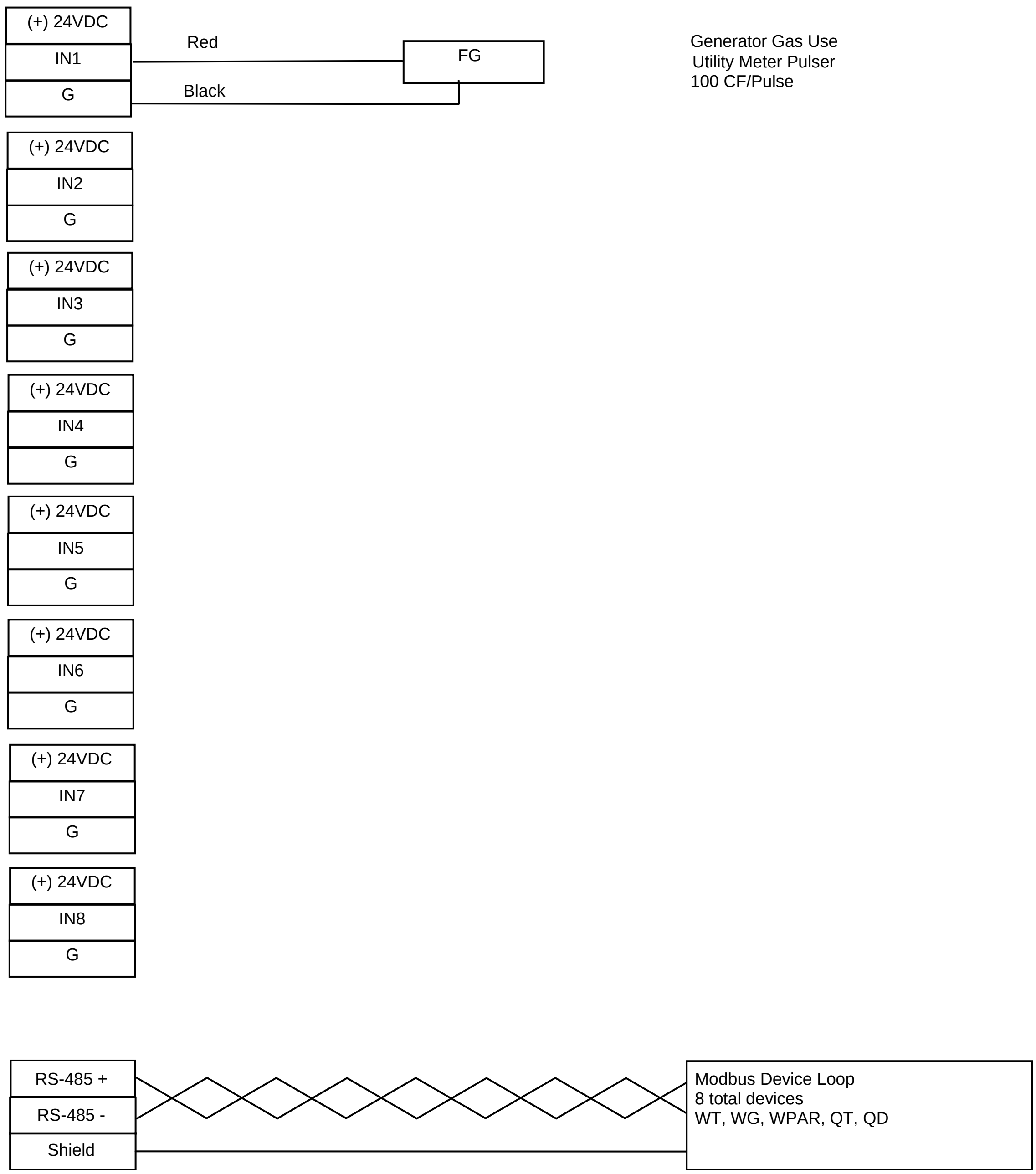


Figure B-1. Obvius Data Logger Wiring Schematic

Addendum – Churchill

300 E. 40th Street
New York, NY 10016

Site Contact

Sarah Florek
Aegis Energy Services, Inc.
413-536-1156
SFlorek@aegisenergyservices.com

Ask for access to boiler room, located in sub basement, at the front desk.

- CDH was on site March 20, 2013 to install the Obvius datalogger, terminate power meters (WT,WG,WP), wire both BTU meters (QT,QD), install current sensor (IEP).
- Website data begins March 20, 2013, testing of cogen units began April 3, 2013, and both units begin running May 6, 2013.
- Power meter (WG) at the facility stopped working July 23, 2013. Generator power output will be stipulated based on the total heat output (QT) until the power meter is fixed.
- CDH on site September 10, 2013 to diagnose failed power meter (WG), verify recovered loop #1 flow (FL1), and fix wire termination for gas meter (FG).
- CDH on site October 30, 2013 to replace the second failed Veris power meter with a new Wattnode power meter (WG).

IP Info

External IP: 24.103.48.216
Netmask: 255.255.255.240
Gateway: 24.103.48.209
DNS #1: 24.29.99.35
DNS #2: 24.29.99.36

Summary

Aegis purchased and installed the metering and ran wires while CDH energy purchased and installed the data logger. CDH also terminated meter wiring.

Monitored Data Points

No.	Data Point	Description	Units	Sensor	Output	Notes
1	WT	Total Facility Power	kW/kWh	Veris E50 C2 with MV Rope CTs	Modbus/Pulse	Provided and Installed by Ageis
2	WG	Generator Power	kW/kWh	Veris H8035-0800-3	Modbus	Provided and Installed by Ageis
3	WPAR1	Parasitic Power - CCP1	amps	Wattnode WNC-3Y-208-MB	Modbus	Install in Cogen Control Panel 1
4	WPAR2	Parasitic Power - CCP2	amps	Wattnode WNC-3Y-208-MB	Modbus	Install in Cogen Control Panel 2
5	WPAR3	Parasitic Power - CCP3	amps	Wattnode WNC-3Y-208-MB	Modbus	Install in Cogen Control Panel 3
6	WPAR4	Parasitic Power - CCP4	amps	Wattnode WNC-3Y-208-MB	Modbus	Install in Cogen Control Panel 4
7	S1	Generator #1 Status	Min.	-	-	Installed and wired by Aegis
8	A1	Generator #1 Alarm	Min.	-	-	Installed and wired by Aegis
9	S2	Generator #2 Status	Min.	-	-	Installed and wired by Aegis
10	A2	Generator #2 Alarm	Min.	-	-	Installed and wired by Aegis
11	FG	Generator Gas Use	CF	Utility pulse output from billing meter	Pulse	Provided and Installed by Ageis
12	QT	CHP Loop 1 Heat Transfer (Total Heat Output)	Mbtu	Badger 380 BTU meter	Modbus	Provided and Installed by Ageis
13	TLS1	CHP Loop 1 Supply Temperature (Total Heat Output)	deg F		Modbus	
14	TLR1	CHP Loop 1 Return Temperature (Total Heat Output)	deg F		Modbus	
15	FL1	CHP Loop 1 Flowrate (Total Heat Output)	GPM		Modbus	
16	QD	Heat Transfer Dump Radiator	Mbtu	Badger 380 BTU meter	Modbus	Provided and Installed by Ageis
17	TLS2	CHP Loop 2 Temperature Before Dump Radiator	deg F		Modbus	
18	TLR2	CHP Loop 2 Temperature After Dump Radiator	deg F		Modbus	
19	FL2	CHP Loop 2 Flowrate	GPM		Modbus	

Procedure

- Hot water loop #1 flow (FL1) was verified using a Portaflow ultrasonic flowmeter, mounted on a straight section of the return piping.

Verification – September 10, 2013

Recovered Heat Loop Flow:

Obvius (gpm)	Portaflow (gpm)
44.97	38
45.08	38.4
44.99	38.3
45.14	38.5

Avg: *45.0* *38.3*

Verification – October 30, 2013

New Power Meter Verification

Obvius (kW)	135

Inverter Disp. #1 (kW)	65
Inverter Disp. #2 (kW)	70

Fluke (kW)	132

Site Photos

 Roots gas meter (right) and Honeywell Mini-Max pulse module (left).	 Recovered heat loop #1 flow (FL1) verification location.
 Initial Veris H8035 Power Meter, located in 480V switchgear.	 Newly installed Wattnode power meter.