MEASUREMENT AND VERIFICATION PLAN

FOR

DG/CHP SYSTEM AT 110 E 59TH STREET – OFFICEPOWER

As Built March 2009

Submitted to:

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

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1. Introduction

This monitoring plan presents the methods of measurement and data collection for the CHP system at 110 East 59th Street. The system is being installed and operated by OfficePower.

The CHP system at 110 East 59th Street consists of eight (8) 100-kW Elliott microturbines. The turbines have roughly a 105-kW gross output to cover the operation of the onboard gas compressor and controls, resulting in a net output of 800 kW for the entire plant. Electricity is being fed into only one of the three facility utility feeds.

The turbines have integrated hot water heat recovery, with a parallel piping arrangement. Each turbine pulls hot water from a return header and injects heated hot water to a supply header. There is a dump radiator for system stability and heat rejection.

The turbines are electrically connected into two groups of four turbines each. These two groups are connected to one of the three utility feeds into the building. The other two feeds are unaffected by the operation of the CHP system. The grouping of turbines and selection of associated utility feed was performed to maximize the opportunity for electrical operation. The turbine groups are sized to be very close to the continuous baseload for the selected service.

Heat from the turbine heat recovery loop can be used to meet thermal loads in the facility via a heat exchanger (for heating season operation), or directly used by an absorption chiller (see Figure 3). The thermal loads include:

- Space heating to the building secondary hot water return (isolated by HX)
- Direct hot water use by a new absorption chiller

Heat not recovered (typically at startup, or low load conditions) will be wasted, first by a bypass exhaust damper in each turbine, then if necessary by heat rejection by a dump radiator located on the heat recovery loop.

The absorption chiller, and the flow meter for the heat recovery loop (FGL/FM-1), have not been installed at this point in time. At the time of installation for the absorption chiller, these sensors are to be installed. Prior to the installation of these sensor, heat recovered from the CHP system will be monitored on the load-side of the CHP-to-Building HW HX.

The chiller will tie into the building's primary chilled water return. Condenser water for this chiller will be provided by the building's condenser water circuit (tie-in on the return side to the condenser). The absorption chiller will not have it's own cooling tower.

The CHP hot water loop will be isolated from the building's hot water loop by a brazed plate heat exchanger. The HX is located upstream of the steam-to-hot water tube-bundle, to allow the CHP system to meet the largest possible fraction of the building heating load.

The heat recovery loop will typically operate between 140°F - 205°F supply temperature, and return to the microturbine arrays at between 105°F - 180°F. The loop flow rate will be 280 gpm, and the heat recovery loop will contain a 30/70 mixture of propylene glycol and water.

At full load the generators will consume approximately 10,800 std cubic feet (cf) of natural gas per hour (1,350 std cubic feet each).

2. Instrumentation

OfficePower's primary revenue stream at this application will be to sell electricity and thermal energy at the prevailing utility rates before the CHP system was installed. This results in a high degree of metering required by OfficePower to ensure that all energy flows are accounted.

OfficePower will supply the instrumentation listed in Table 1 below for use in meeting the NYSERDA CHP program monitoring requirements. These sensors are only a subset of the total sensor array used to track system performance for OfficePower's purposes.

Table 1. Instrumentation Supplied By OfficePower

Point	Instrument	Output Type	Sensor Location	Notes
Facility Power	(3) Power Logic ION7350 3ϕ, 277 L-N, 2,000:5 A CTs	Full data stream (kW, kWh used) Modbus RTU (COM2)	Utility electric switchboards, cellar level (see Figure 1)	• Data points WT1, WT2, WT3
Generator Power Output	(2) Power Logic ION7350 3ϕ, 277 L-N, 800:5 A CTs (TA1) 800:5 A CTs (TA2)	Full data stream (kW, kWh used) Modbus RTU (COM2)	Turbine array disconnects panel 1 & 2, 16 floor setback (see Figure 1)	• Data points WTA1, WTA2
System Parasitic (Combined)	(1) Power Logic ION7350 3ϕ, 277 L-N, 400:5 A CTs	Full data stream (kW, kWh used) Modbus RTU (COM2)	Parasitic Load Panel, 16-floor setback	• Data point WTPLP • Includes absorption chiller, and pumps
System Parasitic (Abs Chiller Only)	(1) Power Logic ION7350 3ϕ, 277 L-N, 400:5 A CTs	Full data stream (kW, kWh used) Modbus RTU (COM2)	Parasitic Load Panel, 18-floor setback	• Data point WTCHM • Includes absorption chiller, and pumps
Generator Gas Input	(2) Roots B3 Series Model #16M1751 (utility supplied)	Solid State Pulse (1TWPS) output, 100 cf/pulse (temp-compensated)	At gas service entrance, cellar level (see Figure 2)	• Data points FGM1, FGM2 • Meter and rate selection subject to Con-Ed discretion
Heat recovery loop flow rate	Micrometer V-Cone & Foxboro DP differential pressure transmitter	4-20 mA output0 – 280 GPM10:1 turndown(Flow < 28 GPM = 0 GPM)	On heat recovery loop piping, before abs. chiller and dump radiator (see Figure 3)	• Data point FGL • 5" OD pipe diameter • 280 GPM nominal flow
Heat recovery loop temperatures	ACI 10k Ω thermistor	Direct read to ALC SCADA system using 5 VDC half bridge	In thermowells installed on heat recovery loop piping, (see Figure 3)	• TGLS, TGLR1, TGLR

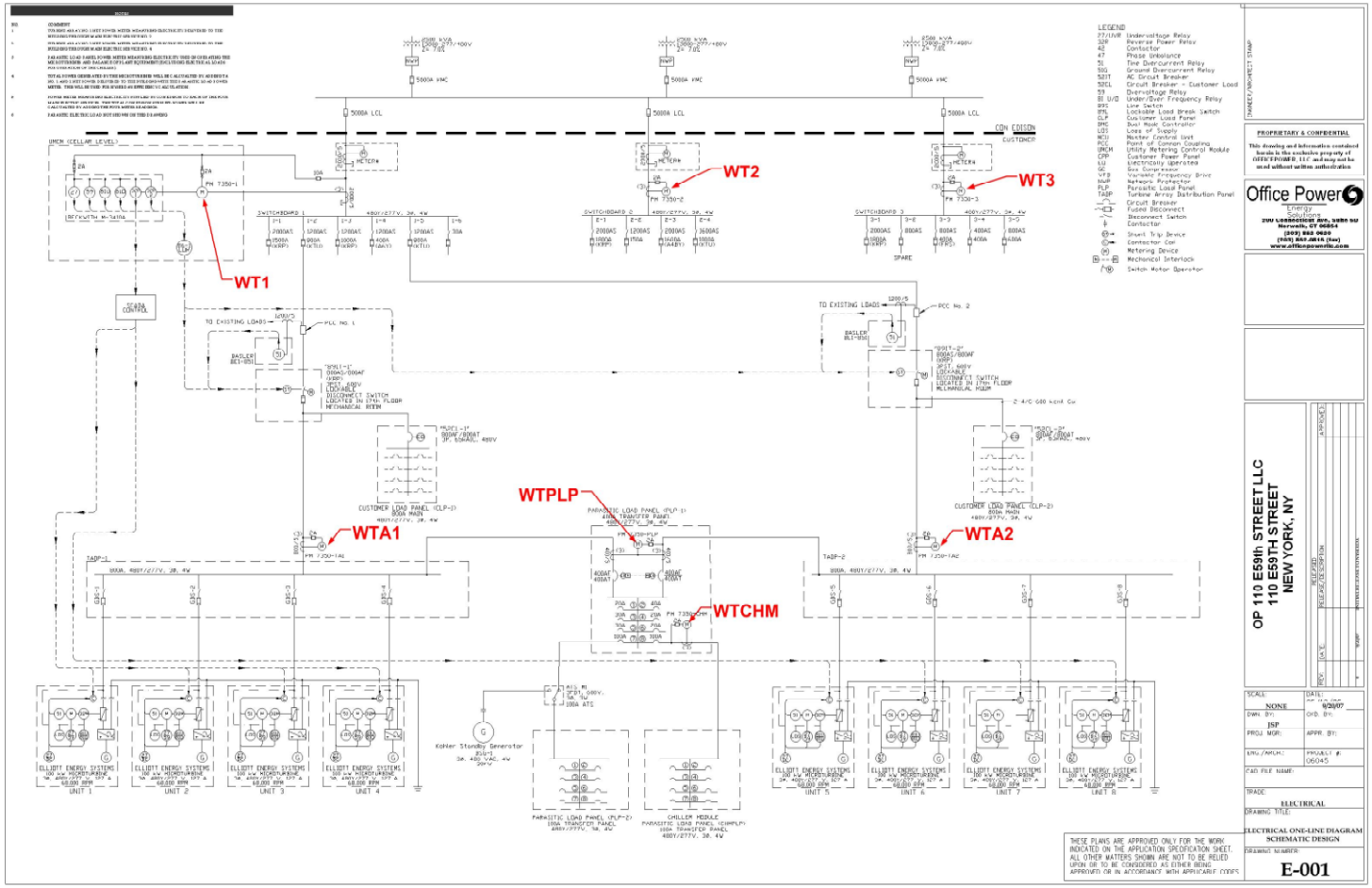

Figure 1. Power Transducer Locations

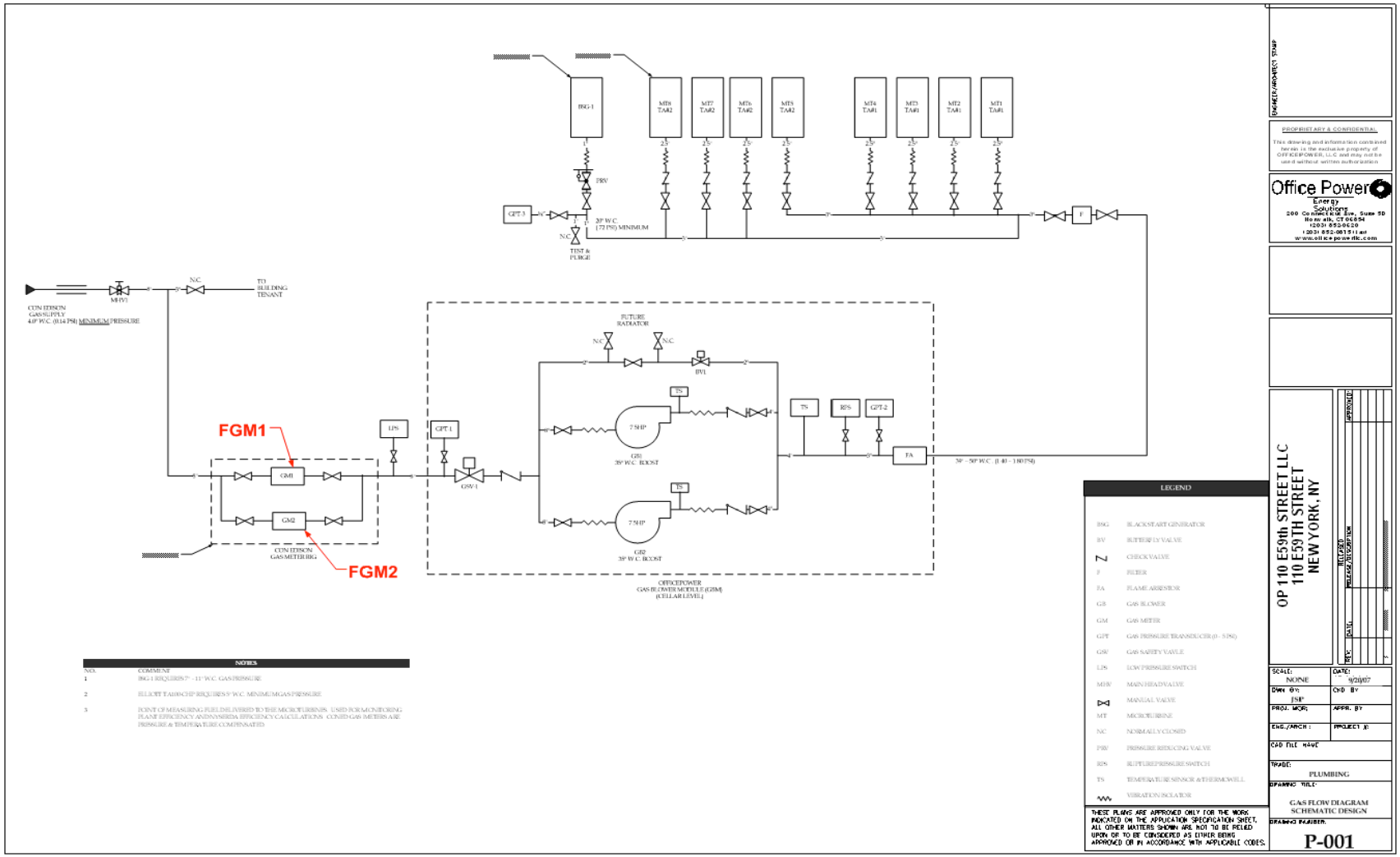

Figure 2. Gas Meter Locations (Con Ed Billing Meters)

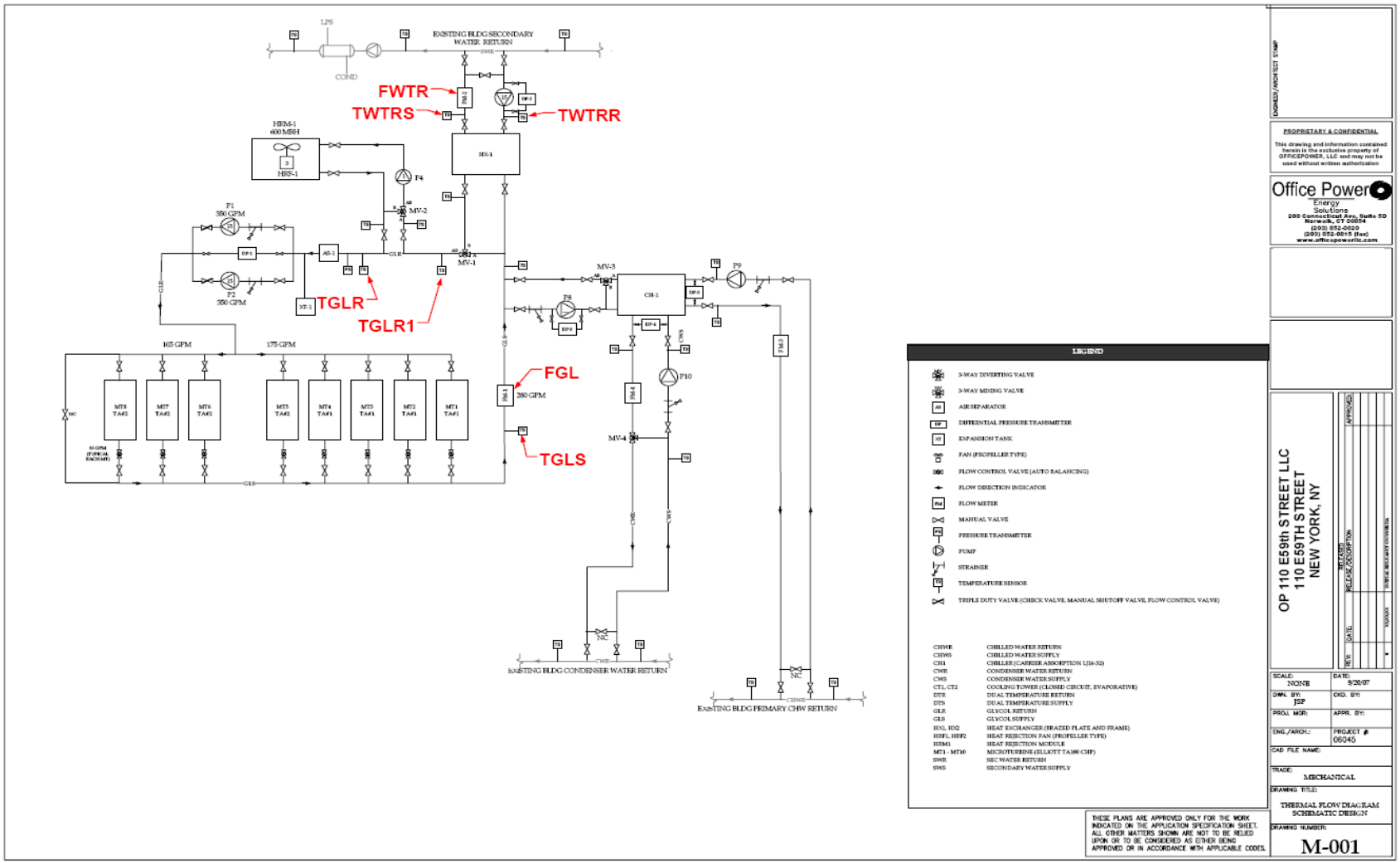

Figure 3. Heat Recovery Temperature and Flow Sensor Locations

OfficePower is installing an Automated Logic based SCADA system as the basis for monitoring the system performance. The SCADA system will also act as the conduit for data to be transferred to the data logger installed by CDH Energy. Figure 4 in the OfficePower Instrumentation Plan (Appendix B) displays the overall hierarchy of the data collection system at the site.

Sensor readings from this system will be conveyed to the CDH Energy data logger via a MODBUS RTU connection. The CDH Energy data logger will conform to the communication specification defined in the Instrumentation Plan Table 1 (Appendix A).

Datalogger

A CR1000 Campbell Scientific datalogger will be installed to record the required data. The logger will interface with OfficePower's Automated Logic SCADA controller via a two wire twisted pair MODBUS RTU connection. The CDH data logger will act as the MODBUS master in this arrangement, polling the SCADA system for the required registers every 30-seconds. It is assumed that each polling of the registers from the SCADA system will provide the data logger with the most current "real-time" data reading. The scanned data will then be averaged or totaled (depending on the type of data point measured) into 15-minute data and stored on the data logger. Based on the number of points monitored (14 points), the logger will have enough storage capacity to hold 180-days of data if communications are lost.

The datalogger will continue to log data for a few hours in the event of a power outage at the site. The data will be downloaded from the datalogger twice a day by a DSL Line and loaded into a database. Further discussion with Office Power will dictate the need for a separate CDH Energy supplied DSL modem. CDH Energy will provide a 100MBPS LAN connection with an RJ-45 jack at its monitoring panel. The data will be checked for validity and posted on the NYSERDA web site.

Onsite Installation

CDH Energy will install a datalogger panel at a location in the cogeneration room agreeable to the site and developer. The monitoring system panel will be approximately 2 ft x 2 ft x 1 ft. The panel will be mounted near a 120 VAC power receptacle (it will require 1 amp or less). The panel should be conveniently located relative to the sensors listed above as well as the communications line provided by the site.

Communications

The DSL line will be supplied by the site or developer. Further communications requirements are being determined.

On Site Support

As the monitoring arrangement at this site will involve utilizing sensors foreign to the data logger, it is expected that OfficePower will provide on site support for CDH Energy during the monitoring system installation and configuration. There will be a need to support in diagnosing and debugging communications between the data logger and OfficePower's SCADA system.

Also, it will be necessary to have on-site support from OfficePower when the readings collected by the data logger are verified using handheld measurements. It may be necessary to perform such actions during verification as removing temperature sensors from the thermowells and expose them to ambient conditions – without disrupting system operations or tripping system alarms. By removing temperature sensors (one at a time) from the thermowells, a step change in temperature will be observed both at the SCADA system, and at the CDH data logger. This will help in verifying that the proper temperature measurement is being placed in the proper holding register on the SCADA system, and that the data logger logs this register properly.

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 2. Summary of Monitored Data Points

No.	Data Point	Description	Engineering Unit
1	WT1	Building Main Service #1 Energy Import	kWh
2	WT2	Building Main Service #2 Energy Import	kWh
3	WT3	Building Main Service #3 Energy Import	kWh
4	WTA1	Turbine Array #1 (4 Turbines) Energy Production	kWh
5	WTA2	Turbine Array #2 (4 Turbines) Energy Production	kWh
6	WT1_kW	Building Main Service #1 Demand Import	kW
7	WT2_kW	Building Main Service #2 Demand Import	kW
8	WT3_kW	Building Main Service #3 Demand Import	kW
9	WTA1_kW	Turbine Array #1 (4 Turbines) Demand Production	kW
10	WTA2_kW	Turbine Array #2 (4 Turbines) Demand Production	kW
11	WTPLP	Parasitic Panel Energy Consumption	kWh
12	WTPLP_kW	Parasitic Panel Demand Consumption	kW
13	WTCHM	Absorption Chiller Component Electric Consumption	kWh
14	WTCHM_kW	Absorption Chiller Component Demand Consumption	kW
15	FGM1	Microturbine Array Gas Consumption Meter 1	cu ft
16	FGM2	Microturbine Array Gas Consumption Meter 2	cu ft
17	TGLR	Glycol Return Temperature to Microturbine Array	F
18	TGLR1	Glycol Temperature after HX and Abs. Chiller	F
19	TGLS	Glycol Supply Temperature from Microturbine Array	F
20	FGL	Glycol Flow (Flow Meter FM-1)	gpm
21	TWTRR	Building Hot Water Return Temperature (Entering HX)	F
22	TWTRS	Building Hot Water Supply Temperature (Leaving HX)	F
23	FWTR	Building Hot Water Flow through HX	GPM

Peak Demand or Peak kW

The peak electric output or demand for each power reading will be taken as the average kW in a 15-minute interval, or

$$kW = \frac{kWh}{\Delta t} = \frac{\text{kWh per interval}}{0.25\ h}$$

Heat Recovery Rates

The heat recovery rates will be calculated in the datalogger at each scan interval and averaged for each 15-minute recording interval.

Measuring the recovered heat at this site will be performed in two stages. Until the CHP loop side instrumentation is installed, the following load side measurement will used:

Useful heat recovery (**QU**) $= K \cdot \Sigma [FWTR \cdot (TWTRS - TWTRR)] / n$

Please note that these measurements do not allow for any heat rejected by the dump radiator to be measured. Dumped heat is not required to be measured for compliance with this program, but is needed to conform with the NYSERDA Integrated Data system. Also, this load-side measurement will only be valid for heat recovered for space-heating (which should not be an issue, as the absorption chiller will not be installed during this period).

Once the instrumentation is added to the CHP loop, then the heat recovery, and dumped heat can be measured directly. The piping arrangement at this site allows for multiple heat rates to be determined with three temperature sensors and one flow reading:

Useful heat recovery (**QU**) = $K \cdot \Sigma\ [FGL \cdot (TGLS-TGLR1)] / n$

Rejected (unused) heat recovery (**QR**) = $K \cdot \Sigma\ [FGL \cdot (TGLR-TGLR1)] / n$

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 30% glycol). 'n' is the number of scan intervals included in each recording interval (e.g., with 30 sec scans and 15-minute data, n=30)

We envision continuing to measure the "load-side" recovered heat after the CHP loop sensors are installed. We will compare the two heat recovery rates measured simultaneously to substantiate the heat recovery measurements when only the load-side instrumentation is installed.

Calculated Quantities

The net power output from the CHP system will be defined as the gross power from the microturbines minus the parasitic power. Note that for this particular site, WTA1 and WTA2 represent the net power output from the turbine arrays, and therefore can be used directly to calculate the fuel conversion efficiency (FCE), without involving the parasitic energy in the computation.

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

$$FCE = \frac{QU \cdot \Delta t + 3{,}412 \cdot (WG)}{0.9 \cdot LHV_{gas} \cdot FG}$$

where:

QU	-	Useful heat recovery (Btu/h)
WG	-	Microtubine net output (kWh) (WTA1+WTA2)
FG	-	Generator gas consumption (Std CF)
Δt	-	0.25 for 15-minute data
LHV_{gas}	-	Lower heating value for natural gas (~905 Btu per CF). Where 0.9 is the conversion factor between HHV and LHV

The parasitic power for the entire CHP system is measured at WTPLP. To determine the portion of the parasitic loads consumed solely by the microturbine arrays, the difference of WTPLP and WTCHM will be calculated.

$$WP = WTPLP - WTCHM$$

where:
WP - Microturbine parasitic energy (kWh)
WTPLP- Total parasitic energy for CHP system (kWh)
WTCHM- Parasitic energy for absorption chiller only (kWh)

The microturbine parasitic power is being recorded for consistency with other NYSERDA CHP monitored sites, but will not used directly 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, each value is summed and then the formula is applied:

$$FCE = \frac{\sum^{N} QU \cdot \Delta t + 3{,}412 \cdot \sum^{N} (WG)}{0.9 \cdot HHV_{gas} \cdot \sum^{N} FG}$$

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

4. Clarifications Required

The following issues require clarification by OfficePower before this monitoring plan can be approved and implemented.

1.) A black-start generator (BSG) is observed on P-001. This generator shares the same fuel feed as the microturbine arrays. No corresponding electrical interconnection was observed on the E-001 one-line drawing. Operation of this generator will penalize the annual efficiency of the microturbine arrays as gas use will be recorded, with no corresponding power production at WTA1 and WTA2.

Office Power February 13, 2008: Included earlier is a revised E-001 one-line drawing showing the BSG.

CDH Energy February 21, 2008: Ok, no further comments.

Describe the operational sequence of this generator as it relates to the microturbine arrays. If this BSG is required to operate continuously in conjunction with the microturbines during a utility outage, then power generated by this unit should be measured. If the BSG is only operated for a short period, to generate a synch signal for the microturbine arrays, then monitoring the power is not necessary and a proxy for runtime and power, such as average amperage should be monitored.

Office Power February 13, 2008: The BSG is used only to black start the plant. Once the turbines are operating in stand-alone mode, the BSG will shut down and all parasitic loads will be powered by the microturbines. Given that the BSG is not intended to operate for more than 10 minutes when black starting the plant, we agree that there is no need to sub-meter its output.

CDH Energy February 21, 2008: Ok, no further comments.

2.) Confirm the parasitic panel connection for the absorption chiller hot water pump P-8. Ideally this pump should be feed from panel PLP, where the corresponding power will be captured by WTPLP. We believe this to be the case, based on the text on page A3 of the instrumentation plan, but seek confirmation.

Office Power February 13, 2008: Yes, P8 will be fed from panel PLP.

CDH Energy February 21, 2008: Ok, no further comments.

3.) According to the instrumentation plan, flow meter FM-1 will be scaled at 280 GPM @ 20 mA. This corresponds to full flow through all microturbines (8 turbines × 35 GPM/turbine). Consider setting the full flow to 300 GPM if possible, to allow for some leniency if any of the holdback valves begin to inadvertently open further at a later date.

Office Power February 13, 2008: 35 GPM is preset at each microturbine using pressure independent flow control valves. Maximum flow will be 280 GPM and cannot go higher unless the existing valves are replaced.

CDH Energy February 21, 2008: Ok, no further comments.

4.) Due to the location of WTA1 and WTA2 on each microturbine array collector bus, the parasitic power can be removed from EQ 11 and EQ 12 in the instrumentation plan (page A11). WTA1 and WTA2 measure the net power output of the turbine arrays directly, as is required by the CHP systems manual. This has been noted in the instrument plan markups.

Office Power February 13, 2008: We agree.

5.) Address the markups in the attached copy of the instrumentation plan (though page A18 only).

Office Power February 13, 2008: We will forward a markup of the instrumentation plan separately.

CDH Energy February 21, 2008: Submit revised IP with information based on load-side measurements describe in this M&V plan.

CDH Energy February 28, 2008: Sufficient updated information has been provided to eliminate the need for an updated IP. All new information is included in this M&V plan.

6.) Some descriptive text in this monitoring plan is based on past work with OfficePower. Verify that the temperature, flow, and gas flow parameters highlighted on pages 1-2 of this document are representative of the system operation.

Office Power February 13, 2008: The highlighted flow rates are correct.

CDH Energy February 21, 2008: Ok, no further comments.

Appendix A

Reference Office Power Instrumentation Plan (Future Revised Version)

INSTRUMENTATION PLAN

FOR

DISTRIBUTED GENERATION / COMBINED HEAT AND POWER (DG/CHP) SYSTEM

AT

110 EAST 59TH STREET, NEW YORK

January 28, 2008

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APPENDIX E – ACI TEMPERATURE SENSOR DATASHEET

APPENDIX F – ROOTS GAS METER DATASHEET

APPENDIX G – PETE'S PLUG DATASHEET

INTRODUCTION:

The following provides OfficePower, Inc.'s ("OfficePower") instrumentation plan for its planned Distributed Generation/Combined Heat and Power (DG/CHP) project located at 110 East 59th Street, New York, NY. This plan provides for the monitoring and control of the DG/CHP equipment along with the collection of data required to measure and verify the DG/CHP plant's efficiency and performance as required by NYSERDA.

DG/CHP PLANT DESCRIPTION:

The DG/CHP plant consists of eight (8) Elliott TA100 CHP microturbines with a total power production of 800 kW (100 kW per microturbine). The microturbines are installed in two (2) Turbine Arrays each with four (4) units (400 kW). Electricity generated by the microturbines displaces electricity purchased from the electric utility as well as providing power to the plant's parasitic electric loads. The microturbines are fueled with natural gas supplied by Con Edison, the local distribution company (LDC) serving the host building.

During grid outages, the DG/CHP plant can black-start and operate to deliver backup power and electricity to mission critical loads within the building.

A byproduct of generating electricity using microturbines is a significant amount of heat in the turbine's exhaust. Much of this thermal energy is recovered to heat a glycol/water solution using an exhaust gas to liquid heat exchanger installed within each microturbine. The glycol/water solution provides freeze protection for piping, since the microturbines are located outdoors of the 16th floor setback of the building. The recovered thermal energy is used to offset district steam purchased by the building from Con Edison for both heating (in the winter) and cooling (in the summer). A series of heat exchangers, pumps and control valves are used to deliver heat from the glycol/water solution to the building's secondary water system. An absorption chiller is used to convert the heated glycol/water fluid to chilled water when the building demands cooling.

METERING OVERVIEW:

OfficePower has installed a collection of meters to measure and record (1) the electricity supplied from both the incumbent electric utility (Con Edison) and from each Turbine Array (DG/CHP plant), (2) the thermal energy recovered and delivered to the building and (3) the natural gas used by the microturbines to generate the on-site power. OfficePower will use the data collected by these meters to measure the plant's overall performance and operating efficiency, and will serve as the basis for making the calculations necessary to qualify for NYSERDA's incentive payments for installing and operating the DG/CHP plant.

ELECTRICAL ENERGY AND POWER MEASUREMENTS:

The plant at 110 East 59th Street will use PowerLogic ION7350 meters that provide fully bi-directional, 4-quadrant, revenue accurate energy and demand data. (See Appendix B for a copy of the PowerLogic ION7350 Datasheet.) The meters are wired 277 VAC L-N directly, eliminating the need for potential transformers. Metering and relaying current transformers will provide three-phase current inputs to each meter. All current transformers (CT) have a 5A secondary output. The CT size is based on the electrical bus size on which each CT is measuring current, as shown below. Figure 1 details the locations within the building of the ION7350 meters.

ELECTRIC METER	BUS (A)	CT RATIO
Building Main Electric Services	2,000A	2,000:5A
Turbine Array #1 Net Power	800A	800:5A
Turbine Array #2 Net Power	800A	800:5A
Parasitic Load Panel	400A	400:5A
Chiller Module Parasitic Load Panel	400A	400:5A

A certificate of accuracy will be provided for each ION7350 meter installed. If additional on-site testing is required, a 2-conductor longitudinal switch disconnect terminal block is installed for each voltage and current input to provide a connection point for electrical testing equipment.

Each meter internally converts voltage and current inputs to the meter to digital values. In addition, each meter has a remote display for viewing measured and calculated electrical values, as well as memory for storing the digital electrical data.

Utility power (kW) and energy (kWh) delivered to the building is calculated by:

EQ. 1 $$WT_{Utility(gross)}[kW, kWh] = \sum WT_{1-4}[kW, kWh]$$

Electrical power (kW) and energy (kWh) delivered to the building from the DG/CHP plant is calculated by:

EQ. 2 $$WT_{DG/CHP(net)}[kW, kWh] = \sum WT_{TA1-TA2}[kW, kWh]$$

The building's total demand and consumption of electricity is therefore calculated by:

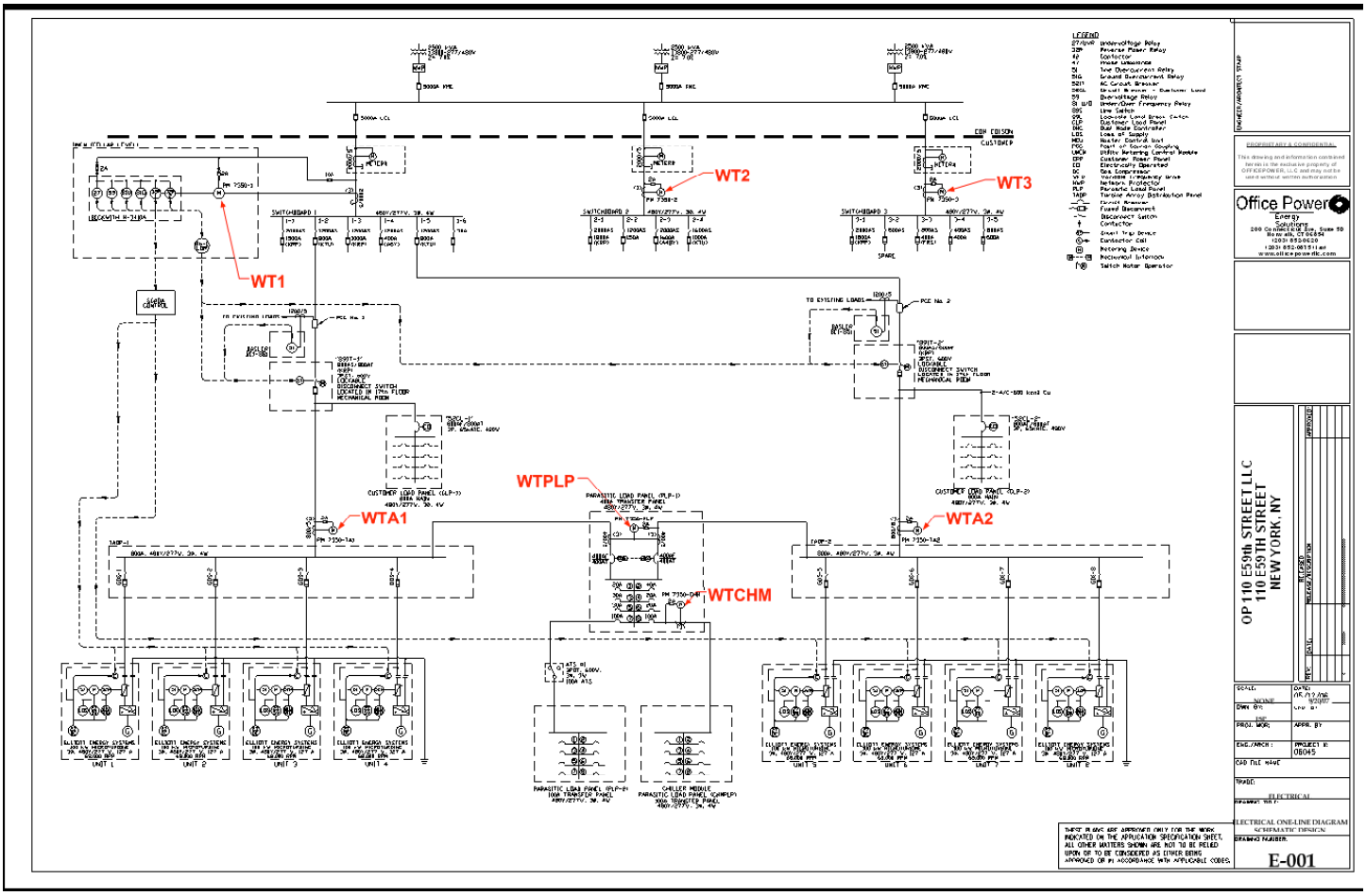
EQ. 3 $$WT_{Building}[kW, kWh] = WT_{Utility(Gross)}[kW, kWh] + WT_{DG/CHP(net)}[kW.kWh]$$

Each ION7350 meter has two RS485 communication ports designated COM1 and COM2. COM1 port is programmed to communicate and upload data to OfficePower's remote metering database using the ION communication protocol. COM2 port is programmed to transmit data to OfficePower's SCADA system using Modbus RTU communication protocol. The SCADA system is the Modbus master device and each ION7350 meter is programmed as a Modbus slave device.

The energy and demand of all electrical loads used in the operation of the distributed generation plant (including the absorption chiller) and those connected to the parasitic load panel will be measured using a Power Measurement PML7350 meter (designated PML7350-PLP). A second PML7530 meter (designated PML7350-CHM) will sub-meter the electrical loads used to operate the absorption chiller and ancillary equipment, consisting of the following equipment:

Absorption chiller
Pump P9 (chilled water)
Pump P10 (condenser water)
Chiller Module exhaust fan & heater
Chiller Module controls

FIGURE 1
ELECTRICAL INTERCONENCT ONE-LINE DIAGRAM



When operating in the power and heating modes, the parasitic electric load for the DG/CHP plant is calculated as:

EQ. 4 $$WT_{Parasitic(heat)}[kW, kWh] = WT_{PLP}[kW, kWh]$$

When operating in the cooling mode, the parasitic electric load for the DG/CHP plant is calculated by subtracting PML7350-CHM from PLP7350-PLP:

EQ. 5 $$WT_{Parasitic(cool)}[kW, kWh] = WT_{PLP}[kW, kWh] - WT_{CHM}[kW, kWh]$$

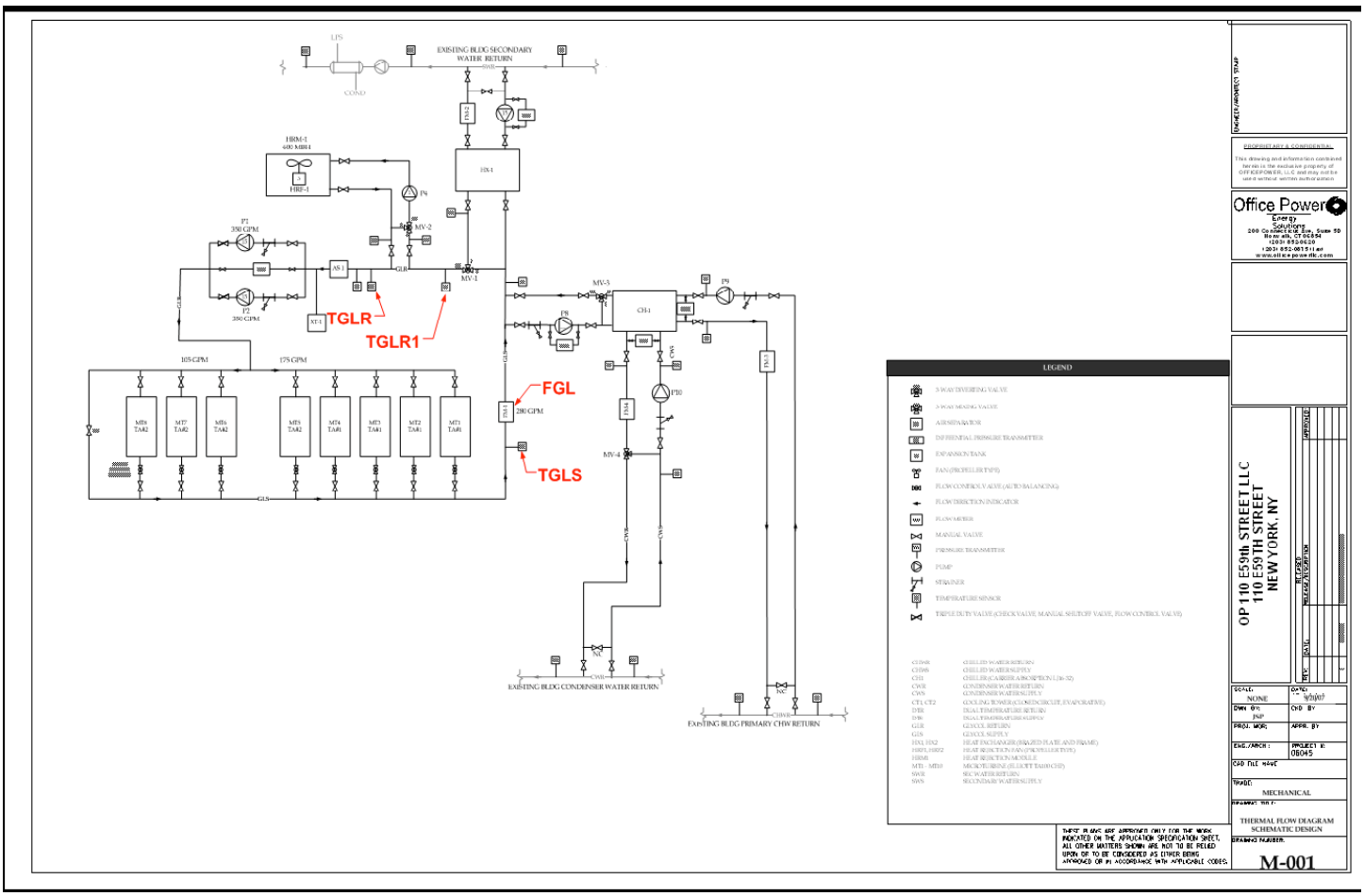
TEMPERATURE MEASUREMENTS:

To calculate the thermal energy delivered to the building from the DG/CHP plant, the heat recovery system's supply and return temperatures are measured. Glycol temperatures (TGLR, TGLR1, TGLS) are measured using 10K Ohm thermistor temperature sensors. Sensors are installed in ½" threaded stainless steel wells. Figure 2 displays the locations where these three temperature sensors are located. (See Appendix E for ACI Temperature Sensor Datasheet.)

The SCADA control module supplies 5 VDC power to each sensor, and measures the return current to determine resistance in the circuit. Using a 12 bit A/D converter and a resistance/temperature curve table, OfficePower's SCADA control module generates a digital temperature value. An offset is used to calibrate each temperature reading with field measurements. Temperature sensors are used to monitor and control the heat recovery piping system in addition to providing information for NYSERDA's measurement and verification.

A Pete's Plug (P/N 110XL) is installed adjacent to each temperature sensor. A test thermometer can be inserted in the Pete's Plug for verification and calibration of temperature sensor measurements. (See Appendix G for Pete's Plug Datasheet.)

FIGURE 2
THERMAL PIPING ONE-LINE DIAGRAM



FLOW MEASUREMENT AND CALCULATION:

To calculate the thermal energy delivered to the building from the DG/CHP plant, the heat recovery system flow also needs to be measured. A McCrometer V-Cone flow meter is used to measure the differential pressure generated by the flow of the glycol/water fluid in the microturbine heat recovery piping. (See Appendix C for McCrometer V-Cone Flow Datasheet.) The flow meter's unique design eliminates or reduces the need for up/down stream straight pipe diameters, under even the most difficult flow conditions.

The nominal flow rate in the heat recovery piping system is 280 GPM (35 GPM per microturbine). Each microturbine is fitted with a pressure independent flow control valve to regulate the maximum flow through each turbine at 35 GPM. The FM-1-VC flow meter is rated for 280 GPM maximum with a 10:1 turndown ratio. Figure 2 shows the location of the flow meter in the common supply header of the heat recovery piping so that total flow, regardless of the operating mode (heating or cooling) is measured.

A Foxboro DP transmitter is used to measure differential gage pressure (inWC) of flow across the V-Cone flow meter. The Foxboro DP transmitter outputs a 4-20 mA current signal in linear proportion to the differential pressure measured from the flow meter. (See Appendix D for Foxboro DP Transmitter Datasheet.) The SCADA control module measures the current input, and using a 12 bit A/D converter, generates a digital differential pressure value. An offset is used to calibrate the control module input with the DP transmitter output.

Heat recovery flow as measured by the flow meter FM-1-VC is calculated using the following formula:

EQ. 6
$$FGL_{(gallons\ /\ \min)} = \sqrt{\frac{DP_{ACTUAL}[inWC]}{DP_{MAX}[inWC]}} \times FGL_{MAX}[gallons\ /\ \min]$$

Where: DP_{MAX} = 49.98 inWC[1]
FCL_{MAX} = 280 GPM

OfficePower's SCADA system will use flow measurements to monitor and control its heat recovery piping system in addition to providing data to meet NYSERDA's measurement and verification requirements. All differential pressure readings of less than 0.5 inWC (28 GPM) will be interpreted and recorded as no flow (0 GPM flow rate).

[1] Data taken from the FM-1-VC McCrometer V-Cone preliminary sizing and is subject to change based on final factory testing of the flow meter. See McCrometer V-Cone preliminary sizing in Appendix B.

The Foxboro DP transmitter is mounted on a stainless steel manifold block equipped with spare test ports for connection of a test pressure gauge(s).

THERMAL (BTU) CALCULATIONS:

The working fluid in the heat recovery piping system is a 30/70 mixture of propylene glycol and water. This brine solution has a specific heat of 0.935 Btu/ lbm- ^{0}F and an equation factor of 480 Btu/gallon-^{0}F-h.

Gross heat recovered from the DG/CHP system is calculated as:

EQ. 7 $$Q_{CHP(gross)}\left[\frac{Btu}{h}\right] = 480\left[\frac{Btu\,\min}{gallon°Fh}\right] xFGL\left[\frac{gallon}{\min}\right] x(TGLS - TGLR)\left[°F\right]$$

Net useful heat recovered from the DG/CHP system is calculated as:

EQ. 8 $$Q_{CHP(net)}\left[\frac{Btu}{h}\right] = 480\left[\frac{Btu\,\min}{gallon°Fh}\right] xFGL\left[\frac{gallon}{\min}\right] x(TGLS - TGLR1)\left[°F\right]$$

During normal operation, the Heat Rejection Module will not operate. When there is no thermal demand (heating or cooling), each microturbine's integral heat exchanger damper will modulate to the full bypass position, rejecting the hot turbine exhaust directly to ambient. Each microturbine controls the modulating of the bypass damper to maintain a pre-set desired temperature setpoint.

The plant's Heat Rejection Module (HRM), consisting of a P4 pump and fan, will only operate when the glycol return temperature (TGLR) to the microturbines exceeds 190F. The HRM is sized to reject the full heat output of one microturbine (~400 MBH) when operating at full power output. In the event the glycol return temperature continues to rise to 210F, the SCADA system will automatically shut down the microturbine whose bypass damper is not functioning.

The thermal energy rejected to ambient by the Heat Rejection Module is calculated as:

EQ. 9 $$Q_{DumpRad}\left[\frac{Btu}{h}\right] = 480\left[\frac{Btu\,\min}{gallon°Fh}\right] xFGL\left[\frac{gallon}{\min}\right] x(TGLR1 - TGLR)\left[°F\right]$$

GAS MEASUREMENTS:

Con Edison has installed a new 8″ gas service dedicated to the distributed generation plant. OfficePower will request Con Edison install solid-state pulsers on each of their revenue gas meters to provide a compensated pulse output from each meter. The pulse output(s) will be wired as a digital input to OfficePower's SCADA control module. The SCADA is programmed to count the pulses and calculate the gas flow (cubic feet) measured by each meter. OfficePower will use the gas meter pulses to monitor the distributed generation plant efficiency as well as for NYSERDA measurement and verification. Figure 3 shows the location of the utility gas meters in the overall fuel delivery piping to the DG/CHP system.

Energy consumed to operate the DG/CHP plant is calculated as:

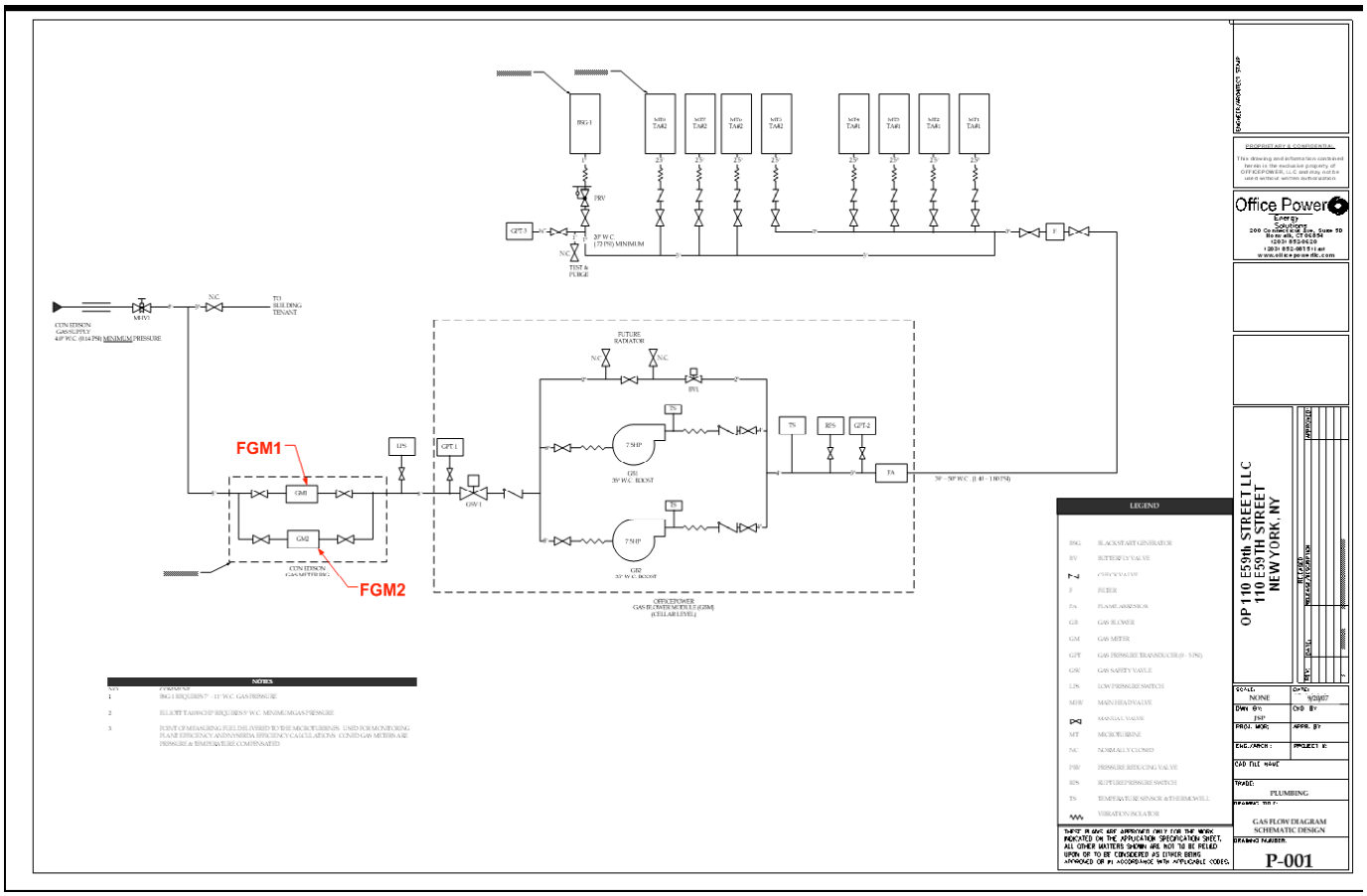
EQ. 10 $$FGM_{Utility(LHV)}\left[Btu\right] = \sum FGM_{1+2}\left[CuFt\right] x1000\left[\frac{Btu}{CuFt}\right] x0.9\left[\frac{Btu_{LHV}}{Btu_{HHV}}\right]$$

Where:

HHV = Higher heating value of natural gas, typically between 950 and 1,020 Btu/Cu Ft.

0.9 = Ratio of lower heating value to higher heating value for natural gas (approximate)

FIGURE 3
FUEL DELIVERY ONE-LINE DIAGRAM



OPERATING MODE:

Thermal energy recovered from the Elliott microturbines will be used to heat and cool the building during winter and summer respectively using the same heat recovery piping. The SCADA system is programmed to provide two binary outputs (1=ON, 0=OFF) signals indicating if thermal energy from the microturbines is being used for heating or cooling of the building.

DG/CHP PLANT EFFICIENCY CALCULATIONS:

The DG/CHP plant efficiency is therefore calculated as:

In the heating mode,

EQ. 11

$$\eta DG/CHP_{(Heat,\,LHV)} = \frac{Q_{CHP(net)}[Btu] + 3{,}412\left[\frac{Btu}{kW}\right] x\left(WT_{DG/CHP(net)}[kW] - WT_{Parasitic(Heat)}[kW]\right)}{FGM_{Utility(LHV)}[Btu]}$$

In the cooling mode,

EQ. 12

$$\eta DG/CHP_{(Cool,\,LHV)} = \frac{Q_{CHP(net)}[Btu] + 3{,}412\left[\frac{Btu}{kW}\right] x\left(WT_{DG/CHP(net)}[kW] - WT_{Parasitic(Cool)}[kW]\right)}{FGM_{Utility(LHV)}[Btu]}$$

DATA DELIVERY TO NYSERDA DATA COLLECTING EQUIPMENT:

OfficePower will utilize its Automated Logic Supervisory Control and Data Acquisition (SCADA) system as the platform for aggregating and distributing metering and sensor data to NYSERDA's data collection equipment. As described previously, electrical, thermal and gas meter/sensor readings are delivered as analog and digital inputs to control modules within the SCADA system. Wiring connections are made to the control module physically closest to the meter/sensor devices. The control modules are connected to an ARC156 network which is used to broadcast information between SCADA control and communication modules using the BACnet communication protocol. Required

meter/sensor data will be written to Modbus registers for reading by NYSERDA data collection equipment. The Modbus registers will be updated at a minimum every thirty (30) seconds[2]. All metering/sensor data sent to NYSERDA's data collector is also used by OfficePower for its monitoring and control of the microturbines and distributed generation plant.

OfficePower has installed a high speed LGR communication module to serve as the portal through which meter/sensor data can be read from the SCADA system by NYSERDA's data collector. The NYSERDA data collector will serve as Modbus Master to poll data from the SCADA communication module, which will be programmed as the Modbus slave device.

Figure 4 provides a hierarchal view of the data delivery system. Table 1 provides specifications for the communication wiring and suggested Modbus communication protocol. Table 2 provides a list of required data points and Modbus register information for use in programming the data logger.

TABLE 1
COMMUNICATION SPECIFICATION

CABLE TYPE	2-WIRE
CABLE SPECIFICATION	18-AWG, SHIELDED PAIR
MAX LENGTH	1,000 FEET
COMMUNICATION TYPE	EIA-485 MODBUS RTU
BAUD	9600 BPS[3]
DATA BITS	8 DATA BITS
PARITY	NO PARITY
STOP BIT(S)	1
MODBUS SLAVE DEVICE NO.	1[4]

[2] Faster update of the Modbus registers may be possible but will require field testing and verification for reliability of data transmission.
[3] Faster Modbus communication speeds available but will require testing to verify data transmission accuracy.
[4] Slave device number to be determined by NYSERDA technical consultant programming the data logger.

FIGURE 4
HIERARICAL VIEW OF DATA DELIVERY SYSTEM

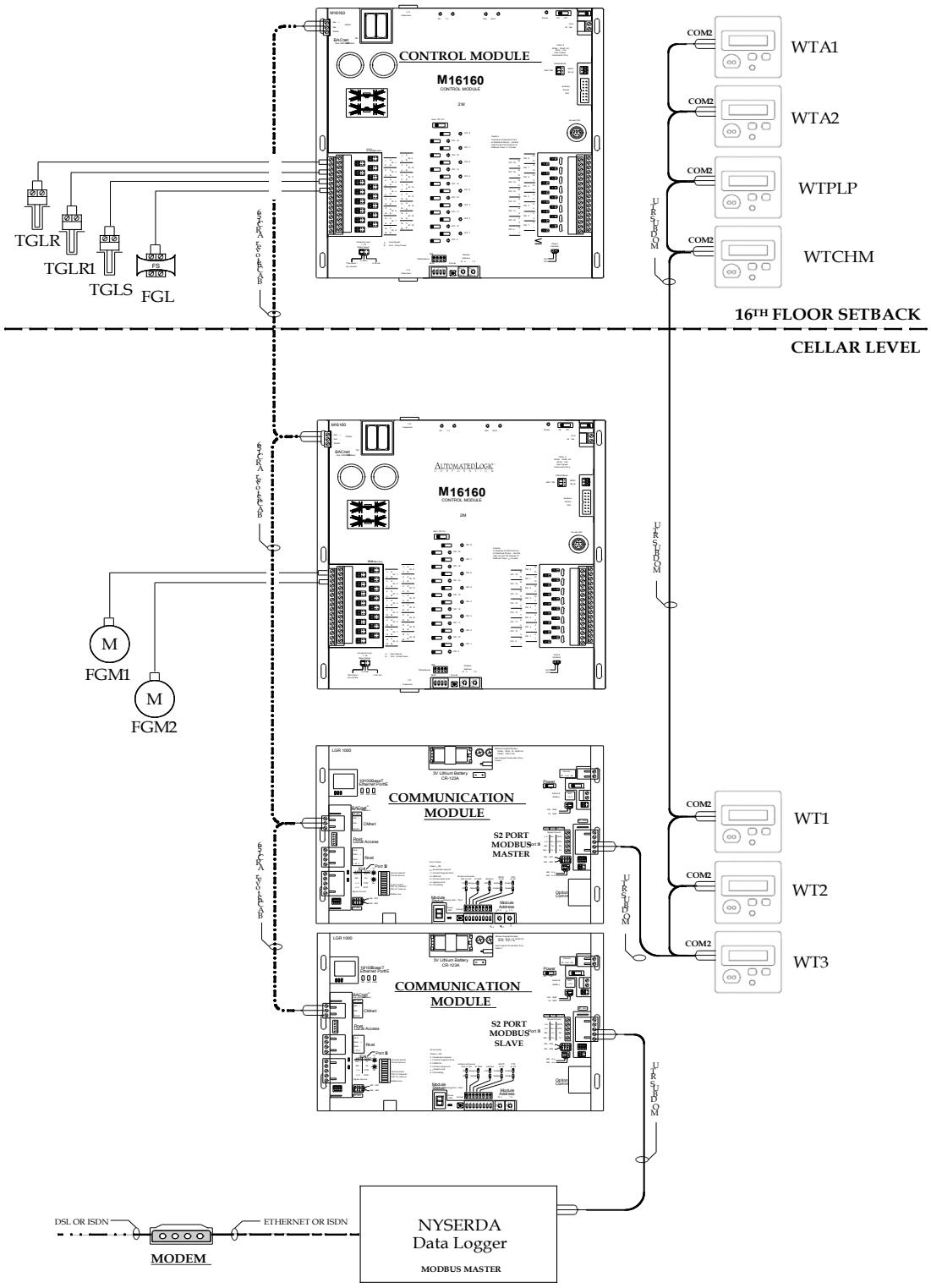


TABLE 2
MODBUS REGISTER LIST

MODBUS ADDRESS	TAG	DESCRIPTION	FORMAT[1]	R/W
	WT1	BUILDING MAIN ELECTRIC SERVICE #1 ENERGY IMPORT (KWH)	SINT32	READ
	WT2	BUILDING MAIN ELECTRIC SERVICE #2 ENERGY IMPORT (KWH)	SINT32	READ
	WT3	BUILDING MAIN ELECTRIC SERVICE #3 ENERGY IMPORT (KWH)	SINT32	READ
	WTA1	TURBINE ARRAY #1 NET ENERGY EXPORT (KWH)	SINT32	READ
	WTA2	TURBINE ARRAY #2 NET ENERGY EXPORT (KWH)	SINT32	READ
	WT1KW	BUILDING MAIN ELECTRIC SERVICE #1 DEMAND IMPORT (KW)	SINT	READ
	WT2KW	BUILDING MAIN ELECTRIC SERVICE #2 DEMAND IMPORT (KW)	SINT	READ
	WT3KW	BUILDING MAIN ELECTRIC SERVICE #3 DEMAND IMPORT (KW)	SINT	READ
	WTA1KW	TURBINE ARRAY #1 DEMAND EXPORT (KW)	SINT	READ
	WTA2KW	TURBINE ARRAY #2 DEMAND EXPORT (KW)	SINT	READ
	WTAPLP	PARASITIC LOAD PANEL ENERGY (KWH)	SINT32	READ
	WTAPLPKW	PARASITIC LOAD PANEL DEMAND (KW)	SINT	READ
	WCHMPLP	CHILLER MODULE PARASITIC LOAD PANEL ENERGY (KWH)	SINT32	READ
	WCHMPLPKW	CHILLER MODULE PARASITIC LOAD PANEL DEMAND (KW)	SINT	READ
	FGM1	GAS METER #1 (CF)	SINT32	READ
	FGM2	GAS METER #2 (CF)	SINT32	READ
	TGLR	GLYCOL RETURN TEMPERATURE POST RADIATOR (^{0}F)	SINT	READ
	TGLR1	GLYCOL RETURN TEMPERATURE PRE RADIATOR (^{0}F)	SINT	READ
	TGLS	GLYCOL SUPPLY TERMPERATURE (^{0}F)	SINT	READ
	FGL	FM-1 GLYCOL FLOW METER (GPM)	SINT	READ
	HEAT	OPERATING MODE – HEATING	BIT	READ
	COOL	OPERATING MODE – COOLING	BIT	READ

NOTE 1 **SINT = SIGNED 16-BIT INTEGER (-32,768 TO +32,767)**
SINT32 = SIGNED 32-BIT INTEGER (-2,147,483,648 TO +2,147,483,647)
BIT = DISCRETE (BINARY) 0 OR 1

DATA PROCESSING AND TRANSFER TO NYSERDA DATABASE

NYSERDA's technical consultant is responsible for furnishing, installing, programming and maintaining a data collector that reads data from OfficePower's SCADA system and for uploading of the data to a remote database.

APPENDIX A – INSTRUMENTATION SPECIFICATIONS

TABLE A1 – POWER AND ENERGY METERS

OP TAG	PML7350-MES1, PML7350-MES2, PML7350-MES3, PML7350-TA1, PML7350-TA2, PML7350-PLP, PML7350-CHM
NYSERDA DATA POINT	WT1, WT2, WT3, WTA1, WTA2, WTPLP,WTCHM
MANUFACTURER	SCHNEIDER ELECTRIC POWER LOGIC
MODEL	ION 7350
PART NUMBER	P7350R0B0B0A0A0A
TYPE	BIDIRECTIONAL THREE PHASE POWER AND ENERGY METER
SIZE (MEMORY)	300 KB
ACCURACY	VOLTAGE 0.25% RDG + 0.05% FS, FREQUENCY ± 0.01% RDG , CURRENT 0.25% RDG +0.05% FS
RANGE	50 TO 347 VAC L-N, 5A NOMINAL / 10A FULL SCALE
OUTPUT SIGNAL	SERIAL RS485 MODBUS RTU
POTENTIAL TRANSFORMER	N/A. METERS WIRED DIRECT 277 L-N, 4-WIRE
CURRENT TRANSFORMER TYPE	RELAY & METER CLASS TRANSFORMER. FINAL SELECTION TBD.
CURRENT TRANSFORMER SIZE	CURRENT TRANSFORMERS WILL BE SIZED BASED ON CURRENT RATING OF THE ELECTRICAL BUS
NOTES	TRAN UNIT WITH REMOTE DISPLAY, -4F TO +140F OPERATING TEMPERATURE. TIMESTAMP RESOLUTION 0.001 SECONDS. SEE ATTACH DOCMENTS FOR ADDITIONAL DETAILS ON ELECTRIC METER AND CURRENT TRANSFORMERS.

TABLE A2 - DIFFERENTIAL PRESSURE FLOW METER

OP TAG	FM-1-VC
NYSERDA DATA POINT	FGL
MANUFACTURER	McCROMETER
MODEL	V-CONE
TYPE	DIFFERENTIAL PRESSURE FLOW METER
PART NUMBER	VS06QE03S
SIZE	5″ FLANGED
ACCURACY	± 0.5% OF ACTUAL FLOW
REPEATABILITY	± 0.1% OR BETTER
RANGE	0.5″ W.C. TO 50″ W.C.
FLOW RATE (MAX)	280 GPM @ 50″ W.C. DP
FLOW RANGE	10:1 OR GREATER
STRAIGHT PIPE REQUIREMENTS	0D UP AND DOWN STREAM
NOTES	SEE ATTACHED V-CONE DOCUMENTS & PRELIMINARY SELECTION

TABLE A3 - DIFFERENTIAL PRESSURE (DP) TRANSMITTER

OP TAG	FM-1-DT
NYSERDA DATA POINT	FGL
MANUFACTURER	FOXBORO
MODEL	IDP10
PART NUMBER	IDP10-A22C1F-V3
TYPE	GAUGE PRESSURE
SIZE	½″ THREADED
ACCURACY	± 0.20% OF SPAN
RANGE	0 – 30 PSI
AMBIENT TEMPERATURE	-20 TO +180F OPERATING
OUTPUT SIGNAL	4 TO 20 mA LINEAR
NOTES	INCLUDES MANIFOLD BLOCK WITH TEST PORTS & ISOLATION VALVES & LCD INDICATOR. SEE ATTACHED FOXBORO TRANSMITTER PRODUCT SPECIFICATION.

TABLE A4 - TEMPERATURE SENSORS

OP TAG	TBD
NYSERDA DATA POINT	TGLR, TGLS, TGLS1
MANUFACTURER	AUTOMATION COMPONENTS INC
MODEL	10K OHM TYPE II THERMISTOR
PART NUMBER	ACI/10K-CP
TYPE	10K OHMS @ 77F
SIZE	4" IMMERSION WITH SS WELL
ACCURACY	± 0.2 ^{0}C (0 TO 70^{0}C)
RANGE	-40F TO +302F
OUTPUT SIGNAL	5 VDC POWER SUPPLY, RESISTANCE
NOTES	SEE ATTACHED PRODUCT DATA SHEET FOR ADDITIONAL INFORMATION

TABLE A5 - GAS METER

OP TAG	GM-1, GM-2
NYSERDA DATA POINT	FGM-1, FGM-2
MANUFACTURER	ROOTS METER
MODEL	SERIES B3 METER, 1TPWS SOLID STATE PULSER[5]
PART NUMBER	16M1751[1]
TYPE	ROTARY POSITIVE DISPLACEMENT GAS METER WITH INTERNAL TEMPERATURE COMPENSATION
FLOW (MAX)	16,000 ACFH
ACCURACY	NA
RANGE	116:1
OUTPUT SIGNAL	1 PULSE PER CCF
NOTES	CON EDISON REVENUE GAS METER WITH PULSE OUTPUT.

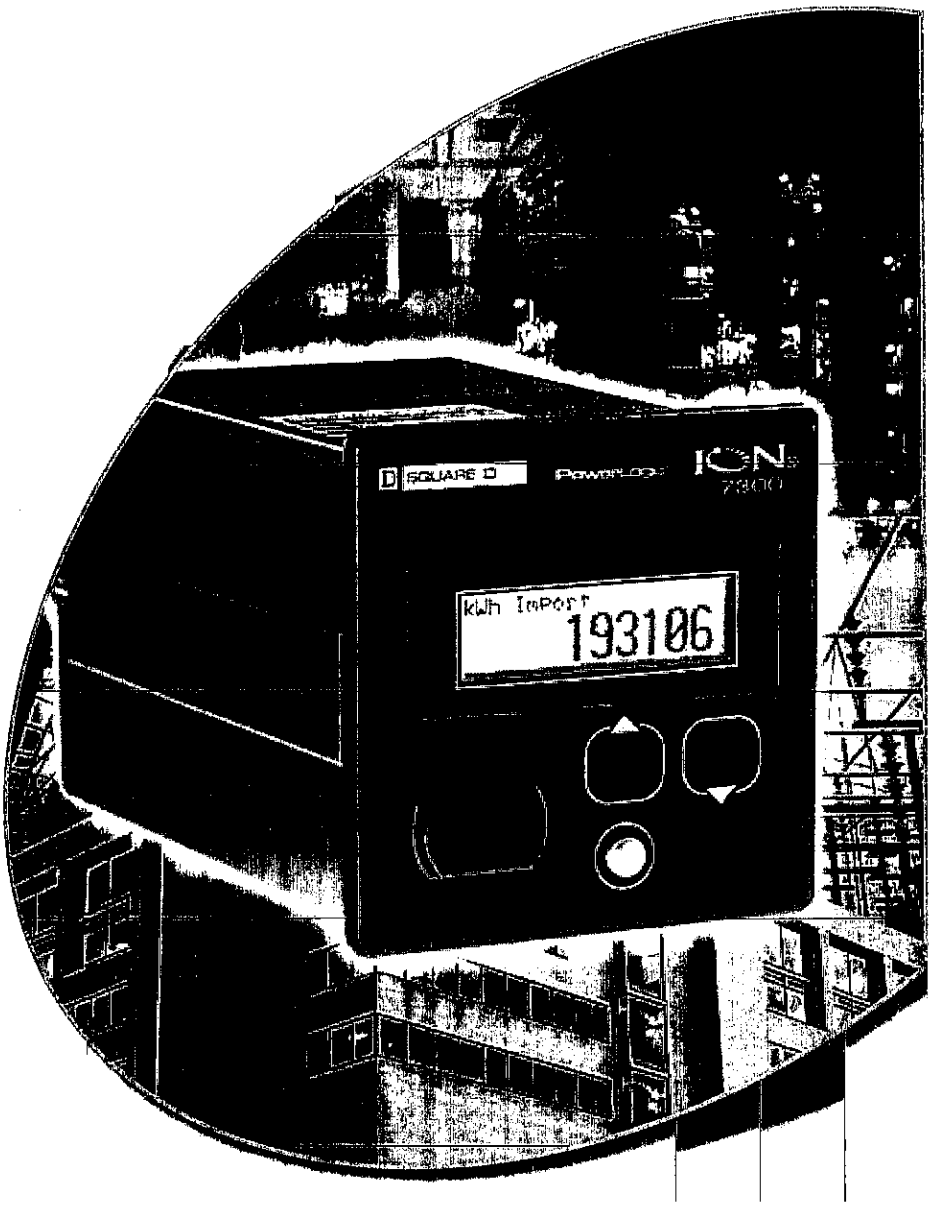
[5] Meter selection subject to change based on final Con Edison selection

APPENDIX B – POWERLOGIC ION7350 METER DATASHEET

APPENDIX B – POWERLOGIC ION7350 METER DATASHEET

PowerLogic® ION7300 / ION7330 / ION7350

Power and energy meters



a brand of Schneider Electric

SQUARE D

Features

Measurements

- Energy: bi-directional, absolute and net
- Demand: rolling block, predicted, and thermal
- Harmonics: individual and total harmonic distortion up to the 15th or 31st
- Advanced logic and mathematical functions

Internet-enabled communications

- Two RS-485 ports
- Optional built-in modem with ModemGate™ allows modem access for 31 other devices
- Optional Ethernet port with EtherGate™ allows direct Ethernet-to-RS-485 data transfer to 31 other devices
- Infrared data port standard
- Modbus® RTU, Modbus® TCP, DNP 3.0, and PROFIBUS DP
- Call-back feature offers fast alarm response
- Web server, MeterM@il® allow distribution of metered data and alarms over the Internet

On-board data logging

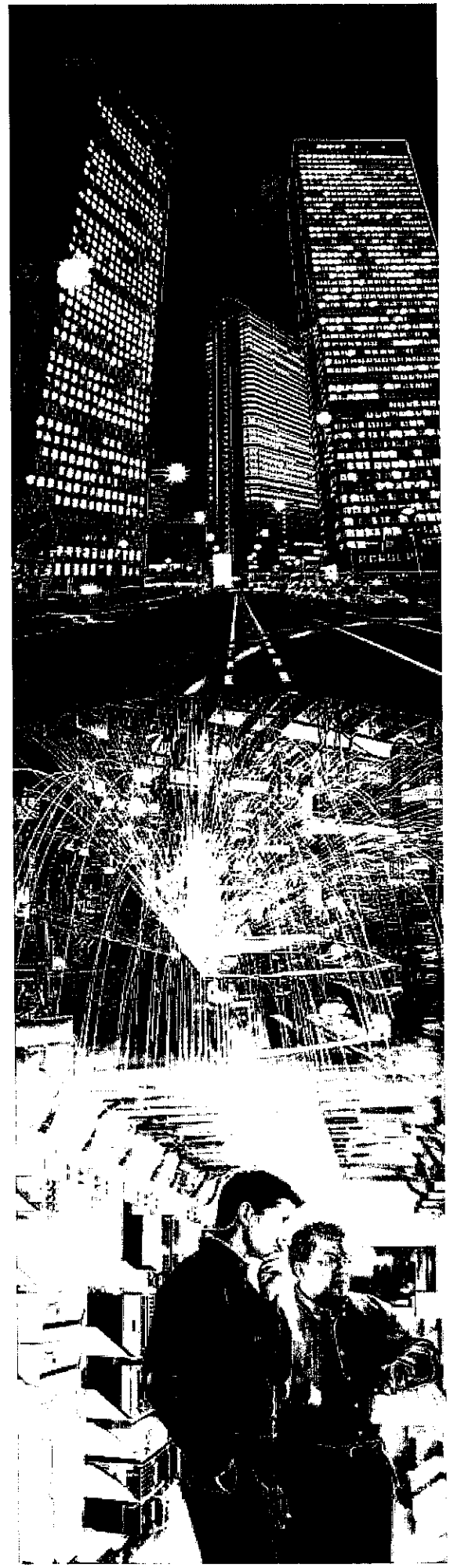
- Scheduled or event-driven logging of up to 96 parameters
- Sequence-of-events and min/max logging

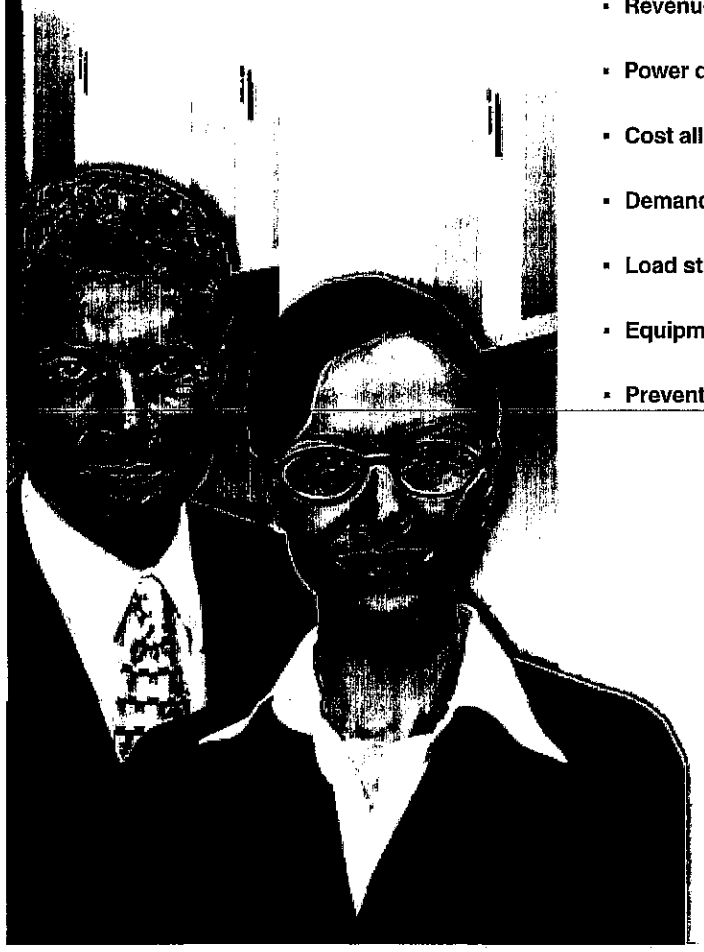
Setpoints for control and alarms

- Setpoint on any parameter or condition
- 1 second operation

Inputs and outputs

- 4 digital inputs for status/counter functions
- 4 digital outputs for control/pulse functions
- Optional analog inputs and outputs





ION7300 series power and energy meters

Used in enterprise energy management applications such as feeder monitoring and sub-metering, ION7300 series meters offer unmatched value, functionality, and ease of use. ION7300 series meters interface to ION Enterprise® software or other automation systems to give all users fast information sharing and analysis.

The ION7300 meters are an ideal replacement for analog meters, with a multitude of power and energy measurements, analog and digital I/O,communication ports, and industry-standard protocols. The ION7330 meter adds on-board data storage, emails of logged data, and an optional modem. The ION7350 meter is further augmented by more sophisticated power quality analysis, alarms and a call-back-on-alarm feature.

Not all features are available with every model. Please refer to the detailed descriptions within for a complete list of feature availability.

Applications summary

- **High-accuracy power and energy metering**
- **Revenue certified models for billing, bill verification and sub-metering**
- **Power quality analysis**
- **Cost allocation and billing**
- **Demand and power factor control**
- **Load studies and circuit optimization**
- **Equipment monitoring and control**
- **Preventative maintenance**

Connections

Installation

- 4-wire Wye, Delta, 3-wire Wye, Direct delta and Single phase systems
- 3 voltage and 3 current inputs
- No PTs required on voltage inputs for wye systems up to 347/600 VAC and delta systems up to 600 VAC
- All inputs pass ANSI/IEEE C37.90.1-1989 surge withstand and fast transient tests

Inputs/outputs*

- The analog I/O option is available for any ION7300 series meter, to monitor flow rates, device cycles (RPM), fuel levels, oil pressures and transformer temperatures, etc. Output energy pulses to an RTU or control equipment.

Control power supply

The meter's basic power supply has a voltage range of 95 - 240 VAC and 120 - 310 VDC.

Measurement specifications[1] (at 50.0 Hz and 60.0 Hz at 25° C / 77° F)	
Parameter	Accuracy ± (%rdg + %fs[2])
Meter	
Voltage	0.25 % + 0.05 %
Frequency	±0.01 Hz
Current	0.25 % + 0.05 %
kVA	0.05 % + 0.1 %
kWh	0.5% (of reading)
kVAR (>5 % FS)	1.5 %
kVAh	1.0 %
kVARh	1.5 %
Power Factor (at Unity PF)	1.5 %
Harmonics	
Total harmonic distortion	1 % Full Scale
I4 derivation	1% reading + 0.2% unbalanced
K Factor	5.0 % Full Scale

Display resolution meets or exceeds accuracy.

[1] 50 VAC to 347 VAC + 25 %

[2] % full scale voltage and current

User programmable log capacity

Example log configurations:

Waveform Recording Settings

Meter	Event	Data	Channel	Samples/ Channel	Cycles	Record Depth	Days
7330	500	A	-	-	-	-	29
	500	B	-	-	-	-	118
	500	C	-	-	-	-	96
	500	D	-	-	-	-	383
7350	500	A	6	32	12	3	28
	500	B	6	32	12	3	111
	500	C	6	16	48	3	26
	500	D	6	64	16	3	331

A 16 parameters recorded every 15 minutes
A 16 parameters recorded hourly
C 4 parameters recorded every 15 minutes
D 4 parameters recorded every hour

Standards compliance

- CE marked
- EMC compliant to:
  - EN 55014-1:1993
  - EN 61000-4-4
  - EN 60687:1993 for immunity to electromagnetic HF fields
  - EN 60687:1993 for immunity to electrostatic discharges
- IEC 1010-1
- IEC 60687 accuracy class 0.5S compliant
- Analog I/O: each analog I/O pin passes IEC 61000-4-4 (4 kVp-p @ 2.5 kHz for 1 min)
- ANSI C12.16 accuracy compliant
- ANSI class 10, (5 A nominal, 10 A max)
- Surge withstand: all inputs pass ANSI/IEEE C37.90-1989 surge withstand and fast transient tests
- OFGEM approved (UK)
- FCC: Part15, FCC Rules for Class A Digital Device
- UL: Certified to UL 3111
- CAN/CSA C22.2 No.1010-1
- Measurement Canada AE-0788

* Analog I/O is not available with all form factors and communications configurations. Please check our on-line order forms for supported combinations.

Operational specifications

Serial RS-485 ports
- ION7300 has a single RS-485 port
- ION7330 and ION7350 meters can have two RS-485 ports
- Supports DNP 3.0

Infrared data port
- Front panel optical port
- Compatible with an ANSI Type 2 magnetic optical communications coupler
- Data rates up to 19,200 bps

Ethernet port (optional)
- Optional 10Base-T port for direct access to metering information via Ethernet LAN/WAN
- EtherGate™ (data transfer between Ethernet and RS-485)

Note: The meter COM2 port functions as a dedicated EtherGate port (RS-485 Master) on ION7330 and ION7350 meters with the Ethernet option

PROFIBUS port (optional)
- PROFIBUS DP standard protocol support via sub-D 9 pin female connector

Internal modem
- ION7330 and ION7350 offer internal modems
- Data rates from 300 bps to 33,600 bps
- ModemGate™ (data transfer between modem and RS-485)

Note: The meter COM1 port functions as a dedicated ModemGate port (RS-485 Master) on ION7330 and ION7350 meters with the internal modem option

- Compatible with power monitoring software that supports Modbus® RTU, ION or DNP 3.0 RJ-11 or a captured wire connector (CWC)
- The ION7350 meter is offered with a call-back feature for quick alarm response

Interoperability
ION7330 and ION7350 communicate via multiple protocols to extend existing Modbus®, DNP or ION Enterprise networks. Logs and real-time values are available via Modbus. Meters supported by UTS MV-90® via serial and Ethernet.

Voltage inputs
- 50 to 347 VAC L-N
- 25% overrange
- CWC option: Pluggable captured-wire connectors
- All options: Overload withstand for 1500 VAC continuous, 3250 VAC for 1 second non recurring. Input impedance: > 2 M Ohms/phase (phase-Vref)

Current inputs
- 5 A nominal / 10 A full scale
- Starting current: 20 mA
- Overload withstand: 20 A continuous, 500 A for 1 second non-recurring
- Worst case burden (at10 A): 0.0625 VA
- 20% Overrange full accuracy

Power supply
- Basic: 95 to 240 VAC (±10 %), (47 to 440 Hz)
- 120 to 310 VDC (±10%), 0.2 A worst case loading (12 W) at 100 VAC at 25° C (77° F)

Digital outputs
- 4 optically isolated digital outputs
- Maximum forward current: 80 mA
- Maximum voltage: 30 V

Status inputs (ION7330 and ION7350 meters)
- Self-excited, dry contact, no external voltage source required
- +30 VDC differential SCOM output to S1 through S4 inputs
- Minimum pulse width: 25 msec

Analog inputs*
- Accuracy: <± 0.3 % of full scale
- Update rate: 1s
- Input impedance: 24.3 W, 475 W (0 to 20 mA, 0 to 1 mA)
- Maximum source impedance (W): 500 W, 10 k Ohms (0 to 20 mA, 0 to 1 mA)
- Channel to channel isolation: None
- Maximum common mode voltage: 30 V

Analog outputs*
- Accuracy: <± 0.3% of full scale
- Maximum load drive capability: 500 W (0 to 20 mA), 10k W (0 to 1 mA)
- Channel to channel isolation: None
- Maximum common mode voltage: 30 V

Features and options	ION7300	ION7330	ION7350
Metering			
Power, energy and demand	■	■	■
Power quality			
Sag/swell monitoring			■
Harmonics: individual, even, odd, up to	15th	15th	31st
Sampling rate, maximum samples per cycle	32	32	64
Logging and recording			
Standard memory		300 kB	300 kB
Min/max logging for any parameter		■	■
Historical logs, maximum # of channels		32	96
Waveform logs, maximum # of cycles			48
Timestamp resolution in seconds		0.001	0.001
Communications and I/O			
RS-485 ports; Ethernet; Optical; IRIG-B	1	2	2
Ethernet/infrared optical ports	1/1	1/1	1/1
Internal modem		1	1
PROFIBUS DP port	1		
DNP 3.0 through serial, modem, and i/r ports		■	■
Modbus RTU slave on serial, modem, and i/r ports	■	■	■
Modbus TCP through Ethernet port	■	■	■
Ethergate data transfer between Ethernet & RS-485		■	■
Modemgate data transfer between internal modem & RS-485		■	■
MeterM@il, logged data alarms via email[1]		■	■
Webmeter, onboard web server	■	■	■
Analog inputs/analog outputs	4/4	4/4	4/4
Digital status inputs/counter		4	4
Digital relay outputs	4	4	4
Setpoints, alarming, and control			
Setpoints, number/minimum response time		1 sec	1 sec
Math, logic, trig, log, linearization formulas		■	■
Single & multi-condition alarms		■	■
Call-out on alarms			■
Revenue metering			
MV-90 on serial, Ethernet ports		■	■
Multi-year scheduling: hourly activity profiles		■	■

1 The ION7330 meter cannot send email alerts as it does not have an Alert module.

Software integration

Easy integration with energy management or SCADA systems for remote display of all measured parameters at a PC workstation, remote configuration and manual control abilities.

- ION Enterprise® compatible
- ION Setup™ compatible
- Internet Connectivity
- MeterM@il®
- WebMeter®

PowerLogic® and ION®

Power Measurement and its ION products were recently acquired by Schneider Electric and integrated within our PowerLogic range of software and hardware, creating the world's largest line of power and energy management solutions.

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SQUARE D

Document#3000BR0605R507 May 2007

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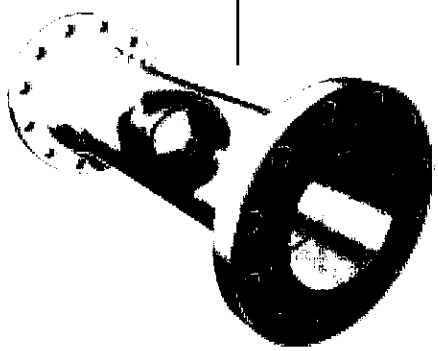
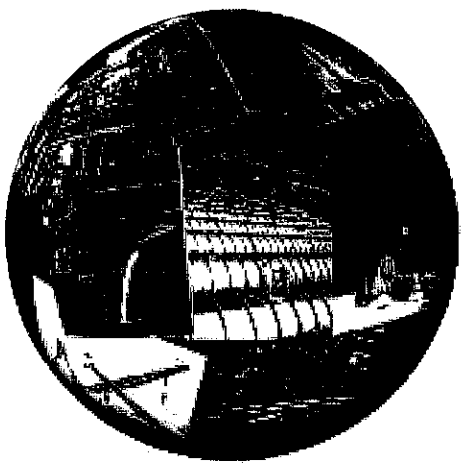
APPENDIX C – McCROMETER V-CONE FLOW DATASHEETS

Advanced
Differential
Pressure
Flowmeter
Technology

V-CONE®



For the Real World.



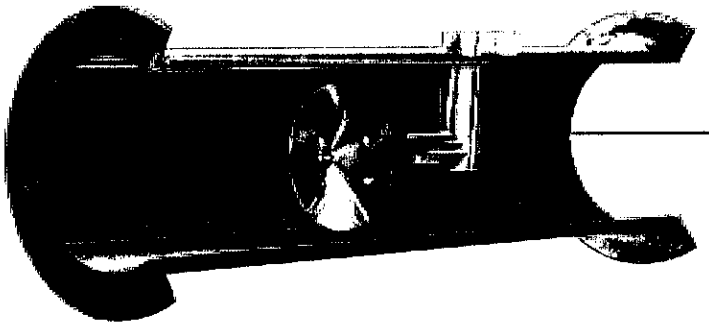
McCROMETER

The Flow Measurement Specialists

50th ANNIVERSARY

V-Cone – A New DP Technology

Designed



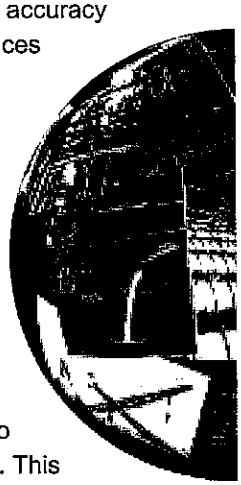
Cut away view of centrally-located cone.

High Performance in "Real World" Applications

McCrometer's V-Cone is an innovative flowmeter that takes differential pressure-type flow measurement to another level. Designed for the harshest operating environments and for the widest variety of fluids, this advanced flowmeter consistently outperforms traditional DP devices and other major flow technologies. The V-Cone offers better accuracy and repeatability, wider rangeability, installation flexibility and reduced maintenance. Its performance is so outstanding, some users say it deserves a technology name all its own.

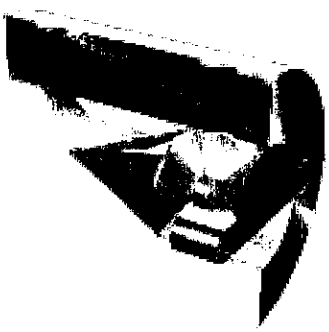
Accuracy You Can Count On

The key benefit to the V-Cone's unique design is its ability to provide repeatable accuracy of up to ±0.5% of rate under even the most difficult flow conditions, and over a wide range of Reynolds numbers. Whether measuring swirling fluids or low pressure flows, the V-Cone delivers the accuracy and reliability other devices only achieve under lab conditions.



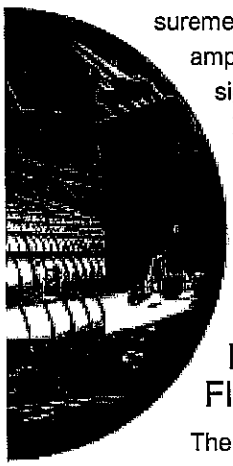
Acts as own flow conditioner

The V-Cone's enhanced performance is due to the shape and position of the cone in relation to the measurement ports. This allows the V-Cone to act as its own flow conditioner, fully conditioning



The Wafer-Cone® can be fitted between two flanges for more compact installation. It is available in a variety of materials and the cone can be easily replaced to accomodate changing flow conditions.

for Difficult-to-Measure Applications



and mixing the flow prior to measurement. The result is a low amplitude, high frequency signal with little "signal bounce." Readings are always precise and reliable, including in low pressure flow situations.

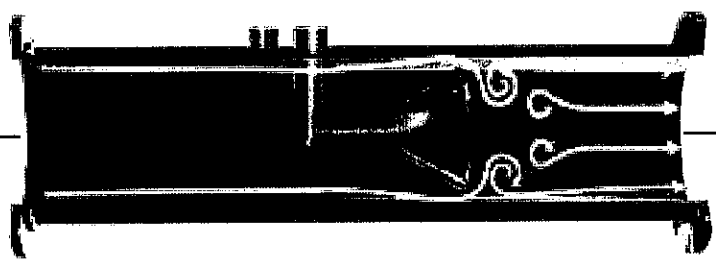
Maximum Installation Flexibility

The V-Cone's ability to condition the flow prior to measurement results in another significant benefit: installation flexibility. Because the V-Cone can accurately measure disturbed flow, it doesn't require the upstream or downstream straight pipe runs of many other flowmeters. This key feature means the V-Cone can be installed virtually anywhere in a piping system or easily retrofit into an existing piping layout. The result can be significant cost savings. It also means the V-Cone can fit where other flowmeters can't due to limited-space or weight requirements.

Low-to-No Operating Costs

The V-Cone assures long-term performance. It has no moving parts to replace and maintain. In addition, the contoured shape of the cone directs the flow without impacting it against an abrupt surface. Instead, a boundary layer forms along the cone, directing fluid away from the beta edge. Because the beta edge remains unchanged, the calibration of the meter is accurate for a much longer time, possibly indefinitely.

The V-Cone forms very short vortices as the flow passes the cone. These short vortices create a low amplitude, high frequency signal for excellent signal stability.



The V-Cone's contour-shaped cone also directs the flow without impacting it against an abrupt surface. As a result, the beta edge of the cone is not subject to wear by dirty fluids. Because it remains unchanged, V-Cones rarely, if ever, require recalibration.

Pipe flow is rarely ideal. Practically any change to the piping can disturb even a well-developed flow. The contoured shape and location of a suspended cone in the V-Cone Flowmeter overcomes this by reshaping the velocity profile upstream. As the flow approaches the cone, the flow profile "flattens" toward the shape of a well-developed profile – even in extreme flow conditions.

V-Cone Performance Advantages

high accuracy

•

high repeatability

•

conditions flow before measuring

•

minimum straight pipe requirements

•

broad rangeability

•

low headloss

•

clean or dirty liquids, wet gases, slurries

•

low signal noise

•

self cleaning

Flexible Design Meets Range of Needs

The V-Cone Flowmeter offers exceptional sizing flexibility. It can be sized for line diameters of 1/2" to over 120". It also comes in two standard configurations: a precision flow tube or insertion weld-on saddle meter. A variety of construction materials is also available.

McCrometer Application Support

At McCrometer, all we make are flowmeters. We have 50 years of flow measurement experience in municipal, industrial and agricultural markets.

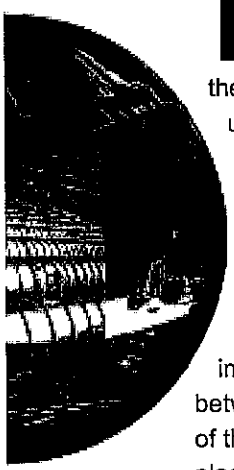
Our knowledgeable staff can accurately evaluate your flow application and specify the best metering technology for your specific flow condition. For a free evaluation of your flow application or to find out about our other flowmeter products, contact your McCrometer representative today.

VCONE®

Difficult-to-Measure Applications

Ideal for Tough Applications

- oil & gas production and delivery
- petroleum refining
- municipal water & wastewater
- chemical/ pharmaceutical processing
- power/co-generation
- mining
- pulp & paper
- industrial manufacturing
- food & beverage

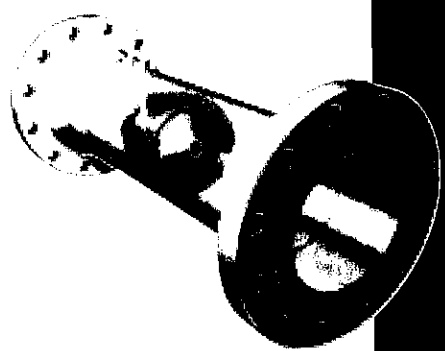


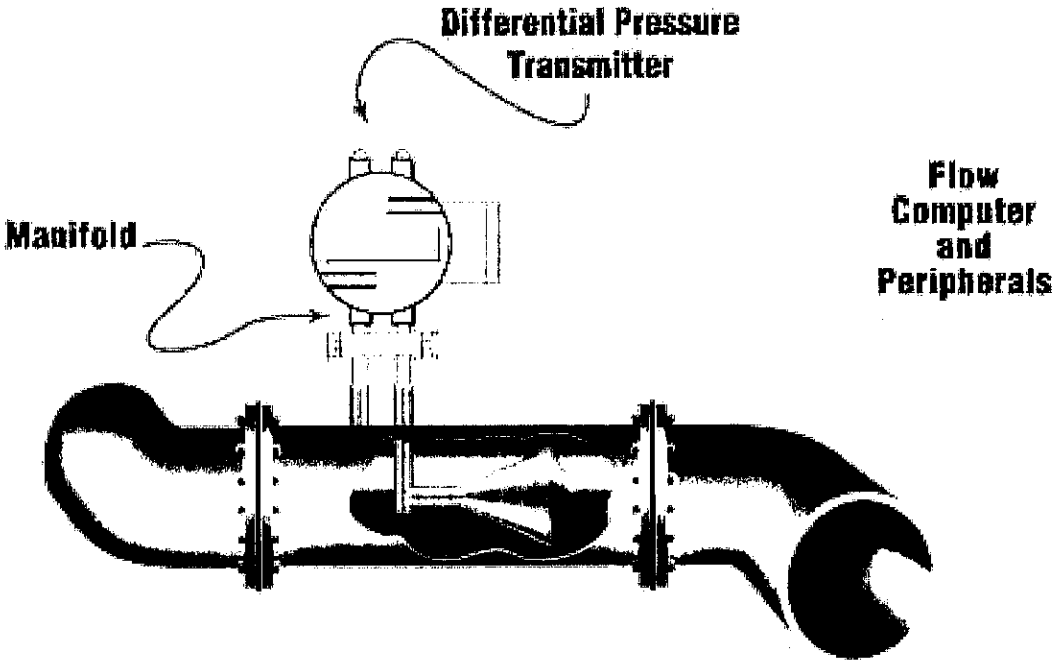
The McCrometer V-Cone Flowmeter is a patented technology that accurately measures flow over a wide range of Reynolds numbers, under all kinds of conditions and for a variety of fluids. It operates on the same physical principle as other differential pressure-type flowmeters, using the theorem of conservation of energy in fluid flow through a pipe.

Advanced DP Technology: Principles of Operation

The V-Cone's remarkable performance characteristics, however, are the result of its unique design. It features a centrally-located cone inside the tube. The cone interacts with the fluid flow, reshaping the fluid's velocity profile and creating a region of lower pressure immediately downstream of itself. The pressure difference, exhibited between the static line pressure and the low pressure created downstream of the cone, can be measured via two pressure sensing taps. One tap is placed slightly upstream of the cone, the other is located in the downstream face of the cone itself. The pressure difference can then be incorporated into a derivation of the Bernoulli equation to determine the fluid flow rate.

The cone's central position in the line optimizes the velocity of the flow at the point of measurement, assuring highly accurate, reliable flow measurement regardless of the condition of the flow upstream of the meter.





Standard Accuracy:	From ±0.5% of actual flow (certain fluids and Reynolds number applications require special calibrations to achieve this value).
Repeatability:	±0.1% or better.
Flow Ranges:	10:1 and greater.
Standard Beta Ratios:	0.45 through 0.80, special betas available.
Head Loss:	Varies with beta ratio and DP.
Installation Piping Requirements:	Typically 0-3 diameters upstream and 0-1 diameters downstream of the cone are required, depending on fittings or valves in the adjacent pipeline.
Materials of Construction Include:	Duplex 2205, 304, or 316 stainless steel, Hastelloy C-276, 254, SMO, carbon steels. Special materials on request.
Line Sizes:	0.5″ to 120″ or larger.
End Fittings:	Flanged, threaded, hub or weld-end standard. Others on request.
Configurations:	Precision flow tube and wafer-type. • Calibrated for customer application. • ASME B31.3 construction available.
Approvals for the V-Cone:	• Canadian custody transfer approved. • Meters in compliance with PED97/23/EC are available upon request. • The V-Cone is manufactured under a quality management system that is certified to ISO 9001:2000.

McCROMETER
The Flow Specialists for 50 Years

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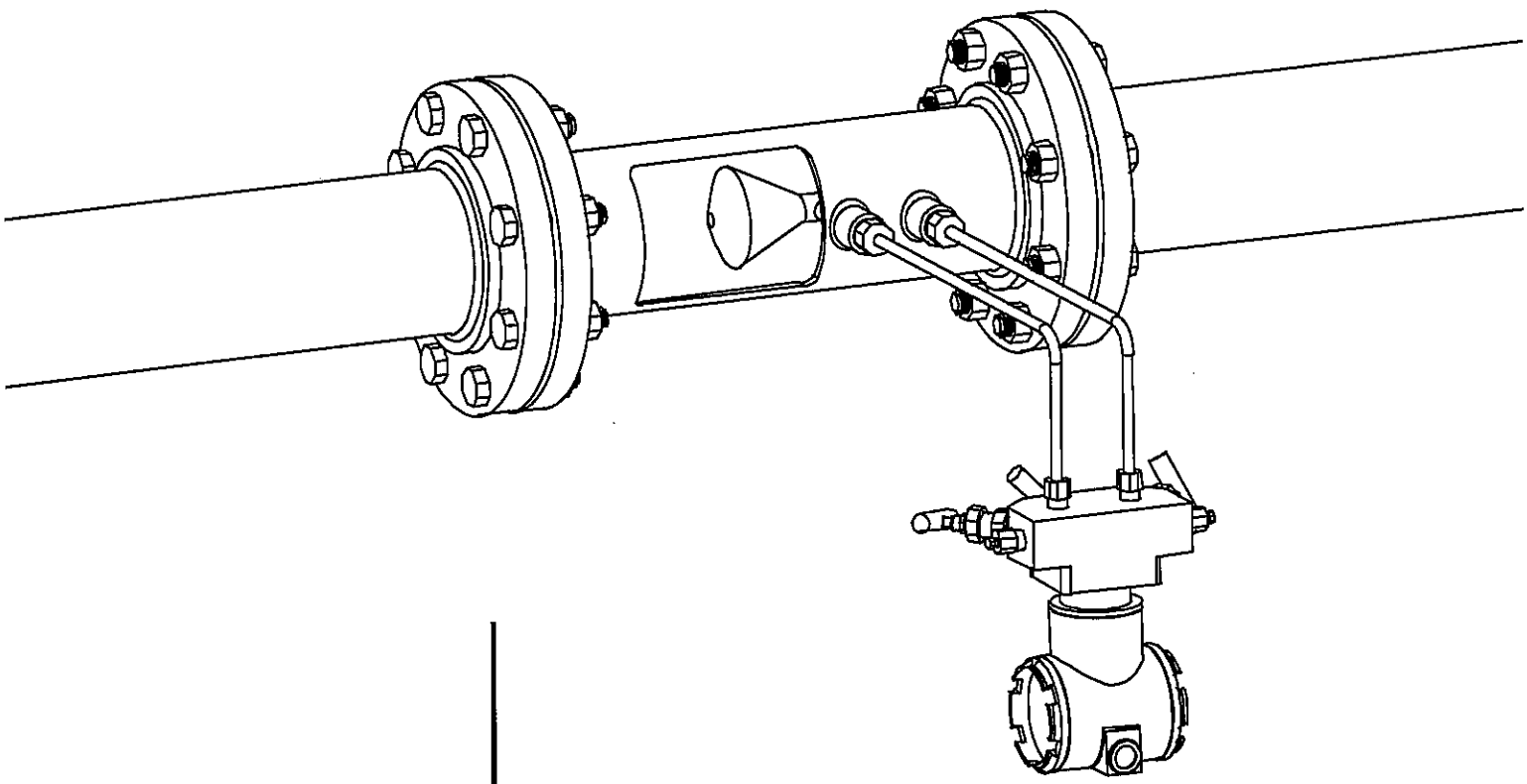
Differential
Pressure
Flowmeter
Technology



V-CONE
TECHNICAL BRIEF

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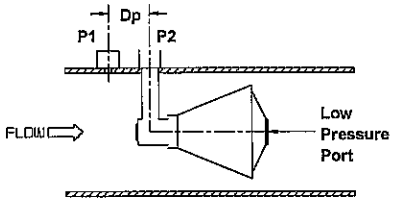
1.0 General

1.1 Introduction

The McCrometer V-Cone Flowmeter is a patented technology that accurately measures flow over a wide range of Reynolds numbers, under all kinds of conditions and for a variety of fluids. It operates on the same physical principle as other differential pressure-type flowmeters, using the theorem of conservation of energy in fluid flow through a pipe. The V-Cone's remarkable performance characteristics, however, are the result of its unique design. It features a centrally-located cone inside the tube. The cone interacts with the fluid flow, reshaping the fluid's velocity profile and creating a region of lower pressure immediately downstream of itself. The pressure difference, exhibited between the static line pressure and the low pressure created downstream of the cone, can be measured via two pressure sensing taps. One tap is placed slightly upstream of the cone, the other is located in the downstream face of the cone itself. The pressure difference can then be incorporated into a derivation of the Bernoulli equation to determine the fluid flow rate. The cone's central position in the line optimizes the velocity profile of the flow at the point of measurement, assuring highly accurate, reliable flow measurement regardless of the condition of the flow upstream of the meter.

1.2 Principles of Operation



High and Low Ports
Figure 1

The V-Cone is a differential pressure type flowmeter. Basic theories behind differential pressure type flowmeters have existed for over a century. The principal theory among these is Bernoulli's theorem for the conservation of energy in a closed pipe. This states that for a constant flow, the pressure in a pipe is inversely proportional to the square of the velocity in the pipe. Simply, the pressure decreases as the velocity increases. For instance, as the fluid approaches the V-Cone meter, it will have a pressure of P_1. As the fluid velocity increases at the constricted area of the V-Cone, the pressure drops to P_2, as shown in Figure 1. Both P_1 and P_2 are measured at the V-Cone's taps using a variety of differential pressure transducers. The Dp created by a V-Cone will increase and decrease exponentially with the flow velocity. As the constriction takes up more of the pipe cross-sectional area, more differential pressure will be created at the same flowrates. The beta ratio equals the flow area at the largest cross section of the cone (converted to an equivalent diameter) divided by the meter's inside diameter (see 3.2.3).

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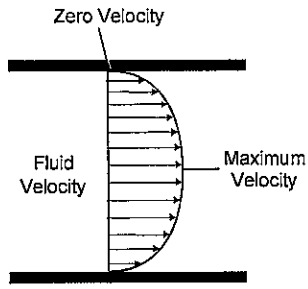
1.3 Reshaping the Velocity Profile

The V-Cone is similar to other differential pressure (Dp) meters in the equations of flow that it uses. V-Cone geometry, however, is quite different from traditional Dp meters. The V-Cone constricts the flow by positioning a cone in the center of the pipe.

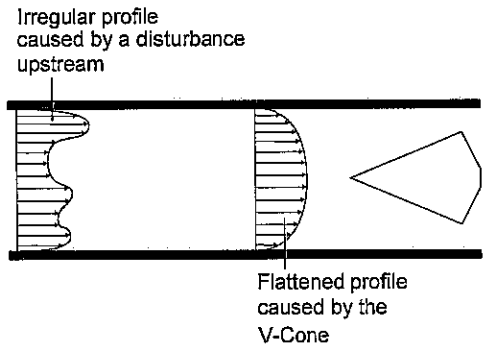
This forces the flow in the center of the pipe to flow around the cone. This geometry presents many advantages over the traditional concentric Dp meter. The actual shape of the cone has been continuously evaluated and tested for over ten years to provide the best performance under differing circumstances.

One must understand the idea of a flow profile in a pipe to understand the performance of the V-Cone. If the flow in a long pipe is not subject to any obstructions or disturbances, it is well-developed flow. If a line passes across the diameter of this well-developed flow, the velocity at each point on that line would be different. The velocity would be zero at the wall of the pipe, maximum at the center of the pipe, and zero again at the opposite wall. This is due to friction at the pipe walls that slows the fluid as it passes. Since the cone is suspended in the center of the pipe, it interacts directly with the "high velocity core" of the flow. The cone forces the high velocity core to mix with the lower velocity flows closer to the pipe walls. Other Dp meters have centrally located openings and do not interact with this high velocity core. This is an important advantage to the V-Cone at lower flowrates. As the flowrate decreases, the V-Cone continues to interact with the highest velocity in the pipe. Other Dp meters may lose their useful Dp signal at flows where the V-Cone can still produce one.



Velocity Profile
Figure 2

The pipe flow profile in actual installations is rarely ideal. There are many installations where a flowmeter exists in flow that is not well developed. Practically any changes to the piping, such as elbows, valves, reductions, expansions, pumps, and tees can disturb well-developed flow. Trying to measure disturbed flow can create substantial errors for other flowmeter technologies. The V-Cone overcomes this by reshaping the velocity profile upstream of the cone. This is a benefit derived from the cone's contoured shape and position in the line. As the flow approaches the cone, the flow profile "flattens" toward the shape of a well-developed profile.



Flattened Velocity Profile
Figure 3

The V-Cone can flatten the flow profile under extreme conditions, such as a single elbow or double elbows out-of-plane, positioned closely upstream of the meter. This means that as different flow profiles approach the cone, there will always be a predictable flow profile at the cone. This ensures accurate measurement even in non-ideal conditions.

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2.0 Features

2.1 High Accuracy

The V-Cone primary element can be accurate to ±0.5% of reading, and the Wafer-Cone can be accurate to ±1.0%. The level of accuracy is dependent to a degree on application parameters and secondary instrumentation.

2.2 Repeatability

The V-Cone and the Wafer-Cone primary element exhibits excellent repeatability of ±0.1% or better.

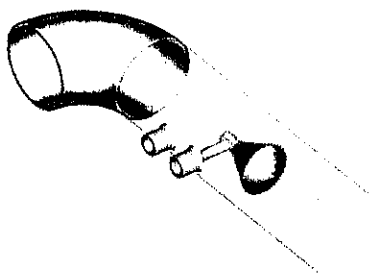
2.3 Turndown

The turndown of the V-Cone can reach far beyond traditional Dp meters. A typical turndown for a V-Cone is 10 to 1. Greater turndowns are attainable. Flows with Reynolds numbers as low as 8000 will produce a linear signal. Lower Reynolds number ranges are measurable and are repeatable by applying a curve fit to the measured Dp, derived from calibration over a specific Reynolds number range.

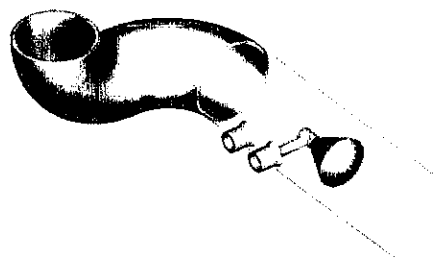
2.4 Installation Requirements

Since the V-Cone can flatten the velocity profile, it can function much closer to upstream disturbances than other Dp meters. The recommended installation for the V-Cone is zero to three diameters of straight run upstream and zero to one diameters downstream. This can be a major benefit to users with larger, more expensive line sizes or users which have small run lengths. McCrometer conducted performance tests of the V-Cone downstream of a single 90° elbow and two close coupled 90° elbows out of plane. These tests show that the V-Cone can be installed adjacent to either single elbows or two elbows out of plane without sacrificing accuracy.

For specific installation recommendations, consult the tables on pages 9-10.



Single Elbow and V-Cone
Figure 4



Double Elbow and V-Cone
Figure 5

2.5 Long Term Performance

The contoured shape of the cone constricts the flow without impacting the flow against an abrupt surface. A boundary layer forms along the cone and directs the fluid away from the beta edge. This means the beta edge will not be as subject to the usual wear by unclean fluids, as is the case with an orifice plate. The beta ratio will then remain unchanged and the calibration of the meter will be accurate for a much longer time.

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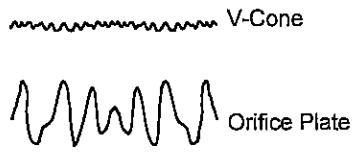
2.6 Signal Stability



Signal Stability
Figure 6

Every Dp meter has a "signal bounce". This means that even in steady flow, the signal generated by the primary element will fluctuate a certain amount. On a typical orifice plate, the vortices that form just after the plate are long. These long vortices create a high amplitude, low frequency signal from the orifice plate. This could disturb the Dp readings from the meter. The V-Cone forms very short vortices as the flow passes the cone. These short vortices create a low amplitude, high frequency signal. This translates into a signal with high stability from the V-Cone. Representative signals from a V-Cone and from a typical orifice plate are shown in figure 6.

2.7 Low Permanent Pressure Loss

Without the impact of an abrupt surface, the permanent pressure loss is lower than a typical orifice plate meter. Also, the signal stability of the V-Cone allows the recommended full scale Dp signal to be lower for the V-Cone than other Dp meters. This will lower the permanent pressure loss.

2.8 Sizing

The unique geometry of the V-Cone allows for a wide range of beta ratios. Standard beta ratios range from 0.45, 0.55, 0.65, 0.75, and 0.80.

2.9 No Areas of Stagnation

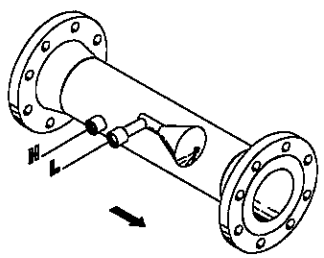
The "swept through" design of the cone does not allow for areas of stagnation where debris, condensation or particles from the fluid could accumulate.

2.10 Mixing

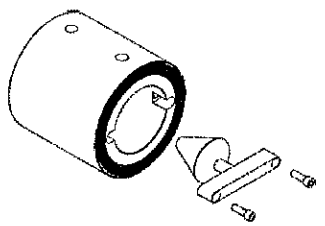
The short vortices described in section 2.6 mix the fluid thoroughly just downstream of the cone. The V-Cone is currently used in many applications as a static mixer where instant and complete mixing are necessary.

2.11 V-Cone Models

Precision tube V-Cones range in line sizes from 1/2" to 72" and larger; Wafer-Cones range from 1" to 6".



Precision Tube V-Cone
Figure 7



Wafer-Cone®
Figure 8

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3.0 The V-Cone Flow Meas. System

3.1 Application Data

The customer must provide application parameters so that the appropriate V-Cone flowmeter may be selected. McCrometer has an extensive meter performance database of fluid properties which can be utilized for sizing purposes.

3.2 General Calculations

Nomenclature:

ΔP	differential pressure (Dp)	inWC	P	operating pressure	psia
D	inside diameter	inch	T	operating temperature	Rankine
d	cone diameter	inch	Z	gas compressibility	.
β	beta ratio	.	S_F	operating specific gravity	.
k	isentropic exponent	.	S_{STP}	specific grav. @ 60°F, 14.696 Psia	.
k_1	flow constant	.	ρ_{water}	water density (62.3663)	lb/ft^3
k_4	flow constant – without C_D	.	P_b	base pressure	psia
G_C	grav. constant (32.174)	f/s^2	T_b	base temperature	Rankine
C_D	flowmeter coefficient	.	Z_b	base gas compressibility	.
Y	gas expansion factor	.	μ	viscosity	cP
ρ	flowing density (rho)	.	Re	Reynolds Number	.
α	material thermal expansion α, or α_{cone}, α_{pipe} (alpha)	.	v	Velocity	fps

3.2.1	Differential Pressure	$\Delta P = P_H - P_L$	ΔP units are inWC
3.2.2	Flowmeter Coefficient	Derived from calibration or from historical data.	Located on sizing and calibration reports.
3.2.3	V-Cone beta ratio	$\beta = \frac{\sqrt{D^2 - d^2}}{D}$	β from sizing report
3.2.4	Flow Constant	$k_1 = \frac{\pi}{576}\sqrt{2G_c}\frac{D^2\beta^2}{\sqrt{1-\beta^4}}C_D$	k_1 from sizing report See note 2.
3.2.5	Material Thermal Expansion Factor	$F_a = 1 + 2\alpha(T - 528)$	See note 1.
3.2.6	Material Thermal Expansion Factor If cone and main line pipe are made of different materials.	See note 1. $F_a = \frac{D^2 - d^2}{((1-\alpha_{pipe}\cdot(T-528))\cdot D)^2 - ((1-\alpha_{cone}\cdot(T-528))\cdot d)^2}$	

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3.2 General Calculations (continued)

3.2.7	Pipeline Velocity	$v = \frac{576\,ACFS}{\pi D^2}$	
3.2.8	Reynolds Number	$Re = 123.9\frac{v D \rho}{\mu}$	Dimensionless number which can be used to correlate meter calibrations in different fluids.
3.2.9	Flow Constant Used when C_D is not constant.	$k_4 = \frac{\pi}{576}\sqrt{2G_c}\frac{D^2\beta^2}{\sqrt{1-\beta^4}}$	This equation can be used in substitute of 3.2.4 when the C_D flow coefficient is not constant. See note 2.

3.3 Calculations for Liquids

3.3.1	Density	$\rho = \rho_{water}\, S_F$	
3.3.2	Flowrate Conversion	$GPM = 448.83\,ACFS$	
3.3.3	Flowrate	$ACFS = F_a\, k_1 \sqrt{\frac{5.197\,\Delta P}{\rho}}$	
3.3.4	Flowrate When C_D is not constant.	$ACFS = F_a\, k_4 \sqrt{\frac{5.197\,\Delta P}{\rho}}\, C_D$	

Notes:

1. Material Thermal Expansion - The thermal expansion equations correct for dimensional changes which occur as the operating temperature deviates from the base temperature of 70° F (see 3.2.5 and 3.2.6 on page 5).

The F_a factor can be excluded from the flow equation if the operating temperature is:

< 100° Fahrenheit , < 560° Rankine, < 38° Celsius

If the F_a factor is significant and the operating temperature is stable then a constant F_a value may be used. If the F_a factor is significant and the temperature varies then an F_a factor should be calculated prior to every flow calculation.

2. Discharge Coefficient - Discharge coefficients can be implemented in the flow equations via several different methods. Following are typical methods: *average C_D* or *C_D look up table.*
If a C_D look up table or fitted data is utilized additional calculations must be made based on the Reynolds number (see example processes 3d and 4b).

3. Liquids - Typical Calculation Processes:

3a. given: D, β, ρ, C_D, and input of ΔP — Calculate: 3.2.4, 3.3.3

3b. given: D, β, ρ, C_D, and input of ΔP, T — Calculate: 3.2.4, 3.2.5 or 3.2.6 if req., 3.3.3

3c. given: D, β, S_F, C_D, and input of ΔP, T — Calculate: 3.2.4, 3.2.5 or 3.2.6 if req., 3.3.1, 3.3.3

3d. given: D, β, μ, ρ, C_D look up, and input of ΔP

Calculate: initially set $C_D = 0.8$, 3.2.9, 3.2.5 or 3.2.6 if required,

→ 3.2.7, 3.2.8, look up C_D , 3.3.4

Iterate until flowrate is < 0.01% different from last calculation.

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3.4 Calculations for Compressible Fluids (gases and vapors)

3.4.1	V-Cone Gas Expansion Factor rev. May. 2001	$Y = 1 - (0.649 + 0.696\beta^4)\frac{0.03613\,\Delta P}{k \cdot P}$	k - Isentropic Exponent note: 0.03613 converts ΔP (inWC at 4°C) to same units as P (Psia)
3.4.2	Wafer-Cone Gas Expansion Factor rev. Oct. 2001	$Y = 1 - (0.755 + 6.787\beta^8)\frac{0.03613\,\Delta P}{k \cdot P}$	
3.4.3	Gas Density	$\rho\,(lb/ft^3) = 2.6988\frac{S_{STP}\,P}{Z\,T}$	
3.4.4	Flowrate Actual Cubic Feet Per Second	$ACFS = F_a\,k_1\,Y\sqrt{\frac{5.197\,\Delta P}{\rho}}$	
3.4.5	Flowrate Actual Cubic Feet Per Second When C_D is not constant.	$ACFS = F_a\,k_4\,Y\sqrt{\frac{5.197\,\Delta P}{\rho}}\,C_D$	
3.4.6	Flowrate Standard Cubic Feet Per Second	$SCFS = ACFS\left(\frac{P\,T_b\,Z_b}{P_b\,T\,Z}\right)$	converts actual flow to standard flow at base conditions

Notes (continued from page 6):

4. Gases and Steam - Typical Calculation Processes:

4a. given: D, β, μ, S_F, Z, k, C_D, and inputs of ΔP, P, T

Calculate: 3.2.4, 3.2.5 or 3.2.6 if needed, 3.4.1 or 3.4.2, 3.4.3, 3.4.4

4b. given: D, β, μ, S_F, Z, k, C_D look up, and inputs of ΔP, P, T

Calculate: initially set C_D = 0.8, 3.2.4, 3.2.5 or 3.2.6 if needed, 3.4.1 or 3.4.2, 3.4.3, 3.4.4,

→ 3.2.7, 3.2.8, look up C_D , 3.4.4 — Iterate until flowrate is < 0.01% different from last calculation.

5. Fluid properties - Fluid properties such as viscosity, compressibility and isentropic exponent vary with temperature and to some extent pressure. The viscosity in the calculations above could effect the selected C_D value, the compressibility directly effects the density and the isentropic exponent effects the Y factor, although to a small degree. The instrumentation industry uses many different approaches to calculate flow. Which fluid properties are calculated at each set of flow conditions and which properties are constant must be determined by the customer and McCrometer application engineering.

3.5 Application Sizing

Each V-Cone is tailored to its specific application. Before manufacturing, every V-Cone will have a "sizing" completed according to the physical parameters of the application. The computer generated sizing uses application data as a basis to predict the V-Cone's performance. Full scale DP, working flow range, expected accuracy, and predicted pressure loss are determined by the sizing process.

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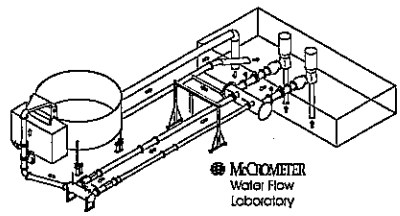
3.6 Calibration

Wafer-Cone and precision tube flowmeters less than 20" diameter are calibrated in one or more of the following McCrometer calibration facilities:

Calibration Facility	*Size Range*	*Calibration Facility*	*Size Range*
Water 40k lb Gravimetric	3" to 18"	Water 1.5k lb Gravimetric	up to 4"
Water 5k lb Gravimetric	up to 6"	Air 80 cfm	up to 2"

McCrometer recommends that every V-Cone meter be calibrated. A calibration is required when the application requires the best accuracy. Insertion top-plate style flowmeters can be calibrated as an option. If an actual calibration is not requested, the coefficient for the meter can be estimated. Data collected over years of independent testing allows for an estimate of the meter's C_D. For V-Cones intended for use in a compressible fluid with high accuracy requirements, McCrometer recommends calibration in a compressible fluid.



Calibration Facility 40k Gravimetric
Figure 9

3.7 Materials of Construction

All materials used for V-Cone flowmeters are certified. Materials furnished to McCrometer include a certified material test report (CMTR) from the original material manufacturer. The test reports include material composition and applicable material grades. Upon request copies of the material test reports can be supplied to our customers.

3.8 Valve Manifolds

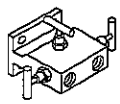
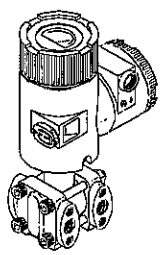


Figure 10

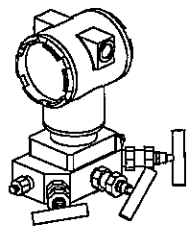
McCrometer recommends a three valve or five valve manifold as part of a V-Cone flow measurement system. Manifolds allow for in-line transmitter calibrations, isolation of the transmitter from the transmission lines, without depressurizing the line, and in-line purging of transmission lines.

3.9 Secondary and Tertiary Instrumentation

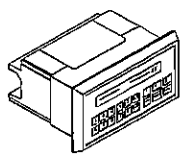
A differential pressure transmitter measures the differential pressure signal from the primary element. Once the signal is measured, the transmitter generates an electronic signal that is then interpreted by a flow monitor or other process control system. For compressible fluids, line pressure and temperature measurements are generally required for accurate flow measurement. McCrometer offers the following flow measurement instrumentation: differential pressure transmitters, flow computers, and pressure and temperature sensors for mass flow measurement.



Typical Dp Trans.
Figure 11



Typ. Dp Transmitter with valve manifold
Figure 12



Flow Computer
Figure 13

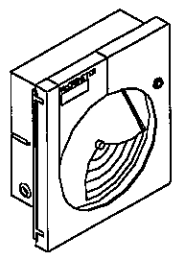


Chart Recorder
Figure 14

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V-Cone® Preliminary Sizing

By Northeast Controls Inc.

Tag #	FM-1 59th St.	Fluid	WATER 30% Propylene Glycol
Serial #	FM-1 59th St.	Fluid State	LIQUID
Job Ref.	FM-1 59th St.	End User	Office Power
Model	VS05QE03N	Industry	Power [Including Cogeneration] (005)

Description	V-Cone 5" S304 S40, ANSI SO CL150 RF
Note	30% Propylene Glycol

C_f	0.84	
P_f	30	psiG
T_f	205	°F
ρ	59.97	lb/ft3
μ	0.2919	cP
G		
Z		
Y		
k		
C_P		
Mw	18.015	
P_b		
T_b		
Z_b		
P_{baro}	14.696	psi
P_c	3198.8	psi
T_c	705.13	°F
F_a	1.002	
aPE	D 6.7e-06	d 6.7e-06
P_v	12.76	psi
HL	31	inWC

⇐ Entered value.

q	max. Flowrate	280	GPM
Re	max. Reynolds	5.774e+05	
V	max. Velocity	4.490	fps
ΔP	max. Dp	50.000	inWC
ΔP	min. Dp	0.4998	inWC
D	Meter I.D.	5.047	in
d	Cone O.D.	4.210	in
β	Beta Ratio	0.5517	
	Turn Down	10	

McCrometer Cal.	
Third Party Cal.	
Dye Pen. Exam.	
Hydro. Test	
X-Ray Exam.	
Mag. Part.	
PMI	
CMTR Copies	
Application Eng.	BCY

	Re	Velocity fps	Gas. Exp. Y	ΔP inWC	Flowrate GPM
1	5.774e+05	4.490		49.98	280.00
2	5.196e+05	4.041		40.49	252.00
3	4.619e+05	3.592		31.99	224.00
4	4.042e+05	3.143		24.49	196.00
5	3.464e+05	2.694		17.99	168.00
6	2.887e+05	2.245		12.50	140.00
7	2.310e+05	1.796		7.997	112.00
8	1.732e+05	1.347		4.499	84.000
9	1.155e+05	0.8981		1.999	56.000
10	57740	0.4490		0.4998	28.000

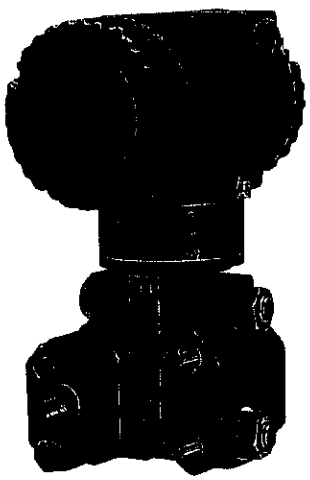
Table based on one flow condition (P, T ,Z , k ...) V25 Version 4.3

Record Start Date	04-16-2007
Print Date	04-16-2007

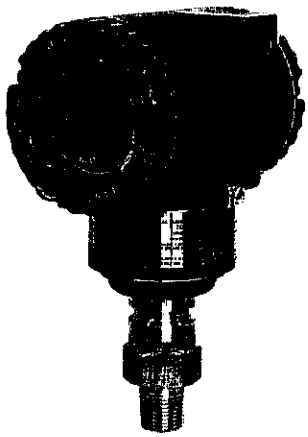
McCROMETER

APPENDIX D – FOXBORO DP TRANSMITTER DATASHEET

I/A Series® Electronic Pressure Transmitters with 4 to 20 mA Analog Output for Absolute and Gauge Pressure Measurement



IAP20/IGP20 TRANSMITTER



IAP10/IGP10 TRANSMITTER STRUCTURE CODES 52, 53, 60-63, D5, D6, S5, S6, SH, AND SJ

IAP10/IGP10 TRANSMITTER STRUCTURE CODES 20-23, 30, 31, D1, D2, S3, S4, SC, AND SD

The IAP10, IGP10, IAP20, and IGP20 Series of electronic analog output, two-wire transmitters provide precise, reliable measurement of absolute or gauge pressure, and transmit a 4 to 20 mA output signal.

HIGH DEPENDABILITY

- Simple, elegant sensor packaging uses very few parts to achieve exceptionally high reliability
- NEMA 4X and IEC IP66 durable epoxy-coated aluminum, or 316 ss housings.
- Co-Ni-Cr, 316L ss, and Hastelloy sensor materials for all transmitters; additional materials available for IAP20/IGP20 Transmitters.
- Can be provided with numerous configurations of direct connect or remote mount seals.
- Integral process connections for sanitary, and pulp/paper installations with IAP10/IGP10.
- CE marked; complies with applicable EMC, ATEX, and PED European Union Directives.
- Meet numerous Agency requirements for hazardous locations. Versions available to meet Agency flameproof and zone requirements.
- Standard 5-year warranty.

INTELLIGENT TRANSMITTER FEATURES AT AN ECONOMICAL PRICE

When you want the flexibility and performance of a configurable, intelligent transmitter but you do not need a digital output signal, these transmitters provide exceptional benefits at a very affordable price:

- Liquid Crystal Display (LCD) digital indicator with on-board pushbuttons
- Pushbutton configuration and calibration:
  - Zero and Span Settings
  - Adjustable Damping
  - Forward or Reverse Output
  - Failsafe Output; Upscale or Downscale
  - Reranging without applying pressure
- Easily upgradeable to FoxCom™, HART, FOUNDATION fieldbus, or PROFIBUS fully intelligent versions

invensys®
FOXBORO®

I/A Series® PRESSURE TRANSMITTER FAMILY

The I/A Series Electronic Pressure Transmitters are a complete family of d/p Cell®, gauge, absolute, multirange, multivariable, and premium performance transmitters, as well as transmitters with remote or direct connect pressure seals, all using field-proven silicon strain gauge sensors and common topworks.

MODULAR ELECTRONICS

A common 4 to 20 mA output electronics module is used with these transmitters. Also, because all configuration and calibration data is stored in the sensor, you can replace this module with another like module without transmitter reconfiguration or recalibration.

Furthermore, if your needs change, the transmitter modular design allows easy migration to other standards, including FoxCom, HART, FOUNDATION Fieldbus, PROFIBUS, and 1 to 5 V dc.

ELECTRONICS VERSION -A TRANSMITTER

This 4 to 20 mA analog output transmitter is a very cost effective analog output transmitter. It provides full configuration capability and represents Invensys Foxboro advancements in providing the greatest functionality for the largest number of applications at the least possible cost to you.

The transmitter even provides the ability to rerange to new calibrated ranges, using the LCD Indicator, without the need to apply calibration pressure.

These transmitters are explosionproof for use in Division 1 hazardous areas and comply with Division 2 requirements. They also provide the flameproof certification for use in Zone 1 hazardous areas.

HIGH PERFORMANCE

Both direct-connected and bracket-mounted transmitters utilize microprocessor-based correction to achieve excellent accuracy and ambient temperature compensation.

EASE OF INSTALLATION

Rotatable Topworks allows transmitter installation in tight places, allows indicator to be positioned in preferred direction, and eases field retrofit.

Two Conduit Entrances offer a choice of entry positions for ease of installation and self-draining of condensation regardless of mounting position and topworks rotation.

Wiring Guides and Terminations provide ease of wire entry and support, plenty of space to work and store excess wire, and large, rugged, rugged screw terminals for easy wire termination.

STANDARD LCD DIGITAL INDICATOR

A two-line digital indicator with on-board pushbuttons displays the measurement with a choice of units. The pushbuttons allow zero and span adjustments as well as local configuration without the need for a PC-based Configurator.

When local process indication is not required or desired, an optional blind (solid) cover can be substituted for the standard window cover.

CHOOSE MOUNTING CONFIGURATION NEEDED

Direct Connected Transmitter (Figure 1)

Light weight and easy-to-install. Uses 316L ss or Hastelloy C process connections and a choice of either 316L ss, Cobalt-Nickel-Chrome, or Hastelloy C for the sensing diaphragm. See Direct-Connected Transmitters on next page.

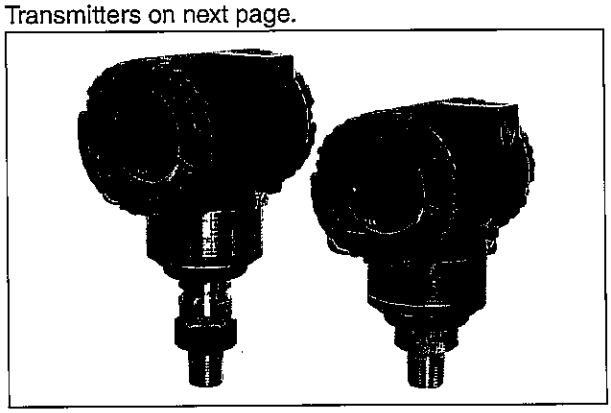


Figure 1. Direct Connected Transmitter (Flameproof Version on Left)

Bracket-Mounted Transmitter (Figure 2)

A large selection of corrosion resistant materials; suitable for applications requiring low spans, vacuum service, and high overrange pressure. See Bracket-Mounted Transmitters on next page.

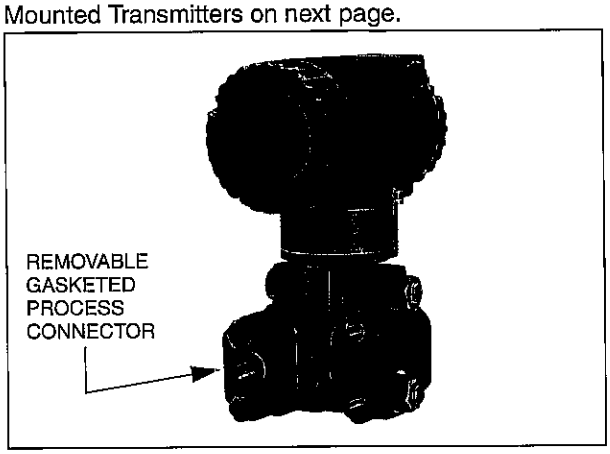


Figure 2. Bracket-Mounted Transmitter with Conventional Process Connector

DIRECT-CONNECTED TRANSMITTERS — IAP10 AND IGP10 (See Figure 1)

EXCEPTIONAL VALUE

The combination of small size, light weight, direct mounting, standard materials, and wide measurement capability with high performance makes these transmitters an exceptionally cost effective solution for process pressure measurement.

DIRECT PROCESS MOUNTING

Because of their light weight and external threaded connection, these transmitters can be installed directly on process piping without mounting brackets. However, for unique requirements, an optional bracket is offered and connection can be made to the standard 1/4 NPT internal thread.

WIDE RANGEABILITY

Three absolute pressure versions are offered to allow spans from 7 to 21 000 kPa (1 to 3000 psi), and four gauge pressure versions are offered to allow spans from 7 to 42 000 kPa (1 to 6000 psi). Refer to the IGP20 Transmitter section below for gauge pressure vacuum service.

316L ss, HASTELLOY C, AND Co-Ni-Cr PROCESS WETTED PARTS

With process connection of 316L ss or Hastelloy C, and sensor diaphragm available in either 316L ss, Hastelloy C, or highly corrosion resistant Co-Ni-Cr, this transmitter is an excellent choice for the vast majority of process pressure measurements.

HIGH GAUGE PRESSURE VERSIONS

Three high gauge pressure versions with URLs of 52, 105, and 210 MPa (7500, 15 000, and 30 000 psi) are available in the IGP10 line. See PSS 2A-1C13 F.

SANITARY AND PULP AND PAPER VERSIONS

These transmitters are also available with integral process connections for use in sanitary and pulp and paper installations. See PSS 2A-1C13 K and PSS 2A-1C13 L, respectively.

FLAMEPROOF DESIGN

The transmitters are designed to meet Agency flameproof and zone requirements.

BRACKET-MOUNTED TRANSMITTERS — IAP20 AND IGP20 (See Figure 2)

SENSOR CORROSION PROTECTION

Choice of Co-Ni-Cr, 316L ss, Gold-Plated 316L ss, Hastelloy C, Monel, or Tantalum materials. High corrosion resistance of Co-Ni-Cr (TI 037-038) means long service life in many difficult applications without the extra cost for exotic materials. Also see TI 37-75b for process application with Co-Ni-Cr and other wetted parts materials.

WIDE RANGEABILITY

Gauge pressure measurement spans may be as low as 0.12 kPa (0.5 inH_2O) to as high as 35 MPa (5000 psi) by choosing one of only six sensors, and absolute pressure spans may be as low as 0.87 kPa (3.5 inH_2O) to as high as 21 MPa (3000 psi) by choosing one of only four sensors. This provides exceptional measurement range capability with a minimum of versions.

EASE OF MOUNTING TWO-VALVE MANIFOLD

Optional two-valve manifold, to isolate transmitter and to vent pressure, is easily mounted directly to the transmitter.

VACUUM SERVICE

A lower range limit of -100 kPa (-14.7 psi, -1 bar or kg/cm^2) means that vacuum measurements are easily handled with the versatile IGP20 Gauge Pressure transmitter.

FLAMEPROOF DESIGN

The transmitters are designed to meet Agency flameproof and zone requirements.

PROCESS CONNECTOR

Removable, gasketed process connector (Figure 3) allows a wide range of selections, including 1/4 NPT, 1/2 NPT, Rc 1/4, Rc 1/2, and weld neck connections.

For highly corrosive chemical processes, a 1/2 NPT pvdf (Kynar) insert is installed in the HI-side 316 ss cover and is used as the process connector. In these applications, tantalum is used as the sensor diaphragm material.

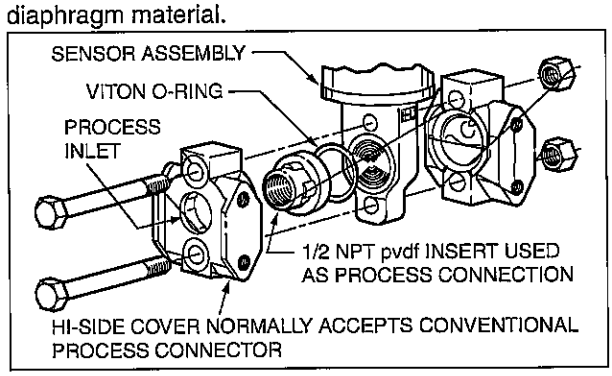


Figure 3. Bracket-Mounted Transmitter Shown with 1/2 NPT pvdf Insert Installed in HI-Side Cover

PRESSURE SEALS

Pressure seals are used with the IAP10, IGP10, IAP20, and IGP20 Series Transmitters when it is necessary to keep the transmitter isolated from the process. A sealed system is used for a process fluid that may be corrosive, viscous, subject to temperature extremes, toxic, sanitary, or tend to collect and solidify.

Tables 1 and 2 list the various seals that can be used with these transmitters. To order a transmitter with seals, both a Transmitter Model Number and Seal Model Number are required. See PSS 2A-1Z11 A for a complete listing of pressure seal models and specifications.

Table 1. Pressure Seals Used with IAP10, IGP10, IAP20, and IGP20 Transmitters

Direct Connect Pressure Seal Assemblies		
Seal Model	**Seal Description**	**Process Connections**
PSFLT	Flanged, Direct Connect (Flanged Level), Flush or Extended Diaphragm	ANSI Class 150/300/600 flanges and BS/DIN PN 10/40, 10/16, 25/40 flanges
PSFAD	Flanged, Direct Connect, Recessed Diaphragm	ANSI CLass 150, 300, 600, 1500 flanges
PSTAD	Threaded, Direct Connect, Recessed Diaphragm	1/4, 1/2, 3/4, 1, or 1 1/2 NPT internal thread
PSISD	In-Line Saddle Weld, Direct Connect, Recessed Diaphragm	Lower housing of seal is in-line saddle welded to nominal 3- or 4-inch (and larger) Pipe
PSSCT	Sanitary, Direct Connect (Level Seal), Flush Diaphragm	Process Connection to Sanitary Piping with 2- or 3-inch Tri-Clamp
PSSST	Sanitary, Direct Connect (Level Seal), Extended Diaphragm	Process Connection to 2-in Mini Spud or 4-in Standard Spud; Tri-Clamp
Remote Mount, Capillary-Connected Pressure Seal Assemblies		
Seal Model	**Seal Description**	**Process Connections**
PSFPS	Flanged, Remote Mount, Flush Diaphragm	ANSI Class 150/300/600 flanges and BS/DIN PN 10/40 flanges
PSFES	Flanged, Remote Mount, Extended Diaphragm	ANSI Class 150/300/600 flanges and BS/DIN PN 10/40, 10/16, 25/40 flanges
PSFAR	Flanged, Remote Mount, Recessed Diaphragm	ANSI Class 150/300/600/1500 flanges
PSTAR	Threaded, Remote Mount, Recessed Diaphragm	1/4, 1/2, 3/4, 1, or 1 1/2 NPT internal thread
PSISR	In-Line Saddle Weld, Remote Mount, Recessed Diaphragm	Lower housing of seal is in-line saddle welded to nominal 3- or 4-inch (and larger) Pipe
PSSCR	Sanitary, Remote Mount, Flush Diaphragm	Process Connection secured with a Tri-Clamp to a 2- or 3-inch pipe
PSSSR	Sanitary, Remote Mount, Extended Diaphragm	Process Connection to 2-in Mini Spud or 4-in Standard Spud; Tri-Clamp

Table 2. I/A Series Pressure Transmitters and Applicable Pressure Seals

Transmitter Model	Used with Pressure Seal Model: (a)												
	FLT	FAD	TAD	ISD	SCT	SST	FPS	FES	FAR	TAR	ISR	SCR	SSR
IAP10	–	✓	✓	✓	–	–	✓	✓	✓	✓	✓	✓	✓
IGP10	–	✓	✓	✓	–	–	✓	✓	✓	✓	✓	✓	✓
IAP20	–	–	–	–	–	–	✓	✓	✓	✓	✓	✓	✓
IGP20	✓	–	–	–	✓	✓	✓	✓	✓	✓	✓	✓	✓

(a) Pressure Seal models are shown with an abbreviated code; all seal codes have a PS prefix; for example, FLT is really PSFLT.

FUNCTIONAL SPECIFICATIONS

Span and Range Limits for IAP10 and IGP10 Transmitters

Span Code	Span Limits			Range Limits (Absolute or Gauge Units)		
	MPa	psi	bar or kg/cm^2	MPa	psi	bar or kg/cm^2
C	0.007 and 0.21	1 and 30	0.07 and 2.1	0 and 0.21	0 and 30	0 and 2.1
D	0.07 and 2.1	10 and 300	0.7 and 21	0 and 2.1	0 and 300	0 and 21
E	0.7 and 21	100 and 3000	7 and 210	0 and 21	0 and 3000	0 and 210
F (a)	14 and 42	2000 and 6000	140 and 420	0 and 42	0 and 6000	0 and 420

(a) Span Limit Code F is applicable to IGP10 Transmitter only.

Maximum Overrange and Proof Pressure Ratings for IAP10 and IGP10 Transmitters

Span Code	Maximum Overrange Pressure Rating (a)			Proof Pressure Rating (a)(b)		
	MPa	psi	bar or kg/cm^2	MPa	psi	bar or kg/cm^2
C	0.31	45	3.15	0.827	120	8.27
D	3.1	450	31.5	8.27	1200	82.7
E	31	4500	315	79.3	11500	793
F (c)	59	8400	588	152	22000	1517

(a) Values listed are in absolute or gauge pressure units, as applicable. Maximum overrange pressure is the maximum pressure that may be applied without causing damage to the transmitter.
(b) Proof pressure ratings meet ANSI/ISA Standard S82.03-1988. Unit may become nonfunctional after application of proof pressure.
(c) Span Limit Code F is applicable to IGP10 Transmitter only.

Span and Range Limits for IAP20 and IGP20 Transmitters

Span Code	Span Limits			Range Limits (Absolute or Gauge Units) (a)		
	kPa	inH_2O	mbar	kPa	inH_2O	mbar
A (b)	0.12 and 7.5	0.5 and 30	1.2 and 75	-7.5 and +7.5	-30 and +30	-75 and +75
B	0.87(c) and 50	3.5(c) and 200	8.7(c) and 500	-50(a) and +50	-200(a) and +200	-500(a) and +500
	MPa	psi	bar or kg/cm^2	MPa	psi	bar or kg/cm^2
C	0.007 and 0.21	1 and 30	0.07 and 2.1	-0.1(a) and 0.21	-14.7(a) and +30	-1(a) and +2.1
D	0.07 and 2.1	10 and 300	0.7 and 21	-0.1(a) and 2.1	-14.7(a) and +300	-1(a) and +21
E (d)	0.7 and 21	100 and 3000	7 and 210	-0.1(a) and 21	-14.7(a) and +3000	-1(a) and +210
F (b)	1.38 and 35	200 and 5000	13.8 and 350	-0.1 and +35	-14.7 and +5000	-1 and +350

(a) For absolute pressure transmitters (IAP20), the lower range limit is 0.
(b) Span Codes A and F applicable to IGP20 Transmitter only. Also, Span Code A is not available when pressure seals are specified.
(c) For IAP20, the minimum span for factory calibration is 1.2 kPa (5 inH_2O, 12.4 mbar). Can be field reranged within limits shown in table.
(d) When certain options are specified, the upper span and range limit values are reduced as shown in the "Options Impact" table.

Maximum Overrange and Proof Pressure Ratings for IAP 20 and IGP20 Transmitters (a)

Transmitter Configuration (See Model Code for Description of Options)	Overrange Pressure Rating			Proof Pressure Rating (b)		
	MPa	psi	bar or kg/cm^2	MPa	psi	bar or kg/cm^2
Standard with IGP20 Span Code F only	51.8	7500	518	100	14500	1000
Standard (c) or with Option -B2, -D3, or -D7	25	3625	250	100	14500	1000
With Option -B3	20	2900	200	70	11150	700
With Option -D1	16	2320	160	64	9280	640
With Option -B1 or -D5	15	2175	150	60	8700	600
With Option -D2, -D4, -D6, or -D8	10	1500	100	40	6000	400
With Structure Codes 78 and 79 (pvdf insert)	2.1	300	21	8.4	1200	84

(a) Refer to Model Code section for application and restrictions related to the items listed in the table.
(b) Proof pressure ratings meet ANSI/ISA Standard S82.03-1988. Unit may become nonfunctional after application of proof pressure.
(c) Standard with IAP20/IGP20 Span Codes A to E.

FUNCTIONAL SPECIFICATIONS (Cont.)

Impact of Certain Options on IAP20/IGP20 Span and Range Limits (a)

Option	Description (Also see Model Code)	Span and Range Limits Derated to:
-B3	B7-M Bolts and Nuts (NACE)	20 MPa (2900 psi, 200 bar, or kg/cm^2)
-D1	DIN Construction	16 MPa (2320 psi, 160 bar or kg/cm^2)
-D5 or -B1	DIN Construction or 316 ss Bolting	15 MPa (2175 psi, 150 bar or kg/cm^2)
-D2, -D4, -D6, or -D8 (a)	DIN Construction (a)	10 MPa (1500 psi, 100 bar or kg/cm^2) (a)

(a) Refer to Model Code section for application and restrictions related to the items listed in the table.

Output Signal
4 to 20 mA, Linear

Field Wiring Reversal
No transmitter damage

Supply Voltage Requirements and External Loop Load Limitations (Figure 4)
Minimum supply voltage is 11.5 V dc. This can be reduced to 11 V dc using a plug-in jumper in the field wiring compartment terminal block as shown in the "Physical Specifications" section.

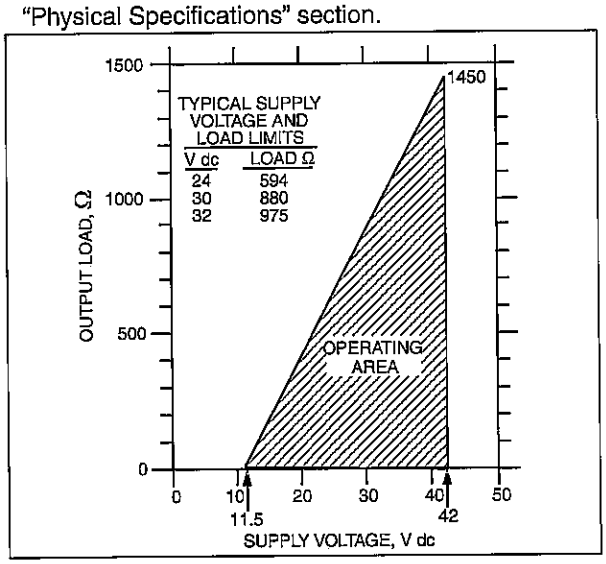


Figure 4. Supply Voltage vs. Output Load

Suppressed Zero and Elevated Zero
Suppressed or elevated zero ranges are acceptable as long as the Span and Range Limits are not exceeded (elevated zero applicable to IGP20 only).

Zeroing for Nonzero-Based Ranges
Dual Function Zeroing is provided to allow zeroing with the transmitter open to atmosphere, even when there is a nonzero-based range. This greatly simplifies position effect zeroing on many pressure and level applications. It applies to the standard LCD Indicator, and External Zero Adjustment option.

Zero and Span Adjustments (See Figure 7)
Zero and span adjustments can be accomplished using the pushbuttons on the LCD indicator.

Optional External Zero Adjustment (See Figure 7)
An external zero pushbutton mechanism is isolated from the electronics compartment and magnetically activates an internal reed switch through the housing. This eliminates a potential leak path for moisture or contaminants to get into the electronics compartment. The external zero adjustment can be disabled by a configuration selection.

Write Protect Jumper
Can be positioned to lock out all configurators from making database changes. This makes transmitter suitable for Safety Shutdown System Applications that require this feature.

Adjustable Damping
Transmitter response time is normally 0.75 s, or the electronically adjustable setting of 0 (none), 2, 4, or 8 seconds, whichever is greater, for a 90% recovery from an 80% input step per ANSI/ISA S51.1. (For 63.2% recovery, 0.5 s with sensors B to F, and 0.6 s with sensor A.)

FUNCTIONAL SPECIFICATIONS (Cont.)

Minimum Allowable Absolute Pressure vs. Transmitter Temperature

WITH SILICONE FILL FLUID
Full vacuum: up to 121°C (250°F)
WITH FLUORINERT FILL FLUID (FIGURE 5.)

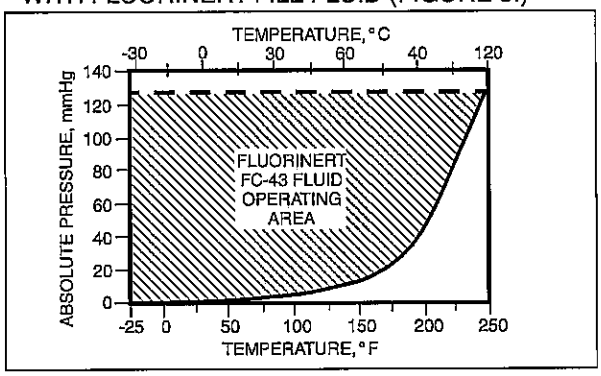


Figure 5. Minimum Allowable Absolute Pressure vs. Transmitter Temperature, Fluorinert FC-43, 2.6 cSt at 25°C (77°F)

European Union Directives

- Complies with Electromagnetic Compatibility Requirements of European EMC Directive 89/336/EEC by conforming to the following CENELEC and IEC Standards: EN 50081-2, EN 50082-2, and IEC 801-2 through 801-6.
- Complies with NAMUR Part 1 Interference Immunity Requirement (EMC).
- Complies with NAMUR 105 overrange and underrange annunciations.
- Conforms to Applicable European Union Directives ("CE" Logo marked on product).

Configuration and Calibration Data, and Electronics Upgradeability

All factory characterization data and user configuration and calibration data are stored in the sensor (Figure 6). This means that the electronics module may be replaced, with one of like type, without the need for reconfiguration or recalibration.

Although module replacement can affect accuracy by a maximum of 0.20% of span, this error can be removed by an mA trim without application of pressure.

Changing module types (e.g., from one protocol to another protocol) may require reconfiguration and recalibration, as well as a different terminal block, but all factory characterization data is retained.

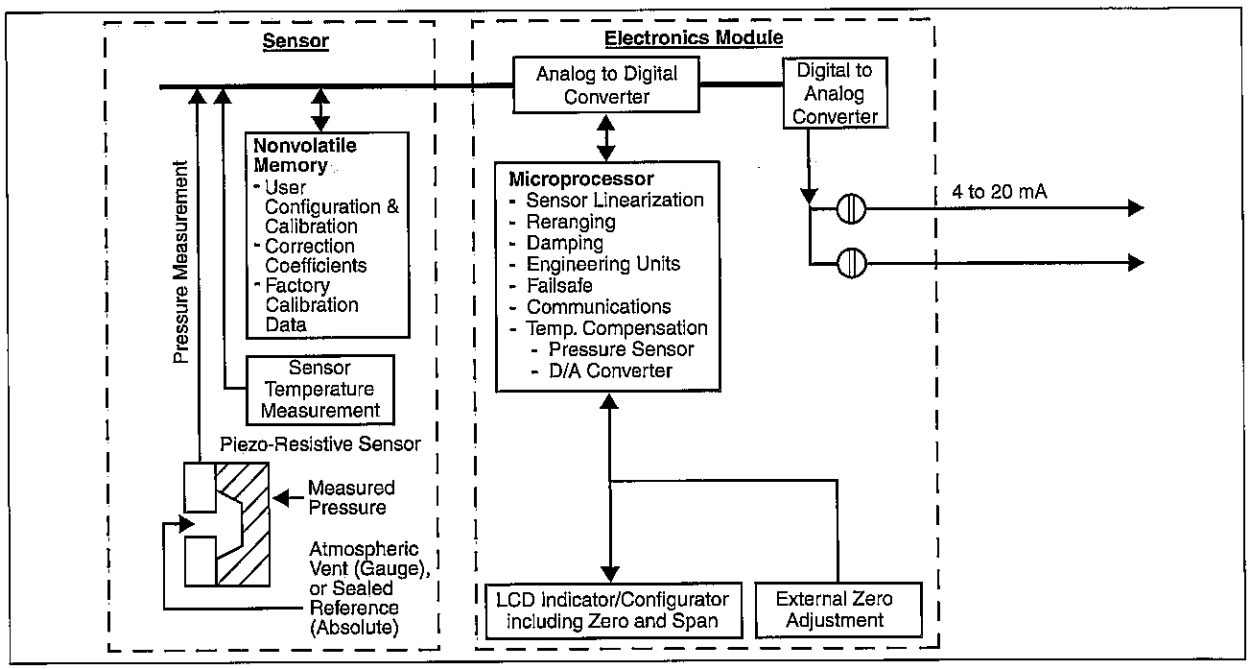


Figure 6. Transmitter Functional Block Diagram

FUNCTIONAL SPECIFICATIONS (Cont.)

Standard LCD Indicator with On-Board Pushbuttons (Figure 7) Provides:

- Two lines; four numeric characters on top line, and seven alphanumeric characters on bottom line.
- Measurement Readout; value on top line and units label on bottom line.
- Configuration and Calibration Prompts.

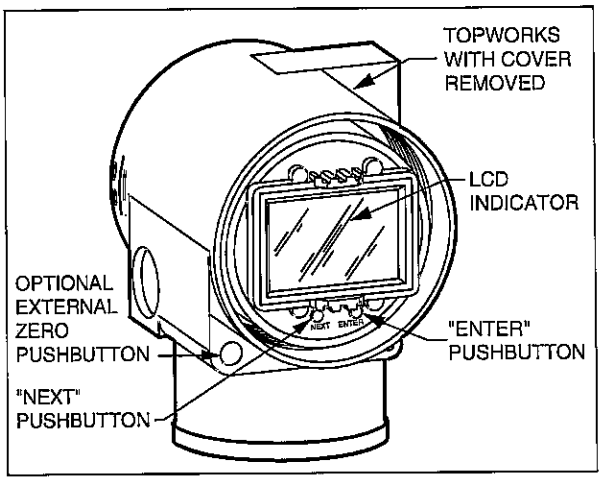


Figure 7. Standard LCD Indicator with Pushbuttons

Optional Custom Configuration (Option -C2)

For the transmitter to be custom configured by the factory, the user must fill out a data form. If this option is not selected, a standard default configuration will be provided. See Tables 3 and 4.

Table 3. Example of Option -C2

Parameter	Standard (Default) Configuration	Example of Custom Configuration Option -C2
Calibrated Range • Pressure EGU • LRV • URV	 per S.O.(a) per S.O. per S.O.	 KG/CM2 (a) 0 1
Output Direction	Forward	Forward
Damping	None	2
Failsafe Action	Upscale	Downscale
Ext. Zero Option	Enabled	Disabled
Other • Label (2nd line) • Display LRV • Display URV	 (b) (c) (c)	 KG/CM2 (b) 0 (c) 1 (c)

(a) Select from list in Table 4 below.
(b) Same as pressure units used for calibrated range, or percent.
(c) Same as calibrated range or 0 and 100 for percent.

Table 4.
Available Pressure Units in Calibrated Range (a)

inH_2O	inHg	kPa	mbar	kg/cm^2
ftH_2O	mmHg	MPa	bar	psi
mmH_2O	Pa	torr	g/cm^2	atm

(a) Absolute or gauge pressure units, as applicable.

NOTE

There is a maximum of 4 digits for entering range values.

OPERATING, STORAGE, AND TRANSPORTATION CONDITIONS

Influence	Reference Operating Conditions	Normal Operating Conditions (a)	Operative Limits (a)	Storage and Transportation Limits
Process Connection Temp. • with Silicone Fill Fluid • with Fluorinert Fill Fluid	• 24 ±2°C (75 ±3°F) • 24 ±2°C (75 ±3°F)	• -29 to + 82°C (-20 to +180°F) • -29 to + 82°C (-20 to +180°F)	• -46 and +121°C (b) (-50 and +250°F) (b) • -29 and +121°C (-20 and +250°F)	• Not Applicable • Not Applicable
Electronics Temperature • with LCD Indicator (Note c)	• 24 ±2°C (75 ±3°F) • 24 ±2°C (75 ±3°F)	• -29 to + 82°C (g) (-20 to +180°F) (g) -20 to + 82°C (g) (-4 to +180°F) (g)	• -40 and +85°C (g) (-40 and +185°F) (g) • -29 and +85°C (g) (-20 and +185°F) (g)	• -54 and +85°C (-65 and +185°F) • -54 and +85°C (-65 and +185°F)
Relative Humidity (Note d)	50 ±10%	0 to 100%	0 and 100%	0 and 100% Noncondensing
Supply Voltage - mA Output	30 ±0.5 V dc	11.5 to 42 V dc (e)	11.5 and 42 V dc (e)	Not Applicable
Output Load - mA Output	650 Ω	0 to 1450 Ω	0 and 1450 Ω	Not Applicable
Vibration	1 m/s^2 (0.1 "g")	6.3 mm (0.25 in) Double Amplitude: from 5 to 15 Hz with Aluminum Housing and from 5 to 9 Hz with 316 ss Housing --- 0 to 30 m/s^2 (0 to 3 "g") from 15 to 500 Hz with Aluminum Housing; and 0 to 10 m/s^2 (0 to 1 "g") from 9 to 500 Hz with 316 ss Housing		11 m/s^2 (1.1 "g") from 2.5 to 5 Hz (in Shipping Package)
Mounting Position	Upright (f)	Upright (f)	No Limit	Not Applicable

(a) Temperature limits are derated as follows:
IAP20 and IGP20 Transmitters:
to -7 and +82°C (20 and 180°F) when Structure Codes 78/79 (pvdf inserts) are used, and
to 0 and 60°C (32 and 140°F) when DIN Construction Options D2/D4/D6/D8 are used.

(b) Selection of Option -J extends the low temperature limit of transmitters with silicone filled sensors down to -50°C (-58°F).

(c) Although the LCD will not be damaged at any temperature within the "Storage and Transportation Limits", updates will be slowed and readability decreased at temperatures outside the "Normal Operating Conditions".

(d) With topworks covers on and conduit entrances sealed.

(e) 11.5 V dc can be reduced to 11 V dc by using a plug-in shorting bar; see "Physical Specifications" sections.

(f) Sensor process wetted diaphragms in a vertical plane for IAP20 and IGP20 Transmitter.

(g) Refer to the Electrical Safety Specifications section for a restriction in ambient temperature with certain electrical certifications.

PERFORMANCE SPECIFICATIONS

Zero-Based Calibrations; Cobalt-Nickel-Chromium or Stainless Steel Sensor with Silicone Fluid;
Under Reference Operating Conditions unless otherwise specified;
URL = Upper Range Limit, and Span = Calibrated Span

Accuracy (includes Linearity, Hysteresis, and Repeatability)
±0.20% of Span

Small Span Accuracy for Spans <5% and <6.7% of URL
See Table 5 below.

Table 5. Accuracy with Small Spans

For Span Code (a)	If Span is:	Then Small Span Accuracy in % of Span is:
B	<5% of URL	$\pm\left[(0.10)+(0.005)\left(\frac{\text{URL}}{\text{Span}}\right)\right]$
A, C, D, E, and F	<6.7% of URL	$\pm\left[(0.10)+(0.0067)\left(\frac{\text{URL}}{\text{Span}}\right)\right]$

(a) See Model Code for Span Codes applicable to each transmitter.

Stability
Long term drift is less than ±0.05% of URL per year over a 5-year period.

Calibration Frequency
The calibration frequency is five years. The five years is derived using the values of allowable error (% span), TPE (% span), performance margin (% span), and stability (% span/month); where:

$$\text{Calibration Frequency} = \frac{\text{Performance Margin}}{\text{Stability}} = \text{Months}$$

Power-Up Time
Less than 5 seconds for output to reach first valid measurement.

Supply Voltage Effect
The output changes less than 0.005% of span for each 1 V change within the specified supply voltage requirements. See Figure 4.

Position Effect
The transmitter may be mounted in any position. Any zero effect caused by the mounting position can be eliminated by rezeroing. There is no span effect.

RFI Effect
The output error is less than 0.1% of span for radio frequencies in the range of 27 to 1000 MHz and field intensity of 30 V/m when the transmitter is properly installed with shielded conduit and grounding, and housing covers are in place. (Per IEC Std. 801-3.)

Vibration Effect
Total effect: ±0.2% of URL per "g" for vibrations in the frequency range of 5 to 500 Hz; with double amplitudes of 6.35 mm (0.25 in) in the range of 5 to 15 Hz, or accelerations of 3 "g" in the range of 15 to 500 Hz, whichever is smaller, for transmitters with aluminum housings; and with double amplitudes of 6.35 mm (0.25 in) in the range of 5 to 9 Hz, or accelerations of 1 "g" in the range of 9 to 500 Hz, whichever is smaller, for transmitters with 316 ss housings.

Switching and Indirect Lightning Transients
The transmitter can withstand a transient surge up to 2000 V common mode or 1000 V normal mode without permanent damage. The output shift is less than 1.0%. (Per ANSI/IEEE C62.41-1980 and IEC Std. 801-5.)

Ambient Temperature Effect
Total effect for a 28°C (50°F) change within Normal Operating Condition limits is:

FOR THE IAP10 AND IGP10 TRANSMITTERS

Span Code (a)	Ambient Temperature Effect
C, D, E, and F	±(0.08% URL + 0.1% Span)

(a) Span Limit Code F applicable to IGP10 Transmitter only.

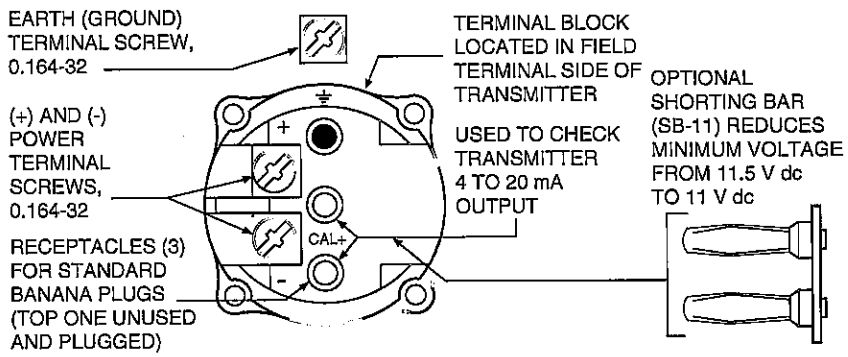
FOR THE IAP20 AND IGP20 TRANSMITTERS

Span Code	Ambient Temperature Effect
A (a)	±(0.18% URL + 0.15% Span)
B and C	±(0.03% URL + 0.20% Span)
D	±(0.05% URL + 0.18% Span)
E and F (a)	±(0.08% URL + 0.15% Span)

(a) Span Limit Codes A and F applicable to IGP20 Transmitter only.

NOTE
For additional ambient temperature effect when pressure seals are used, see PSS 2A-1Z11 A.

PHYSICAL SPECIFICATIONS

Description	Direct Connected Absolute and Gauge Pressure Transmitters IAP10 and IGP10	Bracket-Mounted Absolute and Gauge Pressure Transmitters IAP20 and IGP20
Process Wetted Parts Mat'ls. (High Pressure Side) • Process Connection • Gaskets • Sensor Diaphragm	 • 316L ss or Hastelloy C • Not Applicable • 316L ss, Co-Ni-Cr, or Hastelloy C	 • Carbon Steel, 316 ss, Hastelloy C, Monel, or pvdf (Kynar) • Glass-filled ptfe (Chemloy), Viton • Co-Ni-Cr, 316L ss, Gold-plated 316L ss, Monel, Hastelloy C, or Tantalum
Reference Side Materials (Atmospheric Pressure Side)	IGP10 Transmitter: • Silicon, Pyrex, RTV, and 316 ss IAP10 Transmitter: • N/A	Sensor Diaphragm: • Same as specified for High Pressure side process wetted material. Cover: • 316 ss
Sensor Fill Fluid	Silicone or Fluorinert	Silicone or Fluorinert
Bolts and Nuts for Process Cover and Connector	N/A	Standard Bolting: • ASTM A193, Grade B7 Bolts • ASTM A194, Grade 2H Nuts Optional Bolting: • 316 ss, Type 17-4 ss, or B7M (NACE)
Electrical Housing and Housing Covers	Two compartments to separate electronics from field connections. Material is low copper (1% maximum) die-cast aluminum alloy with epoxy finish; or 316 ss.	
Environmental Protection	Dusttight and weatherproof per IEC IP66 and NEMA 4X.	
Electronics Module	Printed wiring assemblies are conformally coated for moisture and dust protection.	
Electrical Connections	1/2 NPT, PG 13.5, or M20 entrances on both sides of electronics housing, as specified. Unused entrance must be plugged to ensure moisture and RFI protection (aluminum or 316 ss plug supplied by Invensys Foxboro).	
Mounting Position	The transmitter may be mounted in any orientation.	
Approximate Mass (a)	Standard Transmitter 1.5 kg (3.3 lb) With 316 ss Housing Add 1.1 kg (2.4 lb)	With Process Connectors 4.2 kg (9.2 lb) Without Process Connectors 3.5 kg (7.8 lb) With 316 ss Housing Add 1.1. kg (2.4 lb)
Field Terminal Connections		

(a) LCD Indicator is standard with these transmitters. For approximate mass with pressure seals, see PSS 2A-1Z11 A.

ELECTRICAL SAFETY SPECIFICATIONS

IAP10 and IGP10 Transmitters

Testing Laboratory, Types of Protection, and Area Classification	Application Conditions	Electrical Safety Design Code
ATEX flameproof; II 2 GD EEx d IIC, Zone 1.	Temperature Class T6, T85°C, Ta = -40°C to +75°C.	D
CSA explosionproof for Class I, Division 1, Groups B, C, and D; and dust-ignitionproof for Class II, Division 1, Groups E, F, and G; and Class III, Division 1.	Maximum Ambient Temperature 85°C.	C
CSA Class I, Division 2, Groups A, B, C, and D; Class II, Division 2, Groups F and G; and Class III, Division 2.	Temperature Class T6 at 40°C and T4A at 85°C maximum ambient.	
CSA field device zone certified flameproof Ex d IIC. Also, all certifications of Code C above.	Maximum Ambient Temperature 85°C.	B
FM explosionproof for Class I, Division 1, Groups B, C, and D; and dust-ignitionproof for Class II, Division 1, Groups E, F, and G; and Class III, Division 1.	Temperature Class T6 at 80°C and T5 at 85°C maximum ambient.	F
FM nonincendive for Class I, Division 2, Groups A, B, C, and D; Class II, Division 2, Groups F and G, and Class III, Division 2.	Temperature Class T4A at 40°C and T4 at 85°C maximum ambient.	
FM field device zone certified flameproof AEx d IIC. Also, all certifications of Code F above.	Temperature Class T6 at 75°C maximum ambient.	G
IECEx flameproof, Ex d IIC, Zone 1.	Temperature Class T6, Ta = -40°C to +75°C.	V

NOTES

1. Transmitter has been designed to meet the electrical safety descriptions listed. Contact Invensys Foxboro for information or status of testing laboratory approvals or certifications.
2. See Model Codes section for availability of Electrical Safety Design Codes with particular Transmitter Models and Structures.
3. Refer to applicable Instruction Manual for application conditions and connectivity requirements.

ELECTRICAL SAFETY SPECIFICATIONS (Cont.)

IAP20 and IGP20 Transmitters

Testing Laboratory, Types of Protection, and Area Classification	Application Conditions	Electrical Safety Design Code
ATEX flameproof; II 2 GD EEx d IIC, Zone 1.	Temperature Class T6, T85°C, Ta = -40°C to +75°C.	D
CSA explosionproof for Class I, Division 1, Groups B, C, and D; and dust-ignitionproof for Class II, Division 1, Groups E, F, and G; and Class III, Division 1.	Maximum Ambient Temperature 85°C.	C
CSA Class I, Division 2, Groups A, B, C, and D; Class II, Division 2, Groups F and G; and Class III, Division 2.	Temperature Class T6 at 40°C and T4A at 85°C maximum ambient.	
CSA field device zone certified flameproof Ex d IIC. Also, all certifications of Code C above.	Maximum Ambient Temperature 85°C.	B
FM explosionproof for Class I, Division 1, Groups B, C, and D; and dust-ignitionproof for Class II, Division 1, Groups E, F, and G; and Class III, Division 1.	Temperature Class T6 at 80°C and T5 at 85°C maximum ambient.	F
FM nonincendive for Class I, Division 2, Groups A, B, C, and D; Class II, Division 2, Groups F and G; and Class III, Division 2.	Temperature Class T4A at 40°C and T4 at 85°C maximum ambient.	
FM field device zone certified flameproof AEx d IIC. Also, all certifications of Code F above.	Temperature Class T6 at 75°C maximum ambient.	G
IECEx flameproof, Ex d IIC, Zone 1.	Temperature Class T6, Ta = -40°C to +75°C	V

NOTE

1. Transmitter has been designed to meet the electrical safety descriptions listed. Contact Invensys Foxboro for information or status of testing laboratory approvals or certifications.
2. See Model Codes section for availability of Electrical Safety Design Codes with particular Transmitter Models and Structures.
3. Refer to applicable Instruction Manual for application conditions and connectivity requirements.

MODEL CODES

IAP10 and IGP10 Transmitters

Description	Model
I/A Series, Electronic, Direct Connected Absolute Pressure Transmitter	IAP10 (a)
I/A Series, Electronic, Direct Connected Gauge Pressure Transmitter	IGP10 (a)
Electronics Versions and Output Signal	
Analog; 4 to 20 mA dc Output (Version -A)	-A
Structure Code - Select from one of the following six groups:	
1. Transmitter Only (no seals)	
Process Connection: 316L ss; Sensor: Co-Ni-Cr; Fill Fluid: Silicone; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	20
Process Connection: 316L ss; Sensor: Co-Ni-Cr; Fill Fluid: Fluorinert; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	21
Process Connection: 316L ss; Sensor: 316L ss; Fill Fluid: Silicone; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	22
Process Connection: 316L ss; Sensor: 316L ss; Fill Fluid: Fluorinert; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	23
Process Connection: 316L ss; Sensor: Hastelloy C; Fill Fluid: Silicone; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	30
Process Connection: 316L ss; Sensor: Hastelloy C; Fill Fluid: Fluorinert; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	31
2. Transmitter Prepared for Foxboro Model Coded Seals (b)	
Transmitter Prepared for Foxboro Direct Connect Seal; Silicone Fill in Sensor (c)	D1
Transmitter Prepared for Foxboro Direct Connect Seal; Fluorinert Fill in Sensor (IGP10 only) (c)	D2
Transmitter Prepared for Foxboro Remote Mount Seal; Silicone Fill in Sensor (d)	S3
Transmitter Prepared for Foxboro Remote Mount Seal; Fluorinert Fill in Sensor (IGP10 only) (d)	S4
3. Transmitters Prepared for non-Foxboro Seals	
Transmitter Prepared for Remote Seal; Silicone Fill in Sensor (e)	SC
Transmitter Prepared for Remote Seal; Fluorinert Fill in Sensor (f)	SD
4. Flameproof Transmitter Only (no seals)	
Process Connection: 316L ss; Sensor: 316L ss; Fill Fluid: Silicone; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	52
Process Connection: 316L ss; Sensor: 316L ss; Fill Fluid: Fluorinert; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	53
Process Connection: 316L ss; Sensor: Hastelloy C; Fill Fluid: Silicone; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	60
Process Connection: 316L ss; Sensor: Hastelloy C; Fill Fluid: Fluorinert; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	61
Process Connection: Hastelloy C; Sensor: Hastelloy C; Fill Fluid: Silicone; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	62
Process Connection: Hastelloy C; Sensor: Hastelloy C; Fill Fluid: Fluorinert; Connection Type: 1/2 NPT External Thread, 1/4 NPT Internal Thread	63
5. Flameproof Transmitter Prepared for Foxboro Model Coded Seals (b)	
Flameproof Transmitter Prepared for Direct Connect Seal; Silicone Fill in Sensor (c)	D5
Flameproof Transmitter Prepared for Direct Connect Seal; Fluorinert Fill in Sensor (IGP10 only) (c)	D6
Flameproof Transmitter Prepared for Remote Mount Seal; Silicone Fill in Sensor (d)	S5
Flameproof Transmitter Prepared for Remote Mount Seal; Fluorinert Fill in Sensor (IGP10 only) (d)	S6
6. Flameproof Transmitter Prepared for non-Foxboro Seals	
Flameproof Transmitter Prepared for Remote Seal; Silicone Fill in Sensor (e)	SH
Flameproof Transmitter Prepared for Remote Seal; Fluorinert Fill in Sensor (f)	SJ
Span Limits - Absolute or Gauge Pressure Units, as Applicable	
MPa: 0.007 and 0.21; **psi**: 1 and 30; **bar or kg/cm²**: 0.07 and 2.1	C
MPa: 0.07 and 2.1; **psi**: 10 and 300; **bar or kg/cm²**: 0.7 and 21	D
MPa: 0.7 and 21; **psi**: 100 and 3000; **bar or kg/cm²**: 7 and 210	E
MPa: 14 and 42; **psi**: 2000 and 6000; **bar or kg/cm²**: 140 and 420 (IGP10 only)	F

Model Code continued on next page

MODEL CODES (Cont.)

IAP10 and IGP10 Transmitters (Cont.)

Description	
Conduit Connection and Housing Material	
1/2 NPT Conduit Connection, Aluminum Housing	1
PG 13.5 Conduit Connection, Aluminum Housing (With Electrical Safety Code D only)	2
1/2 NPT Conduit Connection, 316 ss Housing	3
PG 13.5 Conduit Connection, 316 ss Housing (With Electrical Safety Code D only)	4
M20 Conduit Connection, Both Sides, Aluminum Housing (With Electrical Safety Code D only)	5
M20 Conduit Connection, Both Sides, 316 ss Housing (With Electrical Safety Code D only)	6
Electrical Safety (See Electrical Safety Specifications Section for Description and Approval Status)	
ATEX II 2 GD, EEx d IIC, Zone 1 (g)(j)	D
CSA Certifications: Division 1 explosionproof and dust-ignitionproof (h) Division 2, Classes I, II, and III	C
CSA zone certified flameproof, Ex d IIC. Also all certifications of Code C above. (g)(j)	B
FM Approvals: Division 1 explosionproof and dust-ignitionproof (h) Division 2 nonincendive, Classes I, II, and III	F
FM zone approved flameproof, AEx d IIC. Also all certifications of Code F above. (g)(j)	G
IECEx flameproof, Ex d IIC, Zone 1 (g)(j)	V
Optional Selections See descriptions below.	
Mounting Bracket Set (k)	
Painted Steel Bracket with Plated Steel Bolts, 1/2 NPT (with Conduit Connection Codes 1 and 3 only)	-M1
Stainless Steel Bracket with Stainless Steel Bolts, 1/2 NPT (with Conduit Connection Codes 1 and 3 only)	-M2
Painted Steel Bracket with Plated Steel Bolts, PG 13.5 (with Conduit Connection Codes 2 and 4 only)	-M3
Stainless Steel Bracket with Stainless Steel Bolts, PG 13.5 (with Conduit Connection Codes 2 and 4 only)	-M4
Painted Steel Bracket with Plated Steel Bolts, M20 (with Conduit Connection Codes 5 and 6 only)	-M5
Stainless Steel Bracket with Stainless Steel Bolts, M20 (with Conduit Connection Codes 5 and 6 only)	-M6
Stainless Steel Bracket with Stainless Steel Bolts (with Structure Codes 52, 53, 60-63, S5, S6, SH & SJ only)	-M7
Blind (Solid) Cover over Standard LCD Indicator	
Blind (Solid) Cover replaces Window Cover	-L2
Vent Screw and Block & Bleed Valve	
316 ss Vent Screw in Process Connection (Not with Structure Codes 32 or 33, or Pressure Seals)	-V1
Block and Bleed Valve, Carbon Steel (Not with Pressure Seals)	-V2
Block and Bleed Valve, 316 ss (Not with Pressure Seals)	-V3
Block and Bleed Valve, 316 ss w/Monel Trim (Not with Pressure Seals)	-V4
Conduit Thread Adapters	
Hawke-Type 1/2 NPT Cable Gland for use with Conduit Connection Codes 1 and 3 only (l)	-A1
M20 Connector for use with Conduit Connection Codes 1 and 3 only (l)	-A3
Electronics Housing Features	
External Zero Adjustment	-Z1
Custody Transfer Lock and Seal	-Z2
External Zero Adjustment and Custody Transfer Lock and Seal	-Z3
Custom Factory Configuration	
Full Factory Configuration (Requires Configuration Form to be filled out)	-C2
Cleaning and Preparation	
Unit Degreased - for Silicone Filled Sensors Only Not for Oxygen/Chlorine Service, Option -V1, or Pressure Seals	-X1
Cleaned and Prepared for Oxygen Service - for Fluorinert Filled Sensors Only Not with Option -V1, or Pressure Seals	-X2
Cleaned and Prepared for Chlorine Service - with Structure Code 33 Only Not with Option -V1, or Pressure Seals	-X3

Model Code continued on next page

MODEL CODES (Cont.)

IAP10 and IGP10 Transmitters (Cont.)

Description	
Instruction Books (Common MI, Brochure, and Full Documentation Set on CD-ROM is Standard)	
Without Instruction Book and CD - Only "Getting Started" Brochure is supplied	-K1
Miscellaneous Optional Selections	
G 1/2 B Manometer Process Connection (Not Available with Option -V1 or Pressure Seals)	-G
Low Temperature Operative Limit of Electronics Housing Extended Down to -50°C (-58°F) (m)	-J
R 1/2 Process Connection (1/2 NPT to R 1/2 Adapter) (n)	-R
Supplemental Customer Tag (Stainless Steel Tag wired onto Transmitter)	-T

(a) Refer to PSS 2A-1C13 F for very high GP versions with upper range limits of 52, 105, and 210 MPa (7500, 15000, and 30000 psi). Refer to PSS 2A-1C13 K and PSS 2A-1C13 L for AP and GP versions for sanitary and pulp/paper industries, respectively.

(b) Both transmitter and pressure seal Model Numbers are required. Refer to PSS 2A-1Z11 A for pressure seal Model Codes.

(c) Direct Connect Seal Models that may be specified are PSTAD, PSFAD, and PSISD.

(d) Remote Mount Seal Models that may be specified are PSFPS, PSFES, PSFAR, PSTAR, PSISR, PSSCR, and PSSSR.

(e) For transmitters with Silicone fill prepared for remote seal by others, specify Structure Code 22 or 52.

(f) For transmitters with Fluorinert fill prepared for remote seal by others, specify Structure Code 23 or 53.

(g) Electrical Safety Codes D, B, G and V are only available with flameproof Structure Codes 52, 53, D5, D6, S5, S6, SH, and SJ.

(h) Electrical Safety Codes C and F are not available with flameproof Structure Codes 52, 53, D5, D6, S5, S6, SH, and SJ.

(j) A cover lock is standard construction with Electrical Safety Codes D, B, G and V.

(k) Mounting sets not offered with direct mounted seals. However, if a direct mounted PSTAD threaded seal with a 1/4 NPT process connection is used, then a mounting set is recommended.

(l) Available with Electrical Safety CodeD only.

(m) Not available with Fluorinert fill in sensor or seal.

(n) Not available with pressure seals, or Hastelloy C sensors.

MODEL CODES (Cont.)

IAP20 and IGP20 Transmitters

Description			Model
I/A Series, Electronic, Bracket-Mounted Absolute Pressure Transmitter			IAP20
I/A Series, Electronic, Bracket-Mounted Gauge Pressure Transmitter			IGP20
Electronics Versions and Output Signal			
Analog; 4 to 20 mA dc Output (Version -A)			-A
Structure Code - Select from one of the following three groups:			
1. Transmitter			
Hi-Side Cover	**Sensor**	**Sensor Fill Fluid**	
Steel	Co-Ni-Cr	Silicone	10
Steel	Co-Ni-Cr	Fluorinert	11
Steel	316L ss	Silicone	12
Steel	316L ss	Fluorinert	13
Steel	Hastelloy C	Silicone	16
Steel	Hastelloy C	Fluorinert	17
316 ss	Co-Ni-Cr	Silicone	20
316 ss	Co-Ni-Cr	Fluorinert	21
316 ss	316L ss	Silicone	22
316 ss	316L ss	Fluorinert	23
316 ss	316L ss, Gold Plated	Silicone	2G
316 ss	Monel	Silicone	24
316 ss	Monel	Fluorinert	25
316 ss	Hastelloy C	Silicone	26
316 ss	Hastelloy C	Fluorinert	27
Monel	Monel	Silicone	34
Monel	Monel	Fluorinert	35
Hastelloy C	Hastelloy C	Silicone	46
Hastelloy C	Hastelloy C	Fluorinert	47
Hastelloy C	Tantalum	Silicone	48
Hastelloy C	Tantalum	Fluorinert	49
pvdf Insert (Kynar)	Tantalum	Silicone (Used with Process Connector Type 7 below)	78 (a)
pvdf Insert (Kynar)	Tantalum	Fluorinert (Used with Process Connector Type 7 below)	79 (a)
2. Transmitter Prepared for Foxboro Model Coded Seals (b)			
Transmitter Prepared for Remote Seal on HI Side; Silicone fill in sensor			S3 (c)
Transmitter Prepared for Remote Seal on HI Side; Fluorinert fill in sensor (IGP20 only)			S4 (c)
Transmitter Prepared for PSFLT, PSSCT, or PSSST Seal, HI Side; Silicone fill in sensor (IGP20 only)			F1
Transmitter Prepared for PSFLT, PSSCT, or PSSST Seal, HI Side; Fluorinert fill in sensor (IGP20 only)			F2
3. Transmitter Prepared for non-Foxboro Seals			
Transmitter Prepared for Remote Seal; Silicone Fill in Sensor			SC
Transmitter Prepared for Remote Seal; Fluorinert Fill in Sensor			SD
Span Limits (Absolute or Gauge Pressure Units)			
kPa	**inH$_2$O**	**mbar**	
0.12 and 7.5	0.5 and 30	1.2 and 75 (IGP20 only)	A (d)
0.87 and 50	3.5 and 200	8.7 and 500	B
MPa	**psi**	**bar or kg/cm^2**	
0.007 and 0.21	1 and 30	0.07 and 2.1	C
0.07 and 2.1	10 and 300	0.7 and 21	D
0.7 and 21	100 and 3000	7 and 210	E (e)
1.38 and 35	200 and 5000	13.8 and 350 (IGP20 only)	F (e)

Model Code continued on next page

MODEL CODES (Cont.)

IAP20 and IGP20 Transmitters (Cont.)

Process Connector Type (Material Same as Process Cover Material)	
None; connect directly to process cover (not available with Structure Codes 78 and 79)	0
1/4 NPT (not available with Structure Codes 46, 47, 48, 49, 78, 79)	1
1/2 NPT (not available with Structure Codes 78, 79)	2
Rc 1/4 (not available with Structure Codes 46, 47, 48, 49, 78, 79)	3
Rc 1/2 (not available with Structure Codes 78, 79)	4
1/2 Schedule 80 Welding Neck (not available with Structure Codes 46, 47, 48, 49, 78, 79)	6
None; pvdf (Kynar) insert tapped for 1/2 NPT on side of 316 ss Process Cover (only with Codes 78/79)	7
Conduit Connection and Housing Material	
1/2 NPT Conduit Connection, Aluminum Housing	1
PG 13.5 Conduit Connection, Aluminum Housing (With Electrical Safety Code D only)	2
1/2 NPT Conduit Connection, 316 ss Housing	3
PG 13.5 Conduit Connection, 316 ss Housing (With Electrical Safety Code D only)	4
M20 Conduit Connection, Both Sides, Aluminum Housing	5
M20 Conduit Connection, Both Sides, 316 ss Housing	6
Electrical Safety (Also see Electrical Safety Specifications section for descriptions and approval status)	
ATEX II 2 GD, EEx d IIC, Zone 1 (h)	D
CSA Certifications: Division 1 explosionproof and dust-ignitionproof Division 2, Classes I, II, and III	C
CSA zone certified flameproof, Ex d IIC. Also all certifications of Code C above. (h)	B
FM Approvals: Division 1 explosionproof and dust-ignitionproof (h) Division 2 nonincendive, Classes I, II, and III	F
FM zone approved flameproof, AEx d IIC. Also all approvals of Code F above. (h)	G
IECEx flameproof, Ex d IIC, Zone 1 (h)	V
Optional Selections Refer to Optional Selection descriptions below.	
Mounting Bracket Set - Not available with Direct Connect Seals, Structure Codes F1 and F2	
Standard Style Painted Steel Bracket with Plated Steel Bolts	-M1
Standard Style Stainless Steel Bracket with Stainless Steel Bolts	-M2
Universal Style Stainless Steel Bracket with Stainless Steel Bolts	-M3
Blind (Solid) Cover over Standard LCD Indicator	
Blind (Solid) Cover replaces Window Cover	-L2

DIN 19213 Construction used with Process Connector Code "0" and 316 ss Process Covers Only (h)

Process Cover Type	Cover Screw Material	Connector Screw Size	Connector Screw Material	
Single Ended (f)	Steel	M10 (by User)	N/A	-D1
Double Ended (f)(g) (Blind Kidney Flange on back)	Steel	M10	Steel	-D2
Single Ended	Steel	7/16 (by User)	N/A	-D3
Double Ended (f)(g) (Blind Kidney Flange on back)	Steel	7/16	Steel	-D4
Single Ended (f)	316 ss	7/16 (by User)	N/A	-D5
Double Ended (f)(g) (Blind Kidney Flange on back)	316 ss	7/16	316 ss	-D6
Single Ended	17-4 ss	7/16 (by User)	N/A	-D7
Double Ended (f)(g) (Blind Kidney Flange on back)	17-4 ss	7/16	17-4 ss	-D8

Model Code continued on next page

MODEL CODES (Cont.)

IAP20 and IGP20 Transmitters (Cont.)

Optional Selections (Cont.)	
Cleaning and Preparation - Not Available w/Gold-Plated Sensor, Structure 2G (h)	
Unit Degreased - for Silicone Filled Sensors Only (Not for Oxygen/Chlorine/Other Fluids that may react with Silicone)	-X1
Cleaned and Prepared for Oxygen Service - for Fluorinert Filled Sensors Only (Not available with Carbon Steel Covers or with Silicone Filled Sensors)	-X2
Cleaned and Prepared for Chlorine Service - for Fluorinert Filled Sensors Only (j) (Not available with Carbon Steel Covers or with Silicone Filled Sensors)	-X3
Bolting for Process Covers/Connectors (k)	
316 ss Bolts and Nuts (Pressure Derated) (f)	-B1
17-4 ss Bolts and Nuts (j)	-B2
B7M Bolts and Nuts (NACE)(Pressure Derated) (f)	-B3
Conduit Thread Adapters	
Hawke-Type 1/2 NPT Cable Gland for use with Conduit Connection Codes 1 and 3 (l)	-A1
M20 Connector for use with Conduit Connection Codes 1 and 3 (l)	-A3
Electronics Housing Features	
External Zero Adjustment	-Z1
Custody Transfer Lock and Seal	-Z2
External Zero Adjustment and Custody Transfer Lock and Seal	-Z3
Custom Factory Configuration	
Full Factory Configuration (Requires Configuration Form to be filled out)	-C2
Tubing Connectors - Specify Only One (Only 316 ss process covers; no side vents on cover) (h)	
Steel, Connecting 6 mm Tubing to 1/4 NPT Process Connector	-E1
Steel, Connecting 12 mm Tubing to 1/2 NPT Process Connector	-E2
316 ss, Connecting 6 mm Tubing to 1/4 NPT Process Connector	-E3
316 ss, Connecting 12 mm Tubing to 1/2 NPT Process Connector	-E4
Gaskets	
Gasket for Vacuum Service with Pressure Seals (m)	-G1
Instruction Books (Common MI, Brochure, and Full Documentation Set on CD-ROM is Standard)	
Without Instruction Book and CD - Only "Getting Started" Brochure is supplied	-K1
Miscellaneous Optional Selections	
Low Temperature Operative Limit of Electronics Housing Extended Down to -50°C (-58°F) Not available with sensors and seals with fluorinert fill, Structure Codes 78 and 79, or DIN Options -D2, -D4, -D6, and -D8	-J
Vent Screw in side of Process Cover (with 316 ss process covers only) Not available with seals, DIN construction options, or Structure Codes 78 and 79	-V (h)
Supplemental Customer Tag (Stainless Steel Tag wired onto Transmitter)	-T
Examples: IGP20-A20B21F-M1Z2; IAP20-AS3C11F-T	

(a) Maximum overrange pressure is 2.1 MPa (300 psi); temperature limits are -7 and +82°C (20 and 180°F).
(b) Transmitter and Pressure Seal Model Codes are both required. See PSS 2A-1Z11 A for the various pressure seal model codes.
(c) Remote Seal Models that may be specified are PSFPS, PSFES, PSFAR, PSTAR, PSISR, PSSCR, and PSSSR.
(d) Span Limit Code A is not available with pressure seals (Structure Codes F1, F2, S3, S4, SC, SD).
(e) Span Limit Codes E and F are not available with Structure Codes 78 and 79 (pvdf insert in HI Side Cover).
(f) Pressure derated. See derating table in specifications section.
(g) Temperature limits derated to 0 and 60°C (32 and 140°F). Also Mounting Sets -M1 and -M2 not available.
(h) Not available when Remote Mount or Direct Connect Pressure Seals are specified.
(j) When -X3 is specified, the standard bolting is replaced with 17-4 ss bolts and nuts. Therefore, there is no need to specify Option -B2 when selecting the Chlorine Service Option -X3.
(k) Not available with DIN construction options. For stainless steel bolts with DIN construction, specify -D5 to -D8, as required.
(l) Available with Electrical Safety Code D only.
(m) Standard offering with IAP20 Transmitters with pressure seals. However, -G1 is a required option with IGP20 Transmitters when pressure seal (Structure Codes S3, S4, F1, F2, SC, and SD) will be used in vacuum applications. This option substitutes vacuum service metal gasket for standard ptfe process cover gasket.
(n) A cover lock is standard construction with Electrical Safety Codes D, B, G, and V.

SUGGESTED RFQ SPECIFICATIONS

The manufacturer shall provide two-wire, 4 to 20 mA dc analog output pressure transmitter(s) suitable for field mounting. These transmitters shall also be provided (as required) with direct connect pressure seals, or remote capillary connected pressure seals. The specifications for these transmitters are as follows:

Accuracy: ±0.20% of calibrated span.

Span Limits: From 1 to 6000 psi for standard direct-connected transmitters, and from 0.5 inH_2O to 5000 psi for standard bracket-mounted transmitters, as specified; or SI and Metric equivalents.

Damping: Settable for a range of none to 8 seconds.

RFI Protection: The maximum error shall be no more than an additional ±0.1% of calibrated span for 30 V/m field intensity between 27 and 1000 MHz.

Electronics Housing: IEC IP66 (NEMA 4X); 316 ss or aluminum housing with Epoxy finish; two compartments (field wiring and electronics); housing sealed with O-rings for double protection against moisture or other contaminants.

Modular Electronics: Easily replaceable modular electronics standard.

LCD Indicator: Liquid Crystal Display (LCD) Indicator, with on-board pushbuttons for calibration and configuration, is standard.

Mounting: Direct to process or bracket mounted to pipe or surface.

Process Connection: IAP10/IGP10 Transmitters: Direct to process piping or pressure seal with 1/2 NPT; optional Rc 1/2 or G 1/2 B external threads to process piping. Internal 1/4 NPT thread also provided as plumbing connection to process; or prepared for a direct connect seal or capillary connected seal.

IAP20/IGP20 Transmitters: Used with process connectors to accept 1/4 NPT, 1/2 NPT, Rc 1/4, Rc 1/2, Schedule 80 welding neck; or a pvdf insert (tapped for 1/2 NPT) in HI side process cover is used as process connection. Process connection can also be prepared to accept a direct connect seal; or prepared for a remote capillary connected seal.

Process Cover Materials Available: Applicable to IAP20/IGP20 transmitters only. Industry Standard 316 ss, Carbon Steel, Monel, and Hastelloy C.

Sensor Materials: Co-Ni-Cr, 316L ss, and Hastelloy C for IAP10/IGP10 transmitters; and Co-Ni-Cr, 316L ss, Hastelloy C, Monel, Tantalum, and Gold-Plated 316L ss for IAP20/IGP20 transmitters.

Electrical Classification: Nonincendive for Class I and Class II, Division 2 locations, and explosionproof for Class I and Class II, Division 1 locations. Versions available to meet Agency flameproof and zone requirements; comply with applicable European Union Directives.

Approximate Mass:

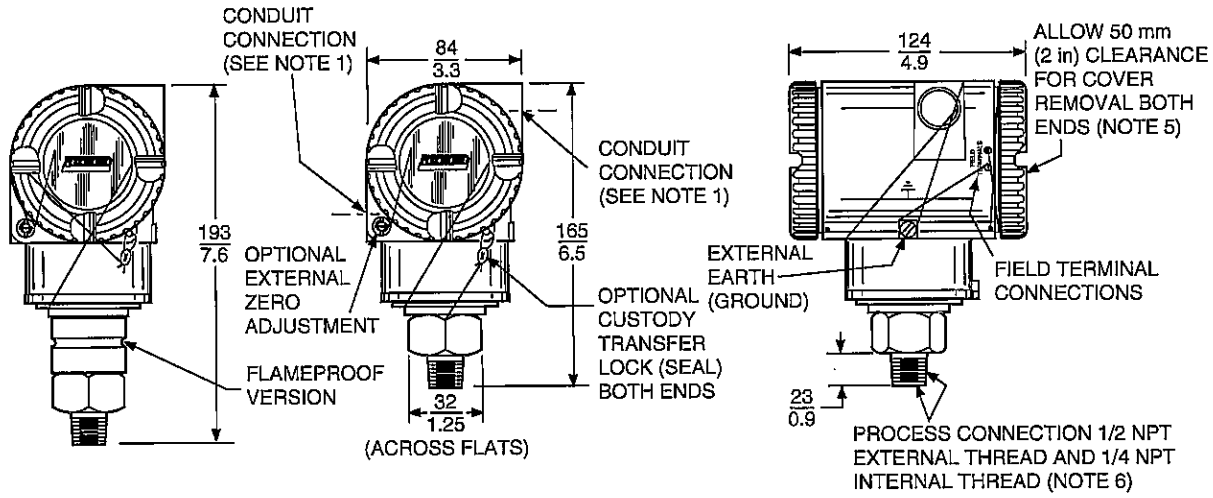
Direct Connected Transmitter:	1.5 kg (3.3 lb)
Bracket-Mounted Transmitter:	3.5 kg (7.8 lb) w/o process connector
	4.2 kg (9.2 lb) w/process connector
With 316 ss Electronics Housing:	Add 1.1 kg (2.4 lb)
With Pressure Seals:	See PSS 2A-1Z11 A

Model Codes: I/A Series IAP10-A or IGP10-A, Direct Connected Absolute or Gauge Pressure Transmitters; or IAP20-A or IGP20-A Bracket Mounted Absolute or Gauge Pressure Transmitters; with or without pressure seals; or equivalent.

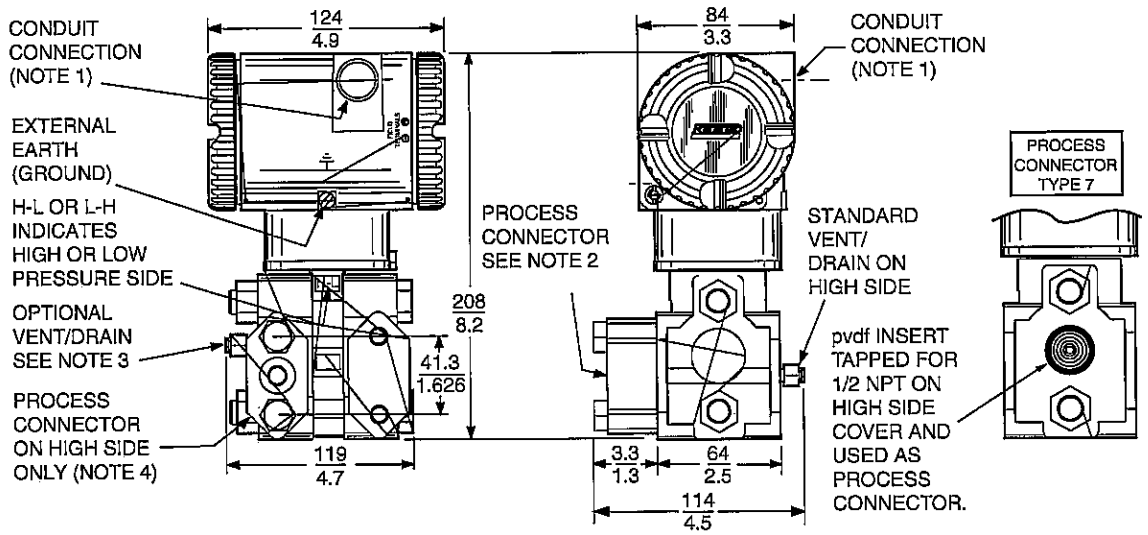
DIMENSIONS-NOMINAL

mm
in

IAP10 AND IGP10 DIRECT CONNNECTED TRANSMITTERS



IAP20 AND IGP20 BRACKET MOUNTED TRANSMITTERS

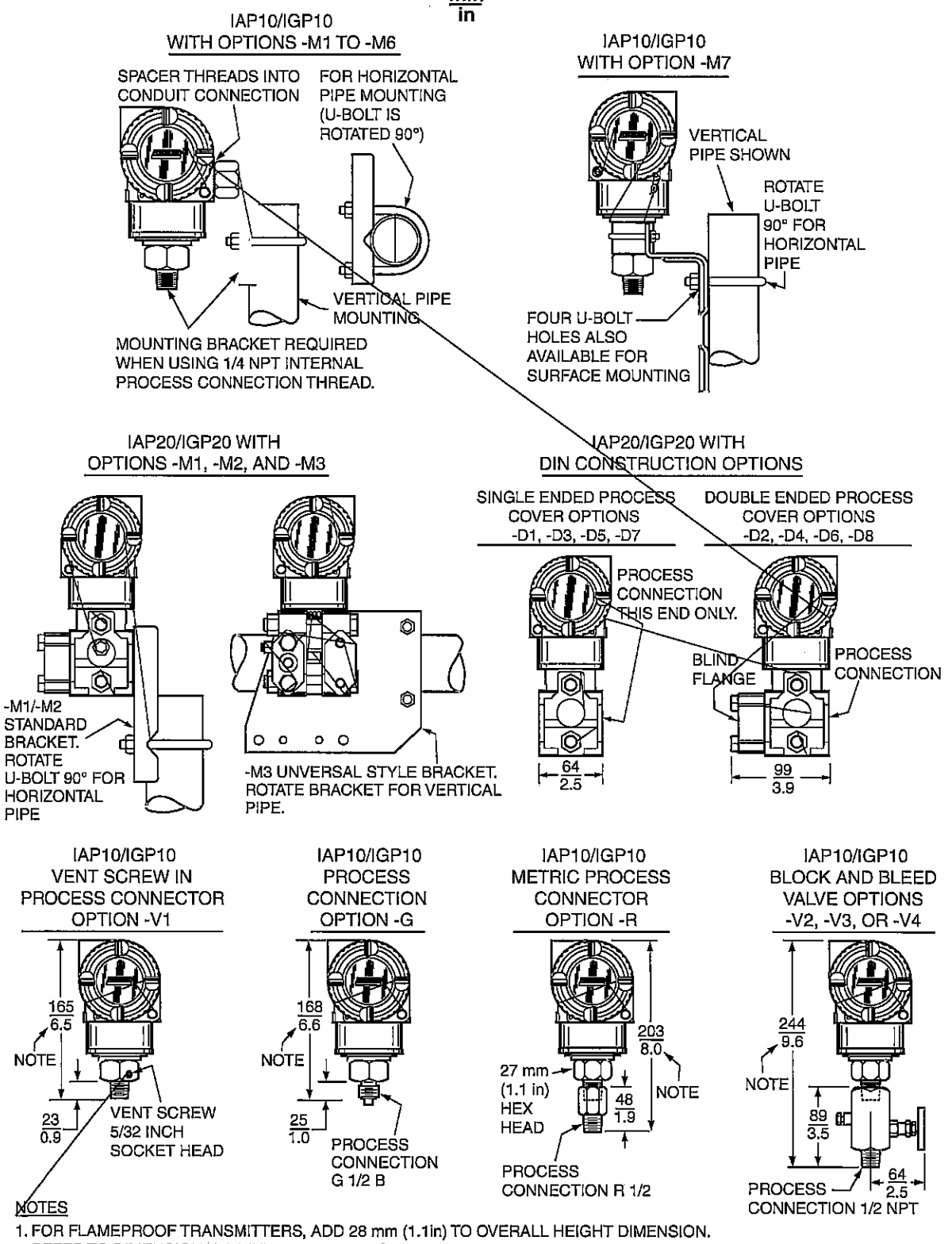


NOTES

1. CONDUIT CONNECTION 1/2 NPT, PG 13.5, OR M20, BOTH SIDES : PLUG UNUSED CONNECTION WITH METAL PLUG (SUPPLIED).
2. PROCESS CONNECTOR CAN BE REMOVED AND CONNECTION MADE DIRECTLY TO PROCESS COVER USING 1/4 NPT INTERNAL THREAD IN PROCESS COVER. NOTE THAT WITH PROCESS CONNECTION CODE "0", THERE IS NO CONNECTOR.
3. PROCESS COVER CAN BE INVERTED MAKING OPTIONAL SIDE VENT A SIDE DRAIN.
4. FOR USERS WHO DESIRE THE PROCESS CONNECTOR ON THE RIGHT SIDE, MERELY ROTATE TRANSMITTER 180° AND RELOCATE PROCESS CONNECTOR SHOWN TO THE RIGHT SIDE.
5. TOPWORKS ROTATABLE TO ANY POSITION WITHIN ONE TURN COUNTERCLOCKWISE OF FULLY TIGHTENED POSITION.
6. DO NOT USE THE 1/4 NPT INTERNAL THREAD TO DIRECT-CONNECT THE TRANSMITTER.

DIMENSIONS-NOMINAL (Cont.)

mm
in



NOTES

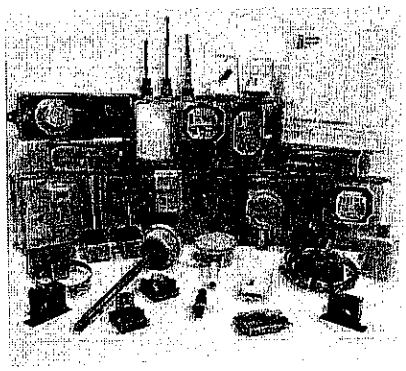
1. FOR FLAMEPROOF TRANSMITTERS, ADD 28 mm (1.1in) TO OVERALL HEIGHT DIMENSION.
2. REFER TO DIMENSIONAL PRINT DP 020-447 FOR FURTHER INFORMATION.

APPENDIX E – ACI TEMPERATURE SENSOR DATASHEET

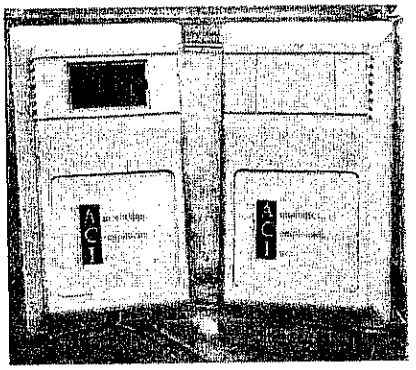
Automation Components Inc.

Product Data

Thermistor Temperature Sensors



ACI/2252 Series
ACI/3K Series
ACI/5K Series
ACI/10K-AN (Type III)
ACI/10K-CP (Type II)



Product Description

The ACI/2252, ACI/3K, ACI/5K, ACI/10K-AN (Type III), and ACI/10K-CP (Type II) Series temperature sensors are thermistor type sensors. These sensors provide a predictable output over a specified temperature range to meet each manufacturers required input values.

Thermistors offer high accuracy and interchangeability over a wide temperature range.

The thermistors higher resistance relative to Platinum RTD's, creates a larger signal with the same measuring current, negating most lead wire resistance problems and eliminating the need for signal conditioners.

These units are offered in Room, Room with Set Point, Room with Override, Room with Setpoint and Override, and Room w/ Setpoint, Override, and RJ11 Jack, Stainless Steel Duct and Duct without Box, Immersion, Stainless Plate, Raw, Bendable Copper and Stainless Steel Rigid Averaging, Strap-On, Bullet Probe, Button Sensor, and Outdoor Air Configurations.

Setpoint options include a linear 400 Ohm, 1K, 2K, 3K, 5K, 8.5K, 10K, 20K, or 100K slide potentiometer. An optional series resistor allows for any offset of the setpoint potentiometer. These may be either Direct or Reverse Acting.

Indication stickers for setpoint include Cool|Warm, 55 to 85, and 10 to 30°C. Others are available upon request.

Override options include a N/O switch in parallel with the sensor or a separate 2 pole terminal block for Tenant override.

All ACI sensors can be ordered with an optional 4 pin RJ11 or 6 pin RJ12 or 1/8" RS232 Stereo communication jack with terminal blocks for remote programming.

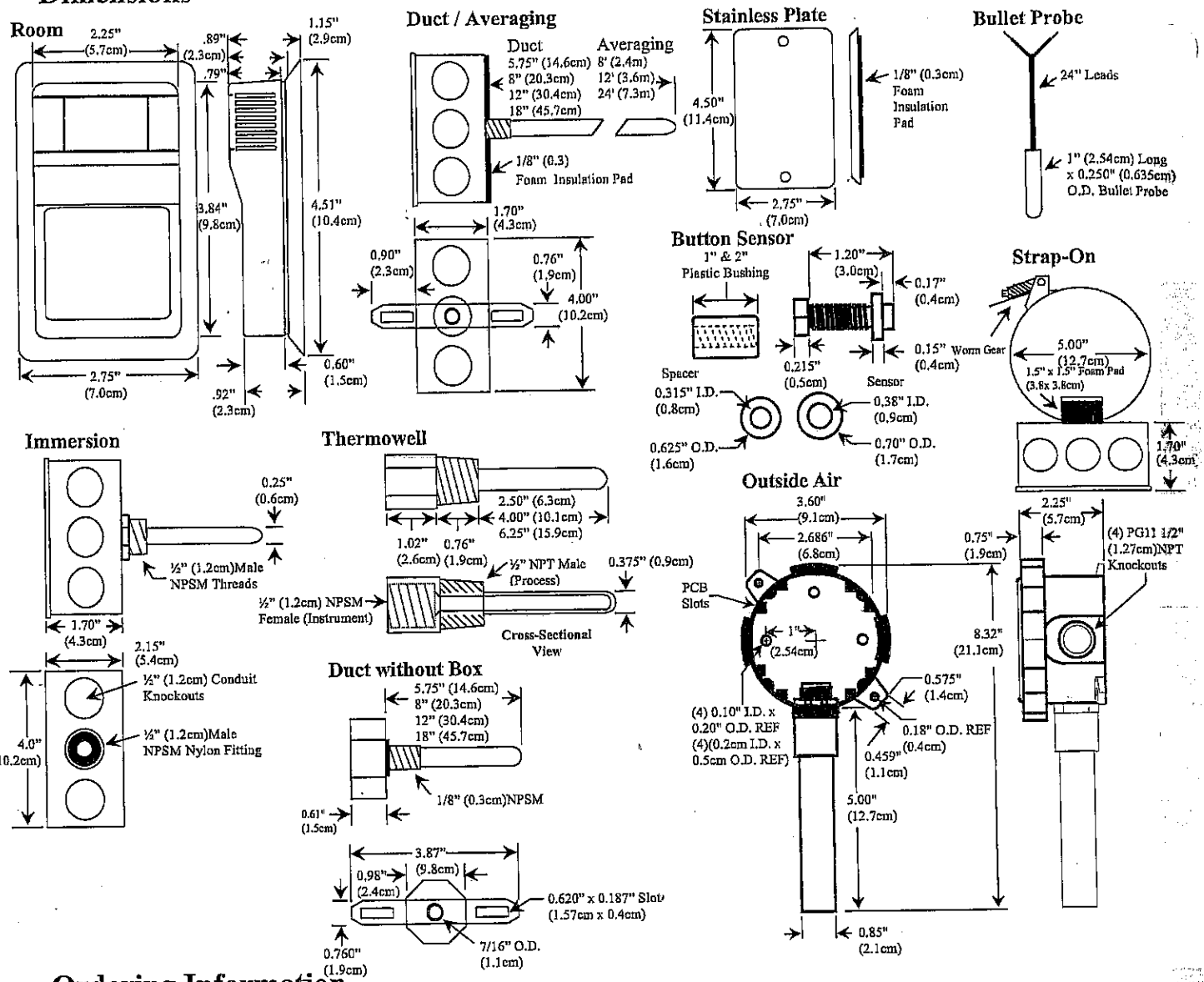
All units come with a two year factory warranty. Please contact ACI for more information regarding these products.

Product Specifications

Output	2,252 Ohms @ 77°F(25°C) 3,000 Ohms @ 77°F(25°C) 5,000 Ohms @ 77°F(25°C) 10K Ohms @ 77°F(25°C) Type II 10K Ohms @ 77°F(25°C) Type III	**Dissipation Constant**	3 mW / °C
		Stability	+/-0.13°C
Temperature Range	-40 to 302°F (-40 to 150°C)	**Accuracy**	+/- 0.2°C (0 to 70°C)
Interchangeability	+/- 0.2°C (0 to 70°C)	**Operating Humidity**	0 to 90% RH non-condensing

2305 Pleasant View Rd. Middleton Industrial Park Middleton, WI 53562
PH: (608) 831-2585 FAX: (608) 831-7407

Dimensions



Ordering Information

Sensor	Configuration	Communication Jack	Pot Value	Setpoint Indication	Pot Action
A/ [ ]	-[ ]	-[ ]	-[ ]	-[ ]	-[ ]
2252	**R** - Room	**RJ4** (4 Pin RJ11)	**400 Ohm**	**Cool | Warm**	**DA** (Direct)
3K	**RS** - Room w/Setpoint	**RJ6** (6 Pin RJ12)	**1K**	**55 to 85**	**RA** (Reverse)
5K	**RO** - Room w/Override	**232** (1/8" Stereo Jack)	**2K**	**10 to 30°C**	
AN (10K-AN)	**RSO** - Room w/Setpoint & Override		**3K**	**Specify**	
CP (10K-CP)	**D** - Duct 4", 8", 12", 18"		**5K**		
	DO - Duct without Box 4", 8", 12", 18"		**8.5K**		
	I - Immersion 2.5", 4", 8"		**10K**		
	A - Averaging 8', 12', 24'		**20K**		
	RA - Rigid Averaging 18", 24", 36"		**100K**		
	S - Strap - On				
	O - Outdoor Air				
	BP - 1" Bullet Probe				
	RP - Remote Probe 6' Lead wire				
	SP - Stainless Plate				
	W - Raw w/18" Leads				
	BBS - Brass Button Sensor				
	SBS - Stainless Button Sensor				

CE

For CE compliance, sensor leads must be no longer than 3 meters in length. Additionally, certain product variations may not be CE compliant. Contact ACI for further details

Example: A/AN -RSO -RJ6 -20K -55 to 85 -DA or A/3K -D -8" or A/AN -RSO -232 -20K -RA -Cool/Warm

2305 Pleasant View Rd. Middleton Industrial Park Middleton, WI 53562

T-16 **PH: (608) 831-2585 FAX: (608) 831-7407**

Automation Components Inc.

Product Data

Thermistor R/T Curve Table

ACI Temp °C	ACI Temp °F	ACI/2252 Resistance Ohms	ACI/3K Resistance Ohms	ACI/5K Resistance Ohms	ACI/10K-AN Resistance Ohms	ACI/10K-CP Resistance Ohms
-40	-40	75,769.0	100,935.0	168,225.0	239,686.0	336,450.0
-35	-31	54,647.0	72,798.0	121,330.0	179,200.0	242,660.0
-30	-22	39,851.0	53,088.0	88,480.0	135,185.0	176,960.0
-25	-13	29,368.0	39,123.0	65,205.0	102,861.0	130,410.0
-20	-4	21,861.0	29,122.0	48,536.0	78,913.0	97,072.0
-15	5	16,429.0	21,885.0	36,476.0	61,020.0	72,951.0
-10	14	12,459.0	16,598.0	27,663.0	47,543.0	55,326.0
-5	23	9,532.0	12,698.0	21,163.0	37,313.0	42,326.0
0	32	7,353.0	9,795.0	16,325.0	29,490.0	32,650.0
5	41	5,718.0	7,617.0	12,696.0	23,457.0	25,391.0
10	50	4,481.0	5,970.0	9,950.0	18,780.0	19,899.0
15	59	3,538.0	4,713.0	7,856.0	15,130.0	15,711.0
20	68	2,813.0	3,748.0	6,246.0	12,263.0	12,492.0
25	77	2,252.0	3,000.0	5,000.0	10,000.0	10,000.0
30	86	1,814.0	2,417.0	4,028.0	8,194.0	8,057.0
35	95	1,471.0	1,959.0	3,266.0	6,752.0	6,531.0
40	104	1,200.0	1,598.0	2,663.0	5,592.0	5,326.0
45	113	983.8	1,311.0	2,184.0	4,655.0	4,368.0
50	122	811.2	1,081.0	1,801.0	3,893.0	3,602.0
55	131	672.5	895.8	1,493.0	3,271.0	2,986.0
60	140	560.3	746.3	1,244.0	2,760.0	2,488.0
65	149	469.0	624.8	1,041.0	2,339.0	2,083.0
70	158	394.5	525.5	875.8	1,990.0	1,752.0
75	167	333.1	443.8	739.7	1,700.0	1,479.0
80	176	282.7	376.6	627.6	1,458.0	1,255.0
85	185	240.9	320.9	534.9	1,255.0	1,070.0
90	194	206.2	274.6	457.7	1,084.0	915.4
95	203	177.1	236.0	393.3	939.3	786.6
100	212	152.8	203.6	339.3	816.8	678.6
105	221	132.3	176.3	293.8	712.6	587.6
110	230	115.0	153.2	255.3	623.6	510.6
115	239	100.3	133.6	222.6	547.3	445.2
120	248	87.7	116.9	194.8	481.8	389.6
125	257	77.0	102.6	171.0	425.3	341.9
130	266	67.8	90.3	150.5	376.4	301.0
135	275	59.9	79.7	132.9	334.0	265.8
140	284	53.0	70.6	117.7	297.2	235.4
145	293	47.1	62.7	104.5	265.1	209.0
150	302	41.9	55.8	93.0	237.0	186.1

2305 Pleasant View Rd. Middleton Industrial Park Middleton, WI 53562
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APPENDIX F – ROOTS GAS METER DATASHEET

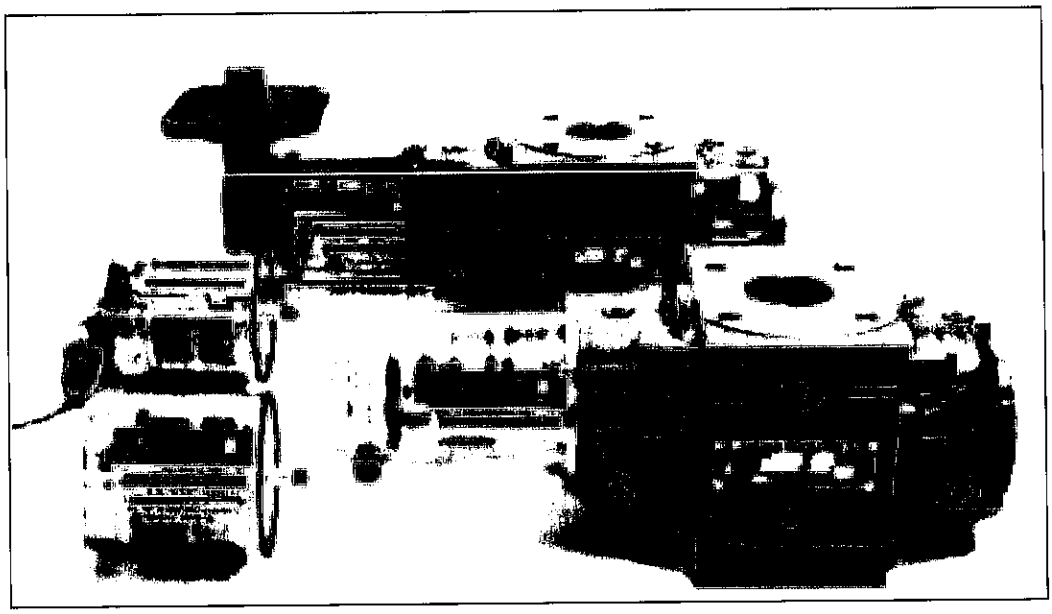
ROOTS Meters Instruments

DRESSER

PRELIMINARY SELECTION

ROOTS® Meter Series B3

Featuring Series 3 Accessory Units



Series B3 version ROOTS® meters are designed to provide accurate gas measurement over a wide range of flow, pressure and temperature conditions.

Available Types Include:

- CTR – Non-Compensated Counter
- CD – Non-Compensated Counter with Instrument Drive
- TC – Temperature Compensated Counter
- TD – Temperature Compensated Counter with Instrument Drive
- CTR or TC with Solid State Pulser – Low Frequency pulse output
- CTR or TC with AMR Adapter
- CEX – Counter (CTR) with High Frequency Transmitter/Pulser

Series B meter bodies are also available with the integral electronic ROOTS® IMC/C2 or IMC/W2 volume, pressure and temperature corrector, or the ROOTS® IMC/W2-T for a "temperature only" corrected reading.

ROOTS® Series B3

Meter Specifications														
SERIES B3	Units	8C175	11C175	15C175	2M175	3M175	5M175	7M175	11M175	16M175	23M175	23M232	38M175	56M175
Base Rating	acfh	800	1100	1500	2000	3000	5000	7000	11000	16000	23000	23000	38000	56000
Max. Operating Pressure	psig	175*	175*	175*	175	175	175	175	175	175	175	175	175	175
Rangeability +/-1%	ratio	26:1	31:1	40:1	100:1	76:1	120:1	67:1	124:1	116:1	40:1	169:1	90:1	53:1
Rangeability +/-2%	ratio	46:1	58:1	78:1	200:1	139:1	215:1	115:1	227:1	223:1	60:1	278:1	110:1	109:1
Start Rate	acfh	2.79	2.30	1.94	1.01	2.1	1.2	5.3	3.9	3.2	23	10.33	27	40
Stop Rate	acfh	2.03	1.74	1.57	0.82	1.8	0.8	3.4	3.2	1.9	18	5.75	20	29
Flow Rate, 0.5" w.c.,Gas	acfh	800	1100	1500	2000	2580	3975	5400	7300	9950	14800	10948	20600	23000
Differential, 100% Flow	in.w.c.	0.45	0.6	0.75	0.65	1.1	1.1	1.6	1.06	2.1	1.3	2.08	1.9	2.2
Drive Rate, CD/TD	cf/rev	10/100	10/100	10/100	10/100	10/100	10/100	10/100	10/100	100/1000	100/NA	100/NA	100/NA	100/NA
Min. CTR Reading	cf	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2	2	2	2	2
Nominal Pipe Size	in.	2	2	2	2	2	3	3	4	4	6	4	6	8
Flange/Flange Dim.	in.	6-3/4	6-3/4	6-3/4	6-3/4	6-3/4	6-3/4	9-1/2	9-1/2	9-1/2	16	15/16	18	21
Oil Capacity: Side Inlet	oz.	0.8	0.8	0.8	1.3	1.3	1.3	3	3	3	40	3.4	40	40
Oil Capacity: Top Inlet	oz.	3	3	3	7.6	7.6	7.6	21.9	21.9	21.9	154	21.8	154	154

Meter Sizing													
Model	8C175*	11C175*	15C175*	2M175*	3M175*	5M175*	7M175	11M175	16M175	23M175	23M232	38M175	56M175
Base Rating (acfh)	800	1100	1500	2000	3000	5000	7000	11000	16000	23000	23000	38000	56000
Meter Pressure (psig)	Corrected Capacity at Metering Pressure - MSCFH												
1	0.84	1.2	1.6	2.1	3.1	5.2	7.3	11.5	16.7	24	24	39.7	58.5
5	1.1	1.5	2	2.6	4	6.6	9.2	14.5	21.1	30.3	30.3	50	73.8
25	2.1	2.9	4	5.4	8	13.4	18.7	29.4	42.8	61.5	61.5	101.7	149.8
60	4	5.6	7.6	10.1	15.2	25.3	35.4	55.6	80.8	116.2	116.2	191.9	282.9
100	6.2	8.5	11.7	15.5	23.3	38.8	54.4	85.4	124.3	178.6	178.6	295.1	434.9
150	8.9	12.3	17	22.3	33	56	78	123	179	256.7	256.7	424.1	625
175	10.3	14.1	19	25.7	39	64	90	141	206	295.7	295.7	488.6	721.5
200	11.7	16	21.9	29.1	43.7	72.8					334.8		
232											384.7		

*Available with 200 psig Rating.

To select proper meter size, use Minimum Operating Pressure and Maximum Instantaneous Hourly Flow Rate.
Complete Data Sheets are available for each meter size. Request Data Sheet by meter model.

DRESSER
Roots Meters & Instruments

Dresser Roots Meters & Instruments
P. O. Box 42176
Houston, TX 77242-2176
website: www.dresser.com

Inside US Ph: 800.521.1114
Outside US Ph: 832.590.2303

Dresser, Inc.
Fax: 800.335.5224
Fax: 832.590.2494
www.rootsmeters.com

TS:B3
12.05

PRODUCT DATA

ROOTS Meters Instruments

Full Range of Sizes:

13 meter sizes offer a competitive range of rotary meters for commercial and industrial metering applications. Select the correct meter size for cost effectiveness and accurate measurement.

Standardized Flanges:

Sizes 8C through 3M have a 6-3/4" (171mm) flange-to-flange dimension for standardization in the meter set design. As loads change, meter sizes are easily interchanged, saving the cost of re-piping.

Accurate Low Flow Performance:

Low start/stop rates extend the rangeability (gas measured) over a wider range of flow conditions.

Low Pressure Differentials:

Reducing the maximum operating speed provides lower pressure differentials for low pressure applications, as well as extending the meter's life-expectancy.

SERIES 3 ACCESSORY UNITS

Oil-free Design:

Series 3 accessories feature high quality and long-term reliability with an oil-free permanently lubricated design. Oil is not required for the Polymer bushings and pre-lubricated, shielded ball bearings. Permanent lubrication equates to easier installation and less maintenance.

Durable, Weather Resistant Cover:

Optical Quality Lexan® covers on Series 3 accessories offer exceptional Ultraviolet protection while the cylindrical design allows the unit to easily shed rain, snow, ice and dirt. The single piece cover design provides added protection against leakage under extreme conditions.

High and Low Frequency Pulser Options:

The Counter with Electronic Transmitter (ICEX) provides a high frequency non-compensated pulse output for applications requiring information on the gas flow rate while the low frequency solid state pulsers are a lower cost option for both non-compensated (ICPWX) and temperature compensated (ITPWX) volume accumulation applications.

Non-Moving Odometer Masking System:

A unique and versatile odometer masking design using opaque or semi-transparent covers offers configurable, trouble-free masking.

Universal Instrument Drive (ID) Assembly:

One size fits all with the Series 3 Instrument Drive Assembly. Inventory costs are reduced by stocking one ID Assembly.

AMR Adapter:

The new direct drive AMR Adapter offers you a low cost solution for Series B3 CTR or TC meters in applications that require the adaptation of a Residential ERT or Cellnet AMR. The AMR Adapter is available as a conversion kit for field installation or factory installed on new meters.

General Information

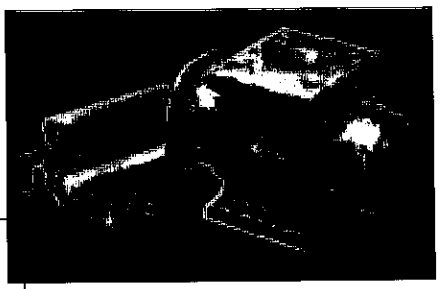
The Series B3 ROOTS® meter is a positive displacement, rotary type gas meter designed for continuously measuring and indicating the accurate measurement of gas. ROOTS® meters are suitable for handling most types of clean, dry, common gases at either constant or varying flow rates. Meters of standard construction are not directly suitable for handling acetylene, biogas or sewage gas. Contact the factory for information on specially constructed meters made of materials more compatible with these and other gases.

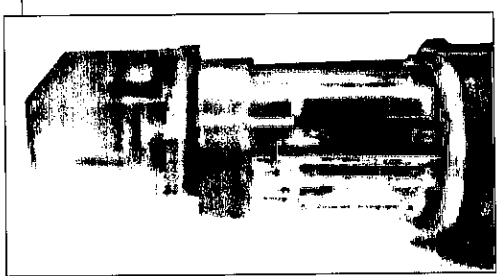
Volumetric accuracy of the ROOTS® meter is permanent, non-adjustable, and is not affected by low or varying line pressure. Series B3 meters may be used satisfactorily for pressures ranging from a few ounces to full Maximum Allowable Operating Pressure (MAOP). Displaced volume measurement is completely independent of the gas specific gravity, temperature, and pressure.

Series B ROOTS® meters have a MAOP rating of 175 psig (1200kPa). Every meter is static pressure tested at the factory at twice its MAOP and leak tested at 125 percent of MAOP in accordance with ASME Boiler Pressure Vessel Codes. Other pressure ratings are available. Consult Factory.

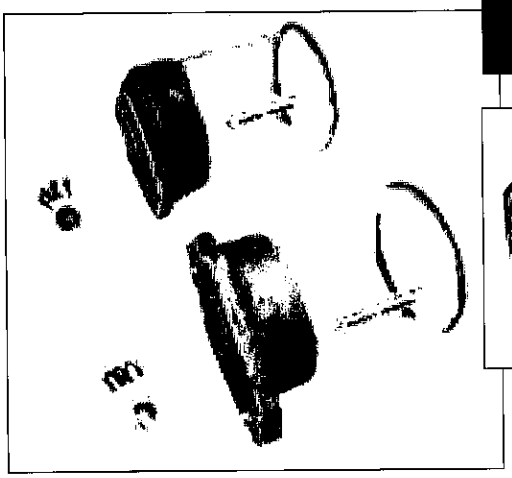
ROOTS® meters are manufactured in accordance with ANSI B109.3 for Rotary Type Gas Displacement Meters. Series B3 ROOTS® meter sizes 8C through 56M, have flanged inlet and outlet connections conforming dimensionally with ANSI/ASME standards. Sizes 8C through 2M are available with 1-1/2" NPT connections, upon special request. The meter operating temperature range is from -40°F to +140°F (-40°C to +60°C) while the temperature compensating mechanism of the TC accessory provides a corrected reading for temperatures ranging from -20°F to +120°F (-29°C to +49°C).

Series B ROOTS® meter bodies accept a wide range of Series 3 accessories for all metering applications.





AMR Adapter and ERT installed on a ROOTS Meter (top inlet meter installation shown)



AMR Adapters for Series B3 ROOTS Meter.

PRELIMINARY SELECTION

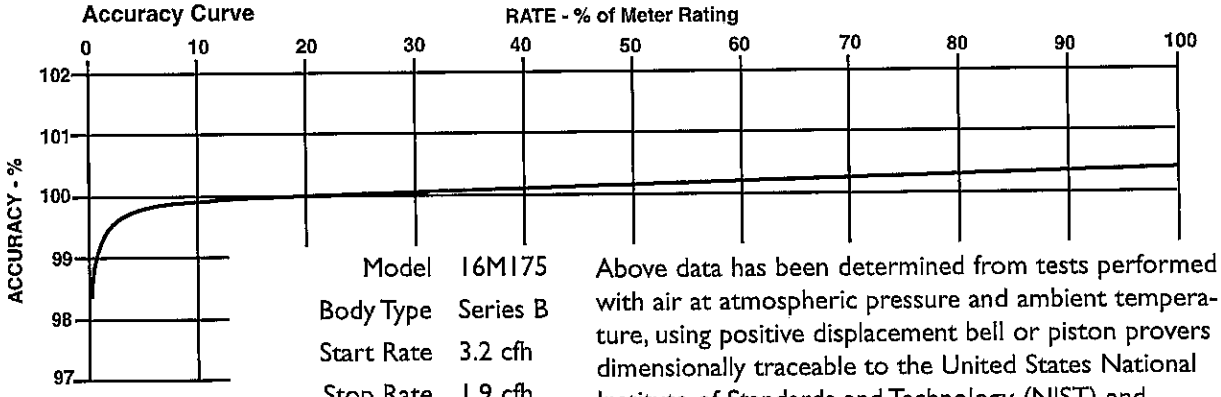
DRESSER

ROOTS Meters DATA SHEETS Instruments

SERIES B3: 16M175 ROOTS® Meter

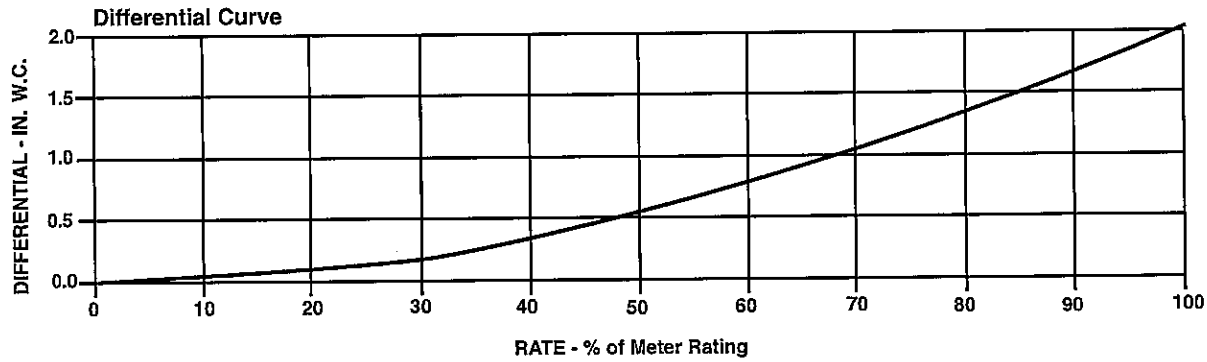
	UNITS	Imperial	UNITS	Metric
Temperature Range	deg. F	-40 to +140	deg. C	-40 to +60
Base Rating (Q Max.)	acfh	16000	m^3/h	450,0
Max. Operating Pressure (MAOP)	psig	175	kPa	1200
Leak Test (125% MAOP)	psig	219	kPa	1510
Static Test (2 x MAOP)	psig	350	kPa	2400
Rangeability +/- 1%	ratio	116:1	ratio	116:1
Rangeability +/- 2%	ratio	223:1	ratio	223:1
Start Rate	cfh	3.2	m^3/h	0,0917
Stop Rate	cfh	1.9	m^3/h	0,0535
Flow Rate @ 0.5" w.c., Gas	cfh	9950	m^3/h	281,8
Avg. Differential, 100% Flow	in. w.c.	2.1	mbar	5,2
Max. Pressurization Rate	psig/sec	5	kPa/sec	35
Max. Operating Speed	rpm	1800	rpm	1800
Gear Ratio	ratio	675:1	ratio	238,2352:1
Displaced Volume/Revolution	cf	0.148148	m^3	0,004195
Drive Rate, CD	cf/rev	100	m^3/rev	1
Drive Rate, TD	cf/rev	1,000	m^3/rev	10
Temp. Compensating Range (TC, TD)	deg. F	-20 to +120	deg. C	-29 to +49
Min. Odometer Reading	cf	2.0	m^3	0,02
Odometer Turnover	yrs.	7.1	yrs.	2,5
Nominal Pipe Size	in.	4	mm	100
Flange-to-Flange	in.	9-1/2	mm	241,3
Flange Connection	ANSI	150#FF	ANSI	150#FF
Bolts per Flange	qty.	8	qty.	8
Bolt Size[1]	in.	5/8 - 11	in.	5/8 - 11
Flange Bolt Hole Depth	in.	1-1/16	mm	23,8
Bolt Torque: Lubricated/Non-Lub.	ft.-lb.	55/60	N-m	74/81
Restricting Orifice (120%)	in.	1-7/32	mm	26,194
Oil Capacity - Side Inlet	oz.	3	ml	89
Oil Capacity - Top Inlet	oz.	21.9	ml	648
Counter Version (CTR)[2]				
Net Weight	lbs.	85	kg	38,6
Shipping Weight	lbs.	94	kg	42,6
Carton Size	in.	34 x 13 x 12	cm	86 x 33 x 31
Counter with Instrument Drive (CD)[2]				
Net Weight	lbs.	86	kg	39,0
Shipping Weight	lbs.	95	kg	43,1
Carton Size	in.	38 x 15 x 16	cm	97 x 38 x 41

NOTES:
[1] Bolt Length varies by application.
[2] Weights and dimensions available for CPS, TC, TD, TPS upon request.

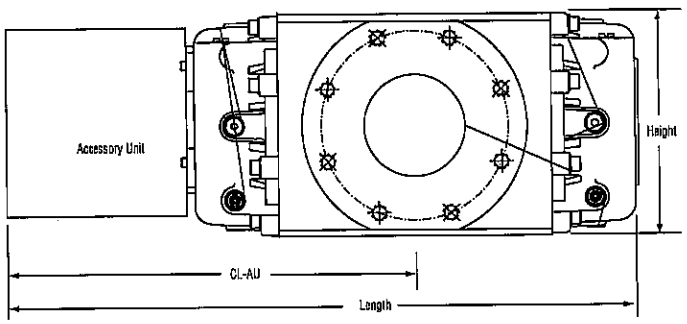


Model	16M175
Body Type	Series B
Start Rate	3.2 cfh
Stop Rate	1.9 cfh
Rangeability ±1%	116:1
Rangeability ±2%	223:1

Above data has been determined from tests performed with air at atmospheric pressure and ambient temperature, using positive displacement bell or piston provers dimensionally traceable to the United States National Institute of Standards and Technology (NIST) and traceable to NMi - Netherlands Measurements Institute for volumetric flow rate.



16M175 Series B3	Overall Length inches	mm	Overall Height inches	mm	Width (Flange/Flange) inches	mm	Centerline to Accessory End (CL-AU) inches	mm	Request Detailed Drawing Number
CTR / TC	26-1/16	662	8-7/8	225	9-1/2	241	15-7/16	392	D054518-000
CD / TD	29-27/32	758	8-7/8	225	9-1/2	241	19-7/32	488	D054432-000
CPS / TPS	28-3/16	716	8-7/8	225	9-1/2	241	17-9/16	446	D054671-000
IMC/C	31-7/16	798	8-7/8	225	9-1/2	241	19-1/16	484	D056487-000
IMC/W	32-7/16	824	8-7/8	225	9-1/2	241	21-13/16	554	D056703-000



To order

Specify: Meter Series, Size and Type (i.e., ROOTS Meter Series B3 16M175 CD).

For CD or TD, specify Inlet (Top or Side) and ID Rotation (CW-B or CCW-A).

For Pulser, specify Single or Dual Connectors and Connector Type (MS Circular, Conduit or Cable Gland).

For more specific ordering information on the electronic products, request: TS:SSP, TS:IMC/C or S: IMC/W.

Contact the factory for other available information, options, or special requests.

DRESSER
Roots Meters & Instruments

Dresser Roots Meters & Instruments

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Houston, TX USA 77242-2176
website: www.dresser.com

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Outside US Ph: 832.590.2303

Dresser, Inc.

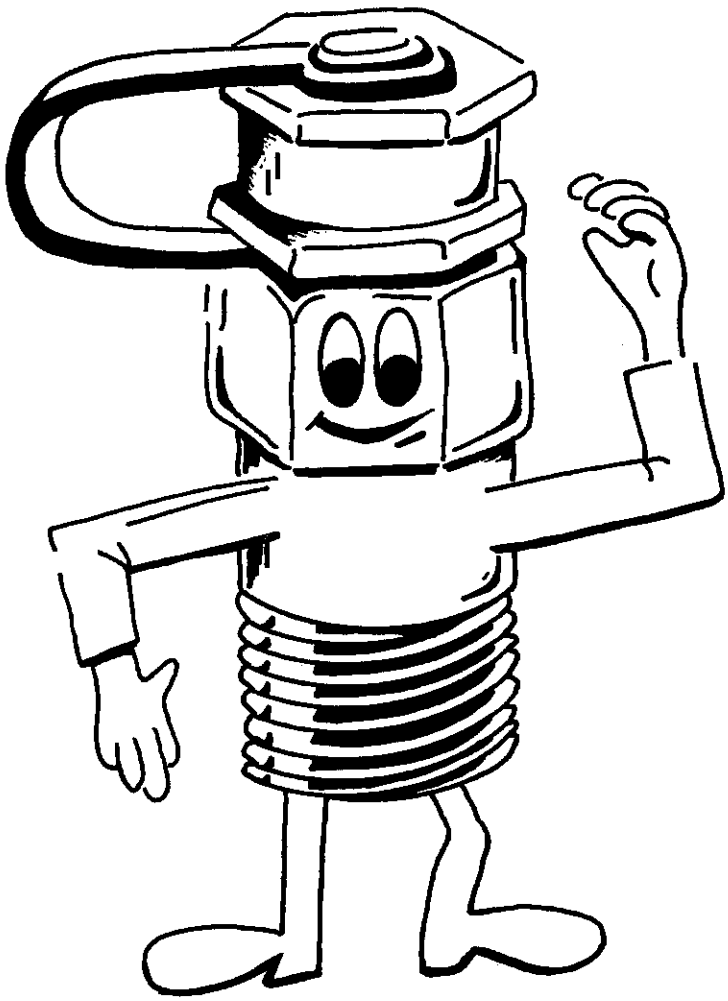
Fax: 800.335.5224
Fax: 832.590.2494
www.rootsmeters.com

APPENDIX G – PETE'S PLUG DATASHEET

PETE'S PLUG II®

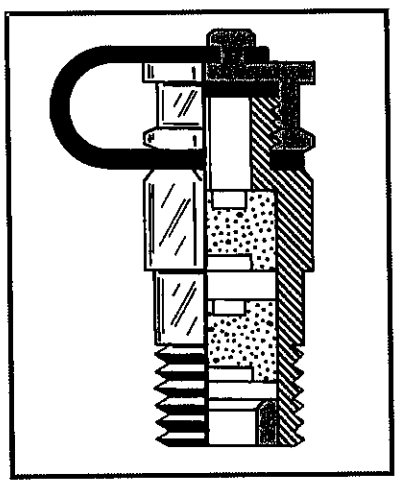
The successor to the real Pete's Plug

PETE'S PLUG II ®WILL ALLOW YOU TO TAKE PRESSURE AND TEMPERATURE READINGS QUICKLY AND ELIMINATE THE NEED FOR LEAVING COSTLY GAUGES OR TEMPERATURE INDICATORS ON THE LINE.



Depending on the application, the Pete's Plug can be operated to a maximum of 500 PSIG and 200° or 275°F for neoprene and nordel respectively. Maximum working pressures of 1000 PSIG can be attained with neoprene or nordel at temperatures from 140°F to -20°F.

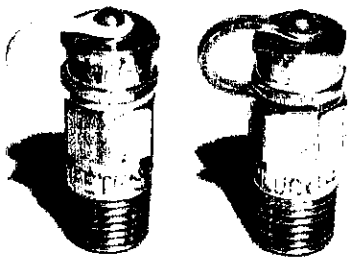
The enhanced version of Pete's Plug II ® is still the only pressure and temperature test plug with two self-closing valves, but the valves are improved with interaction which speeds valve closure.



Patent Number 5,079,962

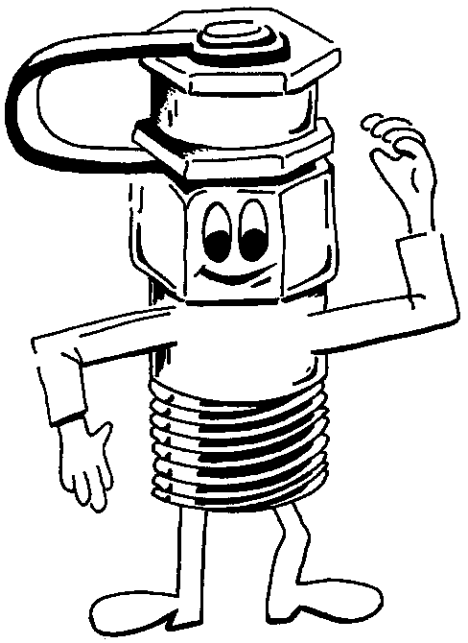
Peterson Equipment Company, Inc

9909 W. University Dr. #509 Mc Kinney, Texas 75071 Ph: 214-544-7584 Fax: 214-544-7585



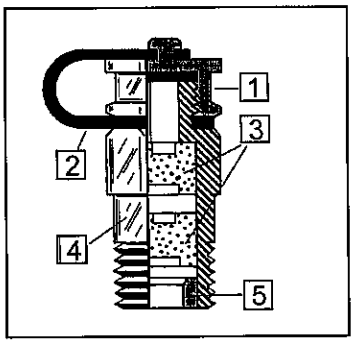
Pete's Plug II is available in various pipe thread sizes, lengths and materials to satisfy each application. The XL Pete's Plug II will allow you to insulate the test point and not completely cover the Pete's Plug II. The XL Pete's Plug II eliminates extra fittings for insulated applications.

Pressure or Temperature Tests
Take pressure and temperature readings quickly with line pressurized. Reduce the need for costly permanent installation of gauges and recorders on the line.



How to operate
The Pete's Plug II is permanently installed in the line at recommended test points. The cap protects the valve and provides an additional seal. After the cap has been removed, either a test thermometer or a gauge adapter with the proper pressure gauge can be inserted through the two, self-closing valves in the Pete's Plug II. Readings are made, adjustments or tests can be accomplished and when the probes are withdrawn the two valves close. The protective cap is then reinstalled. Tests should be made as quickly as possible since the valve reseal time is dependent upon time of insertion ,time and pressure. Slower valve reseal time can be expected at lower temperature and lower pressures.

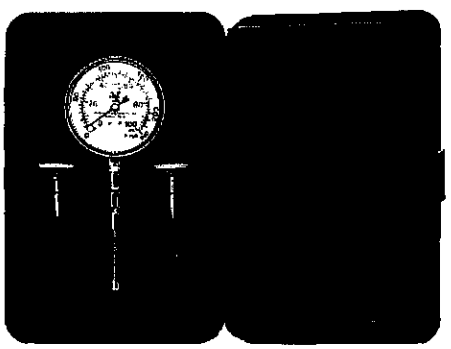
Standard length Pete's Plug II Cross Section:
1. Cap and Gasket
2. Cap retaining strap
3. Two self closing valves with interaction to speed valve closure
4. Valve body
5. Valve retainer



Suggested specifications

Pressure and temperature test stations:
Supply and install where indicated "Pete's Plug II" a 1/4" fitting to receive either a temperature or pressure probe 1/8" OD. Fitting shall be solid brass with two valve cores of Neoprene (Max 200°F) at 500 PSI, or Nordel (Max 275°F) at 500 PSI, fitted with a color coded cap strap with gasket, and shall be rated at 1000 PSI at 140°F. In addition, the installing contractor shall supply the owner with ___ (number) pressure gauge adapters with 1/8" OD probe and ___ (number) five inch stem pocket testing thermometers; 25-125°F for chilled water and ___ (number) 0-220°F or ___ (number) 50-500°F for hot water.

Pressure and temperature test kit:
Supply and present to the owner upon completion of testing a pressure and temperature test kit. It will consist of a 0-100 PSI, 0-230 ft. of water pressure gauge with a Number 500 gauge adapter attached. It will contain one 25-125°F and one 0-220°F pocket testing thermometer, an extra number 500 gauge adapter, and a protective carrying case.



#1500XL test kit works with our extended length Pete's Plugs

Applications

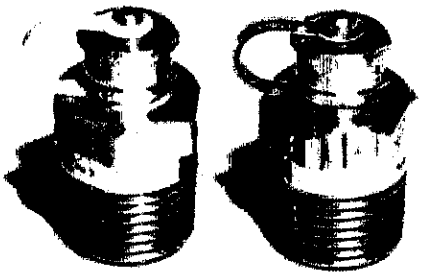
In general the Pete's Plug is a time and money saving device which is well suited for most plant and pipeline systems and is designed to eliminate gauge cocks and thermometer wells. Hot and chilled water systems, heat exchangers, pumps, differential readings, air, gas lines and numerous other applications are only a few of the areas where the Pete's Plug are presently being used.

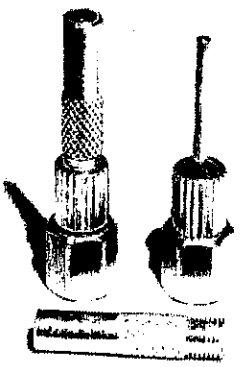
Valve Materials

Neoprene is a chloroprene based synthetic rubber and is resistant to deterioration from waxes, fats, oils, greases, petroleum products and most refrigerants.

Nordel is an ethylene-propylene based synthetic rubber and gives excellent service in hot and cold water and in some applications of low steam. Nordel is resistant to detergents, phosphate esters, ketone, alcohols, and glycols. It is **not** suitable for petroleum products.

Neoprene and nordel are proprietary materials and the information presented herein is believed to accurate and reliable. Peterson Equipment Co., Inc. Can assume no liability for results obtained or damages incurred through the application of this information. The information is intended as a guide and if in doubt ask!





Pressure Tests

The pressure gauge adapter has a probe constructed of 304 stainless steel. The probe is 0.156" in diameter and extends 2 inches on the standard adapter and 3½ inches on the extra long adapter. The 1/8" diameter probe is less likely to become clogged with foreign material and resists bending. Also, the 1/8" diameter probe operates in either the ¼" , 3/8" , or ½" Pete's Plug. Please note the 500XL gauge adapter will operate in any of the Pete's Plug's. It is intended for use with any of the XL Pete's Plug's.

Temperature Tests

The test thermometer is constructed of stainless steel, has a 1 3/4" dial and has a bi-metallic sensing element. Accuracy within ½ % over the entire scale can be expected. Pointer adjustment or recalibrations can be made by turning the hex nut on the back of the dial case while firmly holding the dial case. The stem should be immersed in a known, controlled temperature bath. Stem lengths are 5" and diameters of 0.156" or 4mm are maximum diameters that can be inserted onto the Pete's Plug. Digital thermometers have the same specifications but can not be recalibrated in the field.

Valve Core Material	Recommended Maximum Temperature	Maximum Pressure	Strap Color Coded
Neoprene	200°F	500PSIG	Blue Strap-Neoprene
Nordel	275°F	500PSIG	Yellow Strap-Nordel

ORDERING INFORMATION

Part Number	Valve Core Material	Size	Body and Cap Material	Length
100	Neoprene	¼"NPT	Brass	1½"
110	Nordel	"	Brass	"
100XL	Neoprene	¼"NPT	Brass	3"
110XL	Nordel	"	Brass	"
300	Neoprene	3/8"NPT	Brass	1½"
310	Nordel	"	"	"
400	Neoprene	¼"NPT	316SS	1½"
410	Nordel	"	"	"
700	Neoprene	½"NPT	Brass	1½"
710	Nordel	"	Brass	"
700XL	Neoprene	½"NPT	Brass	3"
710XL	Nordel	"	Brass	"
12500	Neoprene	1/8"NPT	Brass	1¼"

Cap retaining straps are standard on all Pete's Plugs.

Gauge Adapters
(All Connections ¼"NPTF)

500 Gauge Adapter with 1/8" Diameter Probe
500XL Gauge Adapter with 1/8" Diameter Probe for XL Plugs
510 Gauge Adapter with 1/16" Diameter Probe**
520 Gauge Adapter with 1/8" Diameter Probe all 316SS

Test Kits

1500 Temperature and Pressure Test Kit
1500XL Temperature and Pressure Test Kit-XL

Bi-Metal Pocket Testing Thermometers
5" Stem With External Calibration

Part Number	Range	Degree Division
600	-40° to 160°F	2
601	25° to 125°F	1
603	0° to 220°F	2

Digital Pocket Testing Thermometers 5" Stem

Part Number	Range	Degree Division
606	-58° to 571°F	0.1

**510 is the only gauge adapter that will fit part number 12500

Instrumentation, Wiring Schematic, and Installation Details

Site Visits & Timeline of Events

Figure B-1. Timeline of Logger Installation Events

February 6, 2009	• Campbell datalogger installed. • Modbus communication with OfficePower ALC system could not be established. (Adam Walburger – CDH Energy, John Pifer - OfficePower)
March 4, 2009	• Obvius data logger installed, Campbell datalogger removed. • Modbus communication with OfficePower ALC system established. • DSL communications with CDH Energy computers established. • Reading from Obvius and ALC verified with handheld readings. • Data logging begins (Adam Walburger – CDH Energy, John Pifer - OfficePower, Alan Summers - Alpha Engineering)

Description of Monitored Data Points and Schematics

Figure B-2 lists the monitored points use from the OfficePower ALC SCADA system for performance monitoring. The wiring schematics for the logger are shown in Figure B-3.

Point Name (Unit)	Tag	ALC Point Type	NYSERDA Scaling Factor	Suggested Holding Register (40001-49999)	Discrete Coils Register (1-9999)
Service 1 Energy Import (kWH)	WT1	FLOAT	x 0.001	40001	
Service 2 Energy Import (kWH)	WT2	FLOAT	x 0.001	40003	
Service 3 Energy Import (kWH)	WT3	FLOAT	x 0.001	40005	
Service 1 Demand Import (kW)	WT1KW	FLOAT	n/a	40007	
Service 2 Demand Import (kW)	WT2KW	FLOAT	n/a	40009	
Service 3 Demand Import (kW)	WT3KW	FLOAT	n/a	40011	
Turbine Array 1 Net Energy Export (kWH)	WTA1	FLOAT	x 0.001	40021	
Turbine Array 2 Net Energy Export (kWH)	WTA2	FLOAT	x 0.001	40023	
Turbine Array 1 Demand Export (kW)	WTA1KW	FLOAT	n/a	40025	
Turbine Array 2 Demand Export (kW)	WTA2KW	FLOAT	n/a	40027	
Parasitic Load Panel Energy (kWH)	WTAPLP	FLOAT	x 0.001	40041	
Parasitic Load Panel Demand (kW)	WTAPLPKW	FLOAT	n/a	40043	
Chiller Parasitic Load Panel Energy (kWH)	WCHMPLP	FLOAT	x 0.001	40045	
Chiller Parasitic Load Panel Demand (kW)	WCHMPLPKW	FLOAT	n/a	40047	
Gas Meter 1 (cf)	FGM1	FLOAT	n/a	40051	
Gas Meter 2 (cf)	FGM1	FLOAT	n/a	40053	
Glycol Return Temp Post Radiator (degF)	TGLR	FLOAT	n/a	40061	
Glycol Return Temp Pre Radiator (degF)	TGLR1	FLOAT	n/a	40063	
Glycol Supply Temperature (degF)	TGLS	FLOAT	n/a	40065	
Glycol Flow (gpm)	FGL	FLOAT	n/a	40067	
HEX 4 Entering Water Temp (degF)	TS12	FLOAT	n/a	40069	
HEX 4 Leaving Water Temp (degF)	TS13	FLOAT	n/a	40071	
HEX 4 Low Side (Water) Flow (gpm)	FWL	FLOAT	n/a	40073	
Operating Mode - Heating	HEAT	DO	On=True		1
Operating Mode - Cooling	COOL	DO	On=True		2

Figure B-2. Monitored Points via ALC System (Modbus Address 001)

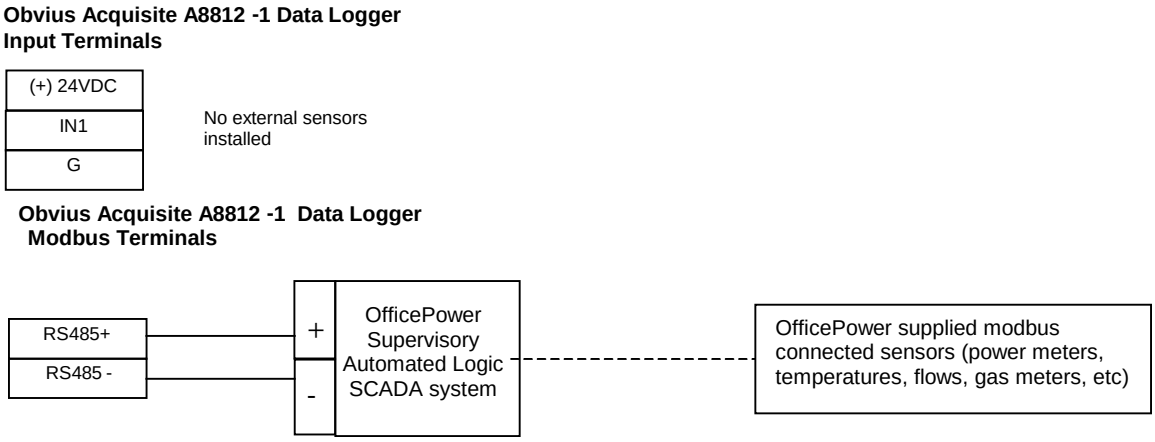


Figure B-3. Wiring Schematic for Obvius Internal I/O Connections (Modbus Address 250)

Photos of Installed Sensors

N/A – Need collect photos of installed sensors on future site visit.

Field Verification

Field measurements were taken using an independent handheld meter to verify the sensors installed at the site yield a proper reading. Where possible a direct measurement was performed for comparison to the OfficePower ALC readings. For the three total facility power measurements, current on the secondary side of the CTs was measured.

The output for the two turbine arrays (WTA1, WTA2) and the parasitic load panel (WPLP) were measured using a Fluke 39 power meter. The Fluke readings were compared to the reading from the ION power transducers that report to the datalogger via the ALC SCADA system. Table XX displays the results of the field verification measurements for three of the power points. Note that no load was present on WCHMPLP (the chiller parasitic load panel) and therefore it was not verified at this point in time.

Data Point	Current (amps)	Measured Power (kW)	ION Meter Power (kW)
WTA1	540 / 560 / 550	457 kW	459.5 kW
WTA2	212 / 216 / 218	179 kW	177.9 kW
WPLP	39 / 33 / 36	27.1 kW	27.2 kW

Due to the location of the total facility power CTs, the facility power for the three utility services could not be measured directly. Instead a comparison was made to handheld current readings on the secondary side of the CT (at a 2000:5 turndown ratio). Only WT3 (Service #3) displayed an extremely low power factor, indicating that the orientation of the CTs on this service should be verified. Note that this does not impact the CHP performance measurements.

Table B-1. Comparing Total Facility Power Measurements Using Secondary CT Measurements

Data Point	Secondary Current (amps)	Primary Current (amps @ 2000:5)	Calculated KVA @ 277 VAC→N	ION Meter Power (kW)
WT1	1.97 / 1.58 / 1.57	788 / 632 / 628	567 kVA	453 kW (0.80 PF)
WT2	1.57 / 1.64 / 1.60	628 / 656 / 640	532 kVA	494 kW (0.92 PF)
WT3	1.10 / 1.54 / 1.30	440 / 616 / 520	436 kVA	280 kW (0.64 PF)

Temperature measurements were performed using a Pete's plug adjacent to each temperature sensor and a direct insertion Fluke 53 II digital thermometer. Figure B-3 displays the temperature verification measurements performed. Based on a single verification measurement, no adjustment is being applied to the data set for temperature correction between sensors. Multiple verification readings at different operating temperatures will be needed to determine the need for an offset or multiplier correction. During the measurement period, no heat was being rejected across the dump radiator, so the difference between TGLR and TGLR1 was minimal. More measurements will be needed with the radiator running to fully quantify the accuracy of this temperature difference.

Table B-2. Comparing System Fluid Temperature Measurements Using Handheld Thermometer Readings

Data Point	Fluke Measurement (°F)	ALC SCADA Measurement (°F)
TGLS	135.9°F	136.2°F
TGLR	110.1°F	110.7°F
TGLR1	110.7°F	109.5°F
TWTRR (T12)	109.3°F	109.2°F
TWTRS (T13)	127.5°F	128.6°F

The CHP system uses two Roots gas meters to measure the low-pressure gas flow to the turbines. The ALC SCADA system counts the raw pulses from the meter and reports the pulse rate as cubic feet per hour (CFH). To verify this rate a visual inspection of the 100 CF hand on the meter face was performed. The time required to consume 100 CF of natural gas was timed, and converted to CFH for comparison to the ALC data.

Table B-3. Comparing Manual Gas Use Readings to ALC SCADA Readings

Data Point	Time for 100 CF Consumption (Read from Meter Face)	Computed Gas Flow Rate (CFH)	ALC SCADA Measurement (CFH)
FGM1	95 seconds	3,789 CFH	3,790 CFH
FGM2	88 seconds	4,090 CFH	4,090 CFH

Data Logging Equipment

An Obvius Acquisuite 8812 datalogger was installed to collect the data. The sensors are sampled or scanned at 1-second intervals. Screen captures of the datalogger settings are shown below.

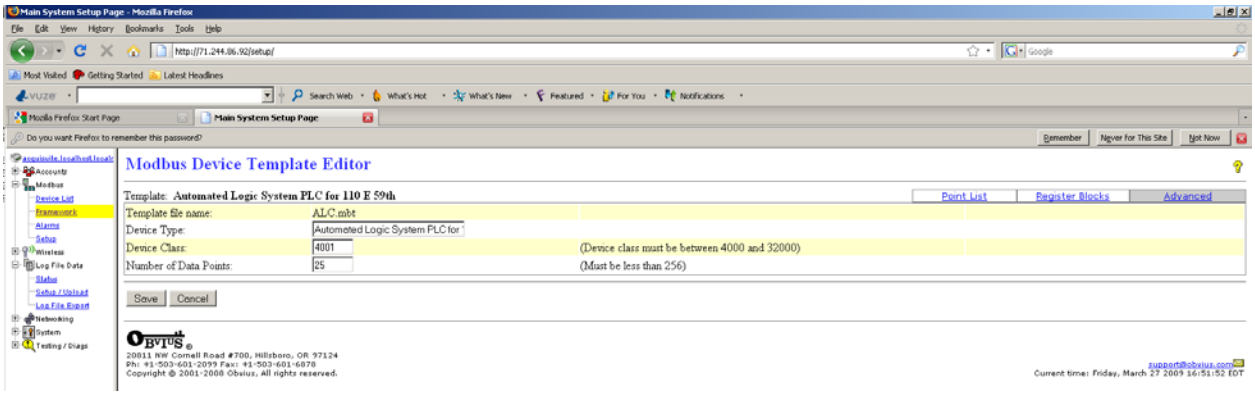


Figure B-4. MODBUS Configuration for Obvius Logger (Screen 1)

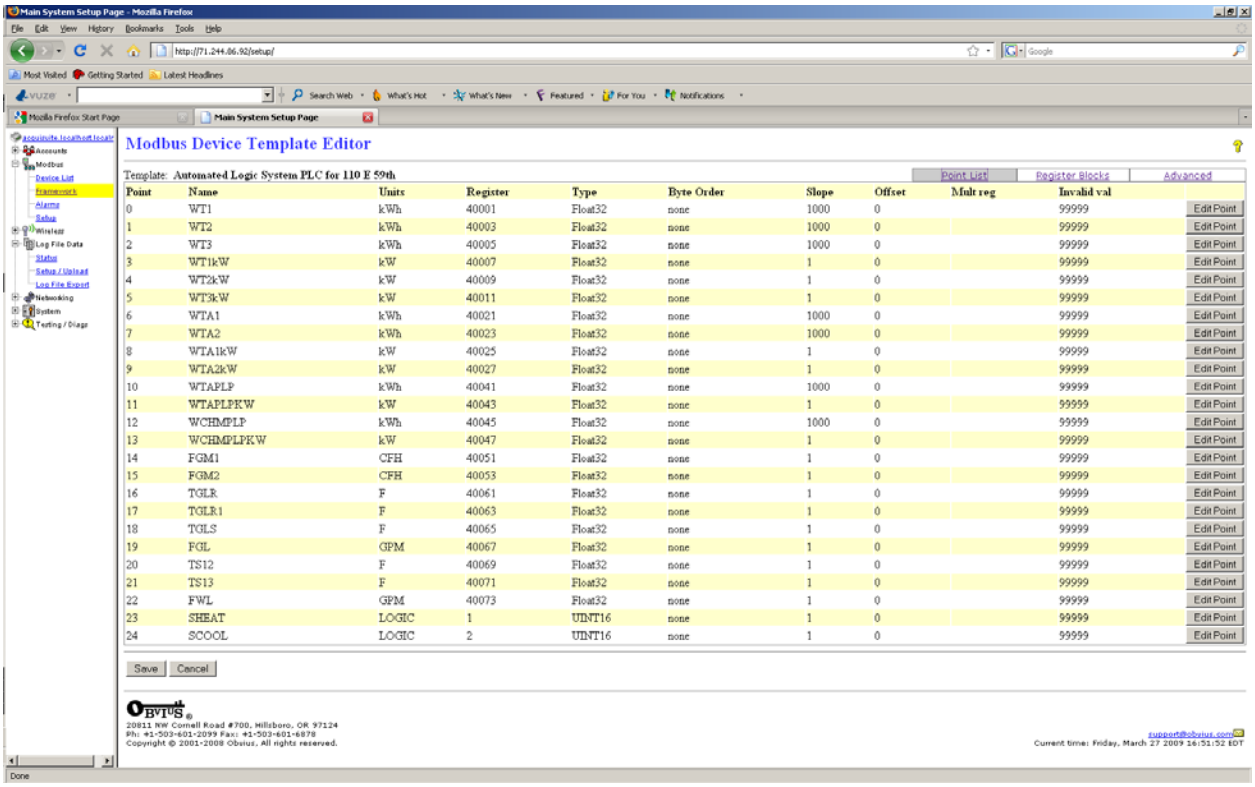


Figure B-5. MODBUS Configuration for Obvius Logger (Screen 2)

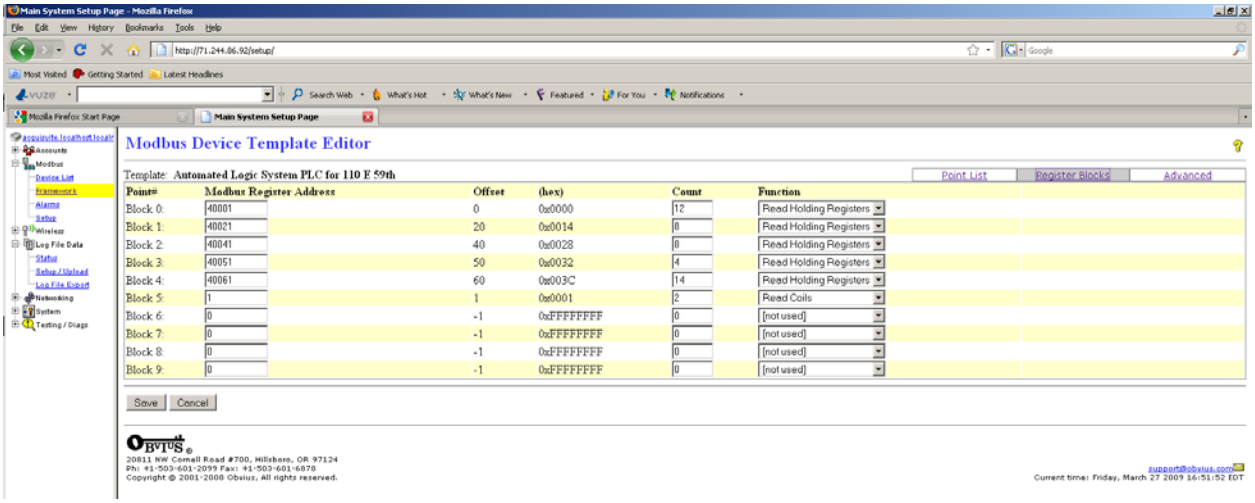


Figure B-6. MODBUS Configuration for Obvius Logger (Screen 3)

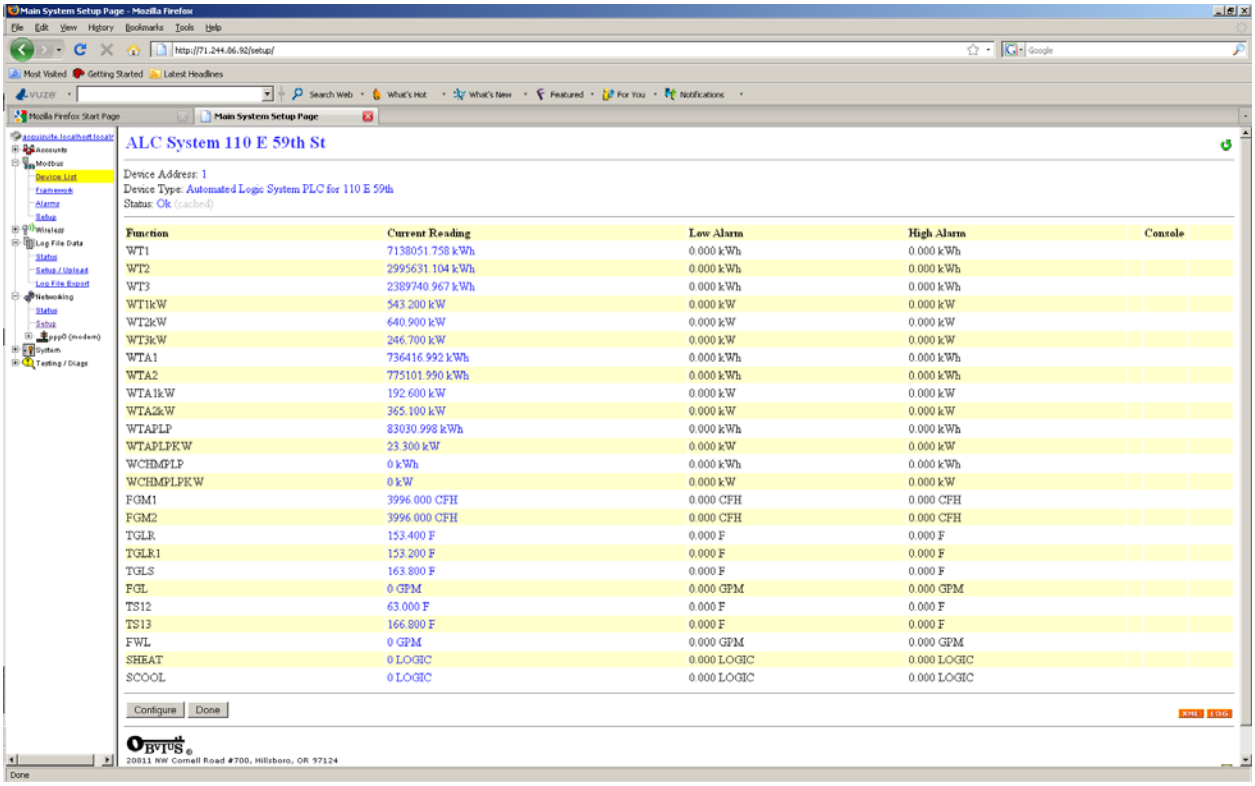


Figure B-7. Typical Real-Time Display Capture

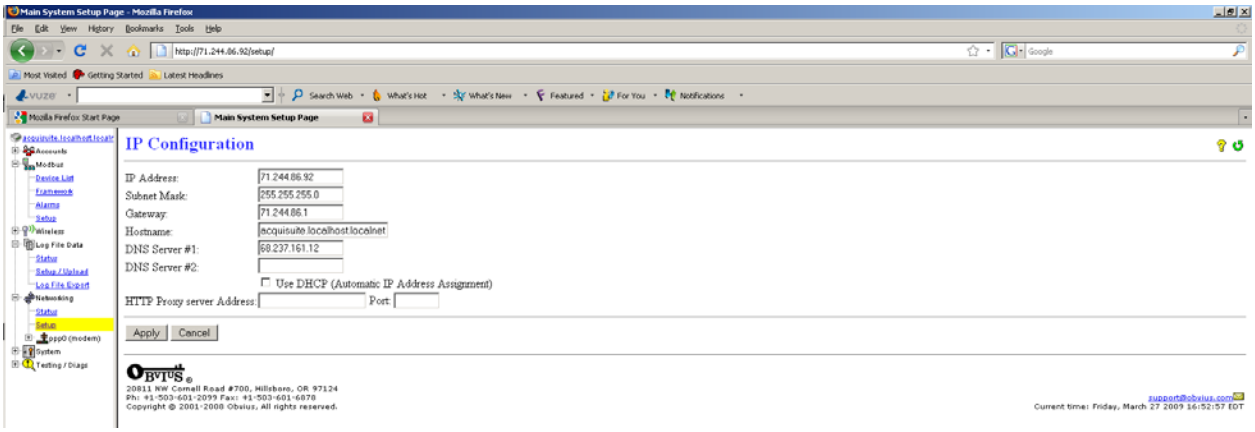


Figure B-8. Obvius Logger IP Configuration