SECTION 23 05 19
METERS AND GAGES FOR HVAC PIPING

P A R T 1 - G E N E R A L

SECTIONS INCLUDED
Ultrasonic Flow Meters
Vortex Shedding Flow Meters
Differential Pressure Flow Meters
Magnetic Flow Meters
Positive Displacement Meters
Energy Consumption Meters
Flow Switch

RELATED WORK
Section 01 91 01 or 01 91 02 – Commissioning Process
Section 23 21 13 - Hydronic Piping
Section 23 22 13 - Steam and Condensate Heating Piping
Section 23 07 00 - HVAC Insulation
Section 23 09 23 – Direct-Digital Control System for HVAC

REFERENCE
ASME MFC-3M – Measurement of Fluid Flow in Pipes Using Orifice, Nozzle and Venturi; The American Society of Mechanical Engineers: 2004.

AWWA Standard C700 – Cold Water Meters

ABREVIATIONS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
AWWA	American Water Works Association
BAS	Building Automation System
CSA	Canadian Standards Association
CUP	Central Utility Plant
DDC	Direct Digital Controls
DP	Differential Pressure
FMO	Facilities Management Operations
NEMA	National Electrical Manufacturers Association
NIST	National Institute of Standards and Technology
NPT	National Pipe Thread
PVC	Polyvinyl Chloride
RTD	Resistance Temperature Detector
UL	Underwriters Laboratories
VAC	Volts Alternating Current
VDC	Volts Direct Current

QUALITY ASSURANCE
Refer to division 1, General Conditions, Equals and Substitutions.

SHOP DRAWINGS
Refer to division 1, General Conditions, Submittals.

Required for all items in this section. Include materials of construction, dimensional data, ratings/capacities/ranges, pressure drop data where appropriate, and identification as referenced in this section and/or on the drawings.

In addition to the general content specified under GENERAL CONDITIONS, supply the following additional documentation:

1. Copy of meter manufacturers' pipe installation guide. Highlight the exact installation type intended to be used. Specifically note upstream and downstream pipe diameters recommended by the manufacturer and coordinate with the Mechanical Contractor before the piping is installed.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DESIGN CRITERIA

The following utilities shall be measured at each building:

1. Chilled Water – An Energy Consumption Meter [consisting of a flow meter, two temperature sensors, and a flow processor] shall be installed on all building main chilled water piping whether it is connected to a separate building or piped directly to the central loop. An ultra-sonic flow meter or a magnetic flow meter shall be used.

2. Heating Hot Water – An Energy Consumption Meter [consisting of a flow meter, two temperature sensors, and a flow processor] shall be installed on all building main heating hot water piping whether it is connected to a separate building or piped directly to the central loop. An ultra-sonic flow meter or a magnetic flow meter shall be used.

3. Process Hot or Chilled Water – An Energy Consumption Meter [consisting of a flow meter, two temperature sensors, and a flow processor] shall be installed on all process hot or chilled water piping. An ultra-sonic flow meter or a magnetic flow meter shall be used.

4. Steam – All buildings that purchase steam from Northwestern University, or are research facilities with a steam turndown ratio less than 15:1, shall have a direct measurement of steam. Steam flow shall be measured using a differential pressure flow meter. Condensate meters shall also be provided in these buildings.

   All buildings where steam is not directly measured shall have condensate metered to determine the steam usage.

   Steam flow meters shall measure volumetric flow. The flow processor shall input the volumetric flow rate, and utilize internal steam tables and a static steam pressure sensor to determine the mass flow rate of the steam. The flow processor shall assume that the steam is saturated.

   Condensate shall be measured using a positive displacement for pipe sizes less than 1", and vortex shedding flow meter for pipe sizes 1" and greater. Flow Switches shall be installed on all condensate receiver drain pipes. Provide a valved (removable/lockable handle) meter bypass and a bleed-off drain for pipe sizes greater than 1".

5. Domestic water – A positive displacement flow meter shall be installed on all domestic water supplies into a building. Irrigation, process, equipment cooling water, etc., shall be separately metered and subtraction used to determine the building water usage.

Direct readings of these utilities are preferred. Where multiple buildings are piped to a common utility source and piping does not allow for this method, total usage shall be measured and subtraction shall be used for the remaining building usage.

Flow meters used to measure Energy Consumption or Mass Flow require a flow processor to input the flow meter and temperature (CHW or HW) or pressure sensors (steam), calculate the Energy Consumption or Mass Flow, and send a pulse output signal to the BAS that represents the results of this calculation. Spare flow processor analog outputs shall be used to output real-time flow rate, steam pressure, return water temperature, and supply water temperature, in that order of preference. The Northwestern FMO Instrumentation Specialist shall define the ranges of these output(s) for proper scaling of the 4-20mA signal.

PART 2 - PRODUCTS

See execution section of this specification for installation services required by the equipment provider.

ULTRASONIC FLOW METERS

Technology:	Transit Time
Pipe size:	2” to 100”
Fluid type:	Liquid
Factory Tested Accuracy:	±0.5%
Field Accuracy:	±2.0%
Repeatability:	±0.15%
Response time:	0.3 to 30 seconds
Velocities:	-40 to 40 ft/sec
Maximum Fluid Temp:	250°F
Input Power:	120 VAC
Output Signal:	Frequency output
Transducers:	Stainless steel clamps
	NEMA 6 rated housings
Other:	No moving parts
	Field programmable
Manufacturer:	EMCO Sono-Trak Transit Time, Fuji Time Delta-C, or approved equal.

VORTEX SHEDDING FLOW METERS

Technology:	Inline vortex shedding
Pipe size:	1” to 12”
Fluid type:	Liquid
Factory Tested Accuracy:	±0.75%
Repeatability:	±0.15%
Response time:	1 to 100 seconds
Velocities:	1.5 to 32 ft/sec
Maximum Fluid Temp:	750°F
Input Power:	24 VDC
Output Signal:	Frequency output
Wetted Parts:	Stainless steel
Connection:	Flanged
Other:	No moving parts
	Noise immunity
	Removable sensor, below 750 psig
	NEMA 4x watertight and dust tight
Manufacturer:	EMCO Vortex PhD, or approved equal

DIFFERENTIAL PRESSURE FLOW METERS

Technology:	Differential pressure
Pipe size:	1/2” to 30”
Fluid type:	Steam
Factory Tested Accuracy:	±0.5%
Repeatability:	±0.1%
Turndown:	30:1
Input Power:	24 VDC or 120 VAC
Output Signal:	Frequency output
Wetted Parts:	Stainless steel
Body:	Carbon steel
Connection:	ANSI 300 Flanged
Install. Piping Requirements:	3 diameters upstream
	3 diameters downstream
Transmitters:	Two DP transmitters, Rosemount 3051 CD or Foxboro IDP10
	Pipe Mounting Bracket and support pipe
	Factory calibrated with certificate
Other:	No moving parts
Steam Usage:	Pressure input used to calculate mass flow
Special:	Three valve manifold per transmitter
	Flow processor for mass flow calculation
Manufacturer:	InFlow MacroFlow, McCrometer V-Cone or approved equal.

MAGNETIC FLOW METERS

Technology:	Electromagnetic volumetric flow
Pipe size:	1/2” to 40”
Fluid type:	Liquid
Factory Tested Accuracy:	±0.5%
Repeatability:	±0.1%
Velocities:	0 to 33 ft/sec
Maximum Fluid Temp:	200°F
Input Power:	120 VAC
Output Signal:	Frequency output
Wetted Parts:	Stainless steel
Body:	Carbon steel
Connection:	ANSI 150 Flanged
Other:	No moving parts
	NEMA 4x enclosure
	Bi-Directional Flow
Manufacturer:	EMCO Model 3100 Magflo, McCrometer UltraMag, or approved equal

POSITIVE DISPLACEMENT FLOW METERS

Technology:	Positive displacement
Pipe size:	5/8” to 2”
Fluid type:	Liquid
Factory Tested Accuracy:	AWWA Standard C700
Maximum Fluid Temp:	80°F
Accuracy:	±1.0%
Repeatability:	±0.25%
Maximum Operating Pressure:	150 PSI
Output Signal:	Frequency output
Body:	Bronze
Connection:	NPT
Other:	360 degree sweep hand
Interface:	Badger ORION RTR Transmitter, with parallel signal input to BAS.
Usage:	Domestic cold water only
Manufacturer:	Badger Recordall Disc Series, or approved equal

Technology:	Impeller
Pipe size:	< 1”
Fluid type:	Liquid
Accuracy:	±1.0%
Repeatability:	±0.7%
Rangeability:	60:1
Maximum Fluid Temp:	300°F
Output Signal:	Frequency output
Body:	Bronze
Connection:	NPT
Interface:	Data Industrial model 320 with pulse signal input to BAS.
Usage:	Steam Condensate
Manufacturer:	Data Industrial BR-250 Tee Flow Sensor, with conduit adaptor, or approved equal.

ENERGY CONSUMPTION METER

An energy consumption meters shall consist of an ultrasonic or magnetic flow meter, two temperature sensors, and a flow processor.

TEMPERATURE SENSORS

Style:	Insertion
Installation type:	Hot tappable, provide weld-o-let
Sensor type:	dual element, 100 or 1000 ohm RTD to meet requirements of the flow processor
Tolerance:	≤0.045°F
Sensor material:	Stainless Steel
Assembly:	Retractable, with gear drive
Output:	Terminal strip
Manufacturer:	InFlow Model ITS, JMS Southeast, or approved equal

FLOW SWITCH

Body:	Brass
Plunger:	PVC
Spring:	Stainless Steel
Output Signal:	Binary
Minimum Switch Point:	1.5 GPM
Connections:	NPT
Size:	¾"

FLOW PROCESSOR

Enclosure:	NEMA 4
Display:	Backlit
A/D Resolution:	16 bit
Input Power:	120 VAC
RTD Input Accuracy:	≤0.06°F
Resolution:	≤0.02°F
Output Signal:	Frequency output
Operating Temp:	32°F to 120°F
Calculation Types:	Energy Consumption Mass Flow
Manufacturer:	EMCO Model FP-93B, KEP Supertrol II ES-749, or approved equal

STATIC STEAM PRESSURE SENSOR

Transmitters:	Two DP transmitters, Rosemount 3051 CD or Foxboro IDP10 Pipe Mounting Bracket and support pipe Factory calibrated with certificate

PART 3 - EXECUTION

WARRANTY
Provide a one year parts and labor warranty to include the meter, all hardware, and the installation.

PRE-INSTALLATION MEETING
Coordinate a pre-installation meeting before the meters are installed. This meeting shall occur at the jobsite, and include the Mechanical Contractor, BAS Contractor, meter manufacturer's representative, Design Engineer, and Northwestern FMO Instrumentation Specialist. Visit each proposed installation, confirm and mark the meter location, orientation, panel/processor location, etc.

STARTUP AND CALIBRATION
Configuration and Startup shall be provided by a factory certified representative of the meter manufacturer. The meter manufacturer's representative shall calibrate all points between the flow processor and end devices, and all points between the flow processor and BAS panel.

The meter manufacturer's representative shall work with the BAS contractor to provide the following services and properly document these actions:

1. Coordinate the weight of the flow processor's frequency output to the BAS panel. Clip negative flow rates to 0GPM prior to the BAS.

2. Generate a known system flow, and validate the accuracy of the pulse signal to the BAS panel by calculating the flow rate and/or energy consumption rate, and recording the values for both the flow processor and the BAS over the same fixed period of time. Compare these values for accuracy.

3. Simulate the maximum and minimum output of the 4-20mA signal(s) and verify proper scaling of at the BAS panel.

4. Insert RTDs in an ice bath and verify proper temperature input to the flow processor.

5. Verify the proper RTD value is being sent to the BAS panel.

POST-INSTALLATION MEETING
Coordinate a post-installation meeting after the meters are installed. This meeting shall occur at the jobsite, and include the Mechanical Contractor, BAS Contractor, meter manufacturers rep, Design Engineer, Northwestern FMO Chief Electrician, and Northwestern FMO Instrumentation Specialist and DDC Specialist.

The meter manufacturer's representative shall turn over all calibration information and startup tags to the Northwestern FMO Instrumentation Specialist. Review the accuracy of the As-Built documents in the field. Final payment will not be made until all documentation is complete.

GENERAL INSTALLATION
Mount all transducers, flow processors, and panels on a nearby wall in an accessible location. Provide plywood panels for mounting as needed.

WIRING AND ELECTRICAL

Equipment and devices shall comply with applicable standards of NEMA and shall be UL listed. All work shall comply with the National Electrical Code, and NFPA. Inspections of the installation by the Northwestern FMO Chief Electrician will be required at 50% and 95% completion, in addition to the review of the as-built documentation noted above.

All wiring and cables shall be in rigid conduit, except the last 36" at a flow processor or flow meter can be seal tight with plastic inserts. Minimum ¾" conduit. All conduit shall have 35% fill or less. Suspending conduit from mechanical devices and hangers is forbidden. No conduits shall be hung from the bottom of unistrut. All fittings shall be throated steel compression. All fire-rated wall and floor penetrations shall utilize stop fittings and appropriately rated sealers.

All 120 VAC power sources shall be from a single source, and only used for meters. Install new breakers in the panel box as required. Label the breaker on the panelboard directory. Directories shall be dated and type written, not hand printed.
In an existing building, a BAS panel circuit can be used for meters, as long as it is less than 70% loaded with the meters installed on that circuit.

Power wiring between the breaker panel and the flow processor shall be stranded 12 AWG with a 10 AWG neutral. All conduit shall be provided with a grounding wire. Provide an inline DIN mounted fuse in the flow processor, with appropriately sized fuse, and 16 AWG wiring between this fuse and the end device power terminals, as permissible by the size of the terminals on the end device.

All low voltage wiring shall be 3-conductor 18 AWG, twisted and shielded, and run in a separate, Blue conduit, not together with the 120 VAC. Wiring between the flow processor and the DDC panels shall be 18 AWG, twisted and shielded. Provide a 5ft whip in the DDC panel for final termination. The as-built documentation shall clearly identify whether this wiring is Class 1 or Class 2 in detail.

Use factory provided knock outs on all meter controller or processor panels. Drilling new penetrations into panels is not acceptable, unless pre-approved by the Northwestern FMO Instrumentation Specialist. Meter controller or processor panels shall not be used as junction boxes, and only wires pertaining to the device shall be contained within each panel.

TRENDS

The BAS Contractor shall setup 15 minute trends for all meters. Data shall be stored at the local BAS panel for a short period of time, and then be regularly offloaded to the main BAS server for long term trend storage. The offloading frequency shall have a safety factor built in so that data is not lost if the BAS panel is unreachable during the offload attempt.

The BAS shall totalize the meter inputs, and provide these values for current usage on a real-time (through time averaging where only pulses are input from the flow processor), daily, weekly, and monthly basis. Consult with Northwestern FMO DDC Specialist.

UNITS

Meters shall transmit usage using the following units. Scaling factors in powers of 10 are acceptable to achieve reasonable monthly pulse-counts.

1. Chilled Water — Ton-hours
2. Hot Water — 1000 btu
3. Steam — 1000 pounds
4. Domestic water — Gallons
5. Condensate — 1000 pounds

ALL FLOW METERS:

Install where indicated on the drawings and details for flow sensing in piping systems. Do not install close to elbows, valves, or other piping specialties which might affect the reading of the sensor. Follow the manufacturer's installation instructions to provide adequate upstream and downstream straight runs to provide accuracy specified for the meter. Contact the Architect or Engineer if design adjustments need to be made to provide enough room for a proper installation.

Follow the manufacturer's calibration procedure, document all settings, and turn over final documentation to Owner.

INSULATION

Provide insulation over each flow meter, and repair any insulation damaged during the installation. Provide manufactured insulation blankets to wrap around the steam meters, condensate meters, and heating hot water meters. Provide an insulation and vapor barrier around the chilled water ultrasonic transducers and clamps, and RTD bodies including all pipe-insert threads.

ULTRASONIC FLOW METERS

Minimum conduit size for transducer cables shall be 1 ½". Conduit shall be run within 2' of the transducers.

Transducers shall be installed on the supply piping.

VORTEX SHEDDING FLOW METERS

Condensate piping shall be Schedule 80 black steel. Install the meter a sufficient distance from the condensate pump to avoid damaging the flow element. The flow meter shall be installed in a vertical pipe on the leaving side of the condensate pump to ensure the flow element is in a flooded pipe. If a horizontal installation is required, install trap piping to ensure the meter stays in a flooded pipe. Maintain all manufacturer's required lengths of straight pipe upstream and downstream of the meter element.

DIFFERENTIAL PRESSURE FLOW METERS

Provide piping and hardware shown in Figure 1. Provide a 3-valve manifold per transmitter, diagram of manifold shown in Figure 2.

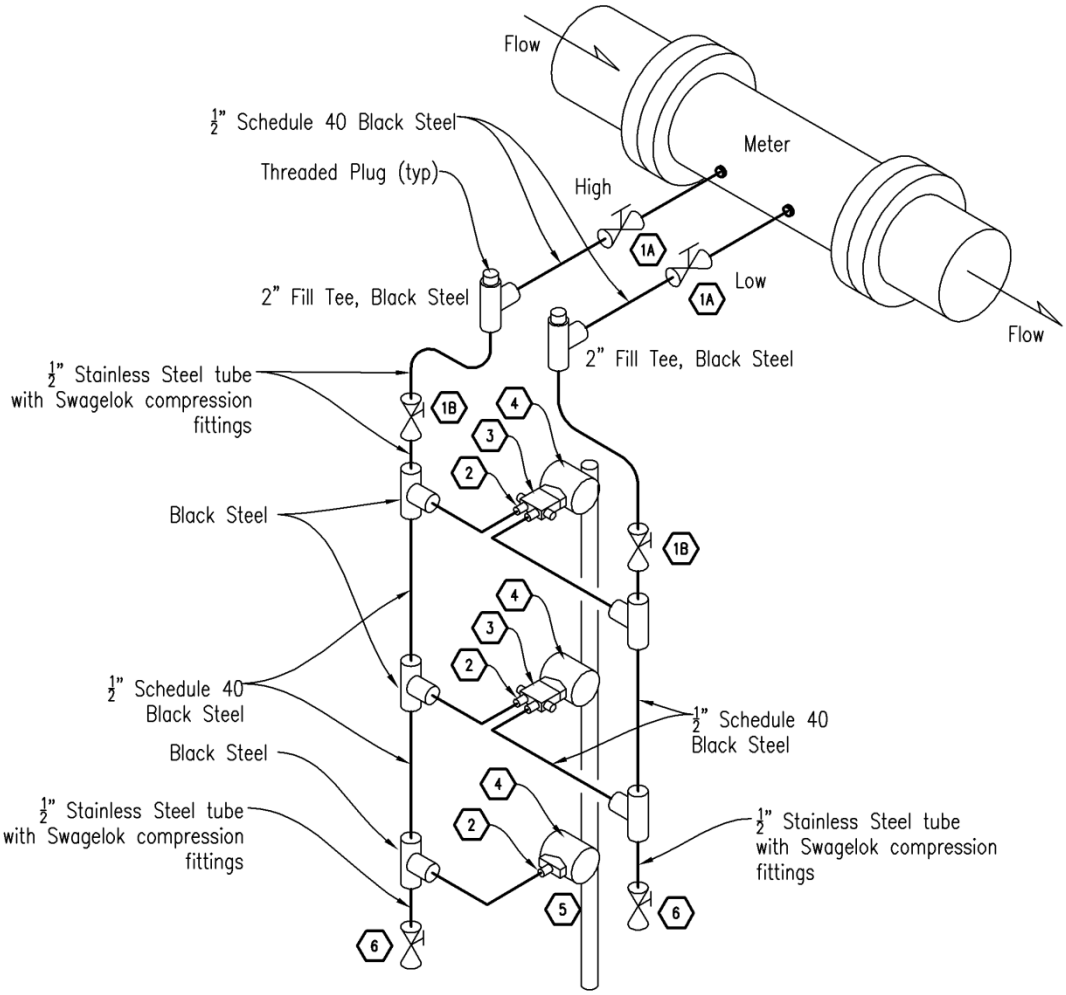


Figure 1: Pressure Transmitter Mounting Diagram

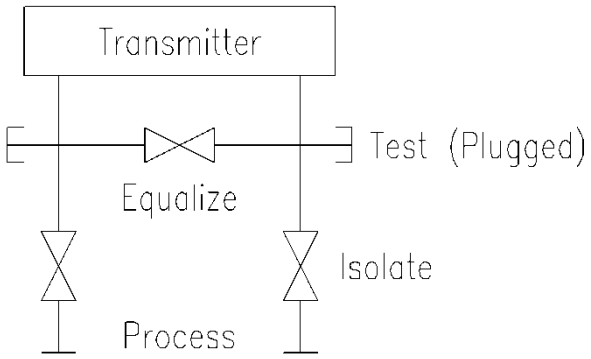


Figure 2: 3-Valve Manifold Diagram

MAGNETIC FLOW METERS

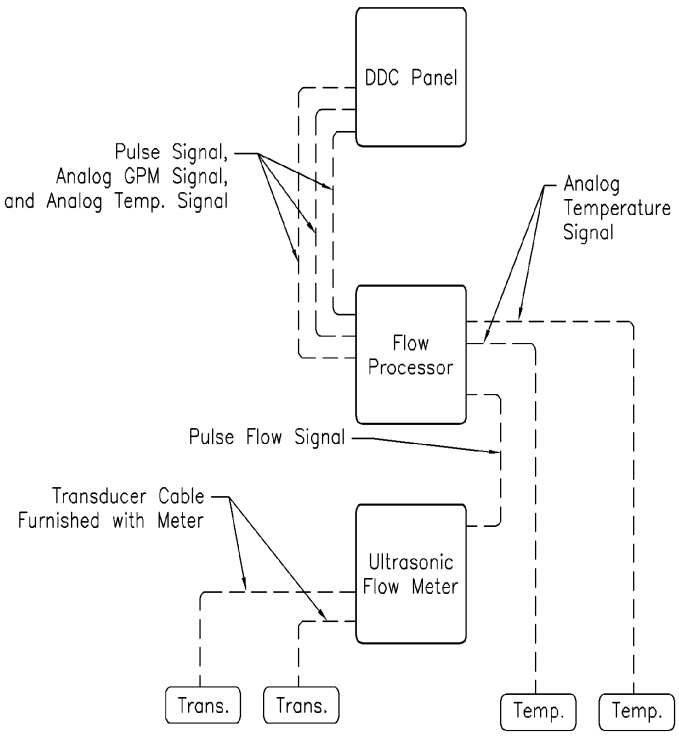
Reserved for future detailed installation notes in addition to manufacturers installation instructions.

POSITIVE DISPLACEMENT METERS

Condensate piping shall be Schedule 80 black steel. Install unions on either side of the meter. Do not insulate unions, strainers, condensate meter body, or check valves.

ENERGY CONSUMPTION METERS

Provide wiring and conduit between the flow meter, temperature sensors, and the flow processor. Validate the inputs to the flow processor are accurate, and the calculations performed are accurate per the requirements identified in the Startup and Calibration portion of this specification.



TEMPERATURE SENSORS

Temperature sensors shall be inserted to the center of the pipe. RTD taps shall not be installed in the bottom of pipes, unless approved by the Owner. Provide enough slack in the wiring and flexible conduit to allow for future full retraction and insertion of the temperature sensor element.

FLOW SWITCH

Install on each drain pipe at all condensate receiver tanks and where indicated on the drawings and details. Follow the manufacturer's installation instructions. Contact the Architect or Engineer if design adjustments need to be made to provide enough room for a proper installation.

The BAS Contractor shall configure each condensate drain flow switch to generate an alarm if the switch shows flow for more than 30 minutes. These alarms shall be routed to the Northwestern CUP.

Validate the flow switch indication transmits to the BAS panel and the alarm is properly transmitted. Submit results to the Owner.

FLOW PROCESSOR

Install the flow processor on a nearby wall in an accessible location. Provide field mounted terminal strips, installed in the back of the cabinet. Provide single ribbon cable with easy disconnect between the flow processor and terminal strip.. Provide painted plywood panel for mounting.

Connect auxiliary 4-20mA output(s) from the flow processor to an analog input(s) in a BAS panel.

GRAPHICS

BAS contractor to provide graphics displaying all information received from the system, including temperatures, pressures, real-time flow, totalized energy consumption for a billing period, pulse counts, and time-averaged pulse counts.

END OF SECTION