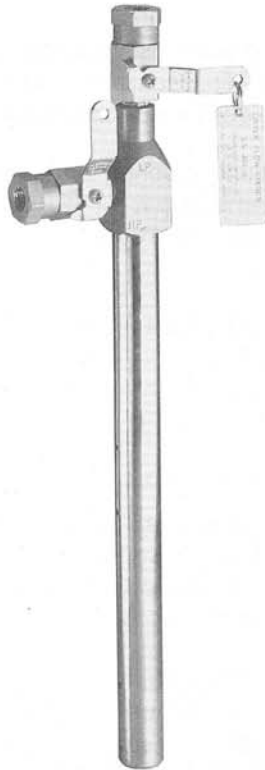## SERIES DS-400 FLOW SENSORS

Installation and Operating Instructions, Flow Calculations

INSPECTION

Inspect the sensor upon receipt of shipment to be certain it is as ordered and not damaged. If damaged, contact carrier.

INSTALLATION

General – The sensing ports of the flow sensor must be correctly positioned for measurement accuracy. The instrument connections on the sensor indicate correct positioning. The side connection is for total or high pressure and should be pointed upstream. The top connection is for static or low pressure.

Location – The sensor should be installed in the flowing line with as much straight run of pipe upstream as possible. This will provide a flow profile as ideal as possible. A rule of thumb is to allow 10-15 pipe diameters upstream and 5 down. The table below lists recommended up and down piping:

PRESSURE AND TEMPERATURE
Maximum 200 psig at 200°F.

UPSTREAM AND DOWNSTREAM DIMENSIONS IN TERMS OF INTERNAL DIAMETER OF PIPE
*SEE NOTE #1

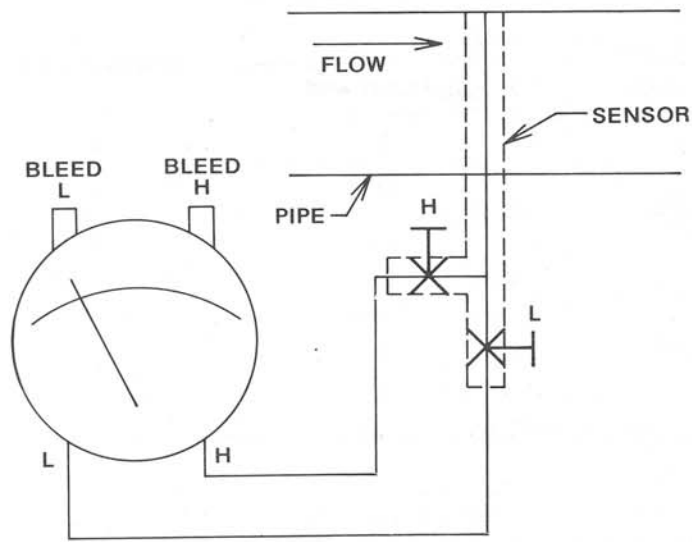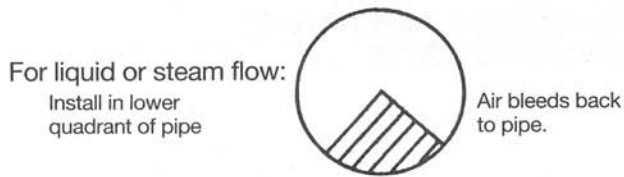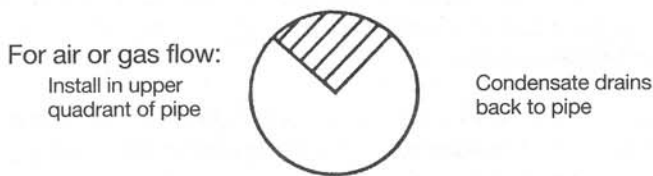| UPSTREAM CONDITION	MINIMUM DIAMETER OF STRAIGHT PIPE		
	UPSTREAM		DOWNSTREAM
	IN-PLANE	OUT-OF-PLANE	
One Elbow or Tee	7	9	5
Two 90° Bends in Same Plane	8	12	5
Two 90° Bends in Different Plane	18	24	5
Reducers or Expanders	8	8	5
All Valves *See Note 2	24	24	5

*Note #1: Values shown are recommended spacing, in terms of internal diameter for normal industrial metering requirements. For laboratory or high accuracy work, add 25% to values.

*Note #2: Includes gate, globe, plug and other throttling valves that are only partially opened. If valve is to be fully open, use values for pipe size change. CONTROL VALVES SHOULD BE LOCATED AFTER THE FLOW SENSOR.

POSITION

Be certain there is sufficient clearance between the mounting position and other pipes, walls, structures, etc, so that the sensor can be inserted through the mounting unit once the mounting unit has been installed onto the pipe.

Flow Sensors should be positioned to keep air out of the instrument connecting lines on liquid flows and condensate out of the lines on gas flows. The easiest way to assure this is to install the sensor into the pipe so that air will bleed into, or condensate will drain back to, the pipe.

For air or gas flow:
Install in upper quadrant of pipe

Condensate drains back to pipe

For liquid or steam flow:
Install in lower quadrant of pipe

Air bleeds back to pipe.

INSTALLATION

1. Attach a ¾" NPT female fitting, such as a thred-o-let or saddle clamp, to the piping in which flow will be measured. Note the required upstream and downstream conditions on page one which should be observed.

2. Drill a hole through the center of the attached fitting into the pipe with a bit that is slightly larger than the flow sensor diameter.

3. Install the packing gland using proper pipe sealant. If the packing gland is disassembled, note that the tapered end of the ferrule goes inside the fitting body.

4. Insert the sensor until it contacts the opposite wall of the pipe and then withdraw it $\frac{1}{16}$" for models -6 through -12 or $\frac{1}{8}$" for models -14 through -24. This is to allow for thermal expansion.

5. Tighten packing gland nut finger tight. Then tighten the nut with a wrench an additional 1¼ turns. Be sure to hold the sensor body with a second wrench to prevent the sensor from turning.

INSTRUMENT CONNECTION

Connect the side pressure tap to the high pressure port of the Magnehelic (air only) or Capsuhelic gage or transmitting instrument and the top connection to the low pressure port. See the connection schematics below.

Bleed air from instrument piping on liquid flows. Drain any condensate from the instrument piping on air and gas flows.

Open valves to instrument to place flow meter into service. For permanent installations, a 3-valve manifold is recommended to allow the gage to be zero checked without interrupting the flow. The Dwyer A-471 Portable Test Kit includes such a device.
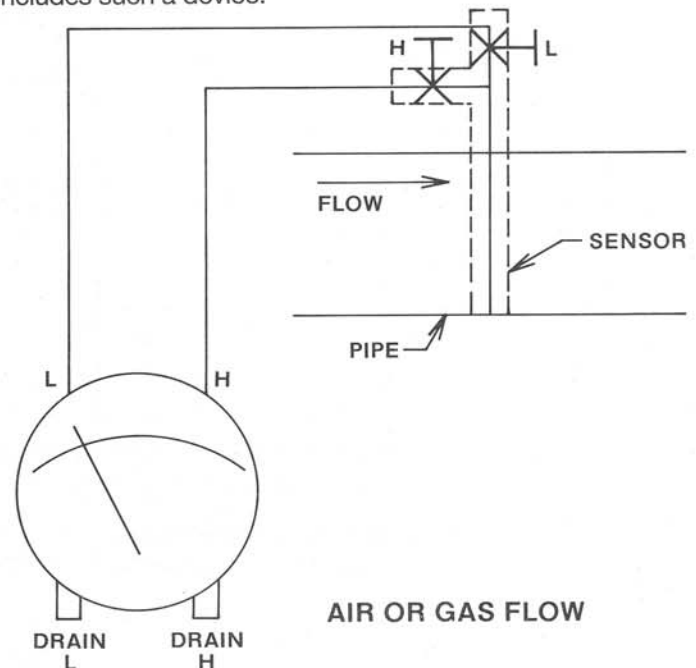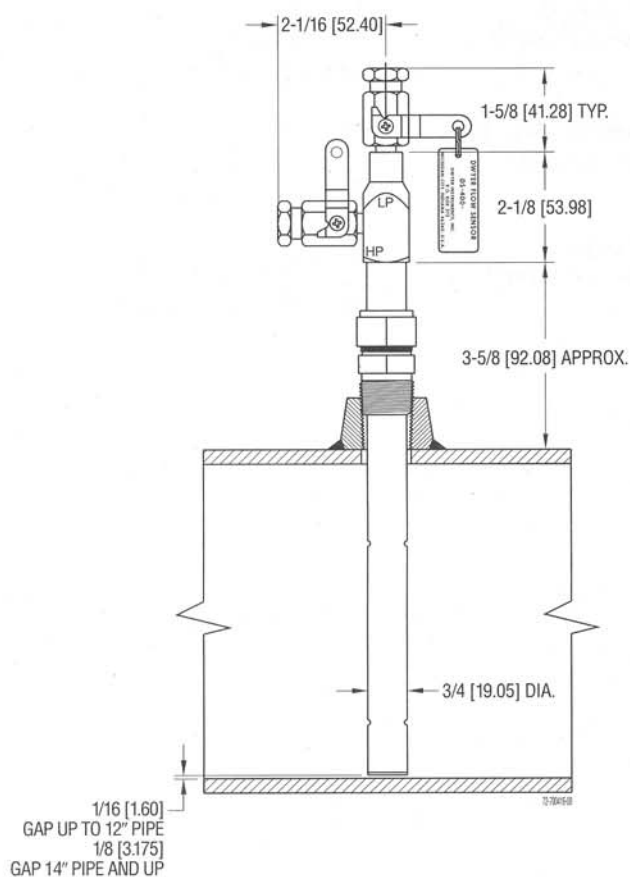
WATER FLOW

AIR OR GAS FLOW

SERIES DS-400 FLOW SENSORS

FLOW CALCULATIONS AND CHARTS

The following information contains tables and equations for determining the differential pressure developed by the DS-400 Flow Sensor for various flow rates of water, steam, air or other gases in different pipe sizes.

This information can be used to prepare conversion charts to translate the differential pressure readings being sensed into the equivalent flow rate. Where direct readout of flow is required, use this information to calculate the full flow differential pressure in order to specify the exact range of Dwyer Magnehelic or Capsuhelic gage required. Special ranges and calculations are available for these gages at minimal extra cost. See bulletin A-30 for additional information on Magnehelic and Capsuhelic gages.

For additional useful information on making flow calculations, the following reference is recommended: Crane Valve Co. Technical Paper No. 410 "Flow of Fluids Through Valves, Fittings and Pipe." It is available from Crane Valve Co., 104 N. Chicago St., Joliet, IL 60431. Phone 815/727-2600. Price including shipping is $20.00

Using the appropriate differential pressure equation from page 4, calculate the differential pressure generated by by the sensor under **normal** operating conditions of the system. Check the chart below to determine if this value is within the recommended operating range for the sensor. Note that the data in this chart is limited to standard conditions of air at 60°F (15.6°C) and 14.7 psia static line pressure or water at 70°F (21.1°C). To determine recommended operating ranges for other gases, liquids and/or operating conditions, consult the factory.

Note the column on the right side of the chart which defines velocity ranges to avoid. Continuous operation within these can result in damage to the flow sensor caused by excess vibration.

Pipe Size (Schedule 40 up to 20″. Std. wt. for 24″)	Flow Coefficient "K"	Operating Ranges Air @ 60°F & 14.7 psia (D/P Inches W.C.)	Operating Ranges Water @ 70°F (D/P Inches W.C.)	Velocity Ranges Not Recommended (Feet per Second)
6	.706	0.70 to 51	2.54 to 187	83 to 124
8	.675	0.64 to 28	2.31 to 102	53 to 79
10	.676	1.12 to 37	4.05 to 136	36 to 54
12	.683	0.19 to 20	0.70 to 72	26 to 40
14	.698	0.17 to 13	0.60 to 46	22 to 33
16	.688	3.78 to 56	13 to 203	17 to 26
18	.689	0.04 to 5.48	0.14 to 19	14 to 21
20	.686	0.39 to 4.93	1.40 to 17	11 to 17
24	.789	0.05 to 11	0.20 to 40	8 to 12

FLOW EQUATIONS

1. Any Liquid

$$Q \text{ (GPM)} = 5.668 \times K \times D^2 \times \sqrt{\triangle P / S_f}$$

2. Steam or Any Gas

$$Q \text{ (lb/Hr)} = 359.1 \times K \times D^2 \times \sqrt{p \times \triangle P}$$

3. Any Gas

$$Q \text{ (SCFM)} = 128.8 \times K \times D^2 \times \sqrt{\frac{P \times \triangle P}{(T+460) \times S_S}}$$

DIFFERENTIAL PRESSURE EQUATIONS

1. Any Liquid

$$\triangle P \text{ (in. WC)} = \frac{Q^2 \times S_f}{K^2 \times D^4 \times 32.14}$$

2. Steam or Any Gas

$$\triangle P \text{ (in. WC)} = \frac{Q^2}{K^2 \times D^4 \times p \times 128,900}$$

3. Any Gas

$$\triangle P \text{ (in. WC)} = \frac{Q^2 \times S_S \times (T+460)}{K^2 \times D^4 \times P \times 16,590}$$

TECHNICAL NOTATIONS

The following notations apply:

$\triangle P$ = Differential pressure expressed in inches of water column.

Q = Flow expressed in GPM, SCFM or PPH as shown in equation.

K = Flow coefficient — See Values Tabulated on page 3.

D = Inside diameter of line size expressed in inches. For square

& rectangular ducts use $D = \sqrt{\dfrac{4 \times \text{Height} \times \text{Width}}{\pi}}$

P = Static Line pressure (psia)

T = Temperature in degrees Fahrenheit (plus 460=°Rankin)

p = Density of medium in pounds per cubic foot

S_f = Sp Gr at flowing conditions

S_S = Sp Gr at 60°F

SCFM TO ACFM EQUATION

$$\text{SCFM} = \text{ACFM} \times \left(\frac{14.7 + \text{PSIG}}{14.7} \right) \left(\frac{520^*}{460 + {}^\circ F} \right)$$

$$\text{ACFM} = \text{SCFM} \times \left(\frac{14.7}{14.7 + \text{PSIG}} \right) \left(\frac{460 + {}^\circ F}{520} \right)$$

$$\text{POUNDS PER CUBIC FOOT STD.} = \text{POUNDS PER CUBIC FOOT ACT.} \times \left(\frac{14.7}{14.7 + \text{PSIG}} \right) \left(\frac{460 + {}^\circ F}{520} \right)$$

$$\text{POUNDS PER CUBIC FOOT ACT.} = \text{POUNDS PER CUBIC FOOT STD.} \times \left(\frac{14.7 + \text{PSIG}}{14.7} \right) \left(\frac{520}{460 + {}^\circ F} \right)$$

1 CUBIC FOOT OF AIR = 0.076 POUNDS PER CUBIC FOOT AT 60°F AND 14.7 PSIA

*(520 = 460 + 60°) Std. Temp. Rankine