Manual on Installation of Refinery Instruments and Control Systems

Part I—Process Instrumentation and Control
Section 1—Flow

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CONTENTS

Tables

Figures

SECTION 1—FLOW

1.1 Scope

This section presents recommended practices for installing differential pressure instruments and area flowmeters. These meters are commonly used to indicate, record, transmit, and control fluid flow.

Flow measurement falls into two broad classifications: refinery process flow measurement and custody transfer. This section is primarily concerned with process flow measurement. Liquid custody transfer is normally done with positive displacement meters or turbine meters, usually combined with meter proving equipment. Custody transfer flow measurement [1, 2, and 3] is covered in Chapters 4, 5, and 6 of the API *Manual of Petroleum Measurement Standards*.[1]

1.2 General

1.2.1 DIFFERENTIAL PRESSURE INSTRUMENTS

The differential-head type of instrument measures flow inferentially from the differential pressure caused by flow through a primary element. This differential pressure is sensed by diaphragms, bellows, or manometers. Transmitters of the force or motion type are either pneumatic or electronic. Electronic transmitters use strain gages, capacitance detectors, or other solid state detectors to provide output with minimal sensing element displacement.

Primary elements are generally one of the types described in 1.2.1.1 through 1.2.1.6.

1.2.1.1 Orifice

Orifices are usually thin concentric plates, but they may be eccentric, segmental, quadrant edge, or some other special form, depending upon their application.

1.2.1.2 Flow Nozzle

Flow nozzles are used in installations where higher velocity and moderately better pressure recovery are required than are obtainable with an orifice plate.

1.2.1.3 Venturi Tube

Venturi tubes are used in installations where high capacity and good pressure recovery are required or where the measured stream contains some solids.

1.2.1.4 Flow Tube

Flow tubes are used in installations where low pressure loss is a major consideration or where piping configurations are restrictive.

1.2.1.5 Pitot Tube

Generally, pitot tubes are used in installations where no appreciable pressure drop can be tolerated on high-volume flows, such as on cooling water. The accuracy of the measurement depends upon the determination of the average velocity from the velocity profile. An averaging pitot tube is also available.

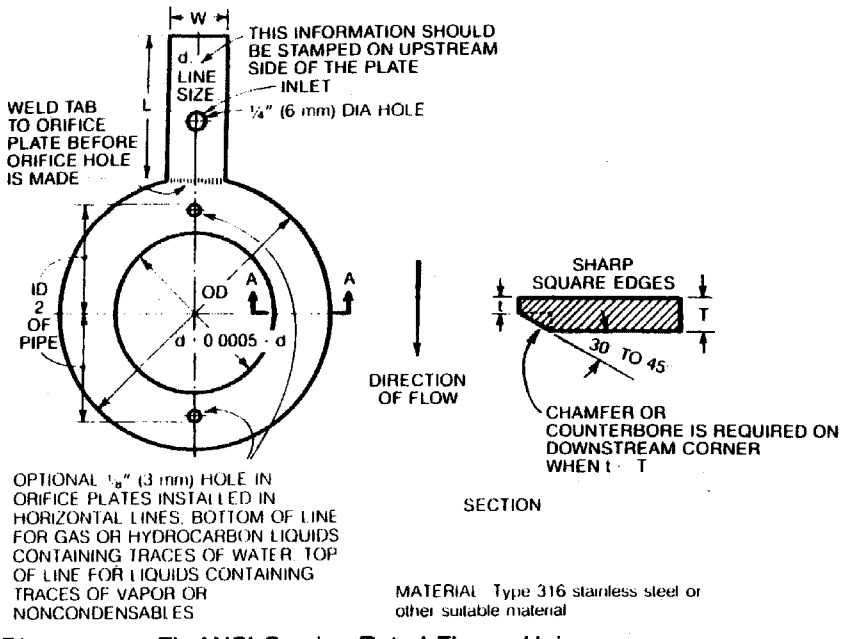
1.2.1.6 Elbow Taps

Elbow taps are used in installations where the velocity is sufficient and where high accuracy is not required [4]. Although they are less accurate than other differential pressure instruments, elbow taps possess good repeatability. A water velocity of 17 feet per second (5 meters per second) will produce a water differential of approximately 100 inches (2500 millimeters). Some test data are available [5, 6].

1.2.2 VARIABLE AREA FLOWMETERS

For refinery service, rotameters are the most commonly used meters in the area class.

[1]Bracketed numbers indicate references to be found on pages 27 and 28.



Orifice Plate Outside Diameters to Fit ANSI Service Rated Flange Unions

Nominal Pipe Size	T	t	CLASS 300	600	900	1500	2500	TAB L	TAB W
2	⅛	1/32	4⅜	4⅜	5⅝	5⅝	5¾	4	¾
3	⅛	1/32	5⅞	5⅞	6⅝	6⅞	7¾	4	¾
4	⅛	1/16	7⅛	7⅝	8⅛	8¼	9¼	6	1
6	⅛	3/32	9⅞	10½	11⅜	11⅛	12½	6	1
8	⅛	⅛	12⅛	12⅝	14⅛	13⅞	15¼	6	1
10	¼	3/16	14¼	15¾	17⅛	17⅛	18¾	6	1
12	¼	7/32	16⅝	18	19⅝	20½	21⅝	6	1
14	¼	7/32	19⅛	19⅜	20½	22¾		6	1
16	⅜	9/32	21¼	22¼	22⅝	25¼		6	1
18	⅜	9/32	23½	24⅛	25⅛	27¾		6	1
20	⅜	⅜	25¾	26⅞	27½	29¾		7	1
24	⅜	⅜	30½	31⅛	33	35½		7	1

NOTES:

1. All measurements in inches.
2. The outside diameter (OD) of the orifice plate is that required to fit inside the bolts of standard ANSI flanges. The outside diameter is equal to the diameter of bolt circle minus the nominal diameter of bolt, within a manufacturing tolerance of +0 inches, −1/32 inch (+0 millimeters, −.8 millimeters).
3. For orifice plate outside diameters in flange sizes and ratings not listed above, refer to gasket OD dimensions given under Figure 3, Table 1, Appendix E in ANSI B 16.5—1981, *Steel Pipe Flanges and Flanged Fittings*, available from the American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.
4. The upstream face of the orifice plate shall be as flat as can be obtained commercially; any plate departing from flatness along any diameter more than 0.010 per inch (.25 millimeters) of dam height, $(D-d)/2$, shall be unacceptable. Surface roughness shall not exceed 50 microinches in a band at least 0.25 diameter wide around the orifice bore.
5. All seating surfaces for spiral-wound gaskets should be clean and free of rust, burrs, nicks, and so forth. Any surface not meeting the following tolerances should be relapped:
   (a) Roughness: Should not exceed 80 root mean square with 63 root mean square or better as optimum.
   (b) Flatness: Out-of-plane tolerances must not exceed 0.0025 inch (0.06 millimeter). The cumulative out-of-flatness for two mating surfaces shall not exceed 0.0040 inch (0.1 millimeter).

Figure 1-1—Concentric Orifice Plate