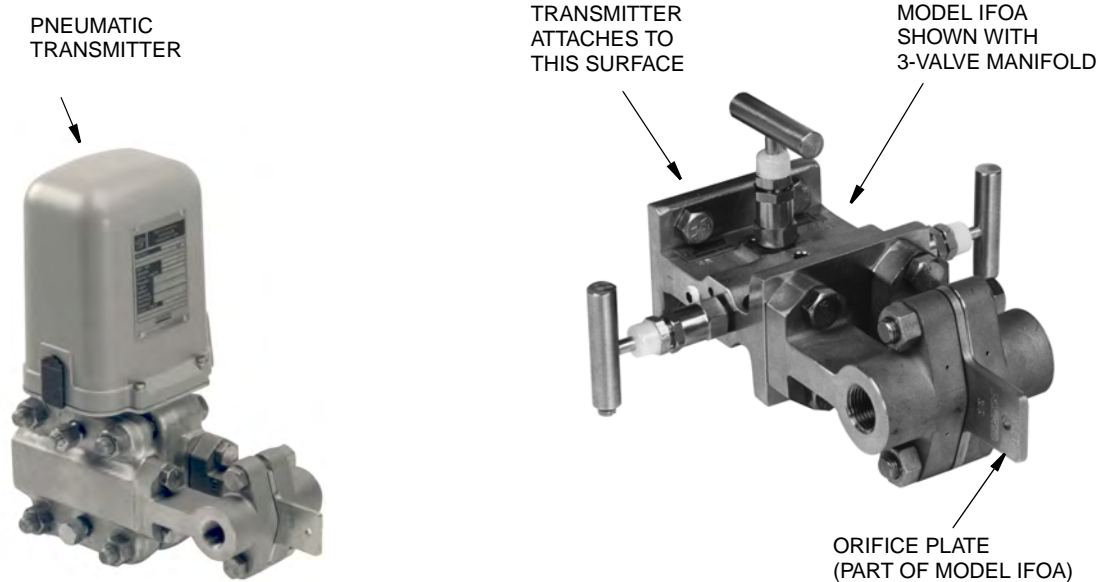


Model IFOA
Integral Flow Orifice Assembly
Used with I/A Series® or Pneumatic d/p Cell Transmitters



The Foxboro® brand Model IFOA Integral Flow Orifice Assembly is available from Invensys Process Systems (IPS). It is used in combination with a Foxboro I/A Series or Pneumatic d/p Cell Transmitter to accurately measure liquid, gas, or steam flow in 1/2 in, 1 in, and 1 1/2 in (approximately DN 15, DN 25, and DN 40) size pipes.

The Model IFOA Integral Orifice Assembly in combination with Foxboro d/p Cell Transmitters uses the differential pressure created by the orifice to measure, with high accuracy, process flows in 1/2 in, 1 in, and 1 1/2 in size pipes.

This integral flow orifice assembly features:

- ▶ Very high accuracy when equipped with associated piping.
- ▶ Process-wetted materials available for use with both corrosive and noncorrosive fluids.
- ▶ Various process pipe end connections available.
- ▶ Can be used with any differential pressure transmitter having standard process connections. The transmitter can be either integrally coupled or remotely connected.
- ▶ A 3-Valve Manifold is recommended for mounting between the Model IFOA and transmitter.
- ▶ Process-wetted material meets NACE Standard MR-01-75.
- ▶ Self-centering orifice plate design.
- ▶ No-flow-through transmitter body.
- ▶ Orifice plate manufacture consistent with ASME, ISO, and AGA-3 standards.

CONVENIENT SIZING

The Model IFOA is suitable for liquid, gas, and steam applications. By choosing the correct combination of assembly size and orifice bore, almost any desired flow rate, with either turbulent or laminar flow conditions, can be measured.

Using flow data supplied by the user at the time the order is placed for the Model IFOA and the transmitter, IPS supplies a flow calculation and specification sheet with the orifice assembly.

This sheet lists complete transmitter-orifice assembly flow data for the user's process. If the user wishes, he can obtain the required differential pressure range or orifice bore himself by using the FlowExpertPro™ sizing program. See paragraph that follows.

FlowExpertPro™

FlowExpertPro is a program primarily used to size Foxboro flowmeters. It also ensures that the user has selected the proper flowmeter for his application. IPS provides this meter selection tool as a free web site to all users, without the need for registration. In addition to flowmeter selection and sizing, FlowExpertPro includes the following features:

- ▶ Incorporates a large library of the physical properties of typical process fluids.
- ▶ Displays results in tabular or graphic format.
- ▶ Allows user to save, print, or E-mail results.
- ▶ Provides reference to applicable flowmeter PSSs and other related flowmeter documentation.

The program calculates minimum and maximum flow rates, rangeability, pressure loss, and Reynolds Number, using established flow equations. It also allows for material and flange selection, and provides ANSI or metric flange recommendations for predicted flow pressure and temperature. You are invited to visit www.FlowExpertPro.com to access this program, or contact IPS for further information and technical support.

HANDLES WIDE RANGES OF FLOW RATES

The flow rate ranges handled by these integral orifice flow assemblies (each range depends on the specific combination of assembly size and orifice bore) are those frequently found in chemical and petrochemical plants, research projects, and high-accuracy metering applications.

In addition, the very low flow rates that the 1/2 in size can measure can be further extended by using an orifice plate with a jewel insert. This insert can have an orifice diameter as small as 0.0508 mm (0.0020 in) and permits measurement of extremely low flow rates. The approximate measurement range of each orifice assembly size is listed in Table 4.

HIGHLY ACCURATE MEASUREMENTS

The orifice assembly can be supplied with associated piping welded to it. This piping can have a variety of end connections (for installation into the user's process piping). All essential parts are bored to assure a precise inside diameter which is highly concentric with the orifice bore. This permits a Beta ratio (ratio of orifice bore to pipe ID) that is tightly controlled. The results are measurements that are far more accurate than could otherwise be obtained.

AVAILABLE IN A VARIETY OF MATERIALS, SIZES, AND CONFIGURATIONS

The orifice plate and body assembly are available in several metals to meet the requirements of almost any process, including NACE material standards. (Only AISI Type 316 stainless steel [316 ss] construction is available when the orifice assembly is supplied with associated piping.) The assembly is available in 1/2 in, 1 in, or 1 1/2 in pipe sizes. The process piping can be either screwed or welded to the body.

Several standard orifice bore diameters are available for each assembly size. In addition, non-standard bore sizes, between Beta ratio limits of 0.1 and 0.8, can be supplied. See Table 2.

REMOTE CONNECTORS

If the temperature of the process fluid exceeds the temperature limit of the transmitter (so that the transmitter must be mounted away from the orifice assembly), or, if for other reasons, it is desirable to locate the transmitter elsewhere, optional connectors are available for remote-mounting the transmitter.

SIMPLIFIED INSTALLATION

The orifice assembly becomes part of the process piping. The transmitter is bolted directly onto the orifice assembly; thus, no transmitter piping is required.

The transmitter can be isolated or bypassed by the addition of a three-valve bypass manifold. This permits the zeroing, calibration check, and maintenance of the transmitter without either interrupting the flow or removing the integral orifice assembly from the process line. Both the bypass manifold and the transmitter are bolted together as a unit, and the pair is mounted directly onto the orifice assembly. Refer to PSS 2B-1Z2 A for a listing of manifolds offered.

FUNCTIONAL SPECIFICATIONS

Pressure-Temperature Ratings

Refer to Table 1.

Table 1. Pressure-Temperature Ratings (a)(b)

Assembly Line Size	End Connection	Pressure-Temperature Rating	
		MPa and °C	psi and °F
1/2 in	Welded	20.7 MPa from -40 to +40°C 15.9 MPa at 150°C	3000 psi from -40 to +100°F 2300 psi at 300°F
	Threaded	10.0 MPa from -40 to +40°C 8.1 MPa at 150°C	1500 psi from -40 to +100°F 1180 psi at 300°F
	Flanged (b)	Flange Rating up to 150°C	Flange Rating up to 300°F max.
1 in	Welded	13.8 MPa from -40 to +40°C 10.7 MPa at 150°C	2000 psi from -40 to +100°F 1550 psi at 300°F
	Threaded	10.3 MPa from -40 to +40°C 8.1 MPa at 150°C	1500 psi from -40 to +100°F 1180 psi at 300°F
	Flanged (b)	Flange Rating up to 150°C max.	Flange Rating up to 300°F max.
1 1/2 in	Welded	9.9 MPa from -40 to +40°C 7.7 MPa at 150°C	1440 psi from -40 to +100°F 1120 psi at 300°F
	Threaded	9.9 MPa from -40 to +40°C 7.7 MPa at 150°C	1440 psi from -40 to +100°F 1120 psi at 300°F
	Flanged (b)	Flange Rating up to 150°C max.	Flange Rating up to 300°F max.

(a) Low temperature limit is -40°C (-40°F). The lowest rating of any component of the system (IFOA, piping, or transmitter) is the maximum allowable rating of the system.

(b) Pressures correspond to ANSI Class 600 flange ratings unless otherwise noted.

FUNCTIONAL SPECIFICATIONS (CONT.)

Remote Pressure Connectors

If the process temperature is higher than the temperature rating of the transmitter, remote connectors (see Model Code section) are available to mount transmitter away from orifice assembly. However, the temperature of transmitter must not exceed its rating. The remote connectors are provided with the necessary bolts and gaskets. Two sets are required: one set is provided with the orifice assembly and one set with the transmitter. Connecting piping is supplied by the user.

Mounting

The orifice assembly is inserted into the user's process line and becomes a permanent part of the piping. The transmitter bolts onto the orifice assembly body. If optional remote connectors are used, the transmitter can be located away from the orifice assembly.

Pressure Taps

Corner

Orifice Inlet Edge

BORE DIAMETER UP TO 1.5 mm (0.06 in)

Quadrant edge

BORE DIAMETER ABOVE 1.5 mm (0.06 in)

Square edge

Pipe Bores

Ass'y Line Size in	Pipe Sched.	With Assoc. Piping (a)		Without Assoc. Piping (b)	
		mm	in	mm	in
1/2	40	16.76	0.660	15.80	0.622
1	40	27.76	1.093	26.64	1.049
1 1/2	80	39.65	1.561	38.10	1.500

(a) When piping is supplied by Invensys Process Systems, ID of both ends of pipe at orifice assembly is precision bored to indicated diameters.

(b) When pipe is supplied by user, nominal ID of commercial size is indicated.

Orifice Bores

Refer to Table 2.

Table 2. Standard and Nonstandard IFOA Orifice Bore Beta Ratios (β); Based on Pipe Supplied by IPS

Type Orifice Plate		Beta Ratios for the Following Orifice Assembly Size								
		1/2 in			1 in			1 1/2 in		
		Orifice Bore		Beta Ratio	Orifice Bore		Beta Ratio	Orifice Bore		Beta Ratio
		mm	in		mm	in		mm	in	
With Standard Bore Diameters		0.508	0.0200	0.03030	6.15	0.242	0.2214	9.70	0.382	0.2447
		0.889	0.0350	0.05303	8.66	0.341	0.3120	13.67	0.538	0.3447
		1.524	0.0600	0.09091	12.14	0.478	0.4373	19.08	0.751	0.4811
		2.54	0.100	0.1515	16.64	0.655	0.5993	25.86	1.018	0.6521
		4.06	0.160	0.2424	21.13	0.832	0.7612	29.97	1.180	0.7559
		6.35	0.250	0.3788	—	—	—	—	—	—
		8.89	0.350	0.5303	—	—	—	—	—	—
With Nonstandard Bore Diameters	All Metal	Sizes between Beta ratio limits of 0.1 and 0.8 can be supplied.								
	Jewel Insert (a)	Beta ratios between 0.00303 and 0.0227			—	—	—	—	—	—

(a) Available in bore diameters from 0.0508 to 0.318 mm (0.0020 to 0.0150 in) in increments of 0.0254 mm (0.0010 in).

FUNCTIONAL SPECIFICATIONS (CONT.)

Process End Connections

ASSEMBLY WITHOUT ASSOCIATED PIPING

Body connections for 1/2 in, 1 in, or 1 1/2 in pipe; NPT or R_C pipe tap, or prepared for socket welding, as specified.

ASSEMBLY WITH ASSOCIATED PIPING

1/2 in, 1 in, or 1 1/2 in pipe is welded to body; outer ends are either threaded (NPT or R),

prepared for welding, or flanged (ANSI; Class 150, 300, or 600), as specified.

Pipe lengths are approximately 18 pipe diameters upstream and 7 pipe diameters downstream.

PERFORMANCE SPECIFICATIONS

(Refer to associated transmitter specifications for transmitter accuracy)

Flow Coefficient Uncertainty

Table 3 lists flow coefficient uncertainties at various orifice bore Reynolds Numbers when using standard

bore orifice plates. The flow coefficient uncertainty can be reduced by a laboratory flow calibration of the orifice assembly. Refer to IPS for details.

Table 3. Flow Coefficient Uncertainty for Standard Bore Orifice Plates

Assembly Line Size	Beta Ratio	Orifice Bore Reynolds Number (R_D)	Uncertainty with Associated Piping	Uncertainty without Associated Piping (a)
1/2 in (Quadrant Edge)	0.03030 to 0.09091	<1500	±5%	±5%
		≥1500	±3%	±5%
1/2 in (Square Edge)	0.1515	< 500	±5%	±5%
	0.2424 to 0.5303	≥1500	±1.25%	±2.5%
1 in (Square Edge)		0.2214 to 0.5993	<1500	±5%
	≥1500		±0.75%	±1.5%
1 1/2 in (Square Edge)	0.7612	<1500	> ±5%	> ±5%
		1500 ≤ R_D < 10 000	±5%	±5%
1 1/2 in (Square Edge)	0.2447 to 0.4811	<1500	±5%	±5%
		≥1500	±0.75%	±1.5%
1 1/2 in (Square Edge)	0.6521 to 0.7559	< 1500	> ±5%	> ±5%
		1500 ≤ R_D < 10 000	±5%	±5%
		≥10 000	±1.5%	±3%

(a) Using Schedule 40 pipe for 1/2 and 1 in sizes, and Schedule 80 pipe for 1 1/2 in size.

PERFORMANCE SPECIFICATIONS (CONT.)

Measurement Range

See Table 4 and also refer to FlowExpertPro.

Table 4. Approximate Measurement Range

Orifice Assembly Size	Flow Limit	Water Flow Rate Limits at 5.6°C (60°F)			Air Flow Rate Limits at 15°C and 101.3 kPa (59°F and 14.7 psia)		
		U.S. gpm	L/s	L/min	ft ³ /min	ft ³ /hr	m ³ /hr
1/2 in	Minimum	0.000045	0.0000028	0.00017	0.00018	0.011	0.00031
	Maximum	30	1.92	115	83.3	5000	140
1 in	Minimum	0.1	0.00667	0.4	0.367	22	0.6
	Maximum	100	6.67	400	367	22 000	600
1 1/2 in	Minimum	0.2	0.0133	0.8	0.75	45	1.3
	Maximum	200	13.3	800	750	45 000	1300

PHYSICAL SPECIFICATIONS

Material of Construction

See Table 5.

Table 5. Materials of Construction

Part	Material	ASTM Designation
Orifice Plate 4.2 mm (0.167 in) thick	316 ss Hastelloy™ C Monel™	A-240 B-626 B-127
Body (a)	316 ss Hastelloy C (Grade CW-2M)	A-351-CF8M A-494
Bolts	Gr. B7 (standard) (b) Gr. B7M (NACE) (b) 17-4 PH	A-193 A-193 A-564
Nuts	Gr. 2H (with B7 bolts) (b) Gr. 2HM (with B7M bolts) (b) 17-4 PH	A-194-2H A-194-2HM A-564
Gasket	Glass reinforced ptfe (Chemloy™)	–
With Associated Piping or Optional Remote Connectors		
Pipe (c)	316 ss	A-312
Pipe Flanges	316 ss	A-182-F316
Remote Connectors	316 ss Hastelloy C-276	A-182-F316 B-564

(a) 316 ss only with associated piping.

(b) Alloy steel.

(c) 1/2 and 1 inch pipes are Schedule 40; 1 1/2 inch pipe is Schedule 80.

PHYSICAL SPECIFICATIONS (CONT.)

Orifice Plate Identification

One side of the handle has “INLET” and the plate material stamped on it; the other side has the part number and bore diameter.

Approximate Mass

Assembly Line Size	Without Piping		With Piping and Flanges	
	kg	lb	kg	lb
1/2 in	2	4	3	7
1 in	2.5	5	5.5	12
1 1/2 in	3.5	8	12	26

OPTIONAL SELECTIONS

Description	AS Reference
Kit of standard-bore orifice plates 7 plates, 1/2 inch size assembly, in Monel 7 plates, 1/2 inch size assembly, in 316 ss 5 plates, 1 inch size assembly, in 316 ss 5 plates, 1 1/2 inch size assembly, in 316 ss	IFOA-KIT-A IFOA-KIT-B IFOA-KIT-C IFOA-KIT-D
Oxygen service cleaning	OS-W
NACE Standard MR-01-75 compliance for process-wetted parts only	MR-01
NACE Standard MR-01-75 compliance for Class II body bolting	B7M
17-4 PH body bolting	SSB

MODEL CODE

<u>Description</u>	<u>Model</u>
Integral Flow Orifice Assembly	IFOA
<u>Assembly Line Size</u>	
1/2 in (15 mm)	-0H
1 in (25 mm)	-01
1 1/2 in (40 mm)	-1H
<u>Body Material</u>	
316 ss	S
Hastelloy C (Grade CW-2M)	H
<u>End Connections</u>	
Without Associated Piping	
Socket Weld	1
Threaded (NPT)	2
R _c threaded (internal)	8
With Associated Piping; 316 ss parts only	
Prepared for Welding	3
Threaded (NPT)	4
Class 150 Flanges	5
Class 300 Flanges	6
Class 600 Flanges	7
R threaded (external)	9
<u>Orifice Plate Material</u>	
Hastelloy C	H
Monel	M
316 ss	S
<u>Orifice Plate Bore - 1/2 inch Line Size (a)</u>	
0.508 mm (0.0200 in)	A
0.889 mm (0.0350 in)	B
1.524 mm (0.0600 in)	C
2.54 mm (0.100 in)	D
4.06 mm (0.160 in)	E
6.35 mm (0.250 in) ^f	F
8.89 mm (0.350 in)	G
Jewel insert, bored as specified between 0.0508 and 0.381 mm (0.0020 and 0.0150 in)	U
Bored as specified between Beta ratios of 0.1 and 0.8	V
<u>Orifice Plate Bore - 1 inch Line Size (a)</u>	
6.15 mm (0.242 in)	H
8.66 mm (0.341 in)	J
12.14 mm (0.478 in)	K
16.64 mm (0.655 in)	L
21.13 mm (0.832 in)	M
Bored as specified between Beta ratios of 0.1 and 0.8	V
<u>Orifice Plate Bore - 1 1/2 inch Line Size (a)</u>	
9.70 mm (0.382 in)	N
13.67 mm (0.538 in)	P
19.08 mm (0.751 in)	R
25.86 mm (1.018 in)	S
29.97 mm (1.180 in)	T
Bored as specified between Beta ratios of 0.1 and 0.8	V

Model Code continued on next page.

MODEL CODE (CONT.)

<u>Description (Cont.)</u>	<u>Model</u>
<p>Optional Selections See Descriptions below.</p>	
<p>Remote Connectors Tapped for 1/2 NPT Tapped for R 1/2</p>	<p>-1 -2</p>
<p>Remote Connector Material (Select only with -1 or -2 Connector) 316 ss Hastelloy C</p>	<p>-S -H</p>
<p>Example: IFOA-01S13SJ-1S</p>	

(a) Select orifice plate bore for either 1/2 in, 1 in, or 1 1/2 in line size only.

DIMENSIONS - NOMINAL

**mm
in**

ASSEMBLY WITHOUT ASSOCIATED PIPING

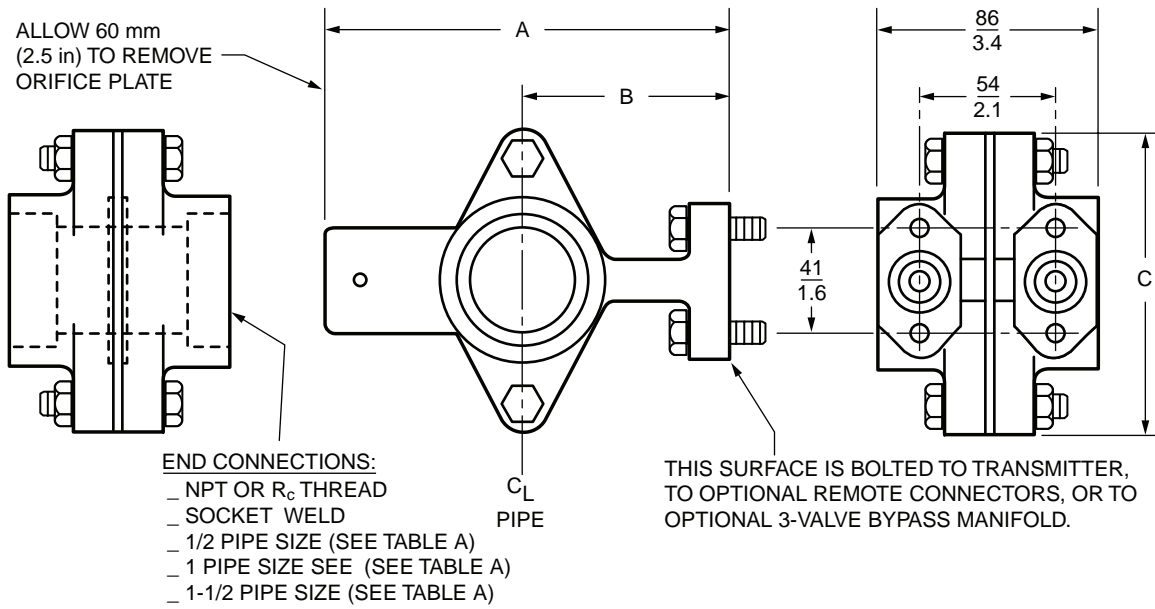


Table A. Socket Weld End of Pipe

ASSEMBLY LINE SIZE	PIPE			SOCKET DEPTH	
	MACHINE O.D. TO		SCHD	mm	in
	mm (a)	in (b)			
1/2	20.32	0.800	40	12.70	0.500
1	32.39	1.275	40		
1 1/2	47.24	1.860	80		

Table B. Assembly Dimensions

ASSEMBLY LINE SIZE	DIMENSION					
	A		B		C	
	mm	in	mm	in	mm	in
1/2	124	4.9	70	2.8	86	3.4
1	135	6.3	76	3.0	97	3.8
1 1/2	150	5.9	81	3.2	117	4.6

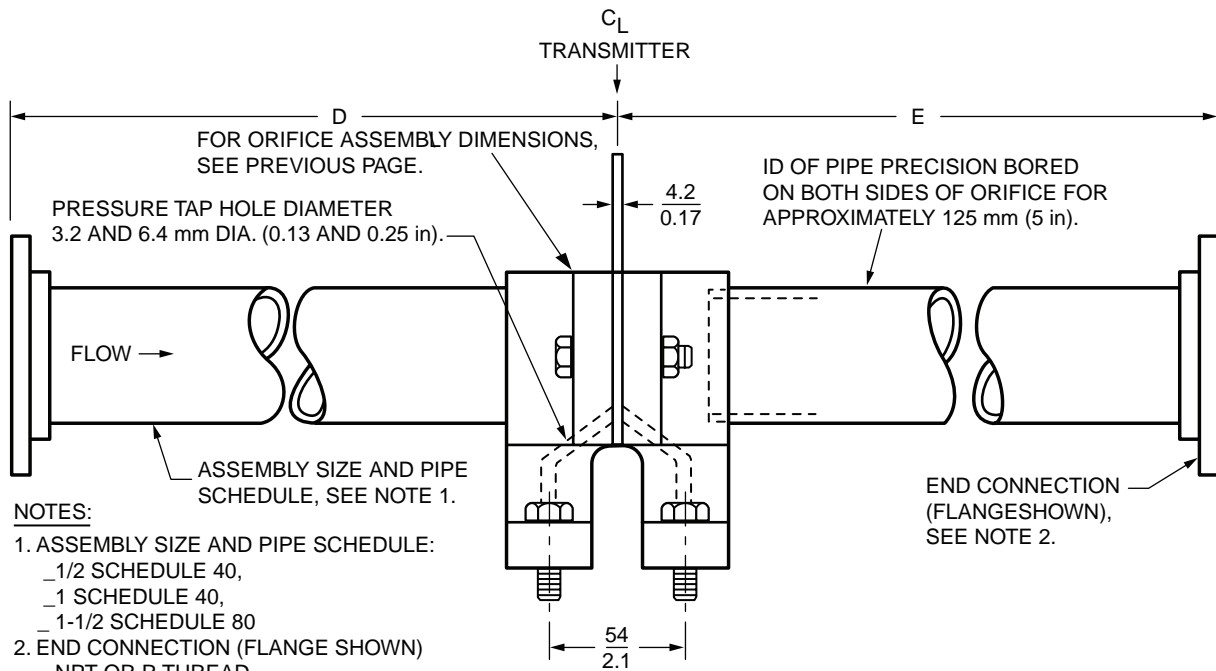
(a) Tolerance is +0, -0.13 mm.

(b) Tolerance is +0, -0.005 in.

DIMENSIONS - NOMINAL (CONT.)

$\frac{\text{mm}}{\text{in}}$

ASSEMBLY WITH ASSOCIATED PIPING



NOTES:

1. ASSEMBLY SIZE AND PIPE SCHEDULE:
 - _ 1/2 SCHEDULE 40,
 - _ 1 SCHEDULE 40,
 - _ 1-1/2 SCHEDULE 80
2. END CONNECTION (FLANGE SHOWN)
 - _ NPT OR R THREAD
 - _ WELDING,
 - _ 150 FLANGE CLASS
 - _ 300 FLANGE CLASS
 - _ 600 FLANGE CLASS

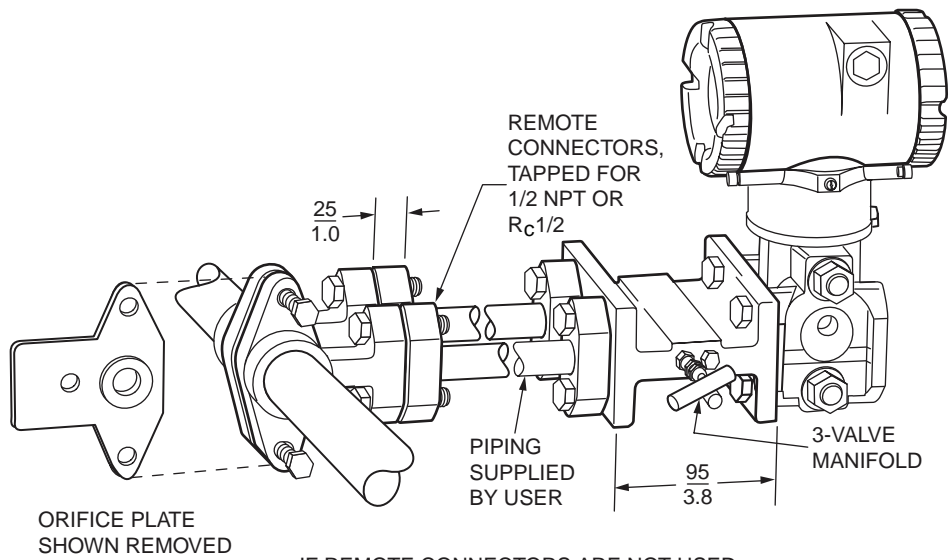
Assembly with Associated Piping

ASSEMBLY LINE SIZE	WITH FLANGE				WITHOUT FLANGE			
	D		E		D		E	
	mm	in	mm	in	mm	in	mm	in
1/2	318	12.5	145	5.7	315	12.4	142	5.6
1	513	20.2	221	8.7	510	20.1	218	8.6
1 1/2	721	28.4	302	11.9	716	28.2	297	11.7

DIMENSIONS - NOMINAL (CONT.)

$\frac{\text{mm}}{\text{in}}$

ASSEMBLY WITH OPTIONAL REMOTE CONNECTORS
AND A 3- VALVE BYPASS MANIFOLD



IF REMOTE CONNECTORS ARE NOT USED,
MANIFOLD BOLTS DIRECTLY ONTO ORIFICE ASSEMBLY.

ORDERING INSTRUCTIONS

1. Model Number
2. Complete flow data if IPS is to make calculations
3. Optional Selections (specify AS Reference Code)
4. Optional three-valve manifold (refer to PSS 2B-1Z2 A)
5. Tag (user data)

OTHER M&I PRODUCTS

IPS provides a broad range of measurement and instrument products, including solutions for pressure, flow, analytical, positioners, temperature, controlling and recording. For a listing of these offerings, visit the IPS web site at:

www.ips.invensys.com



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