



## Designation: D8000 – 15 (Reapproved 2020)

# Standard Practice for Flow Conditioning of Natural Gas and Liquids<sup>1</sup>

This standard is issued under the fixed designation D8000; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This practice covers flow conditioners that produce a fully developed flow profile for liquid and gas phase fluid flow for circular duct sizes 1- to 60-in. (25.4- to 1525-mm) diameter and Reynolds Number (Re) ranges from transition (100) to 100 000 000. These flow conditioners can be used for any type of flow meter or development of a fully developed flow profile for other uses.

1.2 The central single-hole configuration that is derived using fundamental screen theory is referenced as the flow conditioner described herein.

1.3 Piping lengths upstream and downstream of a flow conditioner are considered a critical component of a flow conditioner and constitute the complete flow conditioner system.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

### 2. Referenced Documents

2.1 ASTM Standards:<sup>2</sup>

D4150 Terminology Relating to Gaseous Fuels

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee D03 on Gaseous Fuels and is the direct responsibility of Subcommittee D03.12 on On-Line/At-Line Analysis of Gaseous Fuels.

Current edition approved Nov. 1, 2020. Published December 2020. Originally approved in 1986. Last previous edition approved in 2015 as D8000 – 15. DOI: 10.1520/D8000-15R20.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

2.2 AGA Standard:<sup>3</sup>

AGA Report No. 8 Compressibility Factor of Natural Gas and Related Hydrocarbon Gases

### 3. Terminology

3.1 Refer to Terminology D4150 for general definitions related to gaseous fuels. Definitions specific to this standard follow.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *annuli, n*—ring-shaped object, structure, or region.

3.2.2 *axial symmetry, n*—symmetry around an axis; an object is axially symmetric if its appearance is unchanged if rotated around an axis.

3.2.3 *Reynolds number, n*—dimensionless number used in fluid mechanics to indicate whether fluid flow past a body or in a duct is steady or turbulent.

3.2.4 *velocity profile, n*—variation in velocity along a line at right angles to the general direction of flow.

### 4. Significance and Use

4.1 Flow conditioners are used for the conditioning of the turbulent flow profile of gases or liquids to reduce the ADD (velocity profile distortion) DEL (turbulence), swirl, or irregularities caused by the installation effects of piping elbows, length of pipe, valves, tees, and other such equipment or piping configurations that will affect the reading of flow measurement meters thus inducing measurement errors as a result of the flow profile of the gas or liquid not having a fully developed flow profile at the measurement point.<sup>4</sup>

### 5. Flow Conditioner Design Methodology

5.1 *Pipe Flow Profiles*—Almost any description can be prescribed by using the perforated plate utilizing screen theory. That is, any upstream velocity profile,  $U_1$ , can be changed to a downstream velocity profile,  $U_2$ , with the use of a screen (herein referred to as a flow conditioner) (see Fig. 1).

<sup>3</sup> Available from the American Gas Association, 400 N. Capital St., NW, Washington, DC 20001, [www.techstreet.com/aga](http://www.techstreet.com/aga).

<sup>4</sup> Per various Coriolis Flow Meter manufacturer statements: A Coriolis Flow Meter reportedly does not require flow conditioning, therefore this ASTM standard does not apply.

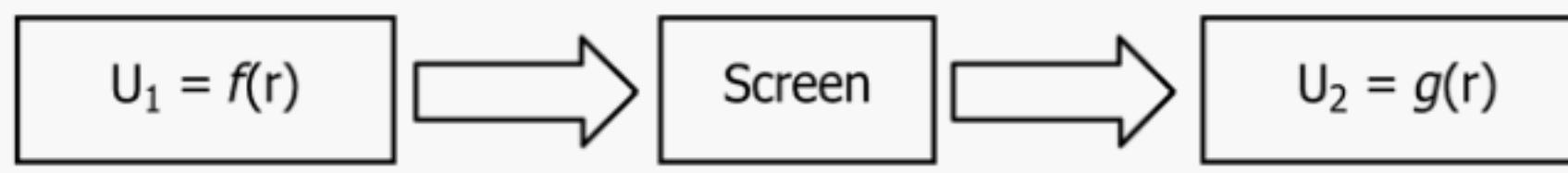


FIG. 1 Pipe Flow Profile

**NOTE 1**—The upstream flow profile need not be mathematically defined or even known.

**5.1.1** The intent of the screen theory methodology is to suppress or allow flow such that the axi-symmetric distribution of the fluid flow eventually manifests itself into a fully developed state— $g(r)$ . Separating the pipe flow into annuli and correlating the openness of each annulus in terms of an effective beta ratio of that annulus with respect to a discretized reference fully developed velocity flow profile is then done to have the resultant velocity flow profile fully developed [or some chosen function,  $g(r)$ ] . The annuli and accompanying nomenclature are defined in Fig. 2.

**5.1.2** For a screen, the relationship between the downstream  $U_2$  and upstream  $U_1$  velocities can be shown to follow the relationship between sudden enlargements and contractions (the flow conditioner holes) as a fully developed state by using Equation X (Karnik and Erdal). This equation relates the pressure drop of the holes considered as sudden enlargements and the designer can use as many annuli ( $n$ ) as they wish. The user of this practice is cautioned that manufacturing difficulty increases with the number of annuli chosen. It is also recommended that the downstream velocity relationship (function, equation) be that which is of a fully developed state.

**5.1.3 Step 1**—Choose a downstream velocity function. For pipeline flow measurement, all flow meters are on a baseline against a fully developed flow profile. It is recommended that a function replicating the fully developed state be used at the chosen Reynolds number.

**5.1.3.1** In this case, a power law flow profile is chosen such as Eq 1:

$$\frac{U_r}{U_{\max}} = \left(1 - \frac{r}{R}\right)^{\frac{1}{n}} \quad \text{or} \quad \frac{U_y}{U_{\max}} = \left(\frac{y}{R}\right)^{\frac{1}{n}} \quad (1)$$

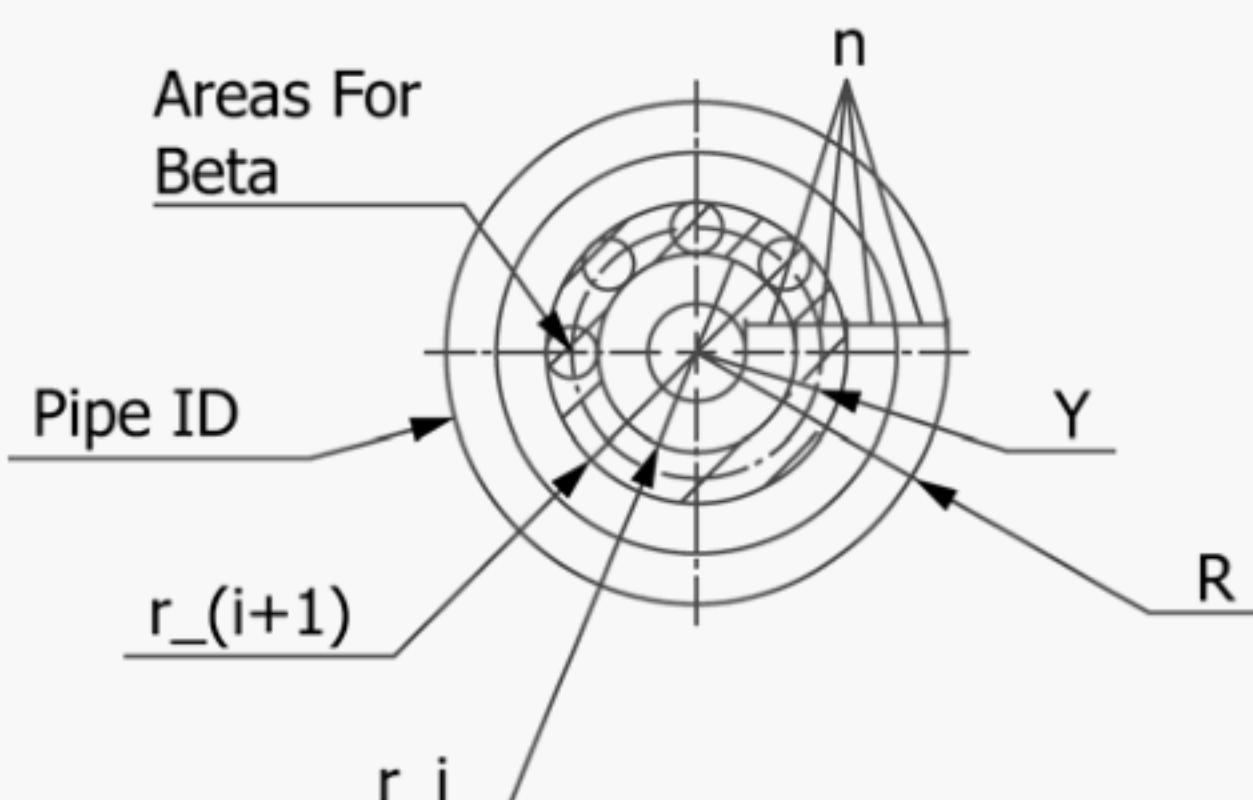


FIG. 2 Annuli and Nomenclature

where:

$U_r$  = velocity at location,  $r$ ;  
 $U_{\max}$  = maximum velocity at pipe center line;  
 $r$  =  $r$  location;  
 $R$  =  $r$  at pipe wall; and  
 $n$  = 1/friction factor.

**5.1.3.2** In terms of  $U_{ave}$  and  $U_{\max}$  (at pipe center line), we obtain:

$$U_{ave} = U_{\max} \left[ \frac{2n^2}{(n + 1)(2n + 1)} \right] \quad (2)$$

where:

values for  $U_{ave}$  and  $U_{\max}$  are in Table 1.

**5.1.4 Step 2**—Choose an overall flow conditioner pressure loss coefficient that is suitable for the intended flow requirements. Note that the overall effectiveness or isolating capability of the flow is a very strong function of the pressure loss. The relationship between effectiveness and pressure drop is indicated in Fig. 2. Eq 4 can be used to accomplish this.

$$K_0 = \frac{\Delta P_0}{\frac{1}{2} \rho U_{ave}^2} \quad (3)$$

**5.1.5 Step 3**—Pressure drop of each ring ( $i$ ).

$$\frac{U_i}{U_{ave}} = \frac{U_{\max}}{U_{ave}} \left( \frac{Y_i}{R} \right)^{\frac{1}{n}} \quad (4)$$

**5.1.6 Step 4**—Plug all terms into flow conditioner pressure drop coefficient Eq 5.

$$K_0 = \frac{0.7(1 - \lambda_i)}{\lambda_i^2} + \left[ \frac{1 - \lambda_i}{\lambda_i} \right]^2 \left[ \frac{U_i}{U_{ave}} \right]^2 \quad (5)$$

**5.1.7 Step 5**—Equate Eq 6 for each hole size and number of holes for each ring.

$$\lambda_i = \frac{n \left( \frac{\pi}{4} \right) a^2}{\pi (R_{i+1}^2 - R_i^2)} \quad (6)$$

TABLE 1  $U_{ave}$  and  $U_{\max}$

$n$	$U_{ave}/U_{\max}$	$U_{\max}/U_{ave}$
1	0.333	3
2	0.533	1.875
3	0.643	1.56
4	0.711	1.41
5	0.758	1.32
6	0.791	1.26
7	0.816	1.22
8	0.836	1.19
9	0.851	1.173
10	0.865	1.155

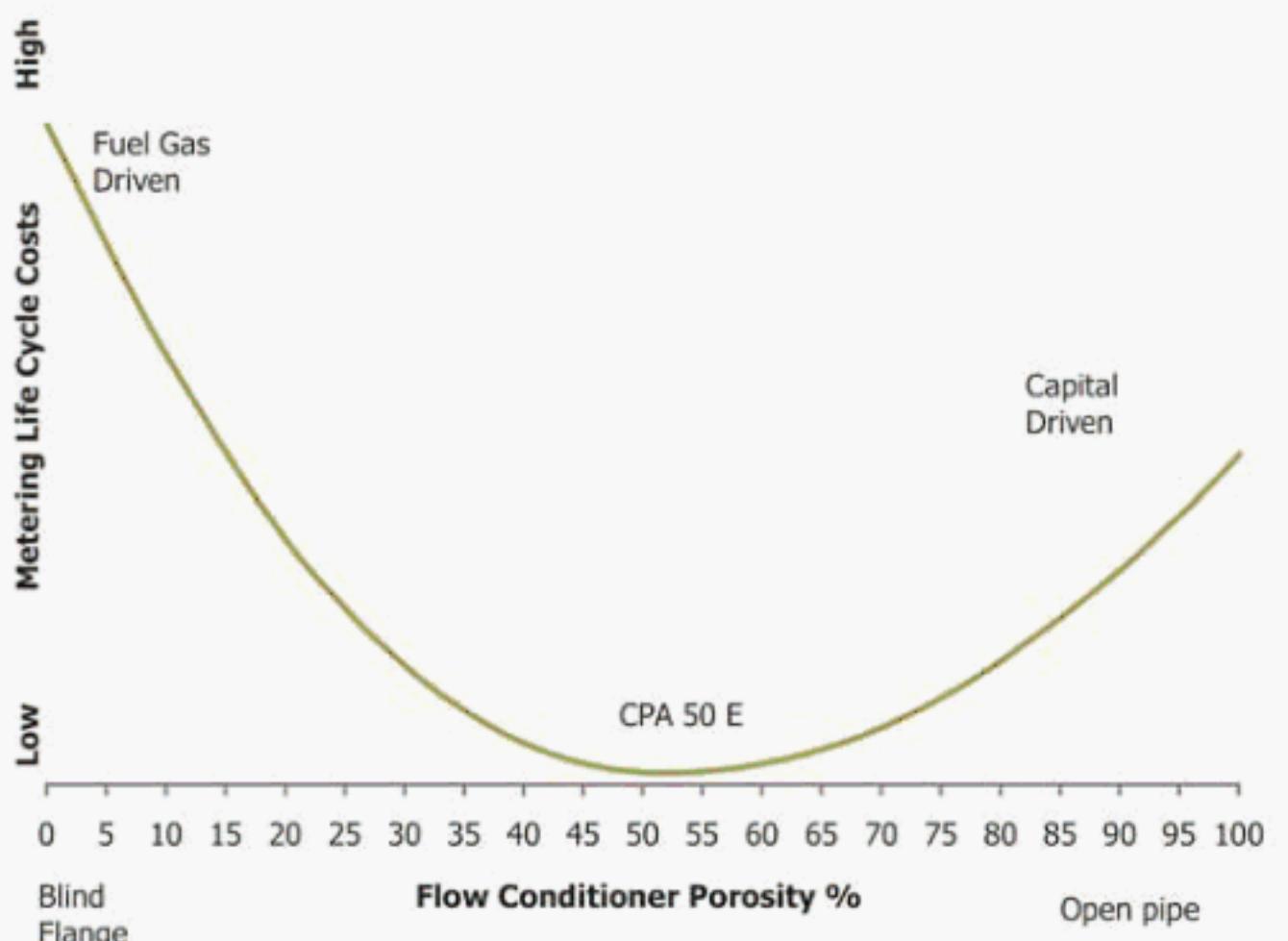
where:

$\lambda_i$  = porosity of ring,  $i$ ;  
 $n$  = number of holes in ring,  $i$ ;  
 $a$  = area of each hole; and  
 $R_x$  =  $r$  at  $x$ .

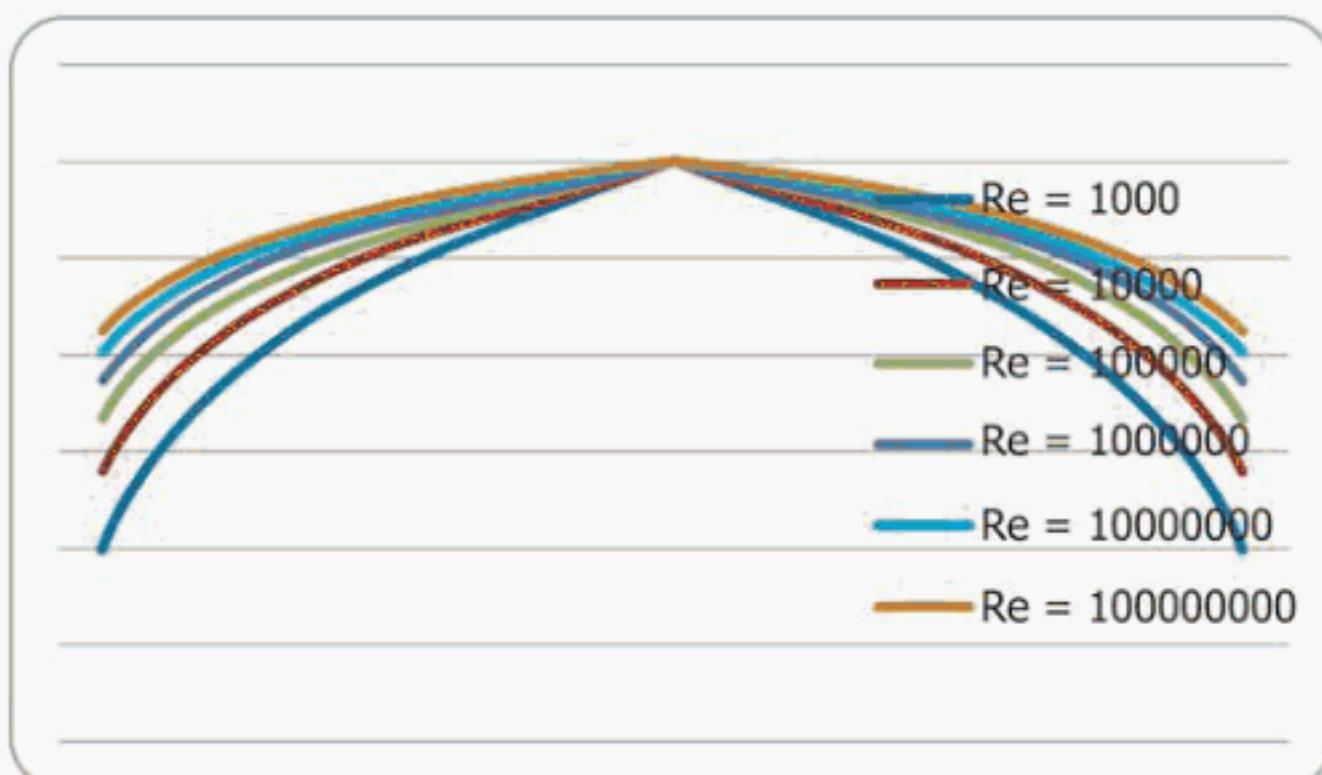
**5.2 Flow Conditioner Qualification Pipe Flow Profiles**—To comply with the requirements of this practice, the flow conditioner shall be shown to provide a state of flow within the pipe that resembles the fluid flow characteristics of a straight piece of pipe not shorter than 200 inside pipe diameters. This shall be shown when installed downstream of any piping installation effect in any pipe length chosen.

**5.2.1** This requirement ensures that specific flow meter type and flow conditioner peculiarities are avoided.

**5.2.2** The mean normalized velocity profile shall resemble that of the “SE” flow profile to within  $\pm 2\%$  at any location within the pipe. The “SE” profile is as shown in Fig. 4.



**FIG. 3 Flow Conditioner Effectiveness as a Function of Pressure Loss**



**FIG. 4 Power Law Velocity Profiles**

**5.3 Configuration Information**—Orders for material under this practice should include the following, as required, to describe the material adequately:

**5.3.1** The nomenclature used to specify a flow-conditioning device is the following (9 in. (23 cm) not included in the description):

[NPS] [AA] [BB] [CC ANSI Rating] [Material Type]

**5.3.2** The terms for a complete description are:

**5.3.2.1 AA = Nominal Pipe Size (NPS)**

(1) NPS does not refer to the pipe outside diameter up to NPS 12-in. (30.5-cm) pipe. For NPS 14-in. (35.5-cm) and larger pipe sizes, NPS corresponds to pipe outside diameter.

(2) In 90 % of applications, NPS will correspond with a published pipe schedule. In applications that exceed NPS 30 in. (76 cm), actual pipe inside diameters are used more than schedules. This may be due to difficulty meeting pressure containment requirements with published pipe schedules in larger pipe sizes. In some instances [even if smaller pipe sizes; NPS 16-in. (40.6 cm) and smaller], the pipe inside diameter may not correspond with a published pipe schedule. Flow conditioners can be manufactured to any pipe inside diameter.

(3) Standard weight pipe and Schedule 40 are equivalent in all sizes to NPS 10-in. (25.4-cm) pipe from NPS 12- to 24-in. (25.4- to 61-cm) standard weight pipe having a wall thickness of 0.375 in. (1 cm). Extra strong weight pipe and Schedule 80 are equivalent to NPS 8-in. (20-cm) pipe from NPS 8- to 24-in. (20- to 61-cm) extra strong pipe having a wall thickness of 0.500 in. (1.3 cm). Extra, extra strong pipe has no corresponding schedule number.

**5.3.2.2 BB = Flange Type**

(1) *Flange application and flow conditioner type*—There are many different flange types used in the measurement industry. Flange type specification is required (see Table 2).

**5.3.2.3 CC = Schedule or Actual Pipe Inside Diameter**—See Table 3.

**5.3.2.4 American National Standards Institute (ANSI) Rating = Pressure Class**

(1) *ANSI rating*—Pressure class rating or PN (pressure nominal). This information is required to size the flow conditioner to the pressure rated flange properly (see Table 4).

**5.3.2.5 Material Type = Steel Type**—The flow conditioner can be made of any type of material. The material of manufacture shall be stated on the purchase order. The most common flow conditioners are of stainless steel construction and these materials can be seen in Table 5.

**5.3.2.6 Ring No.** = only applies to ring-type joint (RTJ) applications (see Table 6).

## 6. Flow Conditioner Markings

**6.1 Markings**—All plates will have the following markings etched or mechanically placed upon the outer flange edge:

6.1.1 ANSI rating;

6.1.2 Temperature range;

6.1.3 Manufacturer model identification;

6.1.4 Size, that is, NPS XX Sch. XX;

6.1.5 Material, that is, 304ss;

6.1.6 Country of manufacture;

6.1.7 Serial number and identification of plate by use of a combination of the purchase order number and number of the plate in the specific purchased lot in the following order;

TABLE 2 Flange Type

Flange Type	Flow Conditioner	Description	Nomenclature
Raised Face	Type A Raised Face (RF)	Compressed between two raised face flanges in meter tube with thin flange—most popular—requires meter tube to be rolled to remove flow conditioner.	FOE (flange on end)
Raised Face	Wafer	Compressed between two raised face flanges in meter tube with full width flange—least popular—does not require meter tube to be rolled to remove flow conditioner.	FWO (full width option)
Pinned in Pipe	Pinned	Flanges are replaced by a threadolette and set screw. Used where conventional tube bundles are to be retrofitted.	TBR (tube bundle replacement)
Ring-Type Joint (RTJ)	RTJ	Compressed between two RTJ flanges in meter tube.	RTJ (ring-type joint)
Ring-Type Joint (RTJ)	RTJ Insert	The flow conditioner is inserted into a counter bore machined into the meter tube RTJ flange.	RIS (ring-type joint insert style)

purchase order number XXXX, followed by plate number XX, out of total number of the lot XX as shown in Example 1.

6.1.7.1 *Example 1*—Purchase order 1234 that has ordered three plates on this order will have the following number for the first plate in the lot: 123431; but, if there is only one plate in this example order, then the number would be 123411, thus, the format: [order number] + [plate number out of the lot] + [total number of plates in the lot];

6.1.8 Flow (see Fig. 5);

6.1.8.1 Top indication (see Fig. 6); and

6.1.9 Heat number [using Material Test Report (MTR)].

6.1.10 The customers paint over the flow conditioners and cannot see the labeling on the flow conditioner—top indication recovery is paramount.

6.1.11 While the holes are being machined, a top indication will be machined as follows:

6.1.11.1 A  $\frac{1}{8}$ -in. (3.155-mm) diameter cutting tool will side cut into the flange of the flow conditioner to a depth of  $\frac{1}{8}$ -in. (3.155-mm) as shown in Fig. 6. To avoid orientation confusion,

there shall be a  $\frac{1}{8}$ -in. (3.155-mm) notch that will be top dead center (tdc). Place new top indication as such “Top ↑notch↑” as shown in Fig. 6.

## 6.2 Bore Scope Marking

6.2.1 To provide a second level of identification, the flow conditioner type can be machined into the downstream face of the flow conditioner as indicated in Fig. 7.

6.2.2 The order of indication shall be: NPSXX\_Sch XX.

## 7. Installation Distances

7.1 *Markings*—To provide the best flow conditions possible, the flow conditioner shall be installed carefully. The flow conditioner shall not be installed in distances less than shown in Fig. 8.

7.2 *Minimum Meter Run Distances*—Any distance longer than indicated will result in higher quality flow profiles (see Table 7).

**TABLE 3 Schedule or Actual Pipe Inside Diameter**

Nominal Pipe Size		Schedule	Inside Diameter	Flange Thickness
Outside Diameter (in.)	Number	Wall Thickness Designation		
1			1.185	0.125
1.315			1.097	0.125
	40	Std	1.049	0.125
	80	XS	0.957	0.125
	160		0.815	0.125
		XXS	0.599	0.125
1 1/4			1.530	0.125
1.660			1.442	0.125
	40	Std	1.380	0.125
	80	XS	1.278	0.125
	160		1.160	0.125
		XXS	0.896	0.125
1 1/2			1.770	0.125
1.900			1.682	0.125
	40	Std	1.610	0.125
	80	XS	1.500	0.125
	160		1.338	0.125
		XXS	1.100	0.125
			0.850	0.125
			0.600	0.125
2			2.245	0.125
2.375			2.157	0.125
	40	Std	2.067	0.125
	80	XS	1.939	0.125
	160		1.689	0.125
		XXS	1.503	0.125
			1.251	0.125
			1.001	0.125
2 1/2			2.709	0.125
2.875			2.635	0.125
	40	Std	2.469	0.125
	80	XS	2.323	0.125
	160		2.125	0.125
		XXS	1.771	0.125
			1.525	0.125
			1.275	0.125
3			3.334	0.250
3.500			3.260	0.250
	40	Std	3.068	0.250
	80	XS	2.900	0.250
	160		2.626	0.250
		XXS	2.300	0.250
			2.050	0.250
			1.800	0.250
4			4.334	0.250
4.500			4.260	0.250
			4.124	0.250
	40	Std	4.026	0.250
	80	XS	3.826	0.250
	120		3.626	0.250
			3.500	0.250
	160		3.438	0.250
		XXS	3.152	0.250
			2.900	0.250
			2.650	0.250
6			6.407	0.250
6.625			6.357	0.250
			6.187	0.250
	40	Std	6.065	0.250
	80	XS	5.761	0.250
	120		5.501	0.250
	160		5.189	0.250
		XXS	4.897	0.250
			4.625	0.250
			4.375	0.250
8			8.407	0.250
8.625			8.329	0.250
			8.187	0.250
	20		8.125	0.250
	30		8.071	0.250
	40	Std	7.981	0.250

**TABLE 3 Continued**

Nominal Pipe Size		Schedule	Inside Diameter	Flange Thickness
Outside Diameter (in.)	Number	Wall Thickness Designation		
60			7.813	0.250
80		XS	7.625	0.250
100			7.439	0.250
120			7.189	0.250
140			7.001	0.250
160			6.813	0.250
			6.625	0.250
			6.375	0.250
10			10.482	0.250
10.750			10.420	0.250
			10.312	0.250
20			10.250	0.250
30			10.136	0.250
40		Std	10.020	0.250
60			9.750	0.250
80		XS	9.564	0.250
100			9.314	0.250
120			9.064	0.250
			9.000	0.250
140			8.750	0.250
160			8.500	0.250
			8.250	0.250
			7.750	0.250
12			12.438	0.250
12.750			12.390	0.250
	20		12.250	0.250
	30		12.090	0.250
		Std	12.000	0.250
	40		11.938	0.250
		XS	11.750	0.250
	60		11.626	0.250
	80		11.376	0.250
			11.250	0.250
	100		11.064	0.250
			11.000	0.250
	120		10.750	0.250
	140		10.500	0.250
			10.250	0.250
	160		10.126	0.250
14			13.688	0.250
14.000			13.624	0.250
			13.580	0.250
			13.562	0.250
	10		13.500	0.250
	20		13.438	0.250
	30		13.376	0.250
		Std	13.312	0.250
	40		13.250	0.250
		XS	13.126	0.250
			13.062	0.250
	60		13.000	0.250
			12.814	0.250
	80		12.750	0.250
	100		12.500	0.250
			12.126	0.250
	120		11.814	0.250
	140		11.500	0.250
	160		11.188	0.250
16			15.670	0.250
16.000			15.624	0.250
	10		15.500	0.250
	20		15.376	0.250
	30		15.250	0.250
	40		15.000	0.250
	60		14.688	0.250
	80		14.314	0.250
	100		13.938	0.250
	120		13.564	0.250
	140		13.126	0.250
	160		12.814	0.250
18			17.670	0.250

**TABLE 3 Continued**

Nominal Pipe Size		Schedule	Inside Diameter	Flange Thickness
Outside Diameter (in.)	Number	Wall Thickness Designation		
18.000	10	Std	17.624	0.250
	20		17.500	0.250
	30		17.376	0.250
	40		17.250	0.250
	60		17.126	0.250
	80	XS	17.000	0.250
	100		16.876	0.250
	120		16.500	0.250
	140		16.126	0.250
	160		15.688	0.250
20.000	20	Std	15.250	0.250
	30		15.250	0.250
	40		14.876	0.250
	60		14.438	0.250
	80		19.634	0.375
	100		19.564	0.375
	120		19.500	0.375
	140		19.000	0.375
	160	XS	18.814	0.375
	24		18.376	0.375
	30		18.250	0.375
	40		17.938	0.375
	60		17.438	0.375
	80		17.000	0.375
	100		16.500	0.375
	120		16.064	0.375
24.00	24	Std	23.500	0.500
	30		23.250	0.500
	40		23.000	0.500
	60		22.876	0.500
	80		22.750	0.500
	100		22.626	0.500
	120		22.500	0.500
	140		23.564	0.500
	160	XS	22.250	0.500
	24		22.064	0.500
	30		21.564	0.500
	40		20.938	0.500
	60		20.376	0.500
	80		19.876	0.500
	100		19.314	0.500
	120		29.500	0.750
30.00	30	Std	29.376	0.750
	40		29.250	0.750
	60		29.000	0.750
	80		28.750	0.750
	100		28.500	0.750
	120		28.250	0.750
	140		28.000	0.750
	160		27.750	0.750
32.000	32	Std	31.500	0.750
	40		31.376	0.750
	60		31.250	0.750
	80		31.000	0.750
	100		30.750	0.750
	120		30.624	0.750
	140		30.500	0.750
	160		30.250	0.750
	24	XS	30.000	0.750
	30		29.750	0.750
	40		35.500	1.000
	60		35.376	1.000
	80		35.250	1.000
	100		35.000	1.000
	120		24.750	1.000
	140		34.500	1.000
36.000	36	Std	34.250	1.000
	40		34.000	1.000
	60		33.750	1.000

**TABLE 4 ANSI Rating**

ANSI Class Designation	Nominal Pressure Class	Approximate Cold Working Pressure Rating <sup>A</sup>
150	PN 20	290 psi (2000 kPa)
300	PN 50	725 psi (5000 kPa)
400	PN 68	986 psi (6800 kPa)
600	PN 100	1450 psi (10 000 kPa)
900	PN 150	2175 psi (15 000 kPa)
1500	PN 250	3625 psi (25 000 kPa)
2500	PN 420	6091 psi (42 000 kPa)

<sup>A</sup> Not to be used in lieu of standards compliant pressure calculations for wall thicknesses and strength requirements. For temperature ranges from -20 to 100 °F (-28.8 to 37.7 °C).

7.3 In bi-directional metering applications, identical meter run distances will increase the chance of pulsation-induced meter run harmonics that can be detrimental to proper meter operation.

#### 7.4 Pressure Drop Determination

7.4.1 Let:

$$k = 0.52 \frac{(1 - \beta^2)}{\beta^2} \quad (7)$$

$$\Delta p = \frac{k \rho U^2}{2} \quad (8)$$

where:

$\Delta p$  = recovered pressure loss across the flow conditioner [lb/in.<sup>2</sup> (Pa)];

$k$  = pressure loss coefficient (experimentally determined);

$\rho$  = fluid density, kg/m<sup>3</sup>;

$U$  = fluid velocity, m/s; and

$K$  = dimensionless pressure drop coefficient.

#### 7.5 $k$ Values

7.5.1 Low Reynolds Number Turbulent Pipe Flow (Inertial Flow)—See Fig. 9.

7.5.2 High Reynolds Number Turbulent Pipe Flow (Inertial Flow)—See Fig. 10.

7.5.3 High Viscosity Fluids Laminar Low Reynolds Number Flow (Frictional Flow):

7.5.3.1 For high viscosity fluids, an additional viscosity adjustment factor is installed into the pressure-drop equation. These values shall be experimentally determined. L. P. Martinez provides a very useful overview of low Reynolds number  $k$  factor determination with comparisons between previous estimations.

7.5.3.2 In the absence of test results availability, we propose the following estimation for lack of a better method presently available.

(1) The pressure-drop  $k$  factor results are extrapolated to extend to very low Re and to obtain the results in Table 8.

#### 7.6 Pressure-Loss Examples

7.6.1 Methodology—The methodology used to determine the pressure losses as a result of fluid movement past the flow conditioner is the following typical pressure-loss approach:

$$\Delta P = k \frac{1}{2} \rho v^2 \quad (9)$$

**TABLE 5 Chemical Requirements for Austenitic Stainless Steel Flow Conditioners**

Grade	C	Mn	P	S	Si	Ni	Cr	Mb	Ti	se
MT 302	0.08 to 0.20	2.0	0.04	0.03	1.0	8.0–10.0	17.0–19.0			
MT 303	0.15 max.	2.0	0.04	0.04	1.0	8.0–11.0	17.0–19.0			0.12–0.20
MT 304	0.08 max.	2.0	0.04	0.03	1.0	8.0–13.0	18.0–20.0			
MT 304L	0.035 max.	2.0	0.04	0.03	1.0	8.0–11.0	18.0–20.0			
MT 305	0.12	2.0	0.04	0.03	1.0	10.0–13.0	17.0–19.0			
MT 309	0.08 max.	2.0	0.04	0.03	1.0	12.0–15.0	22.0–24.0			
MT 310	0.08 max.	2.0	0.04	0.03	1.0	19.0–22.0	24.0–26.0			
MT 316	0.08 max.	2.0	0.04	0.03	1.0	11.0–14.0	16.0–18.0	2.0–3.0		
MT 316L	0.035 max.	2.0	0.04	0.03	1.0	10.0–15.0	16.0–18.0	2.0–3.0		
MT 317	0.08 max.	2.0	0.04	0.03	1.0	11.0–14.0	18.0–20.0	3.0–4.0		
MT 321	0.08 max.	2.0	0.04	0.03	1.0	9.0–13.0	17.0–20.0			5xC min 0.6 max
MT 347	0.08 max.	2.0	0.04	0.03	1.0	9.0–13.0	17.0–20.0			

where:

$k$  = head loss coefficient—experimentally determined and confirmed by NRTC = 1.5 to 1.7;

$\rho$  = density via AGA Report No. 8; and

$v$  = mean fluid flow velocity.

**7.6.2 Density**—Using a typical composition of 93 % methane, 3 % ethane for the AGA 222 Report No. 8 calculation results in the following examples in **Table 9**.

$$\Delta P = k \frac{1}{2} \rho v^2 \quad (10)$$

Therefore see **Table 10**.

## 8. Keywords

8.1 annuli; axi-symmetric distribution; flow conditioners; flow profile; liquid; natural gas; screen theory; velocity profile

### 7.6.3 Pressure Loss

**7.6.3.1** Using the following equation [and measurements of 65 and 100 ft/s (20 and 30.5 m/s)]:

**TABLE 6 Ring Number**

Nominal Pipe Size and Outside Diameter (in.)	Number	Schedule Wall Thickness	Inside Diameter Designation	ANSI 600 Ring #	ANSI 900 Ring #	ANSI 1500 Ring #	ANSI 2500 Ring #
1 1.315			1.185 1.097				
40	Std		1.049				
80	XS		0.957				
160			0.815				
		XXS	0.599				
1 1/4 1.660			1.530 1.442				
40	Std		1.380				
80	XS		1.278				
160			1.160				
		XXS	0.896				
1 1/2 1.900			1.770 1.682				
40	Std		1.610				
80	XS		1.500				
160			1.338				
		XXS	1.100 0.850 0.600				
2 2.375			2.245 2.157	R23	R24	R24	R26
40	Std		2.067	R23	R24	R24	R26
80	XS		1.939	R23	R24	R24	R26
160			1.689	R23	R24	R24	R26
		XXS	1.503 1.251 1.001	R23	R24	R24	R26
2 1/2 2.875			2.709 2.635	R23	R24	R24	R26
40	Std		2.469	R23	R24	R24	R26
80	XS		2.323	R23	R24	R24	R26
160			2.125	R23	R24	R24	R26
		XXS	1.771 1.525 1.275	R23	R24	R24	R26
3 3.500			3.334 3.260	R31	R31	R35	R32
40	Std		3.068	R31	R31	R35	R32
80	XS		2.900	R31	R31	R35	R32
160			2.626	R31	R31	R35	R32
		XXS	2.300 2.050 1.800	R31	R31	R35	R32
4 4.500			4.334 4.260 4.124	R37	R37	R39	R38
40	Std		4.026	R37	R37	R39	R38
80	XS		3.826	R37	R37	R39	R38
120			3.626	R37	R37	R39	R38
			3.500	R37	R37	R39	R38
160			3.438 3.152	R37	R37	R39	R38
		XXS	2.900 2.650	R37	R37	R39	R38
6 6.625			6.407 6.357 6.187	R45	R45	R46	R47
40	Std		6.065	R45	R45	R46	R47
80	XS		5.761	R45	R45	R46	R47
120			5.501	R45	R45	R46	R47
160			5.189	R45	R45	R46	R47
		XXS	4.897 4.625 4.375	R45	R45	R46	R47
8 8.625			8.407 8.329 8.187	R49	R49	R50	R51
20			8.125	R49	R49	R50	R51
30			8.071	R49	R49	R50	R51
40	Std		7.981	R49	R49	R50	R51
60			7.813	R49	R49	R50	R51
80	XS		7.625	R49	R49	R50	R51

**TABLE 6** *Continued*

Nominal Pipe Size and Outside Diameter (in.)	Schedule Number	Schedule Wall Thickness	Inside Diameter Designation	ANSI 600 Ring #	ANSI 900 Ring #	ANSI 1500 Ring #	ANSI 2500 Ring #
100			7.439	R49	R49	R50	R51
120			7.189	R49	R49	R50	R51
140			7.001	R49	R49	R50	R51
160			6.813	R49	R49	R50	R51
			6.625	R49	R49	R50	R51
			6.375	R49	R49	R50	R51
10			10.482	R53	R53	R54	R55
10.750			10.420	R53	R53	R54	R55
			10.312	R53	R53	R54	R55
20			10.250	R53	R53	R54	R55
30			10.136	R53	R53	R54	R55
40	Std		10.020	R53	R53	R54	R55
60	XS		9.750	R53	R53	R54	R55
80			9.564	R53	R53	R54	R55
100			9.314	R53	R53	R54	R55
120			9.064	R53	R53	R54	R55
			9.000	R53	R53	R54	R55
140			8.750	R53	R53	R54	R55
160			8.500	R53	R53	R54	R55
			8.250	R53	R53	R54	R55
			7.750	R53	R53	R54	R55
12			12.438	R57	R57	R58	R60
12.750			12.390	R57	R57	R58	R60
20			12.250	R57	R57	R58	R60
30			12.090	R57	R57	R58	R60
40	Std		12.000	R57	R57	R58	R60
60	XS		11.938	R57	R57	R58	R60
80			11.750	R57	R57	R58	R60
			11.626	R57	R57	R58	R60
100			11.376	R57	R57	R58	R60
			11.250	R57	R57	R58	R60
			11.064	R57	R57	R58	R60
			11.000	R57	R57	R58	R60
120			10.750	R57	R57	R58	R60
140			10.500	R57	R57	R58	R60
			10.250	R57	R57	R58	R60
160			10.126	R57	R57	R58	R60
14			13.688	R61	R62	R63	
14.000			13.624	R61	R62	R63	
			13.580	R61	R62	R63	
			13.562	R61	R62	R63	
10			13.500	R61	R62	R63	
			13.438	R61	R62	R63	
20			13.376	R61	R62	R63	
			13.312	R61	R62	R63	
30	Std		13.250	R61	R62	R63	
40	XS		13.126	R61	R62	R63	
			13.062	R61	R62	R63	
60			13.000	R61	R62	R63	
			12.814	R61	R62	R63	
			12.750	R61	R62	R63	
80			12.500	R61	R62	R63	
100			12.126	R61	R62	R63	
120			11.814	R61	R62	R63	
140			11.500	R61	R62	R63	
160			11.188	R61	R62	R63	
16			15.670	R65	R66	R67	
16.000			15.624	R65	R66	R67	
10			15.500	R65	R66	R67	
20			15.376	R65	R66	R67	
30	Std		15.250	R65	R66	R67	
40	XS		15.000	R65	R66	R67	
60			14.688	R65	R66	R67	
80			14.314	R65	R66	R67	
100			13.938	R65	R66	R67	
120			13.564	R65	R66	R67	
140			13.126	R65	R66	R67	
160			12.814	R65	R66	R67	
18			17.670	R69	R70	R71	
18.000			17.624	R69	R70	R71	
10			17.500	R69	R70	R71	
20			17.376	R69	R70	R71	
	Std		17.250	R69	R70	R71	

**TABLE 6** *Continued*

Nominal Pipe Size and Outside Diameter (in.)	Number	Schedule Wall Thickness	Inside Diameter Designation	ANSI 600 Ring #	ANSI 900 Ring #	ANSI 1500 Ring #	ANSI 2500 Ring #
30			17.126	R69	R70	R71	
40			16.876	R69	R70	R71	
60			16.500	R69	R70	R71	
80			16.126	R69	R70	R71	
100			15.688	R69	R70	R71	
120			15.250	R69	R70	R71	
140			14.876	R69	R70	R71	
160			14.438	R69	R70	R71	
20	20.000		19.634	R73	R74	R75	
			19.564	R73	R74	R75	
10			19.500	R73	R74	R75	
20		Std	19.250	R73	R74	R75	
30		XS	19.000	R73	R74	R75	
40			18.814	R73	R74	R75	
60			18.376	R73	R74	R75	
			18.250	R73	R74	R75	
80			17.938	R73	R74	R75	
100			17.438	R73	R74	R75	
120			17.000	R73	R74	R75	
140			16.500	R73	R74	R75	
160			16.064	R73	R74	R75	
24	10		23.500	R77	R78	R79	
24.000	20	Std	23.250	R77	R78	R79	
		XS	23.000	R77	R78	R79	
30			22.876	R77	R78	R79	
			22.750	R77	R78	R79	
40			22.626	R77	R78	R79	
			22.500	R77	R78	R79	
			23.564	R77	R78	R79	
			22.250	R77	R78	R79	
60			22.064	R77	R78	R79	
80			21.564	R77	R78	R79	
100			20.938	R77	R78	R79	
120			20.376	R77	R78	R79	
140			19.876	R77	R78	R79	
160			19.314	R77	R78	R79	
30	30.000		29.500	R95	R102		
	10		29.376	R95	R102		
		Std	29.250	R95	R102		
20		XS	29.000	R95	R102		
30			28.750	R95	R102		
40			28.500	R95	R102		
			28.250	R95	R102		
			28.000	R95	R102		
			27.750	R95	R102		
32	32.000		31.500	R96	R103		
	10		31.376	R96	R103		
		Std	31.250	R96	R103		
20		XS	31.000	R96	R103		
30			30.750	R96	R103		
40			30.624	R96	R103		
			30.500	R96	R103		
			30.250	R96	R103		
			30.000	R96	R103		
			29.750	R96	R103		
36	36.00		35.500	R98	R105		
	10		35.376	R98	R105		
		Std	35.250	R98	R105		
20		XS	35.000	R98	R105		
30			34.750	R98	R105		
40			34.500	R98	R105		
			34.250	R98	R105		
			34.000	R98	R105		
			33.750	R98	R105		

**TABLE 7 Minimum Meter Run Distances**

Nominal Pipe	Schedule	Inside	Minimum A <sup>A</sup>	Minimum A	64/7D Meter Run his	52/5D Meter Run his	118/13D Meter Run his	91/9D Meter Run his
Size and Outside Diameter (in.)	Number	Wall Thickness Designation	Diameter		Non-harmonic B <sup>B</sup>	Non-harmonic B	Non-harmonic B	Non-harmonic B
1			1.185	5.93	9.48	10.83	12.32	10.76
1.315			1.097	5.49	8.78	10.03	11.41	9.96
	40	Std	1.049	5.25	8.39	9.59	10.91	9.52
	80	XS	0.957	4.79	7.66	8.75	9.95	8.69
	160		0.815	4.08	6.52	7.45	8.48	7.40
		XXS	0.599	3.00	4.79	5.48	6.23	5.44
1 1/4			1.530	7.65	12.24	13.99	15.91	13.89
1.660			1.442	7.21	11.54	13.18	15.00	13.09
	40	Std	1.380	6.90	11.04	12.62	14.35	12.53
	80	XS	1.278	6.39	10.22	11.68	13.29	11.60
	160		1.160	5.80	9.28	10.61	12.06	10.53
		XXS	0.896	4.48	7.17	8.19	9.32	8.13
1 1/2			1.770	8.85	14.16	16.18	18.41	16.07
1.900			1.682	8.41	13.46	15.38	17.49	15.27
	40	Std	1.610	8.05	12.88	14.72	16.74	14.61
	80	XS	1.500	7.50	12.00	13.71	15.60	13.62
	160		1.338	6.69	10.70	12.23	13.92	12.14
		XXS	1.100	5.50	8.80	10.06	11.44	9.98
			0.850	4.25	6.80	7.77	8.84	7.72
			0.600	3.00	4.80	5.49	6.24	5.45
2			2.245	11.23	17.96	20.53	23.35	20.38
2.375			2.157	10.79	17.26	19.72	22.43	19.58
	40	Std	2.067	10.34	16.54	18.90	21.50	18.76
	80	XS	1.939	9.70	15.51	17.73	20.17	17.60
	160		1.689	8.45	13.51	15.44	17.57	15.33
		XXS	1.503	7.52	12.02	13.74	15.63	13.64
			1.251	6.26	10.01	11.44	13.01	11.36
			1.001	5.01	8.01	9.15	10.41	9.09
2 1/2			2.709	13.55	21.67	24.77	28.17	24.59
2.875			2.635	13.18	21.08	24.09	27.40	23.92
	40	Std	2.469	12.35	19.75	22.57	25.68	22.41
	80	XS	2.323	11.62	18.58	21.24	24.16	21.09
	160		2.125	10.63	17.00	19.43	22.10	19.29
		XXS	1.771	8.86	14.17	16.19	18.42	16.08
			1.525	7.63	12.20	13.94	15.86	13.84
			1.275	6.38	10.20	11.66	13.26	11.57
3			3.334	16.67	26.67	30.48	34.67	30.26
3.500			3.260	16.30	26.08	29.81	33.90	29.59
	40	Std	3.068	15.34	24.54	28.05	31.91	27.85
	80	XS	2.900	14.50	23.20	26.51	30.16	26.32
	160		2.626	13.13	21.01	24.01	27.31	23.84
		XXS	2.300	11.50	18.40	21.03	23.92	20.88
			2.050	10.25	16.40	18.74	21.32	18.61
			1.800	9.00	14.40	16.46	18.72	16.34
4			4.334	21.67	34.67	39.63	45.07	39.34
4.500			4.260	21.30	34.08	38.95	44.30	38.67
			4.124	20.62	32.99	37.71	42.89	37.43
	40	Std	4.026	20.13	32.21	36.81	41.87	36.54
	80	XS	3.826	19.13	30.61	34.98	39.79	34.73
	120		3.626	18.13	29.01	33.15	37.71	32.91
		XXS	3.500	17.50	28.00	32.00	36.40	31.77
			3.438	17.19	27.50	31.43	35.76	31.21
	160		3.152	15.76	25.22	28.82	32.78	28.61
			2.900	14.50	23.20	26.51	30.16	26.32
			2.650	13.25	21.20	24.23	27.56	24.05
6			6.407	32.04	51.26	58.58	66.63	58.16
6.625			6.357	31.79	50.86	58.12	66.11	57.70
			6.187	30.94	49.50	56.57	64.34	56.16
	40	Std	6.065	30.33	48.52	55.45	63.08	55.05
	80	XS	5.761	28.81	46.09	52.67	59.91	52.29
	120		5.501	27.51	44.01	50.29	57.21	49.93
	160		5.189	25.95	41.51	47.44	53.97	47.10
		XXS	4.897	24.49	39.18	44.77	50.93	44.45
			4.625	23.13	37.00	42.29	48.10	41.98
			4.375	21.88	35.00	40.00	45.50	39.71
8			8.407	42.04	67.26	76.86	87.43	76.31
8.625			8.329	41.65	66.63	76.15	86.62	75.60
			8.187	40.94	65.50	74.85	85.14	74.31
	20		8.125	40.63	65.00	74.29	84.50	73.75
								82.15

**TABLE 7** *Continued*

Nominal Pipe	Schedule	Inside	Minimum	Minimum	64/7D Meter Run his	52/5D Meter Run his	118/13D Meter Run his	91/9D Meter Run his
Size and Outside Diameter (in.)	Number	Wall Thickness Designation	Diameter	A <sup>A</sup>	A	Non-harmonic B <sup>B</sup>	Non-harmonic B	Non-harmonic B
	30		8.071	40.36	64.57	73.79	83.94	73.26
	40	Std	7.981	39.91	63.85	72.97	83.00	72.44
	60		7.813	39.07	62.50	71.43	81.26	70.92
	80	XS	7.625	38.13	61.00	69.71	79.30	69.21
	100		7.439	37.20	59.51	68.01	77.37	67.52
	120		7.189	35.95	57.51	65.73	74.77	65.25
	140		7.001	35.01	56.01	64.01	72.81	63.55
	160		6.813	34.07	54.50	62.29	70.86	61.84
			6.625	33.13	53.00	60.57	68.90	60.13
			6.375	31.88	51.00	58.29	66.30	57.87
								64.46
	10		10.482	52.41	83.86	95.84	109.01	95.14
10.750			10.420	52.10	83.36	95.27	108.37	94.58
			10.312	51.56	82.50	94.28	107.24	93.60
	20		10.250	51.25	82.00	93.71	106.60	93.04
	30		10.136	50.68	81.09	92.67	105.41	92.00
	40	Std	10.020	50.10	80.16	91.61	104.21	90.95
	60	XS	9.750	48.75	78.00	89.14	101.40	88.50
	80		9.564	47.82	76.51	87.44	99.47	86.81
	100		9.314	46.57	74.51	85.16	96.87	84.54
	120		9.064	45.32	72.51	82.87	94.27	82.27
			9.000	45.00	72.00	82.29	93.60	81.69
	140		8.750	43.75	70.00	80.00	91.00	79.42
	160		8.500	42.50	68.00	77.71	88.40	77.15
			8.250	41.25	66.00	75.43	85.80	74.88
			7.750	38.75	62.00	70.86	80.60	70.35
			12.438	62.19	99.50	113.72	129.36	112.90
								125.76
	12		12.390	61.95	99.12	113.28	128.86	112.46
12.750			12.250	61.25	98.00	112.00	127.40	111.19
	20		12.090	60.45	96.72	110.54	125.74	109.74
	30		12.000	60.00	96.00	109.71	124.80	108.92
	40	Std	11.938	59.69	95.50	109.15	124.16	108.36
	60	XS	11.750	58.75	94.00	107.43	122.20	106.65
	80		11.626	58.13	93.01	106.29	120.91	105.53
	100		11.376	56.88	91.01	104.01	118.31	103.26
	120		11.250	56.25	90.00	102.86	117.00	102.12
			11.064	55.32	88.51	101.16	115.07	100.43
	140		11.000	55.00	88.00	100.57	114.40	99.85
	160		10.750	53.75	86.00	98.29	111.80	97.58
			10.500	52.50	84.00	96.00	109.20	95.31
	140		10.250	51.25	82.00	93.71	106.60	93.04
			10.126	50.63	81.01	92.58	105.31	91.91
	160		13.688	68.44	109.50	125.15	142.36	124.24
								138.40
	14		13.624	68.12	108.90	124.56	141.69	123.66
14.000			13.580	67.90	108.64	124.16	141.23	123.26
			13.562	67.81	108.50	124.00	141.04	123.10
	10		13.500	67.50	108.00	123.43	140.40	122.54
			13.438	67.19	107.50	122.86	139.76	121.98
	20		13.376	66.88	107.01	122.29	139.11	121.41
			13.312	66.56	106.50	121.71	138.44	120.83
	30	Std	13.250	66.25	106.00	121.14	137.80	120.27
	40	XS	13.126	65.63	105.01	120.01	136.51	119.14
			13.062	65.31	104.50	119.42	135.84	118.56
	60		13.000	65.00	104.00	118.86	135.20	118.00
			12.814	64.07	102.51	117.16	133.27	116.31
			12.750	63.75	102.00	116.57	132.60	115.73
	80		12.500	62.50	100.00	114.29	130.00	113.46
	100		12.126	60.63	97.01	110.87	126.11	110.07
	120		11.814	59.07	94.51	108.01	122.87	107.23
	140		11.500	57.50	92.00	105.14	119.60	104.38
	160		11.188	55.94	89.50	102.29	116.36	101.55
								113.12
	16		15.670	78.35	125.36	143.27	162.97	142.24
16.000			15.624	78.12	124.99	142.85	162.49	141.82
	10		15.500	77.50	124.00	141.71	161.20	140.69
	20		15.376	76.88	123.01	140.58	159.91	139.57
	30	Std	15.250	76.25	122.00	139.43	158.60	138.42
	40	XS	15.000	75.00	120.00	137.14	156.00	136.15
	60		14.688	73.44	117.50	134.29	152.76	133.32
	80		14.314	71.57	114.51	130.87	148.87	129.93
	100		13.938	69.69	111.50	127.43	144.96	126.51
								140.93

**TABLE 7** *Continued*

Nominal Pipe		Schedule	Inside	Minimum	Minimum	64/7D Meter Run his	52/5D Meter Run his	118/13D Meter Run his	91/9D Meter Run his
Size and Outside Diameter (in.)	Number	Wall Thickness Designation	Diameter	A <sup>A</sup>	A	Non-harmonic B <sup>B</sup>	Non-harmonic B	Non-harmonic B	Non-harmonic B
	120		13.564	67.82	108.51	124.01	141.07	123.13	137.15
	140		13.126	65.63	105.01	120.01	136.51	119.14	132.72
	160		12.814	64.07	102.51	117.16	133.27	116.31	129.56
18			17.670	88.35	141.36	161.55	183.77	160.39	178.66
18.00			17.624	88.12	140.99	161.13	183.29	159.97	178.20
	10		17.500	87.50	140.00	160.00	182.00	158.85	176.94
	20		17.376	86.88	139.01	158.87	180.71	157.72	175.69
	30	Std	17.250	86.25	138.00	157.71	179.40	156.58	174.42
	XS		17.126	85.63	137.01	156.58	178.11	155.45	173.16
	40		17.000	85.00	136.00	155.43	176.80	154.31	171.89
	60		16.876	84.38	135.01	154.29	175.51	153.18	170.64
	80		16.500	82.50	132.00	150.86	171.60	149.77	166.83
	100		16.126	80.63	129.01	147.44	167.71	146.37	163.05
	120		15.688	78.44	125.50	143.43	163.16	142.40	158.62
	140		15.250	76.25	122.00	139.43	158.60	138.42	154.19
	160		14.876	74.38	119.01	136.01	154.71	135.03	150.41
			14.438	72.19	115.50	132.00	150.16	131.05	145.98
20			19.634	98.17	157.07	179.51	204.19	178.22	198.52
20.000			19.564	97.82	156.51	178.87	203.47	177.58	197.81
	10		19.500	97.50	156.00	178.29	202.80	177.00	197.17
	20	Std	19.250	96.25	154.00	176.00	200.20	174.73	194.64
	30	XS	19.000	95.00	152.00	173.71	197.60	172.46	192.11
	40		18.814	94.07	150.51	172.01	195.67	170.77	190.23
	60		18.376	91.88	147.01	168.01	191.11	166.80	185.80
			18.250	91.25	146.00	166.86	189.80	165.65	184.53
	80		17.938	89.69	143.50	164.00	186.56	162.82	181.37
	100		17.438	87.19	139.50	159.43	181.36	158.28	176.32
	120		17.000	85.00	136.00	155.43	176.80	154.31	171.89
	140		16.500	82.50	132.00	150.86	171.60	149.77	166.83
	160		16.064	80.32	128.51	146.87	167.07	145.81	162.42
24	10		23.500	117.50	188.00	214.86	244.40	213.31	237.61
24.00	20	Std	23.250	116.25	186.00	212.57	241.80	211.04	235.08
		XS	23.000	115.00	184.00	210.29	239.20	208.77	232.56
	30		22.876	114.38	183.01	209.15	237.91	207.64	231.30
	40		22.750	113.75	182.00	208.00	236.60	206.50	230.03
			22.626	113.13	181.01	206.87	235.31	205.37	228.77
			22.500	112.50	180.00	205.71	234.00	204.23	227.50
			23.564	117.82	188.51	215.44	245.07	213.89	238.26
			22.250	111.25	178.00	203.43	231.40	201.96	224.97
	60		22.064	110.32	176.51	201.73	229.47	200.27	223.09
	80		21.564	107.82	172.51	197.16	224.27	195.73	218.04
	100		20.938	104.69	167.50	191.43	217.76	190.05	211.71
	120		20.376	101.88	163.01	186.29	211.91	184.95	206.02
	140		19.876	99.38	159.01	181.72	206.71	180.41	200.97
	160		19.314	96.57	154.51	176.59	200.87	175.31	195.29
30			29.500	147.50	236.00	269.71	306.80	267.77	298.28
30.000	10		29.376	146.88	235.01	268.58	305.51	266.64	297.02
		Std	29.250	146.25	234.00	267.43	304.20	265.50	295.75
	20	XS	29.000	145.00	232.00	265.14	301.60	263.23	293.22
	30		28.750	143.75	230.00	262.86	299.00	260.96	290.69
	40		28.500	142.50	228.00	260.57	296.40	258.69	288.17
			28.250	141.25	226.00	258.29	293.80	256.42	285.64
			28.000	140.00	224.00	256.00	291.20	254.15	283.11
			27.750	138.75	222.00	253.71	288.60	251.88	280.58
32			31.500	157.50	252.00	288.00	327.60	285.92	318.50
32.00	10		31.376	156.88	251.01	286.87	326.31	284.80	317.25
		Std	31.250	156.25	250.00	285.71	325.00	283.65	315.97
	20	XS	31.000	155.00	248.00	283.43	322.40	281.38	313.44
	30		30.750	153.75	246.00	281.14	319.80	279.12	310.92
	40		30.624	153.12	244.99	279.99	318.49	277.97	309.64
			30.500	152.50	244.00	278.86	317.20	276.85	308.39
			30.250	151.25	242.00	276.57	314.60	274.58	305.86
			30.000	150.00	240.00	274.29	312.00	272.31	303.33
			29.750	148.75	238.00	272.00	309.40	270.04	300.81
36			35.500	177.50	284.00	324.57	369.20	322.23	358.94
36.000	10		35.376	176.88	283.01	323.44	367.91	321.11	357.69
		Std	35.250	176.25	282.00	322.29	366.60	319.96	356.42
	20	XS	35.000	175.00	280.00	320.00	364.00	317.69	353.89
	30		34.750	173.75	278.00	317.71	361.40	315.42	351.36

**TABLE 7** *Continued*

Nominal Pipe	Schedule	Inside	Minimum	Minimum	64/7D Meter Run his	52/5D Meter Run his	118/13D Meter Run his	91/9D Meter Run his
Size and Outside Diameter (in.)	Number	Wall Thickness Designation	Diameter	A <sup>A</sup>	A	Non-harmonic B <sup>B</sup>	Non-harmonic B	Non-harmonic B
40			34.500	172.50	276.00	315.43	358.80	313.15
			34.250	171.25	274.00	313.14	356.20	310.88
			34.000	170.00	272.00	310.86	353.60	308.62
			33.750	168.75	270.00	308.57	351.00	306.35

<sup>A</sup> Minimum meter run distances, any distance longer than indicated will result in higher quality flow profiles.

<sup>B</sup> In bi-directional metering applications, identical meter run distances will increase chance of pulsation-induced meter run harmonics, which can be detrimental to proper meter operation.

**TABLE 8 Pressure-Drop *k* Factor Results Extrapolated**

Re	<i>k</i>
1 to 10	4.4+
10 to 100	3.6
100 to 1000	3.2
1000 to 10 000	2.7

**TABLE 9 Examples of Density**

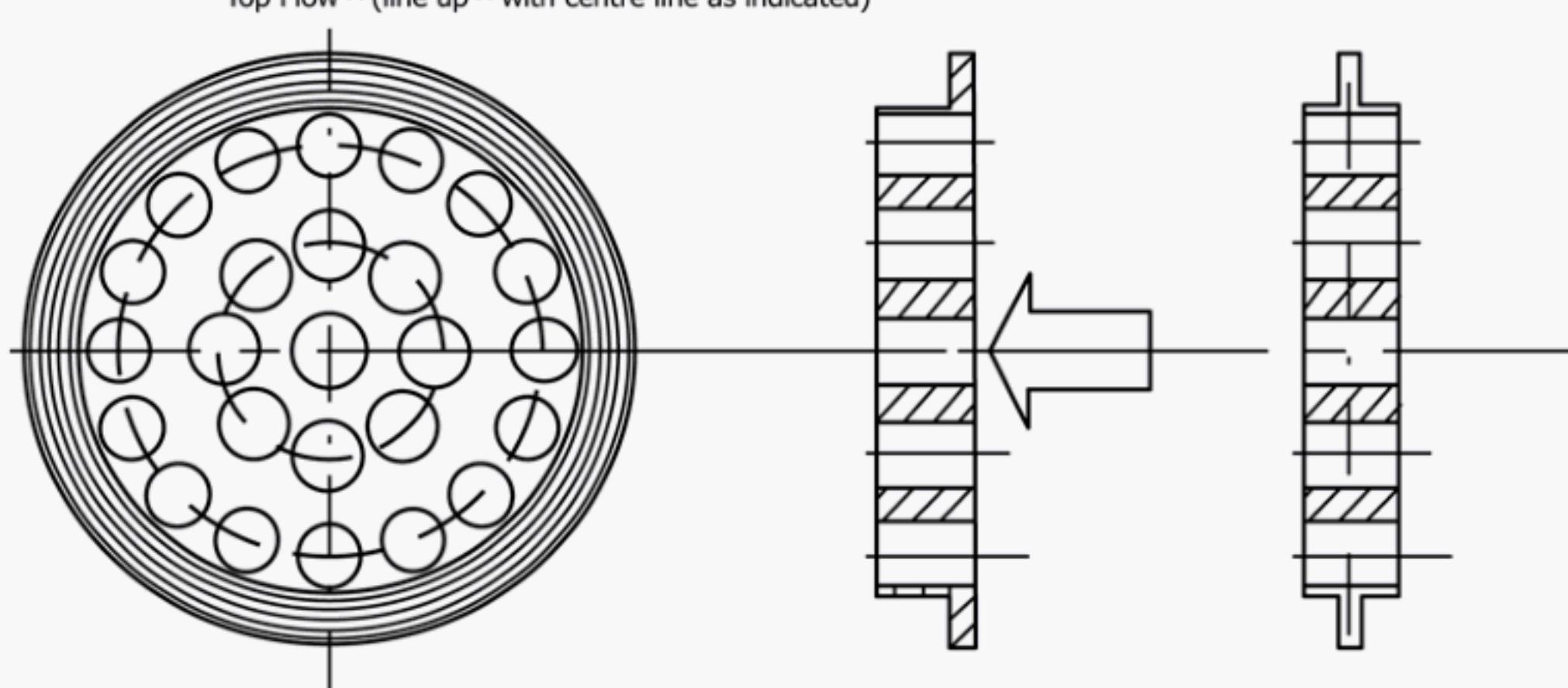
Pressure psia (kPa)	Temperature, °F (°C)	Density, lb <sub>m</sub> /ft <sup>3</sup> (m <sup>3</sup> /kg)
650 psia (4482 kPa)	70 °F (21.1 °C)	2.09 lb <sub>m</sub> /ft <sup>3</sup> (33.6 m <sup>3</sup> /kg)
850 psia (5861 kPa)	70 °F (21.1 °C)	2.82 lb <sub>m</sub> /ft <sup>3</sup> (45.1 m <sup>3</sup> /kg)
1000 psia (6895 kPa)	70 °F (21.1 °C)	3.38 lb <sub>m</sub> /ft <sup>3</sup> (54.1 m <sup>3</sup> /kg)

**TABLE 10 Pressure Loss**

Location Examples	P <sub>loss</sub>	
	65 ft/s (19.8 m/s)	100 ft/s (47.2 m/s)
Location "650 psi"	1.5 psi (10.5 kPa)	8.6 psi (59.8 kPa)
Location "850 psi"	2.0 psi (14.1 kPa)	11.6 psi (80.3 kPa)
Location "1000 psi"	2.5 psi (16.9 kPa)	13.9 psi (96 kPa)



**FIG. 6 Notch Showing Orientation**



**FIG. 5 Indication of "Top" and Direction of Flow**

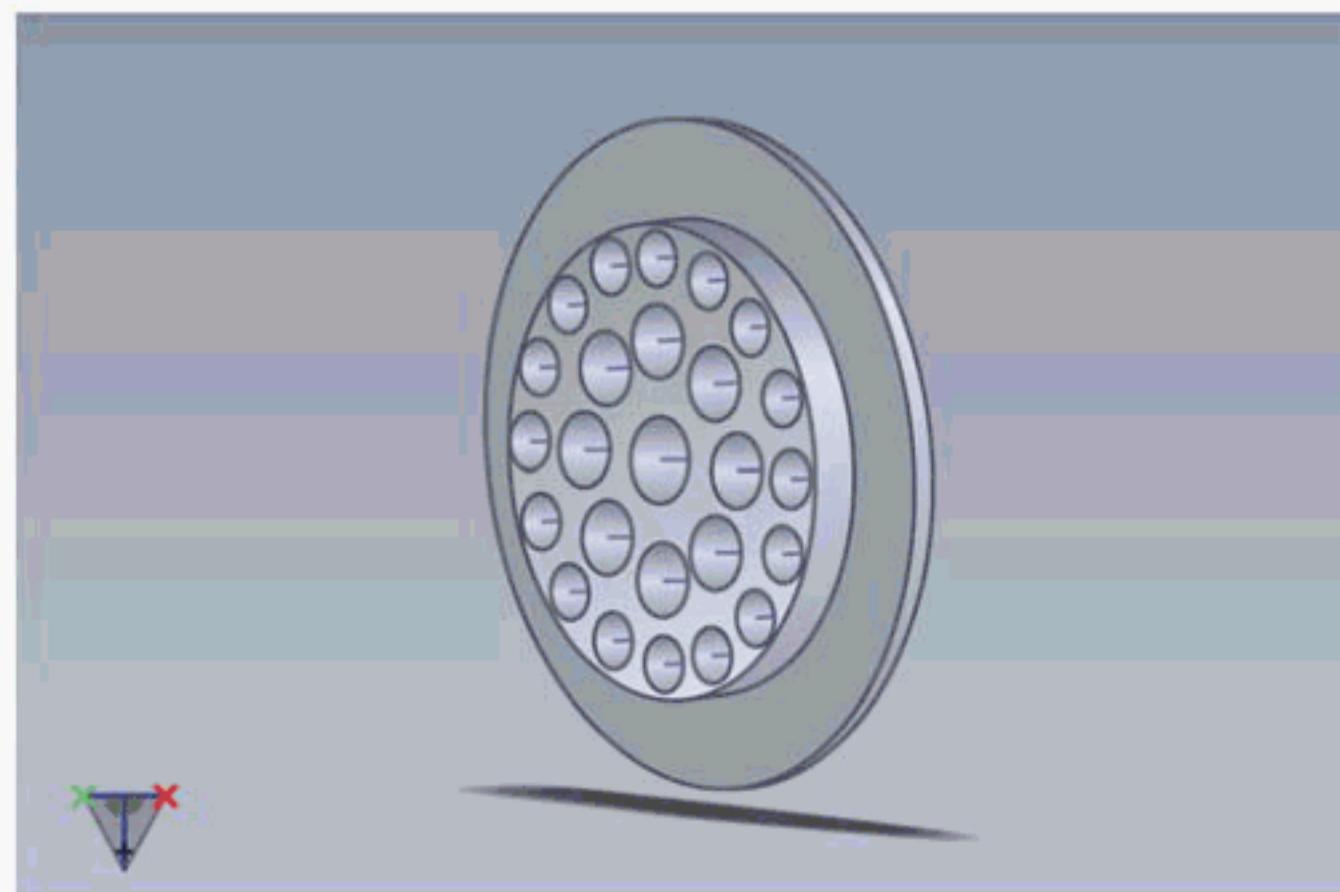


FIG. 7 Order of Marking Indications

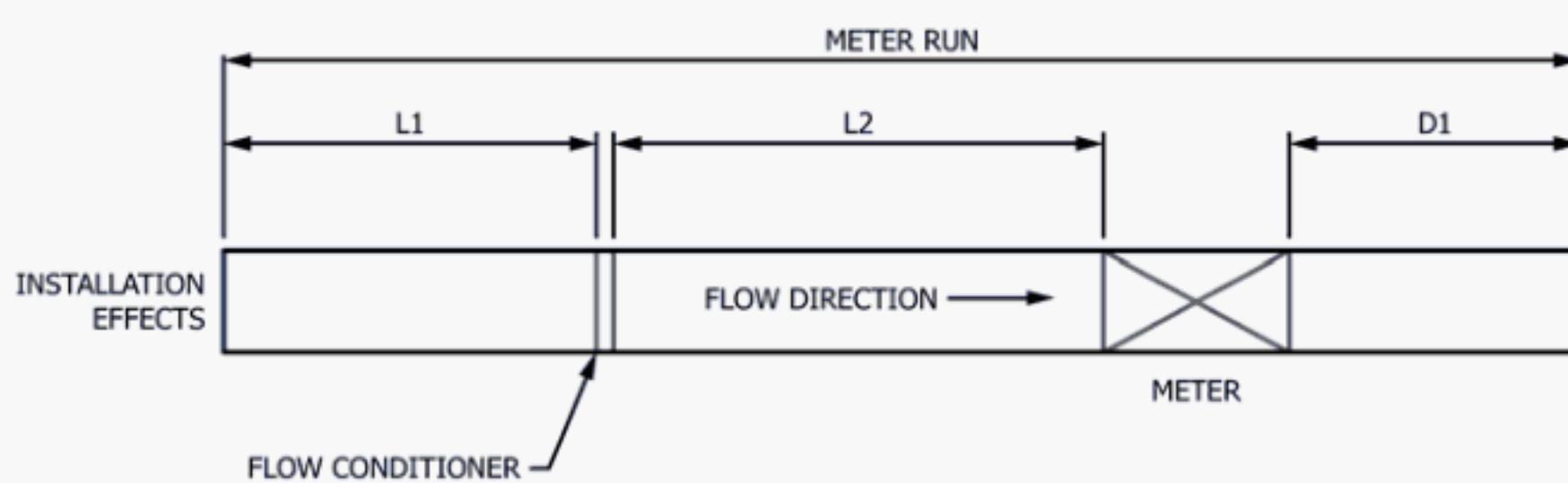


FIG. 8 Installation Distances

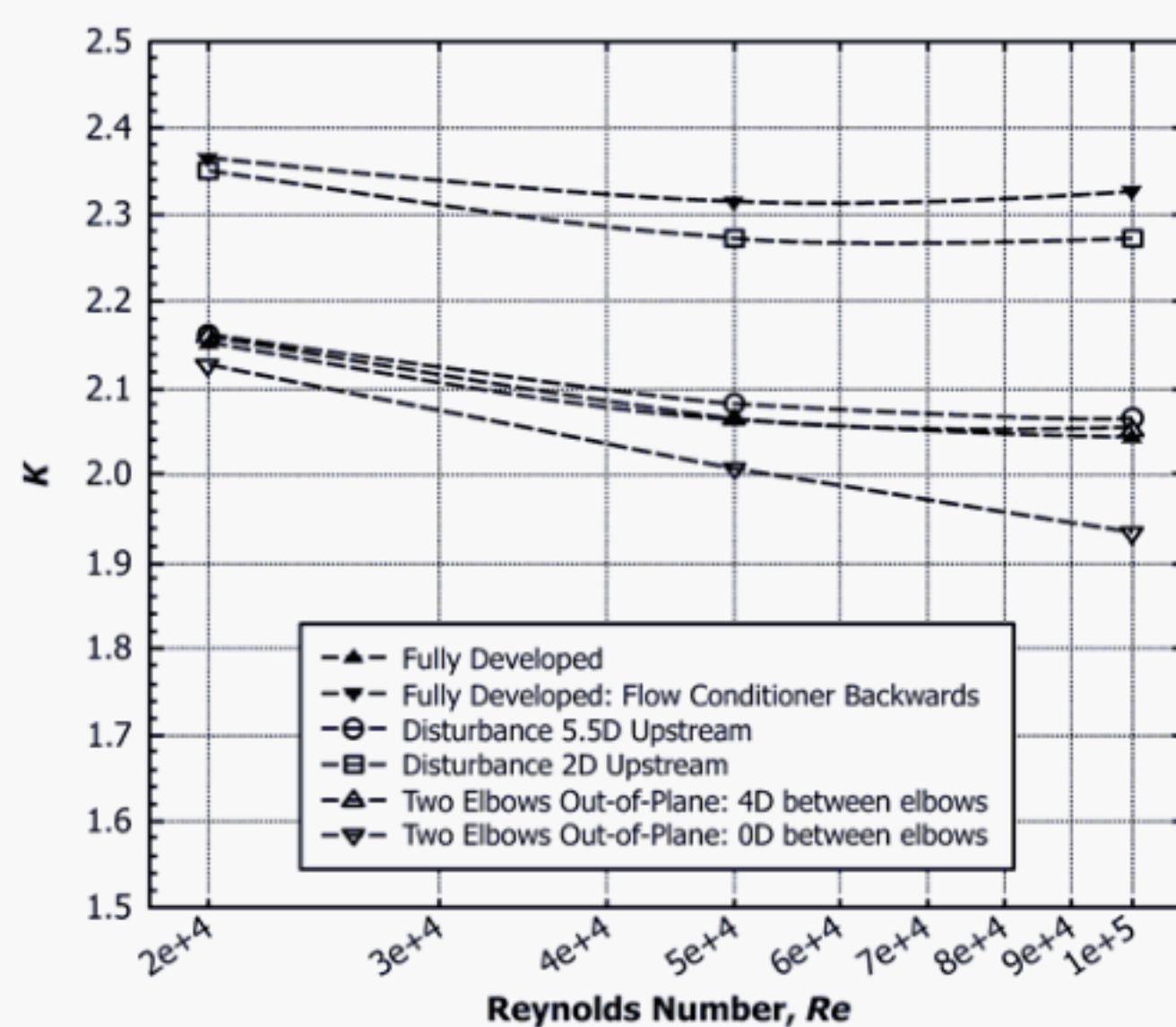
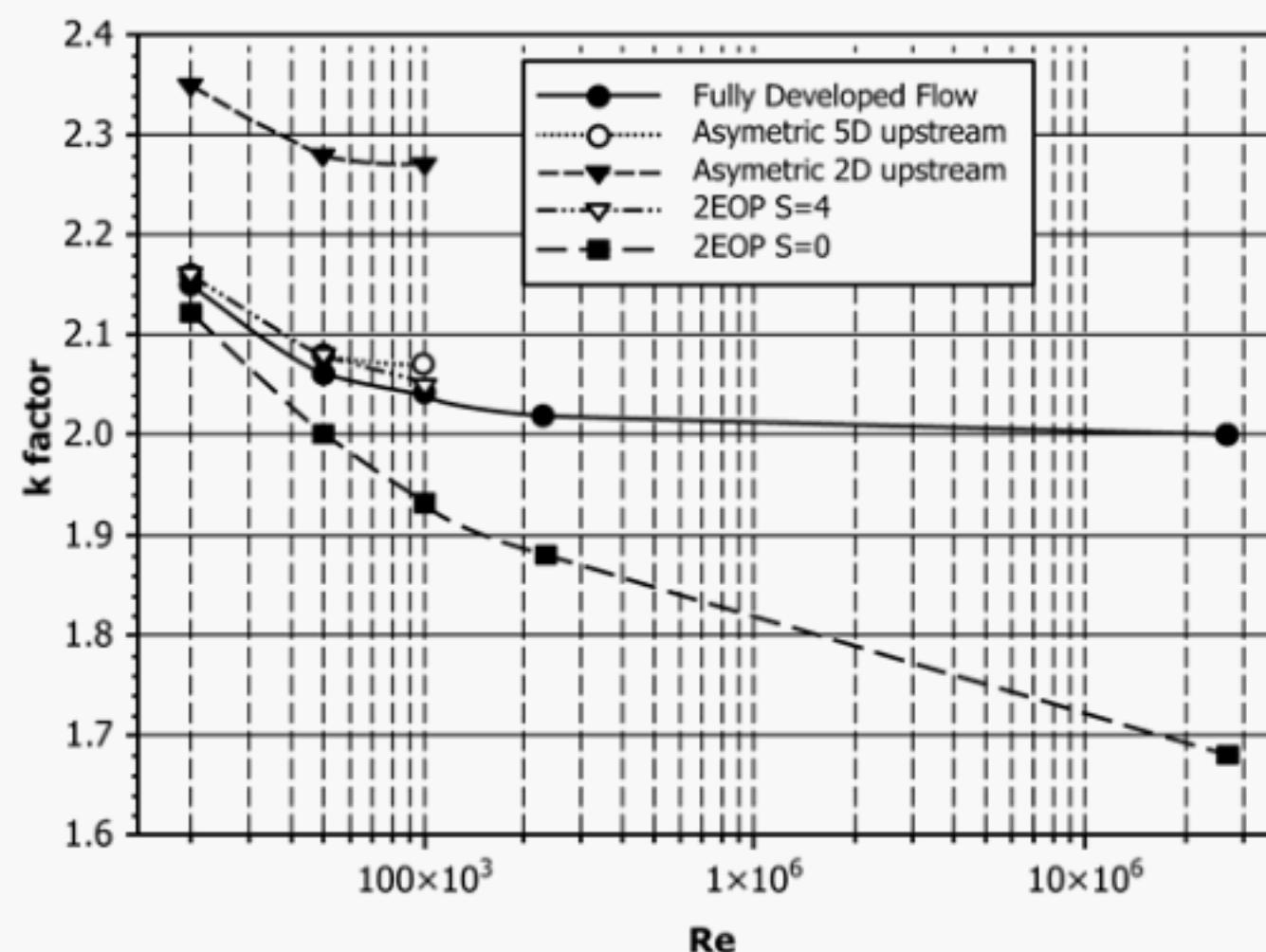


FIG. 9 Low Reynolds Number Turbulent Pipe Flow (Inertial Flow)



**FIG. 10 High Reynolds Number Turbulent Pipe Flow (Inertial Flow)**

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