6.2 Minimum upstream and downstream straight lengths for installation between various fittings and the Venturi tube

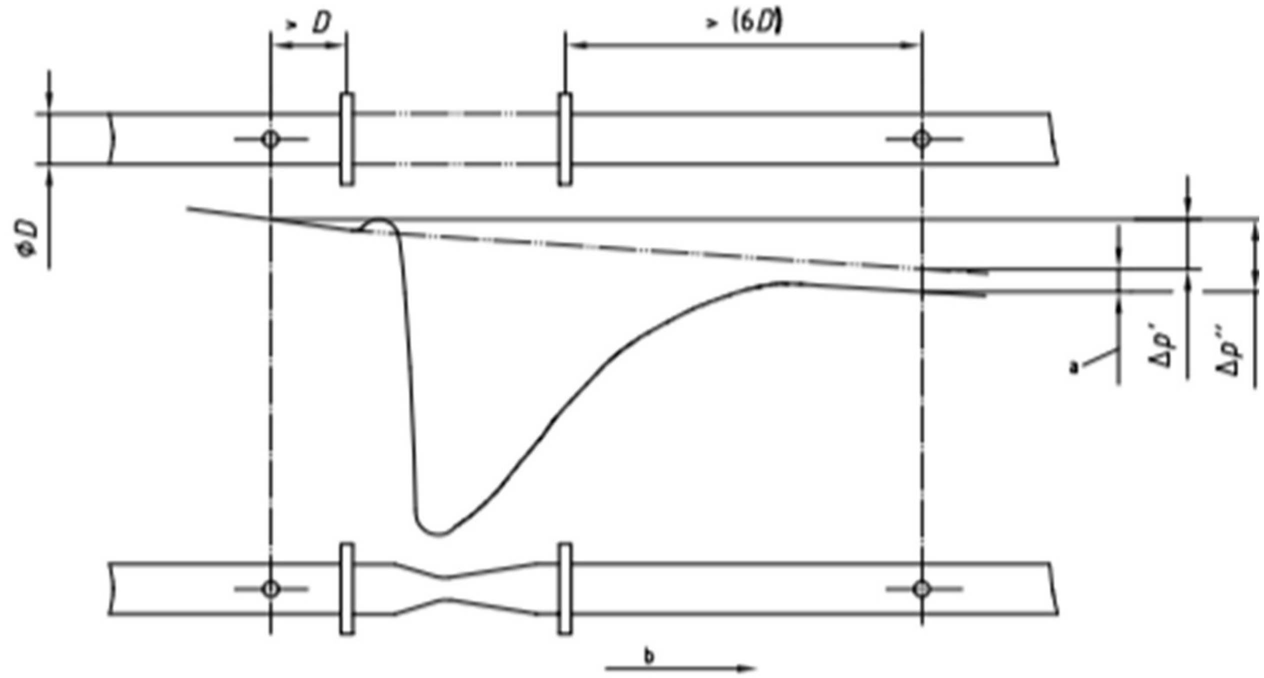
6.2.1 The minimum straight lengths of pipe to be installed upstream of the classical Venturi tube and following the various fittings in the installation without flow conditioners are given in Table 1.

For devices with the same β, the lengths specified in Table 1 for classical Venturi tubes are shorter than those specified in ISO 5167-2 and ISO 5167-3 for orifice plates, nozzles and Venturi nozzles.

This is due to the attenuation of flow non-uniformities taking place within the contraction section of the classical Venturi tube. However in considering the overall installation length for the classical Venturi tube the additional pipe length required to accommodate the primary device itself shall be taken into account.

6.2.2 When a flow conditioner is not used, the lengths specified in Table 1 shall be regarded as the minimum values. For research and calibration work in particular, it is recommended that the upstream values specified in Table 1 be increased by at least a factor of 2 to minimize the measurement uncertainty.

6.2.3 When the upstream straight length used is equal to or longer than the value specified in columns A of Table 1 for "zero additional uncertainty" and the downstream straight length is equal to or longer than the value specified in Table 1, it is not necessary to increase the uncertainty in discharge coefficient to take account of the effect of the particular installation.



a Pressure loss

b Direction of flow

Figure 2 — Pressure loss across a classical Venturi tube

Table 1 — Required straight lengths for classical Venturi tubes

Values expressed as multiples of internal diameter D

Diameter ratio β	Single 90° bend [a]		Two or more 90° bends in the same plane or different planes [a]		Reducer 1,33D to D over a length of 2,3D		Expander 0,67D to D over a length of 2,5D		Reducer 3D to D over a length of 3,5 D		Expander 0,75D to D over a length of D		Full bore ball or gate valve fully open	
1	2		3		4		5		6		7		8	
	A[b]	B[c]	A[b]	B[c]	A[b]	B[c]	A[b]	B[c]	A[b]	B[c]	A[b]	B[c]	A[b]	B[c]
0,30	8	3	8	3	4	[d]	4	[d]	2,5	[d]	2,5	[d]	2,5	[d]
0,40	8	3	8	3	4	[d]	4	[d]	2,5	[d]	2,5	[d]	2,5	[d]
0,50	9	3	10	3	4	[d]	5	4	5,5	2,5	2,5	[d]	3,5	2,5
0,60	10	3	10	3	4	[d]	6	4	8,5	2,5	3,5	2,5	4,5	2,5
0,70	14	3	18	3	4	[d]	7	5	10,5	2,5	5,5	3,5	5,5	3,5
0,75	16	8	22	8	4	[d]	7	6	11,5	3,5	6,5	4,5	5,5	3,5

The minimum straight lengths required are the lengths between various fittings located upstream of the classical Venturi tube and the classical Venturi tube itself. Straight lengths shall be measured from the downstream end of the curved portion of the nearest (or only) bend or the downstream end of the curved or conical portion of the reducer or expander to the upstream pressure tapping plane of the classical Venturi tube.

If temperature pockets or wells are installed upstream of the classical Venturi tube, they shall not exceed 0,13D in diameter and shall be located at least 4D upstream of the upstream tapping plane of the Venturi tube.

For downstream straight lengths, fittings or other disturbances (as indicated in this Table) or densitometer pockets situated at least four throat diameters downstream of the throat pressure tapping plane do not affect the accuracy of the measurement (see 6.2.3 and 6.2.5).

5.ISO 5167提供的整流器

6.3 Flow conditions 流場穩定性要求

6.3.1 ISO 5167 (all parts) does not provide for the measurement of pulsating flow, which is the subject of ISO/TR 3313. The flowrate shall be constant or, in practice, vary only slightly and slowly with time.

The flow is considered as not being pulsating[2] when

$$\frac{\Delta p'_{\mathrm{rms}}}{\overline{\Delta p}} \leqslant 0,10$$

where

$\overline{\Delta p}$ is the time-mean value of the differential pressure;

$\Delta p'$ is the fluctuating component of the differential pressure;

$\Delta p'_{\mathrm{rms}}$ is the root mean square value of $\Delta p'$.

$\Delta p'_{\mathrm{rms}}$ can only be measured accurately using a fast-response differential pressure sensor; moreover, the whole secondary system should conform to the design recommendations specified in ISO/TR 3313. It will not, however, normally be necessary to check that this condition is satisfied.

不確定度-流體-氣體

8.2.2.1 The practical working formula for the uncertainty, δq_m, of the mass flowrate is given by Equation (3) as follows:

$$\frac{\delta q_m}{q_m} = \sqrt{\left(\frac{\delta C}{C}\right)^2 + \left(\frac{\delta \varepsilon}{\varepsilon}\right)^2 + \left(\frac{2\beta^4}{1-\beta^4}\right)^2 \left(\frac{\delta D}{D}\right)^2 + \left(\frac{2}{1-\beta^4}\right)^2 \left(\frac{\delta d}{d}\right)^2 + \frac{1}{4}\left(\frac{\delta \Delta p}{\Delta p}\right)^2 + \frac{1}{4}\left(\frac{\delta \rho_1}{\rho_1}\right)^2} \qquad (3)$$

膨脹係數 密度

In Equation (3) some of the uncertainties, such as those on the discharge coefficient and expansibility [expansion] factor, are given in 8.2.2.2 and 8.2.2.3, while others have to be determined by the user (see 8.2.2.4 and 8.2.2.5).

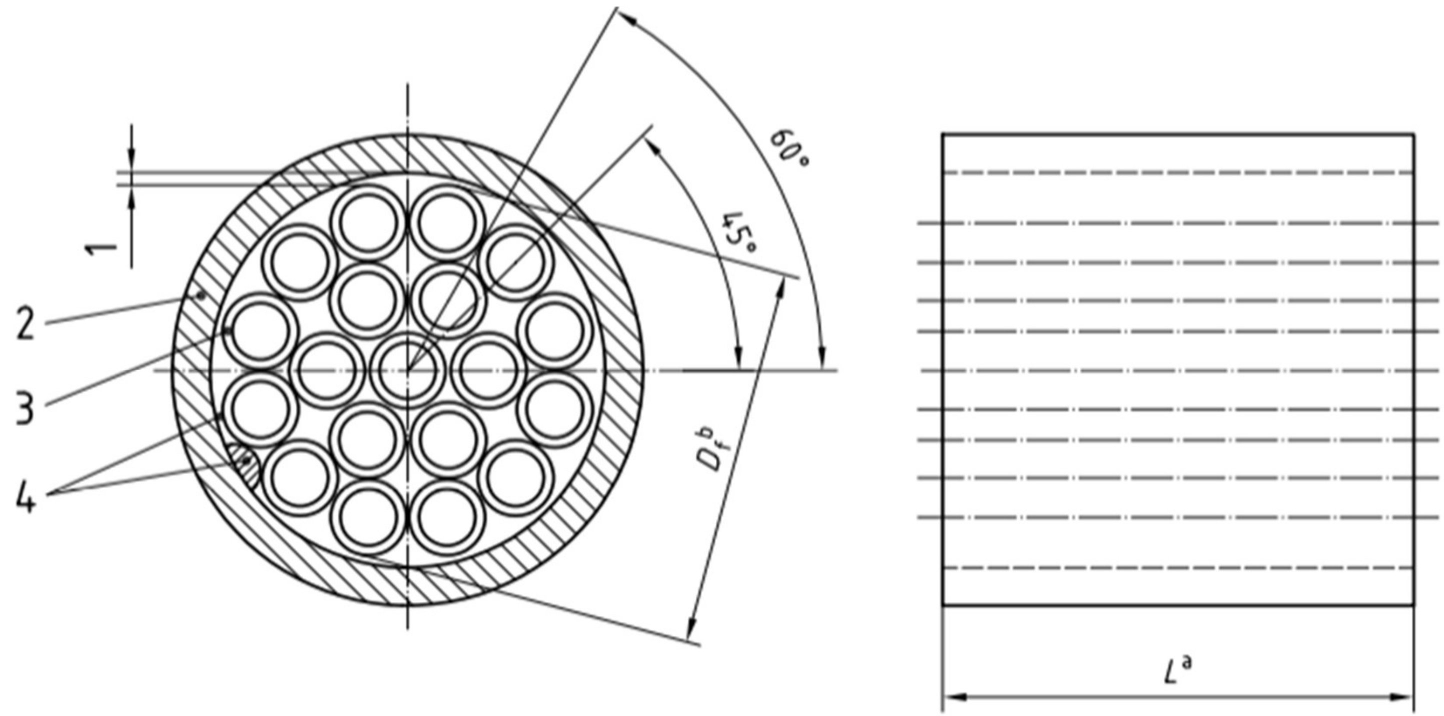
8.2.2.2 In Equation (3), the values of $\delta C/C$ and of $\delta\varepsilon/\varepsilon$ shall be taken from the applicable part of ISO 5167.

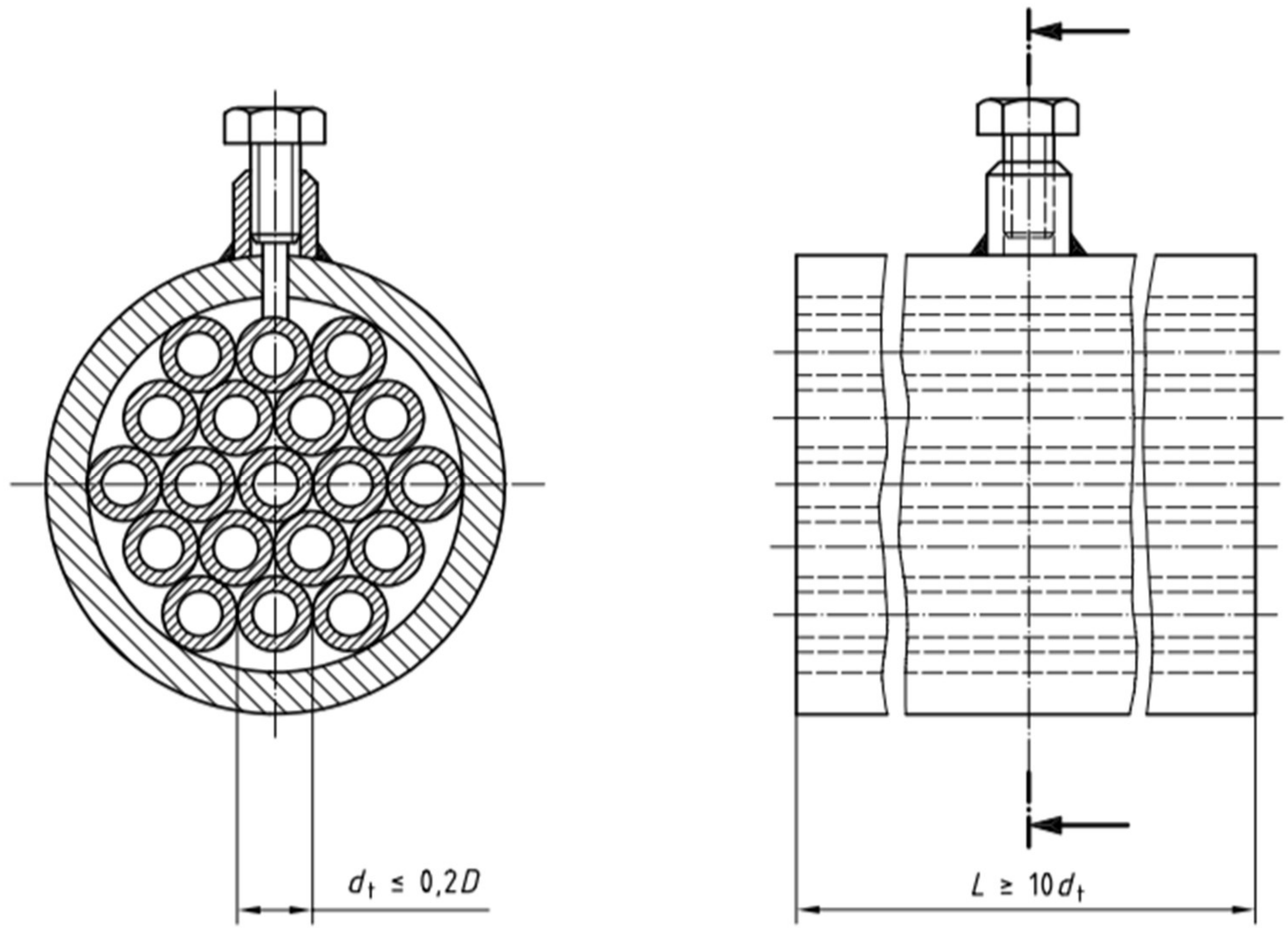
不確定度-流體-常溫水

$$\frac{\delta q_m}{q_m} = \sqrt{\left(\frac{\delta C}{C}\right)^2 + \cancel{\left(\frac{\delta \varepsilon}{\varepsilon}\right)^2} + \left(\frac{2\beta^4}{1-\beta^4}\right)^2 \left(\frac{\delta D}{D}\right)^2 + \left(\frac{2}{1-\beta^4}\right)^2 \left(\frac{\delta d}{d}\right)^2 + \frac{1}{4}\left(\frac{\delta \Delta p}{\Delta p}\right)^2 + \cancel{\frac{1}{4}\left(\frac{\delta \rho_1}{\rho_1}\right)^2}}$$

膨脹係數 密度

Figure C.1 — Examples of the tube bundle flow straightener





$d_t \leq 0{,}2D$
$L \geq 10d_t$

Key

1 minimized gap

2 pipe wall

3 tube wall thickness (which is less than 0,025D)

4 centring spacer options – typically 4 places

a The length, L, of the tubes shall be between 2D and 3D, preferably as close to 2D as possible.

b D_f = flow straightener outside diameter, and $0{,}95D \leqslant D_f \leqslant D$.

The pressure loss coefficient, K, for the tube bundle flow straightener depends on the number of the tubes and their wall thickness, but for the 19-tube bundle flow straightener (1998) it is approximately equal to 0,75, where K is given by the following equation:

$$K = \frac{\Delta p_c}{\frac{1}{2}\rho V^2}$$

where

Δp_c is the pressure loss across the flow straightener or flow conditioner;

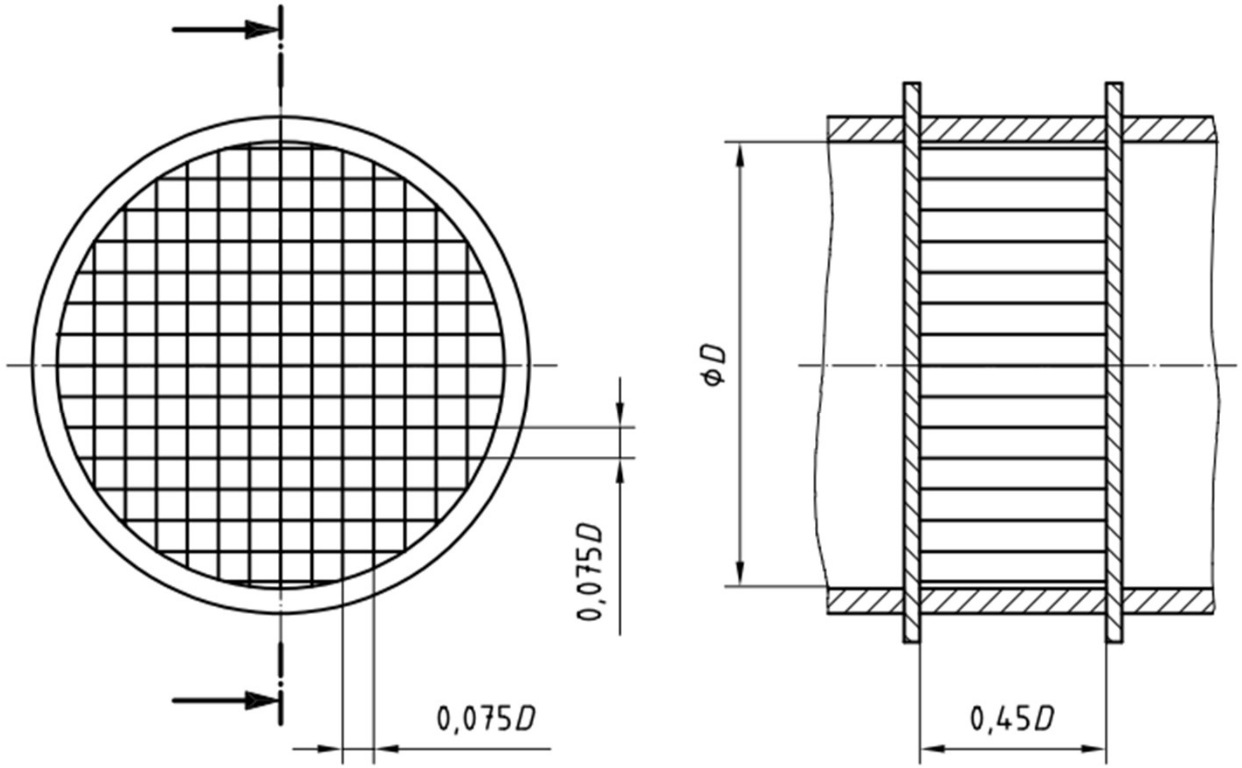
V is the mean axial velocity of the fluid in the pipe.

An alternative design of tube bundle flow straightener has the tubes attached at their outer rim to a flange which very slightly protrudes into the pipe.

C.2.2.2 The AMCA straightener

The AMCA straightener consists of a honeycomb with square meshes, the dimensions of which are shown in Figure C.2. The vanes should be as thin as possible but should provide adequate strength.

The pressure loss coefficient, K, for the AMCA straightener is approximately equal to 0,25.



C.2.2.3 The Étoile straightener

The Étoile straightener consists of eight radial vanes at equal angular spacing with a length equal to twice the diameter of the pipe (see Figure C.3). The vanes should be as thin as possible but should provide adequate strength.

The pressure loss coefficient, K, for the Étoile straightener is approximately equal to 0,25.

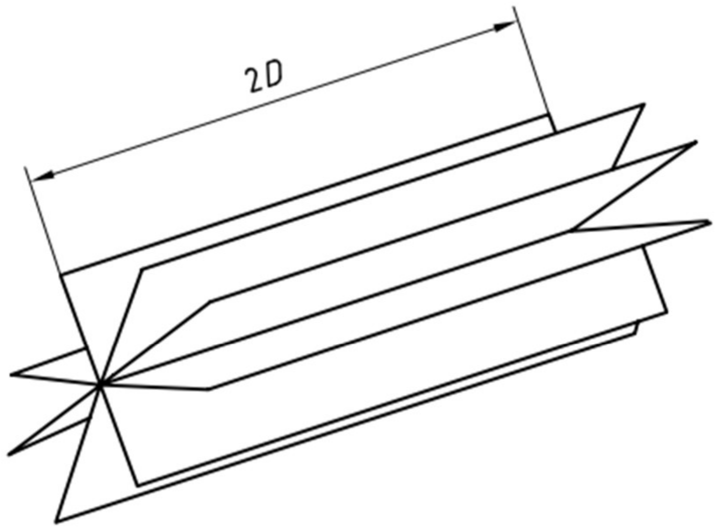


Figure C.3 — The Étoile straightener

C.3.2.1 The Gallagher flow conditioner

The Gallagher flow conditioner is covered by an existing patent. It consists of an anti-swirl device, a settling chamber and lastly a profile device as shown in Figures C.4 and C.5.

The pressure loss coefficient, K, for the Gallagher flow conditioner depends on the manufacturing specification of the conditioner; it is approximately equal to 2.

Key

1 anti-swirl device

2 profile device

a D_{nom} = nominal pipe diameter

b Length equal to diameter of raised face

c 3,2 mm for D_{nom} = 50 mm to 75 mm tube style

6,4 mm for D_{nom} = 100 mm to 450 mm tube style

12,7 mm for D_{nom} = 500 mm to 600 mm tube style

12,7 mm for D_{nom} = 50 mm to 300 mm vane style

17,1 mm for D_{nom} = 350 mm to 600 mm vane style

d 3,2 mm for D_{nom} = 50 mm to 75 mm

6,4 mm for D_{nom} = 100 mm to 450 mm

12,7 mm for D_{nom} = 500 mm to 600 mm

e Direction of flow

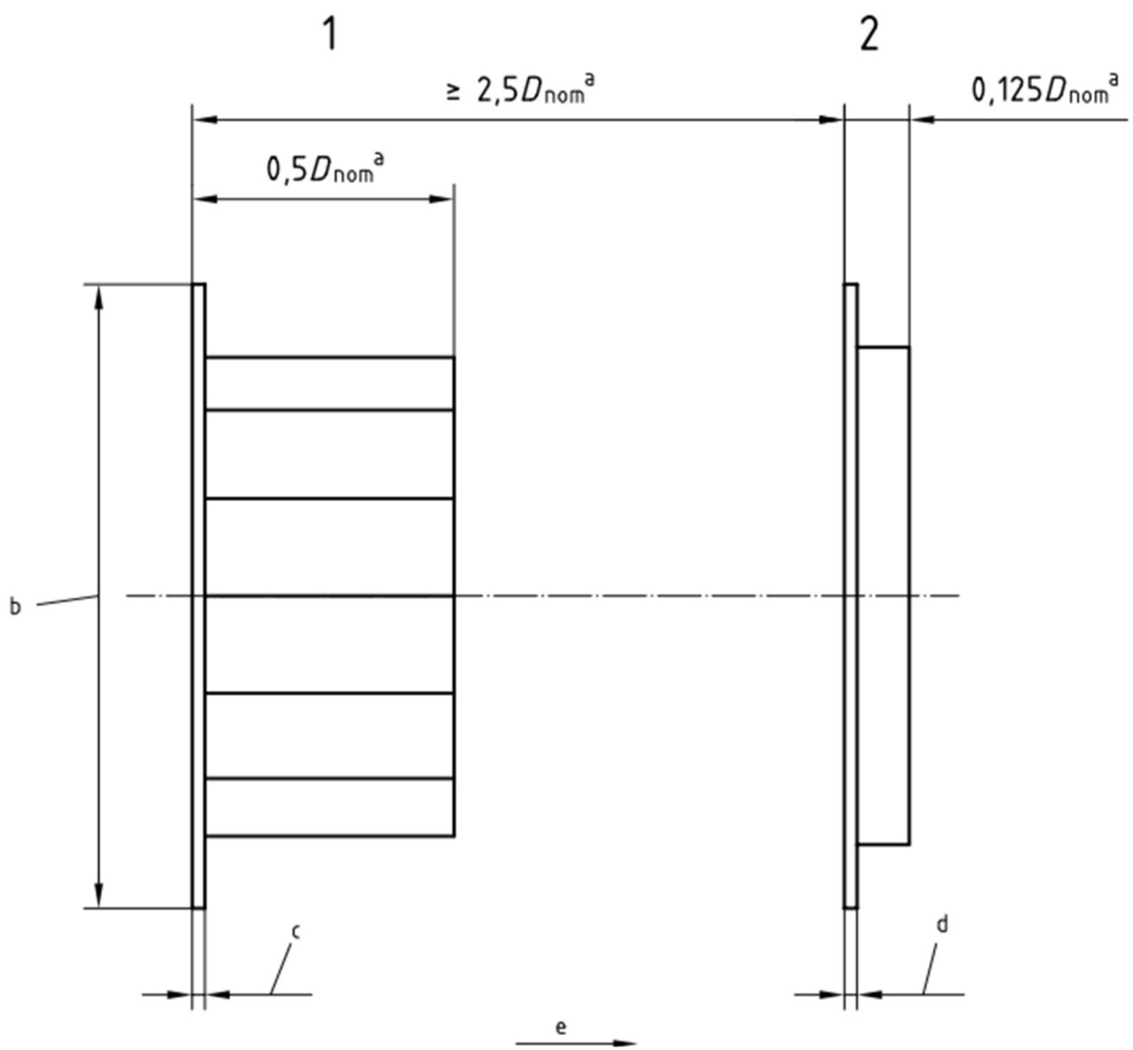


Figure C.4 — Typical arrangement of a Gallagher flow conditioner

Figure C.5 — Typical components (face views) of a Gallagher flow conditioner

Key

1 anti-swirl device – tube style option: 19-tube uniform concentric bundle (it may be pin-mounted)

2 anti-swirl device – vane style option: 8 vanes of length 0,125D to 0,25D, concentric with the pipe (the device may be placed at the entrance to the meter run)

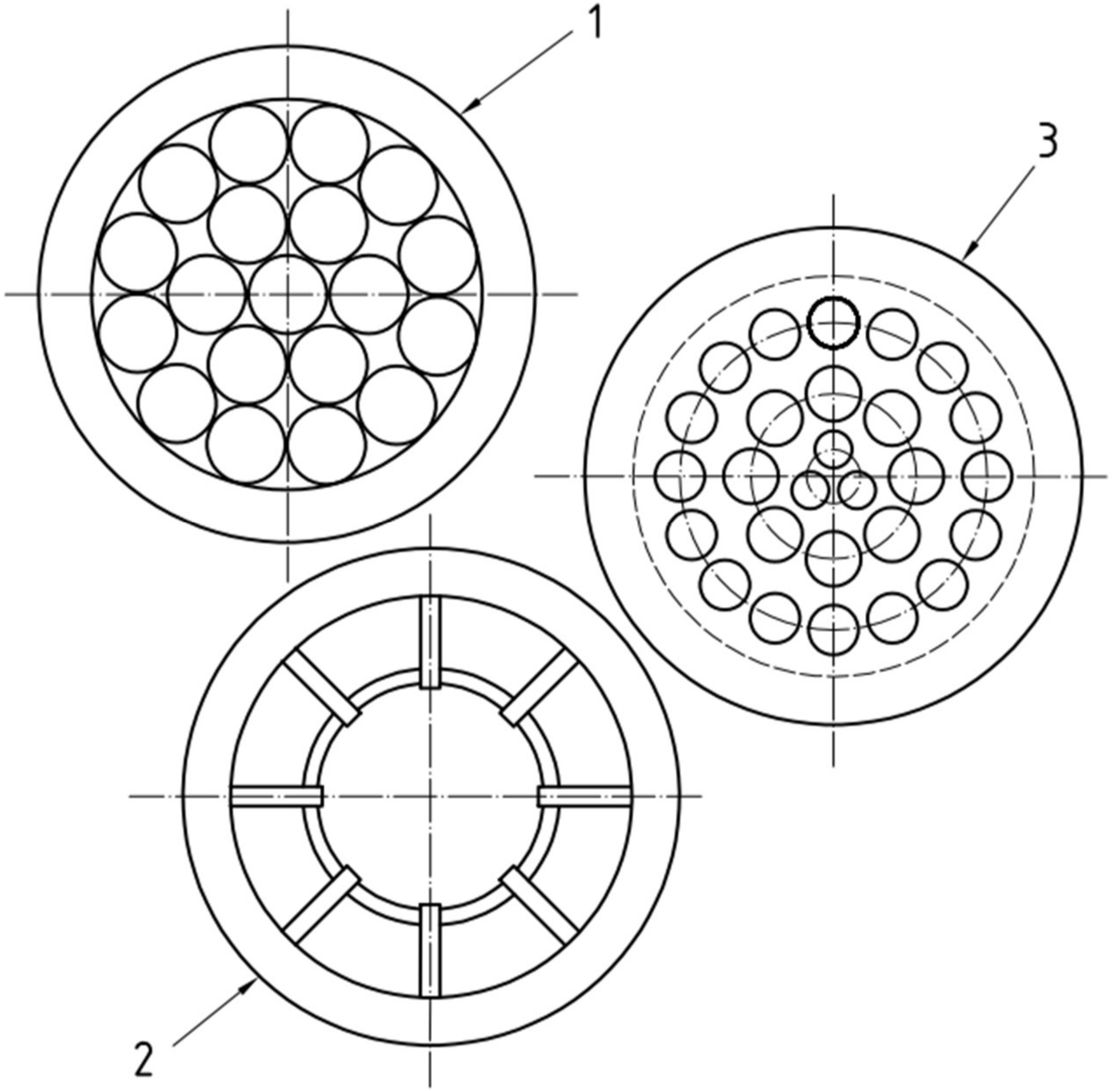
3 profile device: 3-8-16 pattern (see Note)

NOTE The 3-8-16 pattern for a profile device is:

— 3 holes on pitch circle diameter 0,15D to 0,155D; their diameter is such that the sum of their areas is 3 % to 5 % of the pipe area;

— 8 holes on pitch circle diameter 0,44D to 0,48D; their diameter is such that the sum of their areas is 19 % to 21 % of the pipe area;

— 16 holes on pitch circle diameter 0,81D to 0,85D; their diameter is such that the sum of their areas is 25 % to 29 % of the pipe area.


1
3
2

C.3.2.2 NOVA's design of K-Lab perforated plate flow conditioner

NOVA's design of K-Lab perforated plate, known as the K-Lab NOVA flow conditioner, is covered by an existing patent. It consists of a plate with 25 bored holes arranged in a symmetrical circular pattern as shown in Figure C.6. The perforated plate thickness, t_c, is such that $0{,}125D \leqslant t_c \leqslant 0{,}15D$. The flange thickness depends on the application; the outer diameter and flange face surface depend on the flange type and the application. The dimensions of the holes are a function of the pipe inside diameter, D, and depend on the pipe Reynolds number.

Provided that $Re_D \geqslant 8 \times 10^5$ there are

— a central hole of diameter $0{,}186\ 29D \pm 0{,}000\ 77D$;

— a ring of 8 holes of diameter $0{,}163D \pm 0{,}000\ 77D$ on a pitch circle diameter of $0{,}5D \pm 0{,}5$ mm, and

— a ring of 16 holes of diameter $0{,}120\ 3D \pm 0{,}000\ 77D$ on a pitch circle diameter of $0{,}85D \pm 0{,}5$ mm.

Provided that $8 \times 10^5 > Re_D \geqslant 10^5$ there are

— a central hole of diameter $0{,}226\ 64D \pm 0{,}000\ 77D$;

— a ring of 8 holes of diameter $0{,}163\ 09D \pm 0{,}000\ 77D$ on a pitch circle diameter of $0{,}5D \pm 0{,}5$ mm, and

— a ring of 16 holes of diameter $0{,}124\ 22D \pm 0{,}000\ 77D$ on a pitch circle diameter of $0{,}85D \pm 0{,}5$ mm.

The pressure loss coefficient, K, for the K-Lab NOVA flow conditioner is approximately equal to 2.

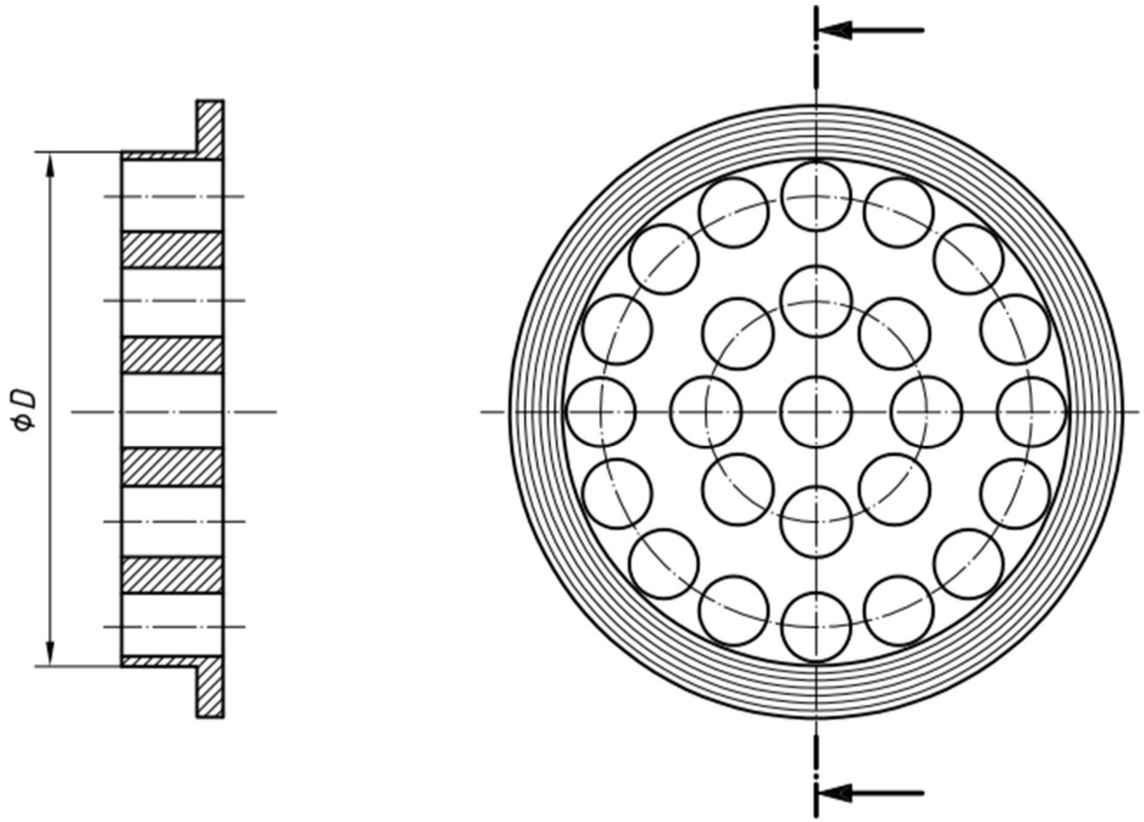


Figure C.6 — The K-Lab NOVA flow conditioner

C.3.2.3 The NEL (Spearman) flow conditioner

The NEL (Spearman) flow conditioner is shown in Figure C.7. The dimensions of the holes are a function of the pipe inside diameter, D. There are:

a) a ring of 4 holes (d_1) of diameter 0,10D on a pitch circle diameter of 0,18D;

b) a ring of 8 holes (d_2) of diameter 0,16D on a pitch circle diameter of 0,48D, and

c) a ring of 16 holes (d_3) of diameter 0,12D on a pitch circle diameter of 0,86D.

The perforated plate thickness is 0,12D.

The pressure loss coefficient, K, for the NEL (Spearman) flow conditioner is approximately equal to 3,2.

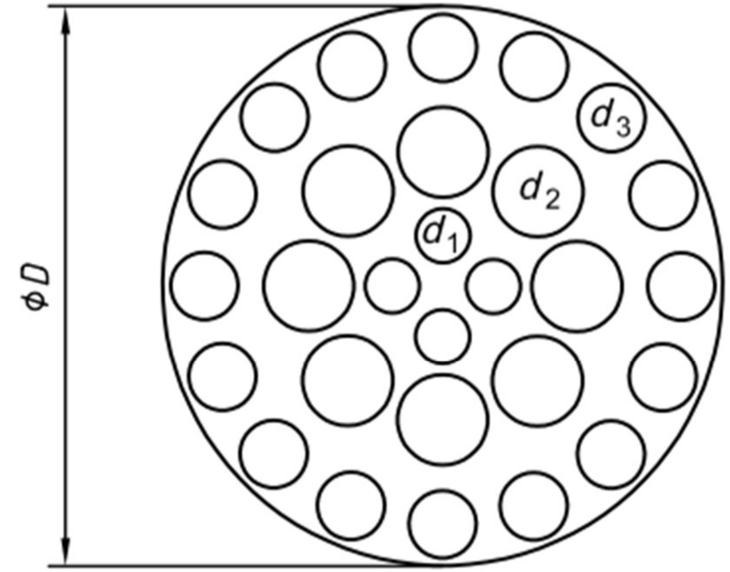


Figure C.7 — NEL (Spearman) flow conditioner