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Rotodynamic pumps — Recommendations for fitting of inlet and outlet on piping

ICS 23.080

British Standards

National foreword

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Pompes rotodynamiques - Recommandations pour les raccordements des tuyauteries d'aspiration et de refoulement

Kreiselpumpen - Empfehlungen für Rohrleitungsanschlüsse an Ein-und Autrittstutzen

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Foreword

This document (CEN/TR 13932:2009) has been prepared by Technical Committee CEN/TC 197 “Pumps”, the secretariat of which is held by AFNOR.

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This document supersedes CR 13932:2000.

Introduction

The inlet and outlet piping of a pump almost always includes peculiarities or accessories (changes of cross-sectional area, elbows, connections, valves, filters, check valves, etc.). Particularly in the case of inlet piping, flow disturbances such as swirl, unbalance in the distribution of velocities and pressures and sudden variations in velocity are harmful to the hydraulic performance of the pump, its mechanical behaviour and its reliability.

This document cannot attempt to cover the almost infinite range of disturbances that may be encountered as well as all their types, geometries and possible combinations. In cases that are not dealt with below, the layout of the piping should be determined by mutual agreement between the parties in keeping with the spirit or a certain number of principles:

- straight lengths indicated in this document are adequate values in most cases but it is always beneficial, from a purely hydraulic point of view, to increase them. The optimum length is usually the result of a cost-benefit trade-off.
- the most hazardous disturbances are those which create a swirling flow as a result of several changes of direction in various planes, this swirl always takes a very long time to settle down, or disturbances which create a very marked unbalanced flow due to a sudden change in cross-sectional area.
- generally speaking, the higher the specific speed of a pump, the more sensitive it is to feed conditions. For this reason, especially strict requirements should be imposed in the case of an axial-flow pump.

In fact, the correct operation of a rotodynamic pump is closely linked to the features of the piping system in which it is fitted. The noise level of this system as well as any vibrations originating from turbulence or hydraulic shocks also depend on its layout as well as the choice and arrangement of components such as valves, filters, convergent pipes, divergent pipes, etc.

The following recommendations are intended to reduce the risk of incorrect operation of the pump and the system as far as possible. Under no circumstances can they guarantee perfect operation for several reasons:

- the need to make allowance for economic considerations which very often imposes deviation from the ideal arrangement and the risk of incorrect operation which this involves increases the greater such deviation becomes.
- the extremely complex influence on the recommended values of several factors which cannot be described in detail without complicating the implementation of these recommendations excessively. This is the reason why somewhat wide "average" values have been adopted even though they may sometimes lead to excessive precautions which may still sometimes nevertheless be inadequate.

The main factors in question are as follows:

- the type of pump (centrifugal, mixed flow, axial flow);
- the size and speed of the pump;
- the margin between the available "NPSHA" and the "NPSHR" required by the pump;
- the characteristics of the liquid (nature, viscosity, presence of dissolved gas or solids in suspension, etc.);
- the flow rate of the liquid.

The last two factors have a very marked effect on the behaviour of the system and on the measures to be taken in order to limit unwanted conditions.

1 Scope

This CEN Technical Report lays down stipulations relating to installation conditions for sudden change in section or direction (elbows, tee fittings, junctions) and the most widely used accessories at the inlet and outlet of pumps (valves and fittings) in order to minimise the effect of disturbances in the flow of liquid thereby created upstream and downstream from the pump and on the operation of the pump.

NOTE 1 The recommendations given in this document permit to solve a majority of the most current cases.

These recommendations relate to three aspects of installation:

— the fitting of the pump to pipework by convergent and divergent pipes;

— in the case of elbows, tees and branching, their direction with respect to the axis of the pump;

— the minimum clearances to be adhered to between a disturbing (elbow, valve, etc.) and the mounting flange of the pump.

This document applies to the installation of rot dynamic pumps (centrifugal, mixed flow and axial flow) fitted in piping. It applies to pumps having intake diameters equal to or less than 500 mm. The recommendations may be adapted in agreement with the pump manufacturer for intakes having dimensions exceeding 500 mm or for special applications. This document is not applicable to pumps of which the inlet is located in reservoirs, sumps or tanks and which will be dealt with in a subsequent standard.

The recommendations in this document are only valid under the following conditions:

— Newtonian fluids having a maximum viscosity of 2.10^{-4} m^2/s;

— occluded gas content at pumping temperature and inlet pressure not exceeding 2 % by volume for water and 4 % for other fluids;

— solids content (small particle size, such as sand) not exceeding 1 % by volume, nor 1 % by weight;

— in piping with diameters D_1 and D_2 (see Figure 11), flow rate velocity, should be in the following ranges:

  — 3 m/s to 5 m/s at inlet;

  — 4 m/s to 10 m/s at outlet.

NOTE 2 These flow rate velocity values are not optimal; they are limits which are not to be exceeded unless special precautions are taken.

NOTE 3 In all cases where these limits are exceeded, it is essential that the pipework design engineer consults the pump manufacturer before finalizing the installation drawings.

Even if conditions are well within the stated limits, it is highly advisable to adopt this approach sufficiently early to allow any modifications requested by the manufacturer to be made.

Many difficulties experienced in a pumping system actually originate from errors in the design and/or production of piping.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 593, *Industrial valves — Metallic butterfly valves*

EN 736-1:1995, *Valves — Terminology — Part 1: Definitions of types of valves*

EN 736-3:2008, *Valves — Terminology — Part 3: Definition of terms*

EN 1171, *Industrial valves — Cast iron gate valves*

EN 1983, *Industrial valves — Steel ball valves*

EN 1984, *Industrial valves — Steel gate valves*

EN 12334, *Industrial valves — Cast iron check valves*

EN 13397, *Industrial valves — Diaphragm valves made of metallic materials*

EN 13709, *Industrial valves — Steel globe and globe stop and check valves*

EN 13789, *Industrial valves — Cast iron globe valves*

EN 14341, *Industrial valves — Steel check valves*

EN ISO 9906, *Rotodynamic pumps — Hydraulic performance acceptance tests — Grades 1 and 2 (ISO 9906:1999)*

ISO 7194, *Measurement of fluid flow in closed conduits — Velocity-area methods of flow measurement in swirling or asymmetric flow conditions in circular ducts by means of current-meters or Pitot static tubes*

3 Definitions

For the purposes of this document, the definitions of EN 736-1:1995 apply, and also the following which are in accordance with EN 736-3:2008.

3.1
full bore valves
valve with a flow section equal to or greater than 80 % of the section corresponding to the nominal inside diameter of the body end port

NOTE The nominal inside diameter of the body end for the particular valve type is specified in the corresponding product or fitness for purpose standard.

3.2
clearway valve
valve designed to have an unobstructed flow way to pass a theoretical sphere having a diameter not less than the body end port nominal inside diameter

NOTE The nominal inside diameter of the body end for the particular valve type is specified in the corresponding product or fitness for purpose standard.

3.3 reduced bore valve
valve with a flow section equal to or greater than 36 % of the section corresponding to the port nominal inside diameter of the body end port and which does not correspond to the full bore valve

NOTE The nominal inside diameter of the body end for the particular valve type is specified in the corresponding product or fitness for purpose standard.

4 Minimum installation precautions

4.1 Pipework components

4.1.1 Convergent - divergent pipes

4.1.1.1 Convergent transition section

4.1.1.1.1 Horizontal installation

For a horizontal installation, the configuration of the convergent transition section is usually non-symmetrical. Its top generating line should then be horizontal, so as to avoid the formation of pockets of air or gas. The angle (α) should not exceed 20° (see Figure 1).

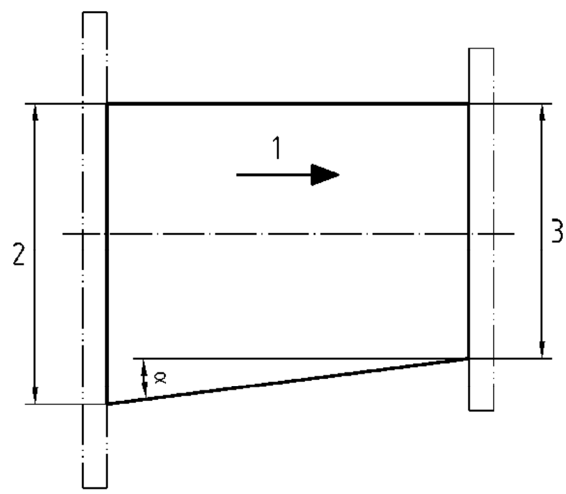
When the angle exceeds 20°, the fitting of the convergent to the pump intake should be made by means of a transition zone with a radius of at least ¼ of the pump inlet diameter.

However, when the degassing is carried out on the upstream side of the convergent transition section continuously:

— either naturally; or

— by means of a suitable device.

It will be possible to use a symmetrical convergent transition section as described in Clause 4.1.1.1.2.



Key

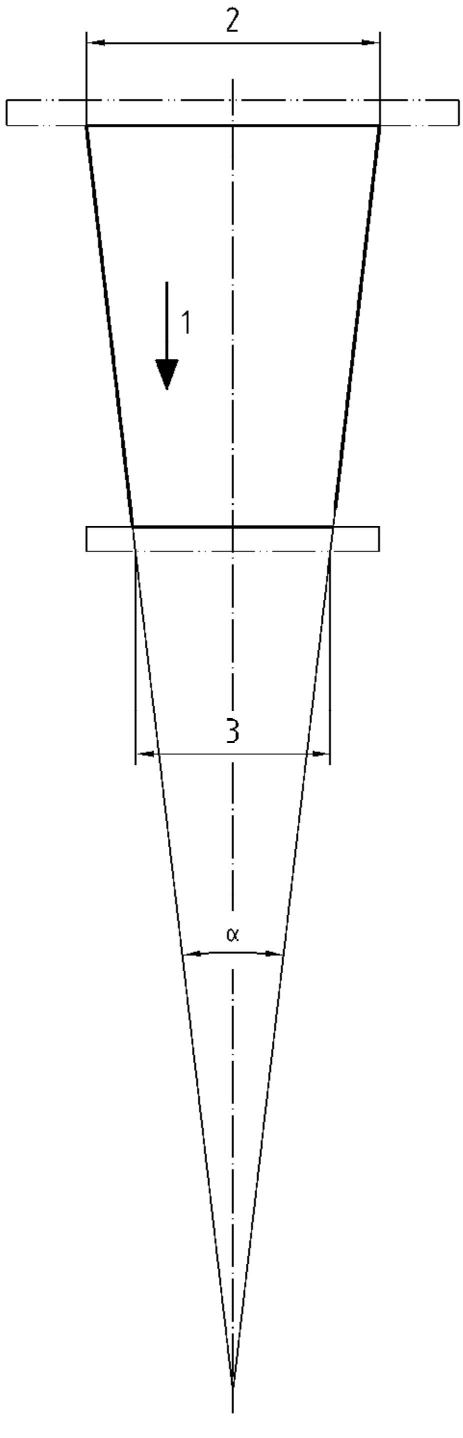
1 Direction of fluid flow
2 Diameter of the pipework inlet
3 Diameter of the pump inlet

Figure 1 — Non-symmetrical convergent transition section

NOTE In some cases, particularly when the pump incorporates an inducer, it is not recommended fitting a convergent transition section to the pump inlet. In this case, the inlet pipeline near the pump should be studied jointly between the pump manufacturer and those responsible for the installation.

4.1.1.1.2 Vertical installation

The configuration of the convergent transition section is symmetrical for a vertical installation (see Figure 2). The included angle (α) should not exceed 25°.



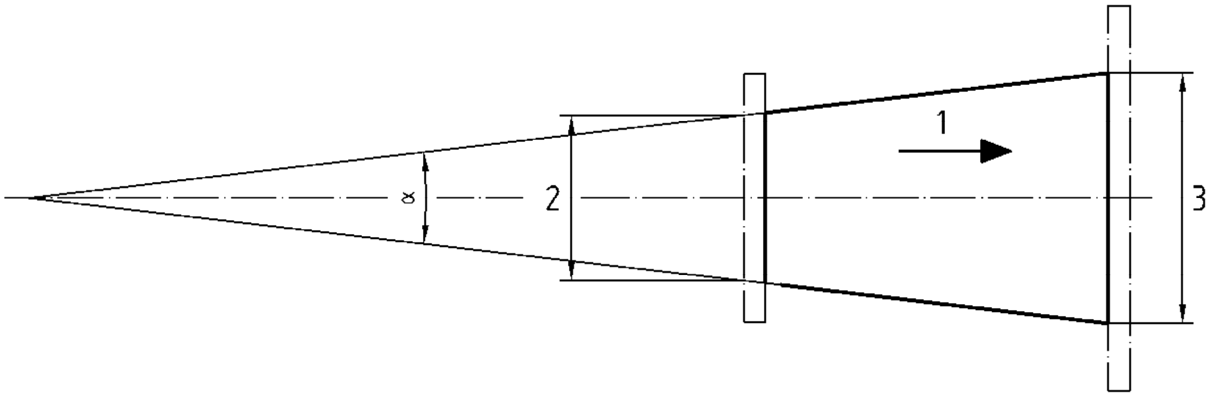
Key

1 Direction of fluid flow
2 Diameter of the pipework inlet
3 Diameter of the pump inlet

Figure 2 —Symmetrical convergent transition section

4.1.1.2 Divergent transition section

The configuration of the divergent transition section is usually symmetrical, irrespective of the installation (see Figure 3).



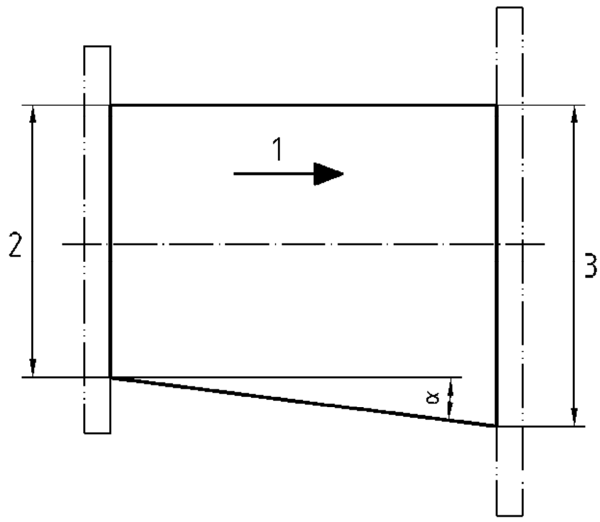
Key

1 Direction of fluid flow
2 Diameter of the pump outlet
3 Diameter of the pipework outlet

Figure 3 — Symmetrical divergent transition section

The include angle (α) for a divergent transition sections is recommended to be between 7° and 12° to avoid excessive energy losses.

In some special cases, "on-line" pumps for example, the non-symmetrical configuration of the divergent may be permitted with a maximum angle of 8° (see Figure 4).



Key

1 Direction of fluid flow
2 Diameter of pump
3 Diameter of pipework

Figure 4 — Non-symetrical divergent transition section

4.1.2 Elbows

4.1.2.1 Shapes of elbows

4.1.2.1.1 Standardised elbows

This document only applies to standardised elbows of which there are two types:

— small-radius elbows referred to as 2 *D*: $R \leq D$; and

— preferably, large-radius elbows referred to as 3 *D*: $R \leq 1{,}5\ D$.

R is the bending radius; and

D is the diameter of the piping (inside or outside diameter as appropriate).

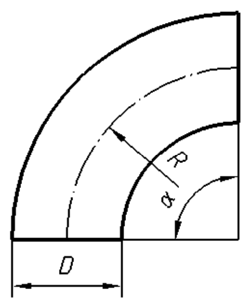


Figure 5 — Dimensions of standardised elbows

The use of large-radius elbows is strongly recommended, particularly in inlet piping, or for $D \geq 100$ mm.

4.1.2.1.2 Angle of elbows

The following sub-clauses make provision for 90° elbows that are the most commonly encountered.

If an elbow having an angle $\alpha < 90°$ is used, reference should be made to the rules stated for 90° elbows by multiplying the stipulated lengths by $\sqrt{\alpha / 90}$.

If an elbow having an angle $\alpha > 90°$ is used, such elbows are comparable to 90° elbows.

4.1.2.1.3 Other shapes of elbows

Sharp elbows without a bend radius are to be prohibited (except those with fins that are mentioned below).

Segmented elbows, if they have at least five segments, may be likened to standardised elbows.

Other shapes of elbows (convergent elbows, elbows with guide fins, etc.) should be the subject of an agreement between the parties concerned because the wide variety of their shapes and dimensions makes it impossible to state a generally applicable rule.

4.1.2.2 Orientation of elbows

Since the orientation of an elbow located in the outlet of a pump has no effect on the operation of the pump regardless of its type, this sub-clause only deals with elbows located in the inlet.

The consequences of disturbance generated by an elbow depend on the type of pump and on the position of the inlet flange with respect to the axis of the pump. The most common different configurations should therefore be examined separately.

4.1.2.2.1 Centrifugal or mixed-flow pump with single suction and axial inlet

For this type of pump, the orientation of the elbow may be in all the possible directions (see Figure 6).

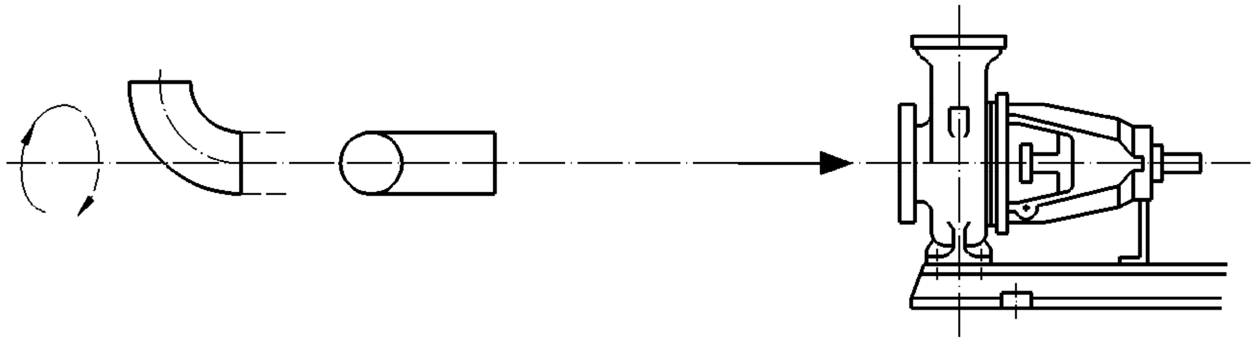


Figure 6 — Pump with single suction and axial inlet

4.1.2.2.2 Centrifugal or mixed-flow pump with single suction and lateral inlet

The recommendations below apply regardless of whether the shaft of the pump is horizontal (Figure 7) or vertical (Figure 8, particularly in-line pumps). They are also valid for multi-stage pumps having an impeller comprising only a single suction.

It is preferable for the plane of the elbow to be parallel to the shaft (Figure 7a and Figure 8a). If the plane is perpendicular to the shaft (Figure 7b and Figure 8b), the effect of the elbow depends on its orientation relative to the direction of rotation of the impeller:

— If the elbow deflects the fluid in the direction of rotation, this encourages pre-swirl at the inlet to the impeller and might reduce the head generated by the pump.

— If the elbow deflects the fluid in a direction opposite to the direction of rotation, this discourages pre-swirl and might increase the generated head, but with a drop in efficiency.

Note that, for a given distance, it is easier to increase pre-swirl than to reduce it. Particularly in the first case, the minimum distances stipulated in Table 1 (see sub-clause 4.1.2.3.1) should therefore be adhered to in order to prevent the risk of loss of head.

Figure 7a — Plane of elbow parallel to shaft

Figure 7b — Plane of elbow perpendicular to shaft (to avoid as far as possible)

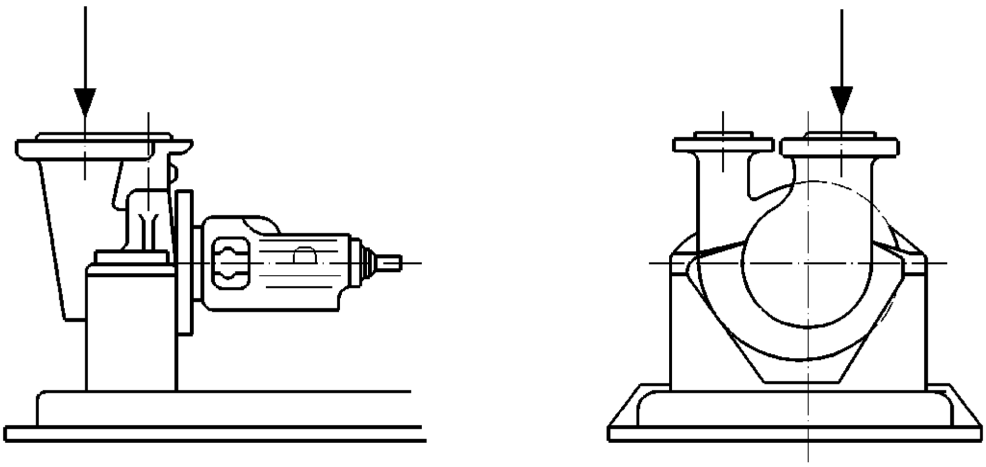


Figure 7 — Pumps with a single suction with horizontal shaft and lateral inlet

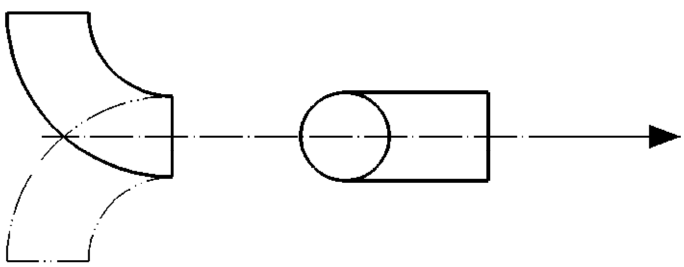


Figure 8a — Plan of elbow parallel to shaft

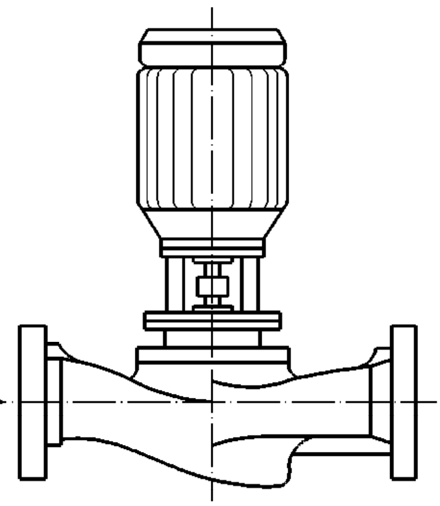


Figure 8b — Plan of elbow perpendicular to shaft
Acceptable but not recommended

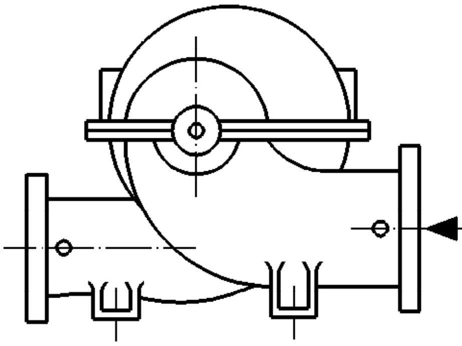
Figure 8 — Pump with single suction with vertical shaft and lateral inlet

4.1.2.2.3 Centrifugal or mixed-flow pump with double suction (lateral inlet)

The following stipulations are valid regardless whether the pump has a horizontal shaft (as shown in Figure 9) or a vertical shaft. They are also valid for multi-stage pumps having an impeller having a double suction impeller.

It is necessary that the inlet be lateral.

It is highly desirable for the plane of the elbow to be perpendicular to the shaft (Figure 9a). A position in which the plane of the elbow is parallel to the shaft (Figure 9b) should be avoided as far as possible because it can cause unbalance in the feed to the double suction.



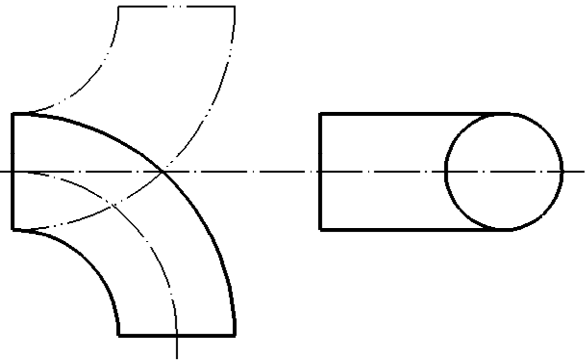


Figure 9a — Plane of elbow perpendicular to shaft

Figure 9b — Plane of elbow parallel to shaft (to avoid)

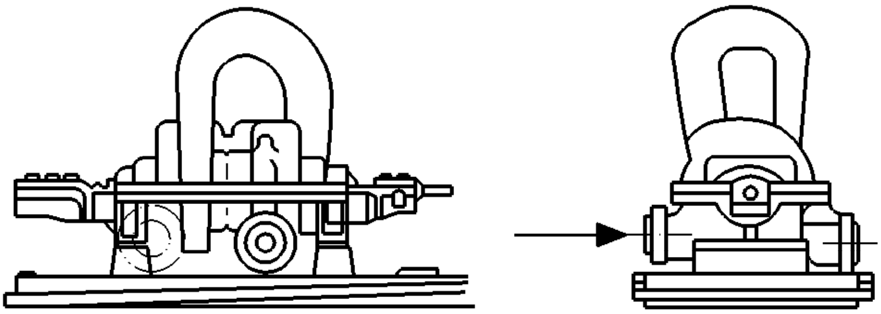


Figure 9 — Pump with double section

4.1.2.2.4 Vertical pump with intake in barrel or header tank

For this type of pumps, the orientation of the elbow may be in all the possible directions (see Figure 10).

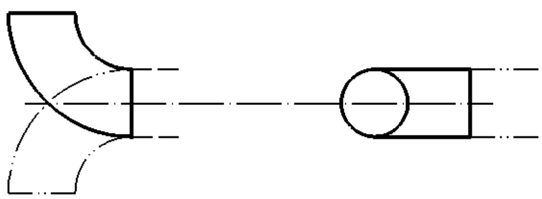


Figure 10a — Plane of elbow perpendicular to shaft

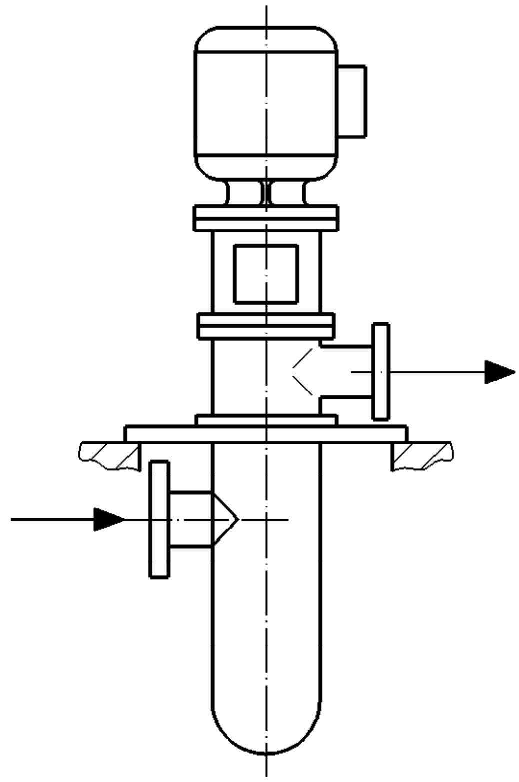


Figure 10b — Plane of elbow parallel to shaft

Figure 10 — Pump in vertical tank

4.1.2.2.5 Axial-flow pump fitted in piping

For this type of pumps, the orientation of the elbow may be in all the possible directions (see Figure 11).

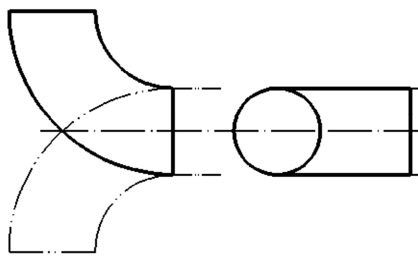


Figure 11a — Plane of elbow perpendicular to shaft

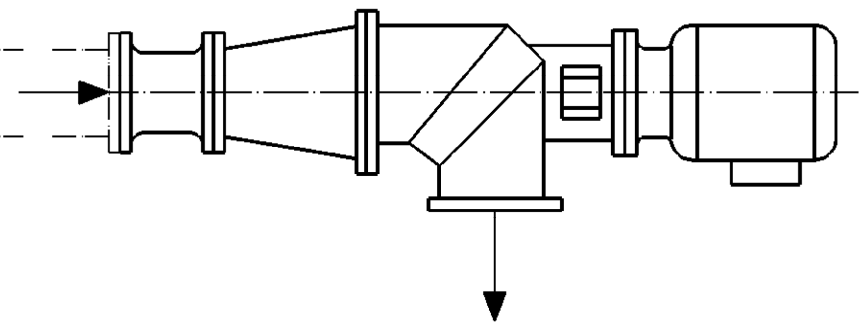
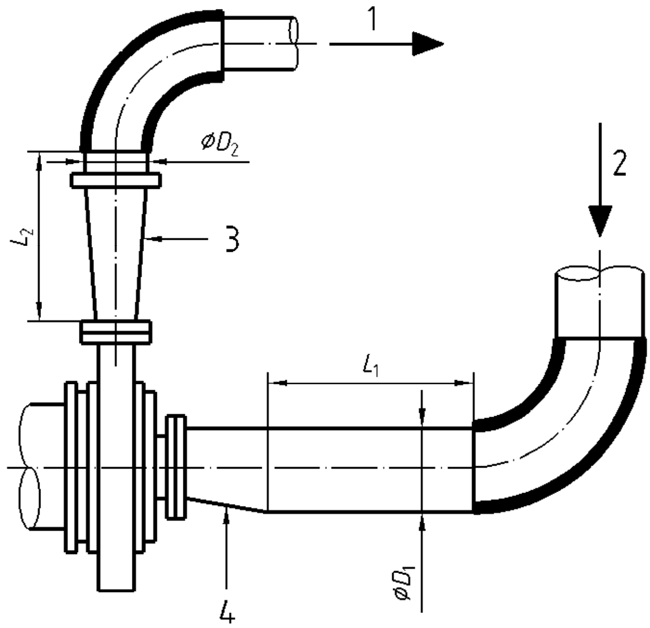


Figure 11b — Plane of elbow parallel to shaft

Figure 11 — Axial-flow pump (Horizontal or vertical arrangement)

4.1.2.3 Distance of one elbow only



Key

1 Direction of fluid flow
2 Direction of fluid flow
3 Divergent pipe
4 Convergent pipe

Figure 12 — Pump installed with elbows

The minimum straight lengths mentioned in this sub-clause, for pumps having an inlet exceeding 250 mm, may be planned in agreement with the pump manufacturer depending on the piping diameters to avoid excessive minimum lengths.

4.1.2.3.1 Straight length at inlet

The minimum straight length L_1 to be provided between a standardised elbow and the entrance of the convergent pipe at the inlet of the pump is stated, depending on the type of inlet and the orientation of the elbow, in Table 1 (D_1 is the piping diameter).

Table 1 — Minimum straight length L_1

Length L_1 to adhere to	**In a configuration which complies with**		
Type of elbow fitting	**Figures** 6 7b 8b 11	**Figures** 7a 8a 9a	**Figure** 10
Large-radius elbow Small-radius elbow (avoid if possible)	5 D_1 8 D_1	3 D_1 5 D_1	3 D_1 3 D_1

4.1.2.3.2 Straight length at outlet

The minimum recommended straight length L_2 to be allowed between the outlet flange of the pump and a standardised elbow is usually:

$L_2 = 3\ D_2$ without divergent pipe.

Nevertheless, if there is an intention to verify the characteristics of the pump in accordance with EN ISO 9906, the user should refer to the stipulations laid down in this document.

4.1.2.4 Several accessories simultaneously present

4.1.2.4.1 Two elbows on inlet

The minimum straight length L_1 to be allowed between the second elbow and the entrance of the convergent pipe of the pump is stated, depending on the type of pump and the type and arrangement of the elbows, in Table 2. Risks of vibration may nevertheless be higher.

In addition, as far as possible, arrange the two elbows in the configuration shown in Figure 13b.

Table 2 — Length L_1

Arrangement and type of elbow			Length L_1 in a configuration which complies with		
			Figures 7b - 8b 9b - 11	**Figures 6 - 7a 8a - 9a**	**Figure 10**
Distance between elbows > 5 D_1	Coplanar elbow or elbows in perpendicular planes	Large-radius elbows	5 D_1	3 D_1	3 D_1
		Small-radius elbows	8 D_1	5 D_1	3 D_1
Distance between elbows < 5 D_1	Coplanar elbows	Large-radius elbows	5 D_1	3 D_1	3 D_1
		Small-radius elbows	8 D_1	5 D_1	3 D_1
	Elbows in perpendicular planes	Large-radius elbows	10 D_1	6 D_1	6 D_1
		Small-radius elbows	16 D_1	10 D_1	6 D_1

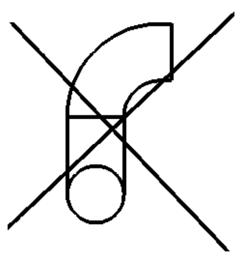


Figure 13a — Prohibited arrangement

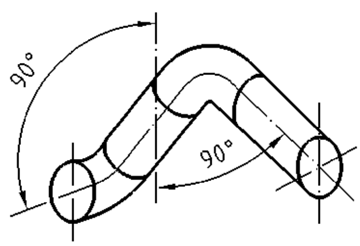


Figure 13b — Preferred arrangement

Figure 13 — Two elbows on inlet

4.1.2.4.2 Two elbows on outlet

The second elbow is deemed to have no influence on the operation of the pump. Risks of vibration may nevertheless be higher.

4.1.2.4.3 One elbow and fittings on inlet

As a general rule, the most severe disturbance should be located farthest from the pump.

If an elbow and one or more fittings (valve, filter, check valve, etc.) have to be fitted on the inlet of the pump, it is advisable for the elbow to be located downstream from the fittings (Figure 14).

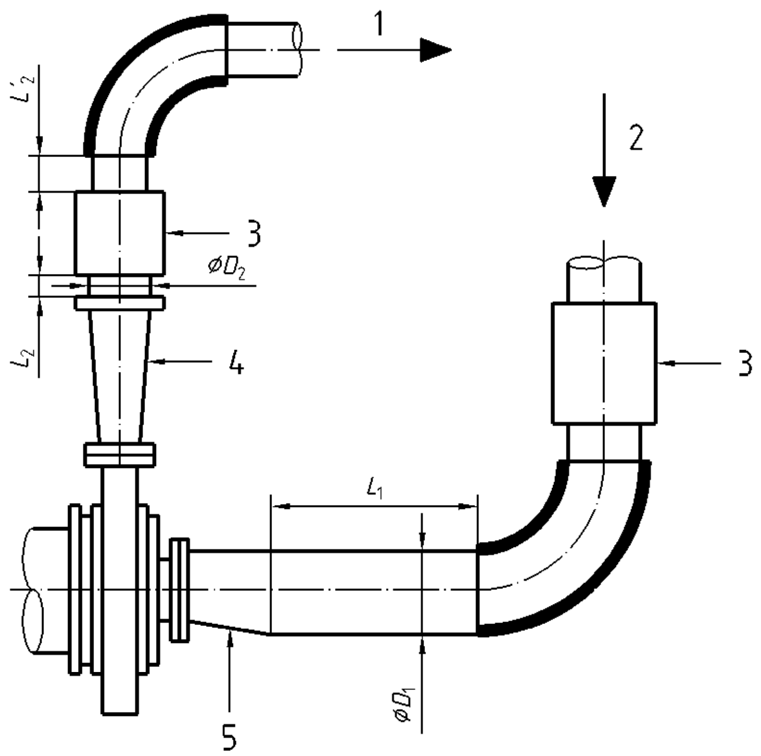
It may nevertheless be permissible to locate the elbow before the fittings but the straight length L_1 at the inlet should then satisfy the stipulations in sub-clause 4.2.

In every case, the specific rules for each of the fittings should be complied with as a minimum (see Table 1 and sub-clause 4.2).

4.1.2.4.4 One elbow and fittings on outlet

If an elbow and one or more fittings have to be fitted on the outlet of the pump, the orientation of the elbow may be in all possible directions.

The distance between the elbow and the first fitting or between the last fitting and the elbow may be nil, provided that the specific rules for each of the fittings are complied with (see sub-clauses 4.1.2.3.2 and 4.2).



Key

1 Direction of fluid flow
2 Direction of fluid flow
3 Fitting
4 Divergent pipe
5 Convergent pipe

Figure 14 — Pump installed with elbows and fittings

4.1.3 Tees

4.1.3.1 Shapes of connections

As far as possible, avoid fitting tees on the inlet piping. They should be replaced by junctions (see sub-clause 4.1.4).

If, however, use of a fitting of this type cannot be avoided, it should have one of the shapes shown in Figure 15 and make provision, as far as possible, for flow velocities less than 1,5 m/s in small diameters.

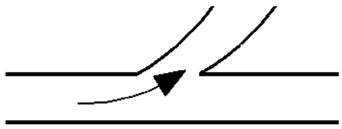


Figure 15a — Similar to tee (large radius)

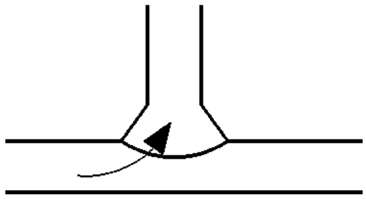


Figure 15b — Similar to tee (small radius)

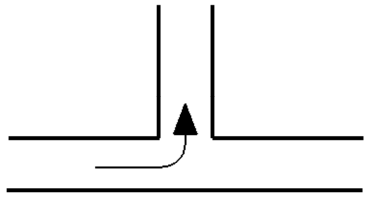


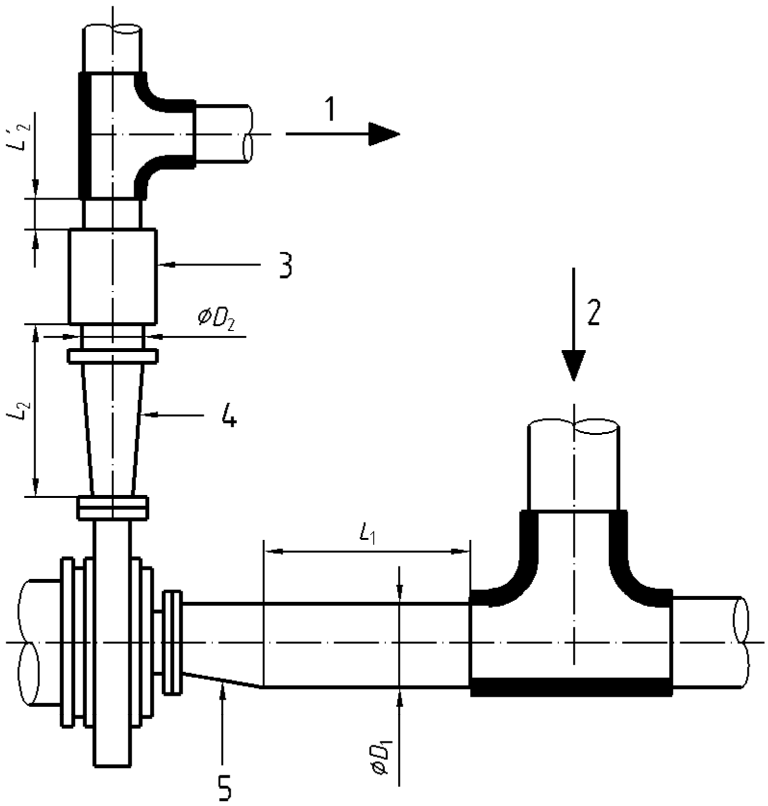
Figure 15c — Similar to tee angle tee

Figure 15 — Recommended shapes of fittings on inlet piping

4.1.3.2 Orientation of tees

The rules stated in sub-clause 4.1.2.2 for the orientation of elbows with respect to the pump also apply to tees and other junctions located on the inlet.

4.1.3.3 Distance of tees



Key

1 Dimension of fluid flow
2 Dimension of fluid flow
3 Fitting
4 Divergent pipe
5 Convergent pipe

Figure 16 — Pump installed with tees and a fitting

The minimum straight lengths stated in this sub-clause, for pumps having an inlet greater than 250 mm, may be planned in agreement with the pump manufacturer depending on piping diameters to avoid excessively long minimum lengths.

4.1.3.3.1 Straight length at inlet

4.1.3.3.1.1 Individual operation

If only one leg of the tee delivers fluid, the minimum straight length L_1 to be allowed between the tee and the entrance to the inlet convergent pipe (Figure 16) is stated regardless of the type of pump in Table 3.

Table 3 — Mininum straight length L_1

Minimum straight length	Junction similar to elbow	Sharp-angle tee
Shape of the connection	Figures 15a and 15b	Figure 15c
L_1	8 D_1	15 D_1

4.1.3.3.1.2 Parallel operation

If the tee delivers fluid simultaneously via both its legs (two pumps fed in parallel), an anti-gyration device (spider, wall of length roughly equal to D_1) in the piping downstream from the tee in order to avoid the pre-swirl inherent to each pump from clashing at the level of the tee. In this case, the value 15 D_1 can be adopted. In the absence of such a device, this minimum straight length should be increased to $L_1 = 25\ D_1$.

4.1.3.3.2 Straight length at outlet

If there is no valve or fitting between the pump and the tee, the recommended minimum straight length L_2 between the outlet flange and the tee is $L_2 = 3\ D_2$. This value applies to pumps having an intake of which the diameter is less than or equal to 250 mm and in the absence of an anti-gyration device.

If the tee is fitted after one or more valves or fittings, the recommended minimum straight length L'_2 between the last device and the tee is $L'_2 = 3\ D_2$; the straight length L_2 specific to the device (see sub-clause 4.2) in front should be adhered to.

4.1.4 Junctions

4.1.4.1 Shape of junctions

Junctions may be symmetrical (Figure 17a) or asymmetrical (Figure 17b) and should always be arranged in the direction which is most favourable in terms of the flow. The angle α of the two legs should be 45° maximum.

It is advisable to dimension junctions located on the inlet so that flow velocities are less than 2 m/s.

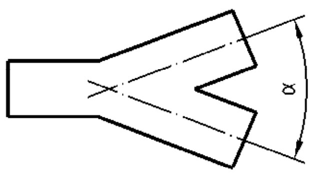


Figure 17a – Symmetrical junction

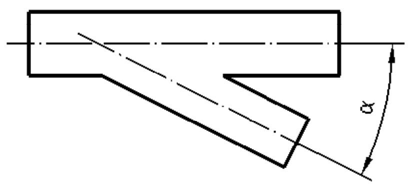


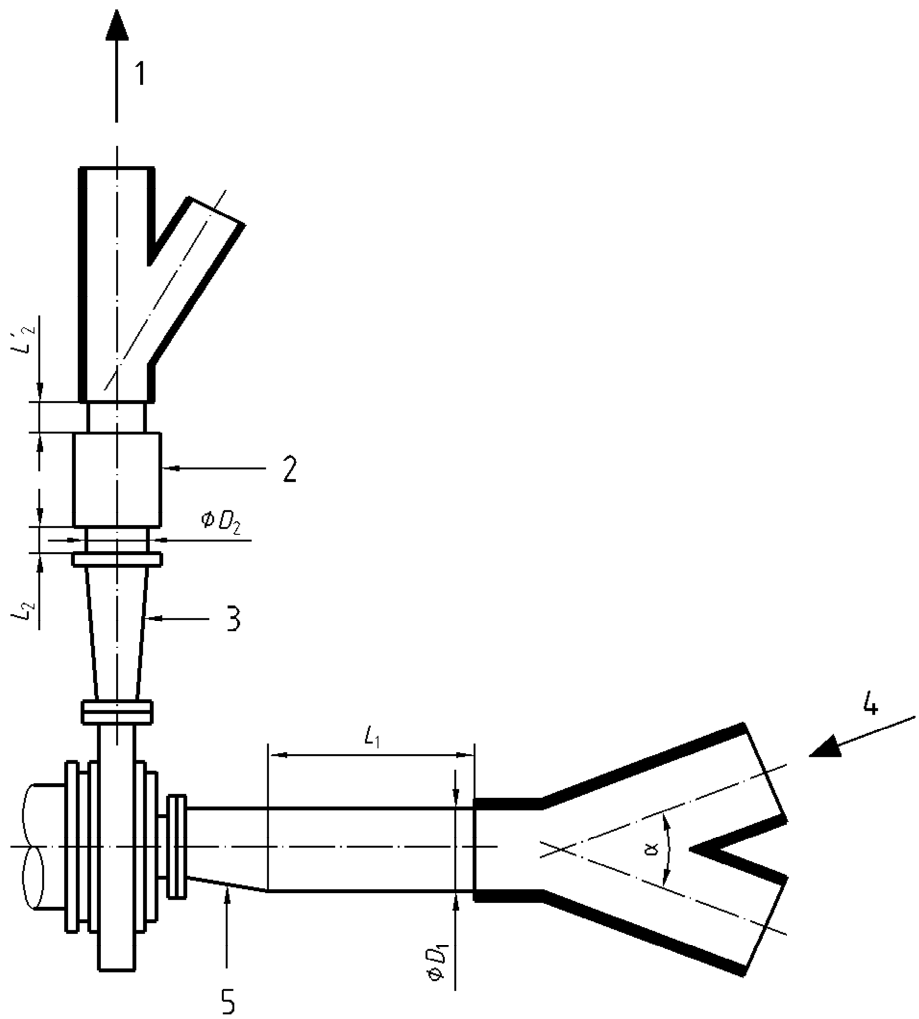
Figure 17b – Asymmetrical junction

Figure 17 — Shape of junctions

4.1.4.2 Orientation of junctions

The rules stated in sub-clause 4.1.2.2 for the orientation of elbows relative to the pump also apply to junctions.

4.1.4.3 Distance of junctions



Key

1 Direction of fluid flow
2 Fitting
3 Divergent pipe
4 Direction of fluid flow
5 Convergent pipe

Figure 18 — Pump installed with junctions and one valve or fitting

The minimum straight lengths mentioned in this sub-clause, for pumps having an intake exceeding 250 mm, may be planned in agreement with the pump manufacturer depending on piping dimensions to avoid excessively long minimum lengths.

4.1.4.3.1 Straight length at inlet

4.1.4.3.1.1 Individual operation

If the junction only delivers fluid via one of its legs, the minimum straight length at the inlet should be determined as follows:

— if $\alpha = 30°$, treat the junction as a standardised short-radius 45° elbow,

— if $\alpha = 45°$, treat the junction as a standardised short-radius 90° elbow.

See Table 1.

4.1.4.3.1.2 Parallel operation

If the junction delivers fluid simultaneously via both its legs, provide an anti-gyration device (spider, wall of length roughly equal to D_1) in the piping downstream from the junction so as to prevent the pre-swirl inherent to each pump from clashing at the level of the junction. In this case, the rules defined in sub-clause 4.1.4.3.1.1 can be adopted. In the absence of such a device, the minimum straight length at the inlet should be increased to $L_1 = 25\ D_1$.

4.1.4.3.2 Straight length at outlet

4.1.4.3.2.1 Individual operation

The minimum straight length L_2 between the divergent outlet pipe and the junction (if there is no valve or fitting between them) or L'_2 between the last valve or fitting and the junction are as follows:

— if $\alpha = 30°$, $L_2 = 3\ D_2$ $L'_2 = D_2$

— if $\alpha = 45°$, $L_2 = 4\ D_2$ $L'_2 = 2\ D_2$

4.1.4.3.2.2 Parallel operation

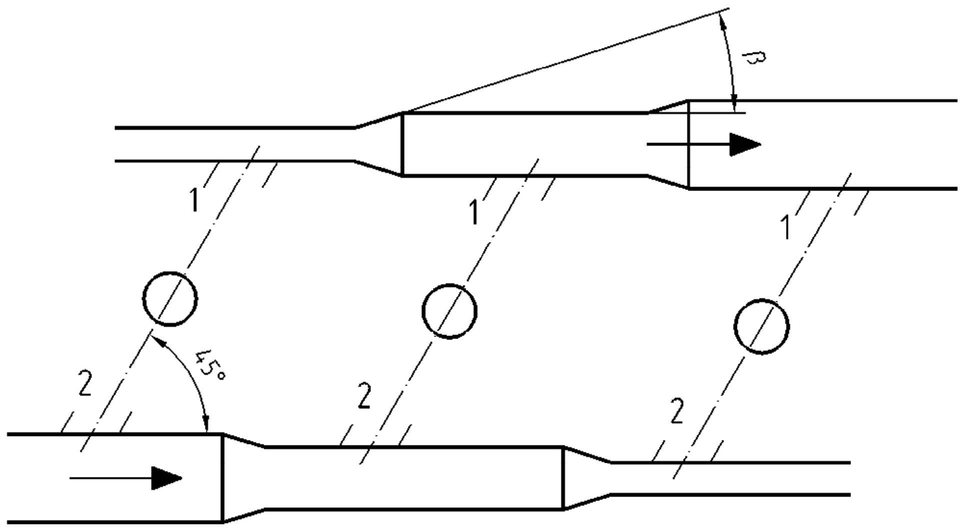
Similarly:

— if $\alpha = 30°$, $L_2 = 6\ D_2$ $L'_2 = 2\ D_2$

— if $\alpha = 45°$, $L_2 = 8\ D_2$ $L'_2 = 4\ D_2$

4.1.4.4 Recommended connection for the simultaneous operation of two or more pumps in parallel

In order to keep flow velocities essentially equal in piping, in particular, the type of connection recommended is shown in Figure 19. The value of the angle β should be equal to that stated in 4.1.1.



Cross Section S_I Cross Section $S_{II} = \frac{2}{3} S_I$ Cross Section $S_{III} = \frac{1}{3} S_I$

Key

1 Outlet
2 Inlet

Figure 19 — Example of connection of three pumps in parallel

NOTE As an alternative, the connection may be done with a radius equal to or greater than 0,3 *D* (at least on inlet side).

4.1.5 Devices to improve flow

In certain cases, the implementation of this document and, in particular, compliance with length L_1 at the inlet of the pump result in large installations whose cost and overall dimensions may seem prohibitive.

It is then possible, in particular, to reduce length L_1 by fitting a baffle before or after the inlet convergent pipe. For details, see standard ISO 7194 which defines several types of baffle and gives an estimate of the mass mechanical energy loss which they involve (from 0,25 times to 5 times kinetic energy depending on their type).

The baffle, designed and dimensioned in agreement with the pump manufacturer, should only be fitted with the mutual consent of the latter and the installer. The length L_1 should then be agreed between the parties concerned.

4.2 Valves and fittings

4.2.1 Stop valves

The stipulations relating to the positioning of stop valves are stated in Table 4 hereafter.

Table 4 — positioning of stop valves

<table>
<tr><th colspan="2">Type of valve</th><th>Inlet</th><th>Outlet</th></tr>
<tr><td rowspan="2">Continuous bore valve</td><td>Gate valve
(according to EN 1171 EN 1984)</td><td rowspan="2">Recommended at a distance $L_1 > 3\ D_1$ from the inlet flange.
The valve can be closed to the convergent pipe.</td><td rowspan="2">Regardless of distance and placed before or after the divergent pipe.</td></tr>
<tr><td>Steel ball valve
(according to EN 1983)</td></tr>
<tr><td rowspan="3">Full bore valve</td><td>Butterfly valve
(according to EN 593)</td><td rowspan="2">If unavoidable, permitted at a distance $L_1 > 5\ D_1$.</td><td>At a distance $L_2 \geq D_2$.</td></tr>
<tr><td>Diaphragm valve
without sill
(according to EN 13397)</td><td rowspan="5">At a distance
$L_2 > 3\ D_2$</td></tr>
<tr><td>Globe valve
(according to EN 13709 and EN 13789)</td><td rowspan="4">Prohibited</td></tr>
<tr><td rowspan="3">Reduced bore valve</td><td>Diaphragm valve
with sill
(according EN 13397)</td></tr>
<tr><td>Steel ball valve
(according to EN 1983)</td></tr>
<tr><td>Gate valve
(according to EN 1171 and EN 1984)</td></tr>
</table>

The definition of valve types are in accordance with EN 736-1.

4.2.2 Regulating valves

Regulating valves are always set on the outlet at a distance $L_2 > 3\ D_2$; they are prohibited on the inlet. This distance should be increased if there is a risk of the valve transmitting vibration in a manner which can affect the pump.

4.2.3 Check valves (according to EN 12334 and EN 14341)

If it is essential to maintain the priming of the pump, a check valve may be fitted on the inlet piping at a distance $L_1 > 10\ D_1$. The flap should be designed to handle the maximum working rate of flow.

In other cases, the check valve is fitted on the outlet piping at distance $L_2 > 3\ D_2$.

4.2.4 Valve accessories

4.2.4.1 Filters placed on inlet

The cross-sectional areas of flow of filters or strainers dimensioned in agreement with the pump manufacturer depend on flow rate (velocity), the type of pump, the nature of the fluid and the expected percentage fouling between two servicing operations.

They should be fitted at a distance $L_1 > 6\ D_1$.

4.2.4.2 Expansion bellows

Expansion bellows placed on the inlet or outlet of the pump should have a full bore. Those installed on the inlet should preferably be sleeved.

Bibliography

[1] Hydraulic institute Standard — Section 9.8 "Pump intake design standard".

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