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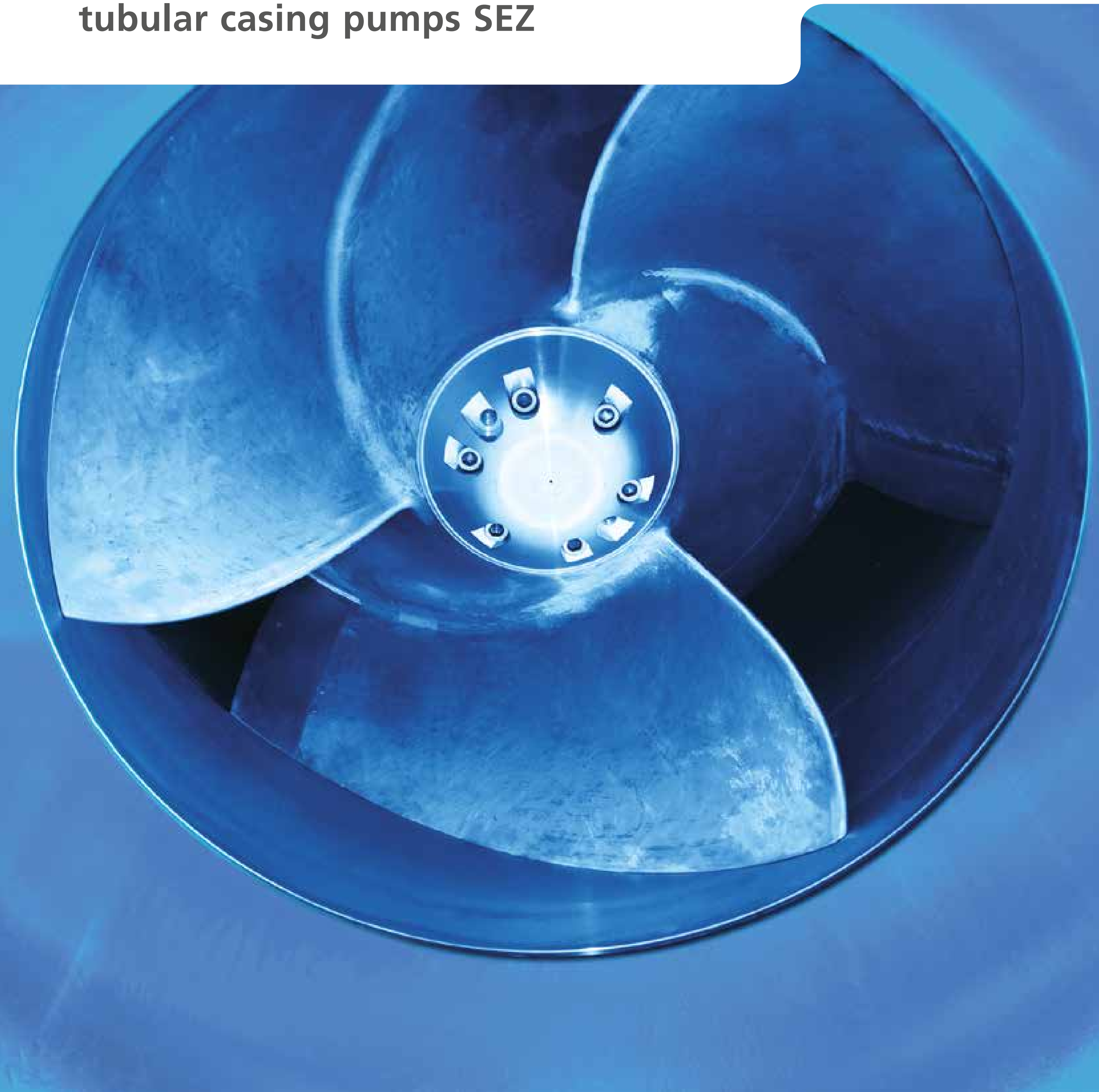
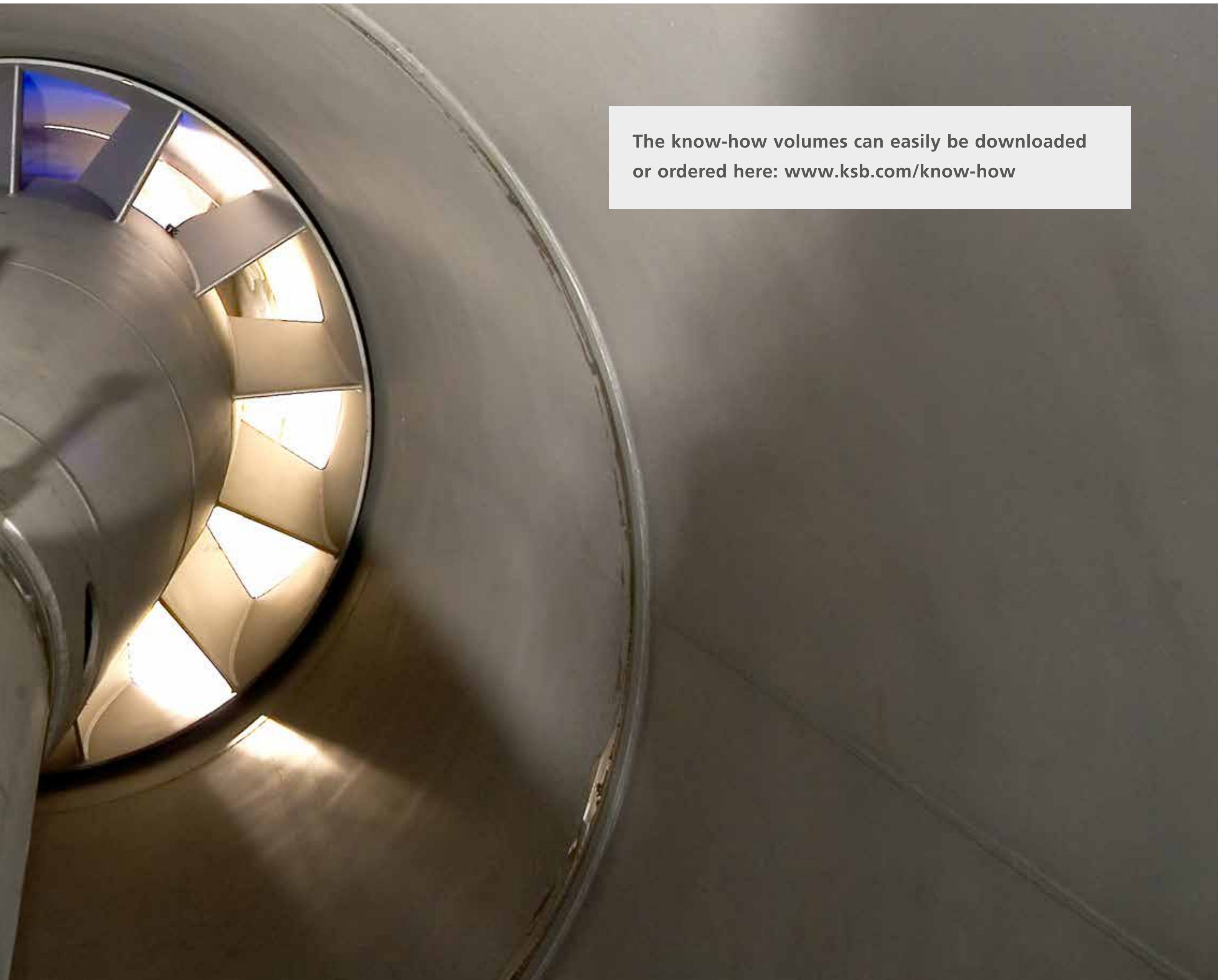
KSB-Know-how – Planning information tubular casing pumps SEZ



Dear Partners,

This brochure provides general information on the interaction between the pump and the system. It is not intended to make project-specific recommendations since aspects such as individual conditions and component requirements have to be considered by a plant engineering consultant. Instead, the brochure only describes some of the important factors that have been disregarded in the past, resulting in substantial damage to pumps and systems. However, it is not intended to provide a complete list of influential factors. The examples given here have proved their worth in practical applications; their suitability for a specific application must however be examined by a consultant.
The contents of this planning information therefore do not affect legal or contractual obligations involving KSB.



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Planning Information for the Integration of Tubular Casing Pumps into a Pumping System

Fig. 1: SEZ

The pump as an interface between environment and the system

Tubular casing pumps are primarily used in surface water extraction applications to provide large amounts of cooling or process water. In such applications, pumps always form one part of a larger system, and can only be considered within the context of this system‘s boundary condi-tions. The pump intake’s geometry and the flow guidance of the fluid handled have a decisive influence on the pump’s performance and operating behaviour. For this reason, the pump must always be selected to meet specific requirements such as individual water levels and intake structures. Considerations regarding pump selection and integration must not only take into account the system characteristic curve’s influence on the pump’s operation but also the forces occurring at the pump and in the system during operation which need to be appropriately managed by the components installed downstream of the pump.
Therefore, the assessment of system conditions and the sizing of the pump are always determined by the interaction of the system components involved.

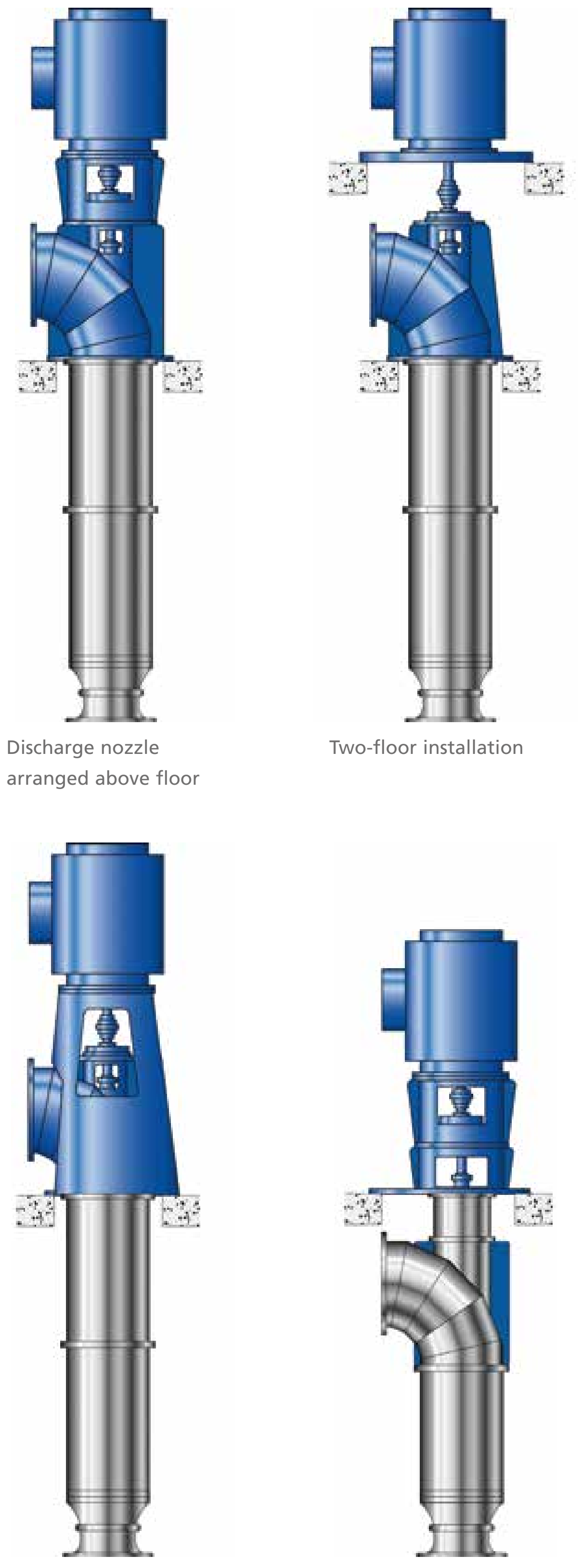
KSB tubular casing pumps – flexible solutions for every application

Tubular casing pumps from KSB can be supplied in four different types of installation which means that individual system requirements and intake structure designs can be catered for.

Foundation frames used to anchor the pumps at the site of installation are able to absorb a portion of the forces and moments.

The two-floor installation provides a second foundation for the motor to absorb motor-induced forces and moments. The permissible loads at the discharge nozzle, i. e. the pump's interface with the system, and all pump-induced forces not absorbed by the pump foundation are explicitly specified in the project documentation for each pump. Observing the project-specific operating ranges such as the minimum flow rate Q min and the maximum permissible flow rate Q max, as well as the minimum water levels NPSH a is absolutely essential as non-compliance with these parameters can lead to severe pump damage.

KSB pumps are provided with suitable corrosion protection depending on the fluid handled. Although corrosion cannot be prevented entirely, it can be reduced to such an extent that the product‘s functions are ensured over an adequate period of time. Corrosion protection is achieved by selecting suitable materials or protective coatings, or the use of special corrosion protection methods. Particularly worth mentioning here are active or passive electrochemical methods such as fitting sacrificial anodes or applying voltage for corrosion protection purposes (cathodic corrosion protection). When such measures are taken either on the pump or other system components, the entire electrically connected system must be taken into account. If this is ignored, a component which has not been connected can unintentionally become a “sacrificial component”.



Discharge nozzle arranged above floor

Two-floor installation

Discharge nozzle arranged above floor, reinforced design (motor stool)

Discharge nozzle arranged below floor

Fig. 2: Installation types

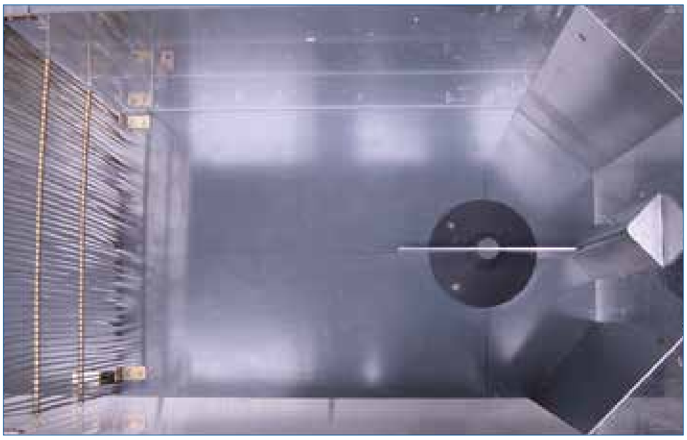


Fig. 3: Intake chamber model testing

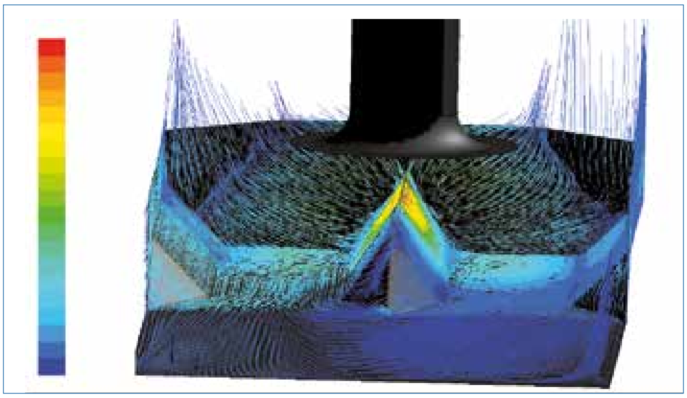


Fig. 4: CFD simulation to demonstrate the intensity of vortices in the intake of an SEZ pump

Fig. 5: Model test to observe the flow in the intake of an SEZ pump

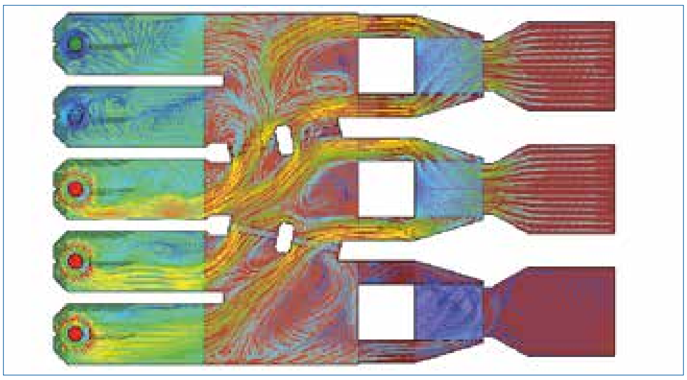


Fig. 6: Velocity distribution in an intake structure showing 5 SEZ pumps

More than just the pump – KSB's services for tubular casing pumps

As mentioned above, the approach flow of the fluid to the pump is of crucial importance for its operating behaviour, and the topic of intake structure design has been dealt with in a variety of publications and standards, including the "ANSI/HI 9.8 Pump Intake Design" standard. KSB pumps are suitable for use in standardised intake chambers, but can also be operated in specially designed chambers. Intake chambers optimised by KSB help to markedly reduce plant construction costs. If standardised intake structures are not suitable for the project's site conditions and the development of a project-specific intake chamber is required, KSB can provide evidence of its functionality using intake chamber model testing. In addition, it is possible to perform computer simulations (the so-called Computational Fluid Dynamics (CFD) modelling) of all possible flow paths. To prevent the generation of excessively high vibration, it is important to ensure that the pump set's natural frequencies do not lie within the range of the operating speeds required. As variable speed pumps have a particularly wide spectrum for excitations, predicting project-specific natural frequencies is essential.
KSB offers to conduct this calculation for individual pump sets using the finite element method (FEM). As well as supplying the pump itself, KSB is also capable of supporting system planning for the entire intake area, from the pump to the discharge nozzle. Due to the large variety of possible components with their individual properties, a more far-reaching examination regarding the pump's integration into the system can only be performed by a plant engineering consultant. To prevent malfunctions at an early stage, some of the important aspects which have a decisive influence on pump operation are mentioned below.

The pump installed in the system – a description of selected forces

Deflection force

The fluid is diverted inside the pump from flow direction X to flow direction Y. The resulting force F_R in Y-direction cannot be fully absorbed by the pump foundation and must therefore be handled by the discharge pipe.

Weight-induced forces

The pump's and motor's weights as well as the water mass inside the pump must be borne by the pump foundation. As far as the piping is concerned, it is necessary to consider the pipe's own weight and in particular that of the fluid mass. The water contained in a pipe with a 2-metre diameter weighs approx. 3 tonnes per 1 metre of piping length.

Cover force or pressure force F_P is the reactive force acting on a theoretical cover fitted to a pipe end.

Thermal or temperature-induced expansion

Temperature fluctuations in the environment and the fluid handled result in the expansion of pipes and components in all directions. If these cannot be compensated, the resulting forces must absolutely be taken into account.

Pressure-induced expansion

Internal pressure acting on the components causes them to expand in all directions. If these expansions cannot be compensated, the resulting forces must absolutely be taken into account.

Expansion joint

If an unbraced expansion joint is installed to absorb axial expansions, reactive forces being equal to the expansion joint's inner surface multiplied by the operating pressure will occur; taking these forces into account is of crucial importance. An expansion joint may also be braced in order to neutralise these reactive forces. The braced expansion joint's stiffness must be considered when calculating the system components and the forces occurring.

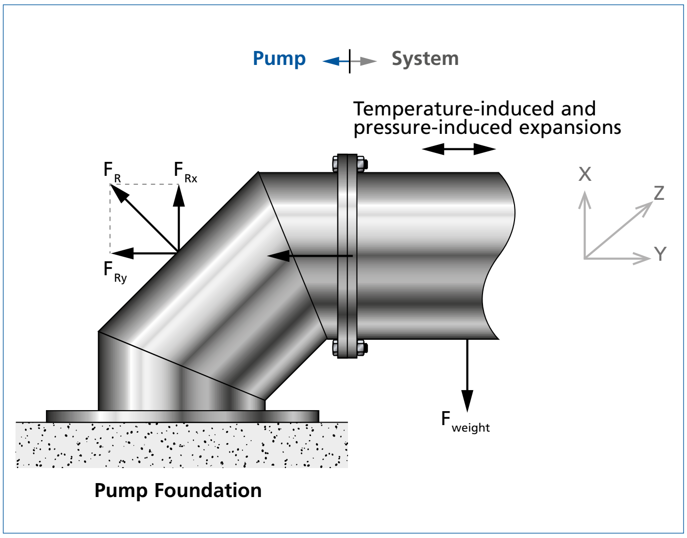


Fig. 7: Forces in pump and system

Fig. 8: Facilitate mounting and dismantling

Fig. 9: Facilitate mounting and dismantling

Parameters to be considered during installation

To facilitate mounting/re-installation and dismantling, it should be possible to easily (in Y-direction) move the discharge pipe away from the pump discharge nozzle. This also creates clearance for mounting. To ensure pipe connection without transmitting stresses or strains, the discharge pipe should have an additional clearance in X- and Z-direction for mounting and also allow position errors to be tolerated.

Within the permissible tolerances, the dimensions of each pump are, of course, different. If the pump is required to be replaceable, it must be ensured that the piping can be adapted to fit the new pump. Position adjustment for foundations and wall passages may also be required due to the building settling in.

The system must be able to tolerate and compensate changing ambient conditions (e. g. temperatures) and operating conditions (e. g. internal pressure during operation and shutdown).
To prevent the negative effects of vibration transmission, vibration isolation measures taken between the pump and the system should be as extensive as possible.

„Best practise" examples of pump and system component configurations

Example 1: Two expansion joints

Description:
A pump is connected to a piping whose weight-induced forces are absorbed by a floating bearing. Before the system's forces are absorbed by an anchorage point, a braced expansion joint and a 90° elbow are installed downstream of the pump, followed by a second braced expansion joint.

Advantages:
The first expansion joint allows the pump to be shifted in Y-direction for ease of pump installation and dismantling. It also allows tolerances in the pump's and piping's mating dimensions to be compensated. The second expansion joint is capable of compensating pressure-induced and temperature-induced expansions in Y-direction by allowing a parallel movement.

Drawbacks:
This configuration requires the investment in two expansion joints and a piping layout with elbow. The significance of the pressure force (i. e. the reactive force acting on a theoretical cover) should in particular be noted for this configuration.

Example 2: Wall anchorage point with expansion joint

Description:
A pump is directly connected to a braced expansion joint. The pipe installed downstream of the expansion joint is firmly anchored in a wall at a defined distance. A variation of this configuration is the so-called "bridged expansion joint", in which the bracing design makes the expansion joint as stiff as the pipe itself. This type of expansion joint has no effect during operation, allowing the system's vibrations to be transmitted.

Advantages:
The expansion joint facilitates the pump's mounting and dismantling. It also allows tolerances in the pump's and piping's mating dimensions to be compensated. The investment is limited to one expansion joint only.

Drawbacks:
The forces resulting from pressure-induced and temperature-induced expansion affect both the pump foundation and the anchorage point depending on the components' stiffness. In order to keep the forces small, temperature fluctuations must be low and the length of piping up to the anchorage point short. The permissible forces at the discharge nozzle must not be exceeded! The piping's contents mass must be borne by both the discharge nozzle and the anchorage point. This variant has proved successful with the use of a steel pipe. In cases where GFRP pipes with a markedly lower stiffness have been used, considerable problems were encountered on multiple occasions.

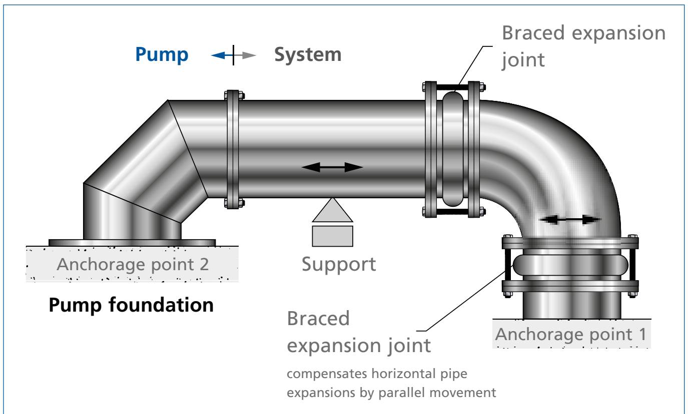


Fig. 10: Examplel 1: Two expansion joints

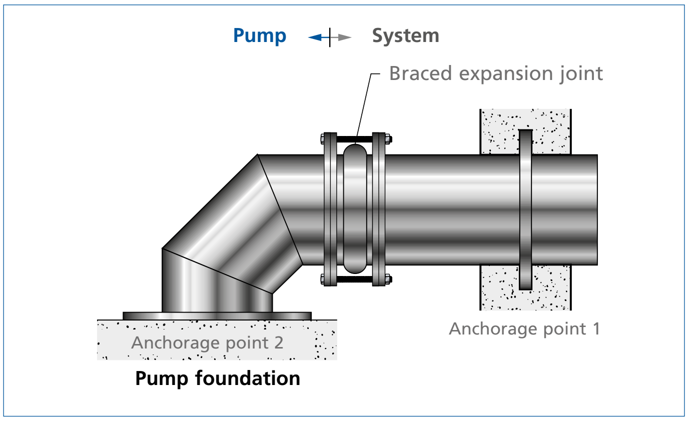


Fig. 11: Example 2: Wall anchorage point with expansion joint

Example 3: The anchorage point can be undone and adjusted

Description:
A pump is directly connected to a braced expansion joint. The pipe installed downstream of the expansion joint is firmly anchored in a wall at a defined distance. A variation of this configuration is the so-called "bridged expansion joint", in which the bracing design makes the expansion joint as stiff as the pipe itself. This type of expansion joint has no effect during operation, allowing the system's vibrations to be transmitted.

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Example 4: Wall anchorage point without expansion joint

Description:
The pump is connected to the downstream pipe which is anchored in the wall at a defined distance.

Advantages:
Investment in additional components is not required.

Drawbacks:
Pump mounting and dismantling is hindered by the anchored discharge pipe. This variant is only recommended for pumps in pull-out design (withdrawable rotating assembly) which means that the pump does not require complete removal for maintenance. Compensating buildings settling in or fitting tolerances when replacing the pump is not possible. The forces resulting from pressure-induced and temperature-induced expansion affect both the pump foundation and the anchorage point depending on the components' stiffness. In order to keep the forces small, temperature fluctuations must be low and the length of piping up to the anchorage point short. The permissible forces at the discharge nozzle must not be exceeded. The piping's contents mass must be borne by both the discharge nozzle and the anchorage point. In cases where GFRP pipes with a markedly lower stiffness than steel pipes have been used, considerable problems were encountered on multiple occasions.

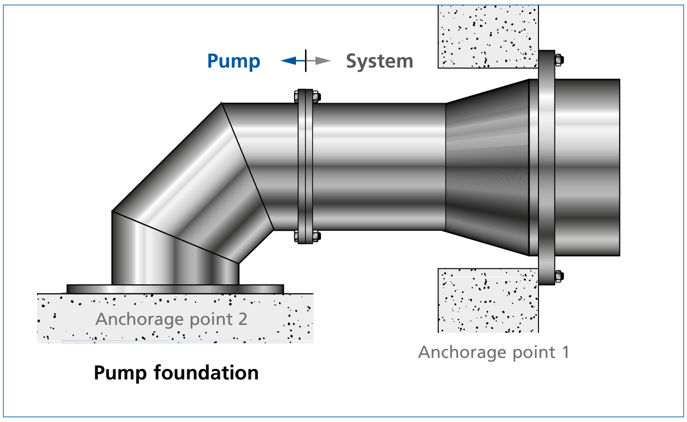

Fig. 12: Example 3: Anchorage point can be undone and adjusted

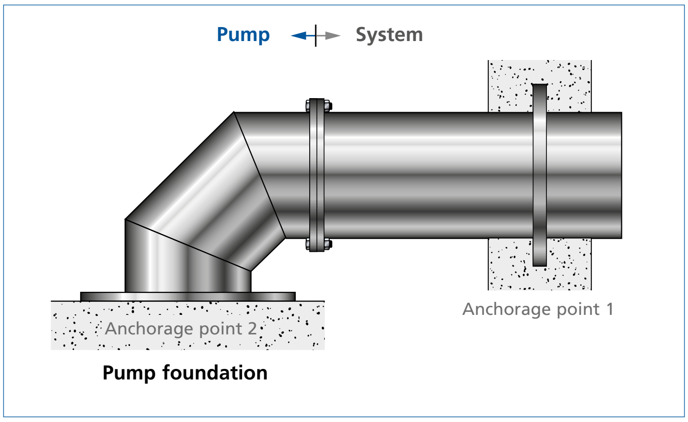

Fig. 13: Example 4: Wall anchorage point without expansion joint

An overview of the advantages and drawbacks:

	Two expansion joints	Wall anchorage point with expansion joint	Anchorage point can be undone and adjusted	Wall anchorage point without expansion joint
Installation friendly design (clearance for installation; alignment/adaptation possible)	++[1)]	+	–	—[1)]
Influence of pipe material and pipe length up to the anchorage point (pressure-induced and temperature-induced expansions, critical)	++[2)]	–	—	—[2)]
Vibration damping	++[3)]	+	–	—[3)]
Investments	—[4)]	–	+	++[4)]
Comment	"Force-free system"	Statically indeterminate system	Statically indeterminate system Expansion joint installed downstream of the anchorage point provides clearance for mounting and ensures vibration isolation	Statically indeterminate system Only suitable for pumps in pull-out design (with-drawable rotating assem-bly) because dismantling is difficult.

++[1)] = Easy to install
—[1)] = Difficult to install

++[2)] = Not critical
—[2)] = Particularly critical

++[3)] = Pump isolated from system in terms of vibrations
—[3)] = System vibrations transmitted to the pump

++[4)] = Low investment
—[4)] = High investment

Table 1: Advantages and drawbacks of pump and system component configurations

Technology that makes its mark

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