



Installation of components in closed processing plants for the food processing industry

– with focus on hygiene

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Prepared by the flow components task group under the auspices of the competence centre of the Danish stainless steel industry.



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This guideline is developed with the support of the Danish Ministry of Science,
Technology and Innovation.

Published for the Centre by:



**TEKNOLOGISK
INSTITUT**

Holbergsvej 10
DK-6000 Kolding

www.teknologisk.dk

© Danish Technological Institute
ISBN: 87-7756-750-1



Introduction

This guideline provides general advice in connection with the installation of components (sensors, valves, pumps, etc.) in closed equipment for the food industry.

The guideline is prepared by the flow components task group under the auspices of the competence centre of the Danish steel industry.

Guideline no. 1: Cabling and electrical cabinets – with focus on hygiene

Guideline no. 2: Check list for the purchase/sale of production equipment – with focus on hygiene

Guideline no. 3: Conveyors – with focus on hygiene

Guideline no. 4: Stainless steel in the food industry – an introduction

Guideline no. 5: Design of piping systems for the food processing industry – with focus on hygiene

Guideline no. 6: Installation of components in closed processing plants for the food processing industry – with focus on hygiene

Enjoy!

Key words

Components, flow, processing plants, food industry, installation, mounting, hygienic design, flowing, measuring instruments, pumps, valves, leak prevention, pressure surge, cleaning.



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1. Domain

This guideline provides general advice for the installation of components in closed processing plants for the food industry.

The selected components (sensors, valves, pumps, etc.) are chosen as typical representatives of groups of flow components. The document includes illustrations and sketches exemplifying the text.

1.1. Limitations

The group has focused on hygienic (CIP/SIP cleanable) systems and introduces a series of parameters that should be considered when installing components.

Links to relevant websites for standards and other guidelines for flow components are found at the end of this guideline.

1.2. Definition and use of guidelines

The guideline can be used by chief installation engineers in connection with the installation of components in existing and new processing plants. The guideline can also be used by construction engineers in connection with the design of new hygienic components.

Furthermore, it can be used by purchasing officers in connection with the selection and specification of components.

Finally, the guideline can be used as a communication tool between purchasing officers and suppliers when coordinating their expectations for the delivery.

It is not the purpose of the guideline to recommend certain types of solutions or suppliers.

2. Component installation in general

Correct component installation is extremely important to ensure a functional processing plant in terms of hygiene as well as process technology.

Components may be well-designed from a hygienic point of view, but if there is a discrepancy between the installation of the components and the plant design, the following errors may occur:

- The creation of undrainable zones, including dead pockets and shadow zones (recirculation and air pockets)
- Unwanted disturbance of the product flow
- Zones where unfavourable flow patterns interfere with the measuring instruments
- Too many couplings
- Incorrect directions of flow



- Bolt thread in the product flow (see EHEDG Guideline Doc. 13, figure 3 ¹)
- Metal-to-metal couplings

2.1. Hygienic installation

It is crucial that welders and engineers who install components in processing plants are trained in hygiene and receive the necessary background knowledge concerning the current hygienic design requirements for food processing plants. A well-performed installation means that the component is *both* cleanable *and* process-technologically functional. The installation guide should be followed strictly so that components are installed with the correct orientation (incline in relation to vertical and horizontal planes and rotation in relation to the centre axis). In some cases, incorrect orientation may render an otherwise drainable component undrainable, which is illustrated in figure 1.



Figure 1. Illustrates how a spherical valve body or instrument casing can cause insufficient drainage through wrong installation. There will always be liquid at the bottom.

2.2. Documentation of cleanability

The components that are to be installed in the plant should meet certain requirements in terms of design and cleanability. There must be no dead pockets and shadow zones as this will reduce the component's cleanability. The component must be installed so as to be drainable.

The cleaning procedure for individual components must be part of the overall cleaning manual.

¹ EHEDG (European Hygienic Engineering Design Group) Doc. 13: *Hygienic design of equipment for open processing, 1996*. The guideline describes hygienic design and construction of equipment used in open processes for the production of foods. Among other things, it includes a description of materials, joints, placement and construction of movable parts, and hygienic design of the immediate surroundings. The guideline includes several examples and illustrations. The guideline can be bought at www.ehedg.org.



Cleanability of closed process equipment must be documented in a test according to guidelines described in the EHEDG Test Method Doc. 2 *A method for assessing the in-place cleanability of food processing equipment, 2004*. The test can verify that equipment can be cleaned by an established CIP cleaning process. The test points out parts of the equipment that cannot be cleaned efficiently, which gives the manufacturer the opportunity to change the design. For reference, a standardised straight pipe is used.

The test can be carried out at the Danish Technological Institute in Kolding who is authorised to issue EHEDG certificates of approval of equipment that passes the test and which otherwise complies with the EHEDG recommendations for hygienic design.

2.3. Essential parameters for component installation

When installing components in closed piping systems, the following parameter should be taken into consideration:

- Product/medium
- Hygienic design, including drainability, flow conditions, etc.
- Pressure (static, allowed pressure loss)
- Direction of flow, velocity of flow and pressure surge
- Control and monitoring options
- Cleaning (requirements, measures, temperature)
- Environment, air humidity
- Vibrations
- Degree of protection
- Thermal expansion and expansion joints
- Serviceability
- Pipe dimensioning
- Location
- Flexibility
- Reaction time
- Gaskets (requirements and maintenance)



3. Valves

With the increasing degree of automation and the requirements for greater production safety, the need for process valves and flow components has also been increased. It has therefore become a highly prioritised focus area in the construction of hygienic processing plants with requirements for thorough cleaning.

In the following, three types of valves are described: Butterfly valves, seat valves and nonreturn valves. In modern processing plants with a high degree of automation, seat valves are the most widespread, and are often combined in valve matrices.

Note: Ball valves (which are yet another type of valve) are not hygienically designed and cannot be CIP cleaned.

3.1. Butterfly valves

When a T-piece is mounted, the valve register must not *enter* the main stream but be placed as *close* to the main line as possible to avoid a dead zone with poor hygiene and to prevent swirl in the product flow (see figure 2).

Where manual operation of the valve is necessary, easy access to the valve handle must be enabled. It must be ensured that the valve can be disassembled, e.g. by installation of unions at the end of a row of butterfly valves, or when using flange valves.

The gasket design at the butterfly valve shaft must be hygienic.

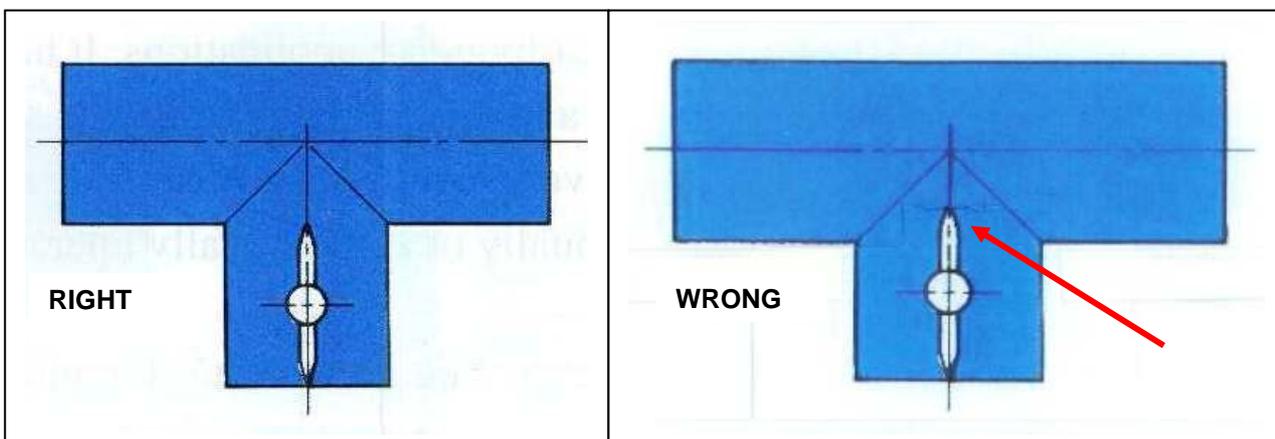


Figure 2. The valve must be installed as close to the main stream as possible. If it is installed too far into the line (the illustration on the right), it will cause swirl in the product flow which may destroy the product quality and create a dead zone where cleaning is difficult.

3.2. Seat valves

Seat valves (e.g. mix-proof valves) are used ever more frequently in connection with large automated installations.



Seat valves are often installed in matrices. In connection with inlets/outlets on fermentation and storage tanks, the individual tank will typically be connected to several shared pipes to allow filling, emptying and cleaning of several tanks simultaneously. Particularly cases when use of the plant is optimised by carrying out several simultaneous actions, involve the risk of e.g. CIP liquids being mixed with the product.

Seat valves can be single or double.

If single seat valves are used and a gasket is not intact, or if a pressure surge occurs, the risk of liquids being mixed is real and should be avoided. The double seat valve may provide the necessary safety as any leak will pass through the leak room.

The main principle in leak proof double seat valves is that there is a leak gap between the two seals/valve parts for further separation of the media on both sides of the valve flap, see figure 3. It will be possible to monitor deficient seals between the seal and the ball in the event of visible dripping. This is ensured by the leak gap on the opposite side of the flow which reaches the surroundings either through a valve spindle, hose or other outlet. It is important that the outlet has no significant counter-pressure.

Hereafter, the defect can be remedied without having caused product damage.

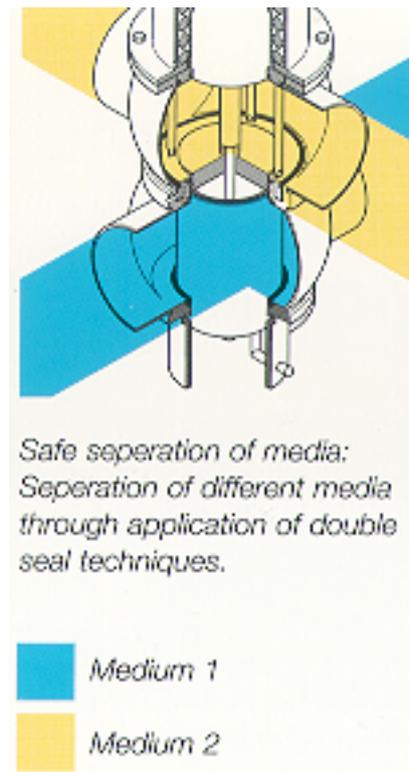


Figure 1. The use of a double seat valve prevents e.g. cleaning liquids (medium 1) leaking into the product (medium 2). Any leak will exit through the leak chamber in the valve. Source: APV A/S.

For all types of seat valves, the installation (orientation to the horizontal) is extremely important with regard to draining. Due to the shape of the valve bodies, swamps may easily settle in them (the cross section is larger inside the house than in the inlet and outlet



pipes). This is especially the case for cylindrical valve bodies. For spherical valve bodies, orientation to the horizontal is crucial as illustrated in figure 4. In cases where spherical valve bodies are used for the insertion of instruments, the orientation to the horizontal must also be taken into consideration.

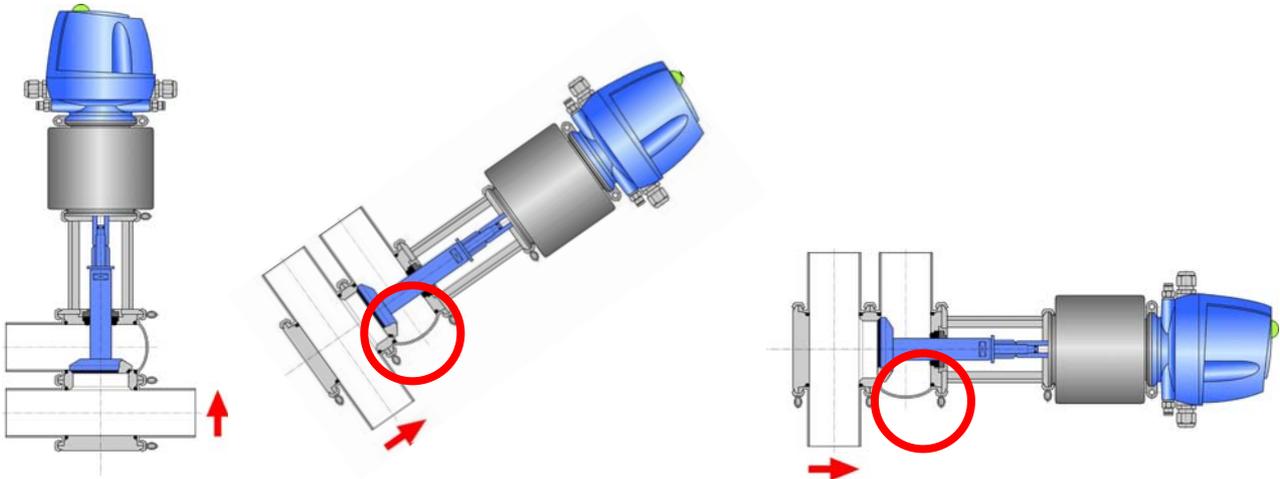


Figure 4. Double seat valves with spherical valve bodies. Drainability of these valves with two valve bodies depends on the orientation to the horizontal and the configuration of inlet and outlet pipes. When the valve is installed vertically, the pipe on which it is mounted is not drainable. Tilting the valve 3° to the vertical will be necessary for the piping system to be drainable, and it must be ensured that the valve body is still drainable when tilted 3° in all directions. If the valve is tilted beyond 3° (in this case to the right) and it is installed on a vertical piping system, it will result in non-drainable zones (marked by the circle). Some of the configurations cannot be drained regardless of the angle of the installation, and for others, the possibilities with regard to orientation are limited.

The double seat valve is very investment heavy. This does not just apply to the valve itself but to a high degree also to indirect costs. Thus, the most complex double seat valve, with the possibility of seat cleaning, will, in addition to the excess price, involve the following extra costs compared to an ordinary valve:

- Control of two additional actuators
- Connection to valve for CIP through the leak chamber
- Programming of safety routines and hardware capacity
- Leak-drainage tray/collection

The double seat valve represents an elegant solution to some complicated problems. To ensure the optimal process installations which are inside a reasonable investment budget, this type of valve should only be used after consulting qualified suppliers.

3.2.1. Valve matrices

The following should be taken into account when considering, selecting and designing double seat valves and subsequently combining them in valve matrices:



Leak detection

- Must be easy.
- Do not connect process drain and leak chamber collection drain (due to contamination).
- Drains of valves should not be placed over open tanks or pump motors.

Sufficient leak capacity

- If this capacity is insufficient, counter-pressure can be developed which effectively only leaves single seat protection.
- The distance between collection drain and drain pipe must be large enough to prevent contact (due to the risk of contamination).

Safety precautions at pressure surge

- If there is a risk of a pressure surge, it should be ensured that the valve flap has sufficient closing pressure and does not “lift” entirely in such incidents. Furthermore, the valve may be placed in the closure direction away from possible pressure surges, i.e. the valve is pressed against the seat and does not open in the event of a pressure surge.
- Alternatively, pressure balanced valves can be used.

Expansion joints

- Pipes expand approx. 1 mm per metre at a 100°C temperature increase. This may cause significant tension and deformation, e.g. in a valve body. Expansion joints should be built in to allow for such expansions. In connection with the installation of valve matrices, the need for expansion joints between the individual lines in the matrix must be taken into account as the temperature in the matrix will vary considerably, e.g. in connection with hot CIP and cold product in the individual separate lines (see figure 5).
- Heat expansions in long pipe runs must, to the extent possible, be absorbed by lyes or elbows.

Easy maintenance and inspection

Double seat valves require a great deal of maintenance, especially because of the large amount of gaskets. As a rule of thumb, all gaskets should be replaced once every 1 to 2 years dependent on the operating conditions.

Of even greater importance than the number of gaskets is their accessibility for the purpose of inspection and preventive maintenance. It generally applies that:

- Valves and valve systems must be provided with joints to enable disassembly for service.
- The leak-drainage tray must be placed so high above the floor, e.g. 1 m, that leak drops from valves can be easily detected during inspection.

In connection with large valve matrices, there must be local catwalks between the valve rows to allow service engineers easy access to the valves.

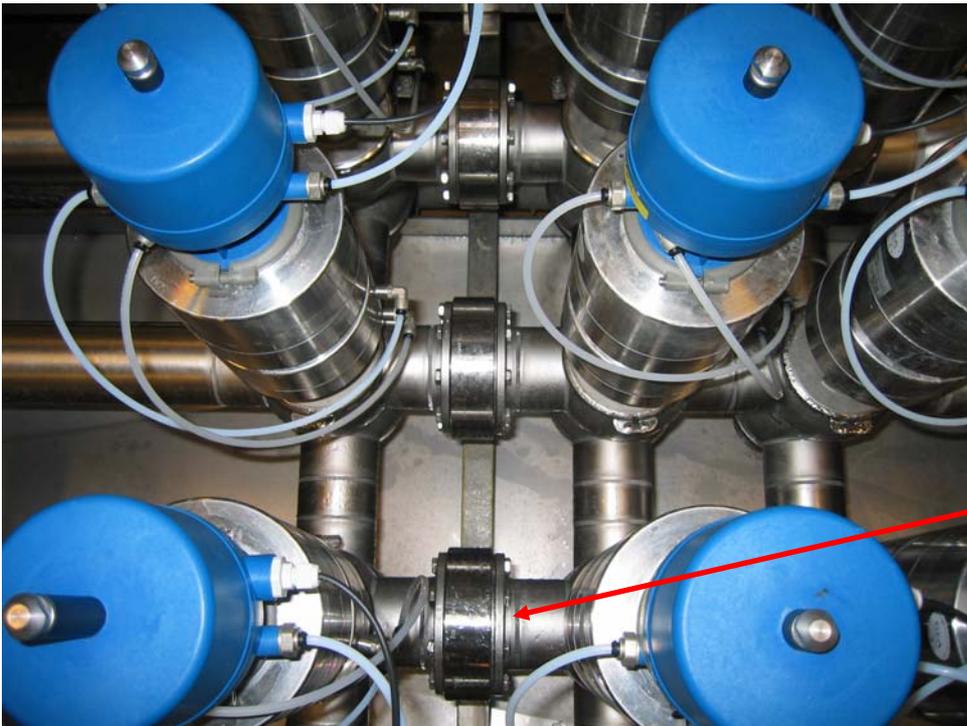


Figure 5. Example of a valve matrix with built-in expansion joints between the valves. The expansion joints absorb the expansions of the pipes caused by temperature fluctuations in the product flows. 0,0,1*100

3.3. Nonreturn valves

Nonreturn valves must be installed in a horizontal line or a vertical line with an upward flow direction, never in a vertical line with downward flow direction. A nonreturn valve must never be installed with a downward flow direction as situations may arise where the pressure on the backside (the side turned downwards) is higher than above the valve and this would mean that the valve cannot open (e.g. there might be a water column below the valve).

In pressurized systems, nonreturn valves on the pipe connected to the upper side of seat valves must be avoided as trapped liquids may otherwise block the opening of the valve.

A CIP pump for e.g. tank cleaning may be provided with a nonreturn valve on the discharge side to prevent backflow/pressure surge on start/stop of the pump.

3.4. The importance of flow direction

The flow direction is greatly significant to how valves are installed in a plant to reduce pressure surges.

3.4.1. *Pressure surges*

A pressure surge occurs when liquid containing high momentum is suddenly stopped or redirected causing great effect on the piping and processing system (torsions, impact,



etc.). With increased production capacity in the companies and with it larger pipe and component dimensions, the problem is increasing. Not least as the velocity of flow has also increased. The pressure difference from ordinary production to complete stoppage through a pressure surge can be 3 to 5 times the operating pressure. A sudden barrier at the end of such a system may lead to serious damage to the processing equipment. Less powerful, but nonetheless noticeable and relatively frequent pressure surges may cause fatigue fractures in welds, loosening of wall anchoring, etc.

For protection against pressure surges caused by sudden, clear mistakes, wrongful operation, air pressure failure, etc, it may prove necessary to mount hygienic safety valves.

One of the ways in which pressure surges can be reduced, is by placing valves correctly in the flow so that a seat valve will always close correctly against the flow direction, as illustrated in figure 6.

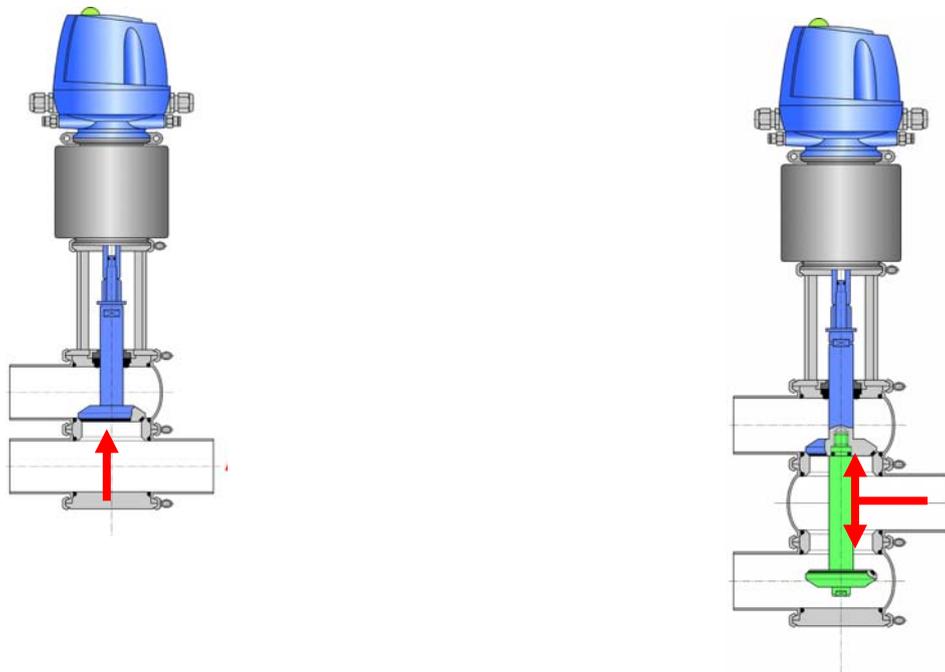


Figure 6. Two different types of seat valves, both of which close against the flow direction (indicated by the red arrow).

If a pressure surge is caused by a powerful pump without counter-pressure, e.g. because the piping system is empty, this can be moderated by a slow-opening valve in front of the pump or a frequency-controlled starting device for the pump.

In connection with long pipe runs, a block valve at the destination must allow throttling. i.e. slow closure, in order to prevent pressure surges.



4. Leak prevention

In any component that incorporates gaskets, there is always the risk of damage to or failure of these. In many cases, a leak will have a visible or audible effect due to leakage.

In the event of an internal valve leak, however, there is no immediate possibility of detecting a possible mix of media from each side of a valve flap. The consequences of the mix may vary from 'unharmful' to a destroyed product. Particularly dangerous, and very much the focus of attention of the authorities, is the mixing of CIP liquids with product, but also the admixture of un-pasteurized raw material or product with a pasteurised or sterilised product can have incalculable consequences.

A programme of regular maintenance and inspection may help prevent many operational failures. But a higher level of safety can be achieved through careful selection of valve and valve site, e.g. the creation of valve matrices with leak proof double seat valves.

5. Pumps

With regard to piping installations with pumps, it is essential that the piping system be designed and installed correctly to achieve optimal efficiency of the pump. The following should be considered:

- There should be a fall on the suction side of the pump.
- Unnecessary elbows on the suction side of the pump should be avoided. The inlet pipe of the pump must be as short and direct as possible.
- The pipe dimension of the suction side must not be smaller than the dimension of the connection of the pump.
- In connection with tank groups, the pump should be located as centrally as possible between the tanks to reduce the suction length.
- If a reducer on the pump's suction side proves necessary, this must be eccentric (with the straight side pointed downwards to prevent air from being trapped in the pump housing).
- When hot products are to be pumped, it is important to check the calculation of NSPH (Net Positive Suction Head) with the pump's specifications.
- Positive pumps must be installed with a hygienic pressure relief device (see figure 7).
- The pump must be provided with a drain valve if it is not self-draining at the expected installation position, just as the pump outlet must be designed so as to prevent air pockets in the pump housing. (see figure 8).
- As a minimum, the supplier's instructions for the pump must always be observed.



Figure 7. Positive pump with a valve as pressure relief device

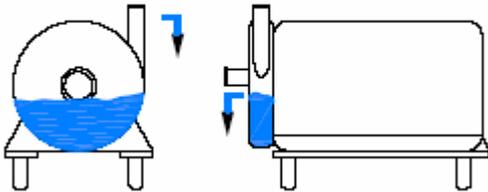


Figure 8. The pump must be provided with a drain valve if it is not self-draining at the expected installation position, just as the pump outlet must be designed so as to prevent air pockets in the pump housing. Front and side view of the pump. Obviously, the pump is not drainable.



6. Measuring instruments

When selecting instruments for plants, it is very important to know the current physical and chemical conditions. Furthermore, it is important – during the selection, and during the design and installation of equipment on the plant – not to introduce zones that are unacceptable from a microbiological and cleaning perspective.

An instrument is never more hygienically designed than its weakest spot. Therefore, it is extremely important that an instrument is purchased with an instrument casing, and that the casing is not subsequently used for other types/makes of instruments. In this case, the new instrument and instrument casing must be tested for cleanability.

It must be ensured that instruments can be drained and aired. If air pockets occur in the instrument installation area, CIP cleaning cannot be carried out according to the instructions. Furthermore, wrong measurements may occur as the sensor may only detect the air and not the product. If product or CIP liquids are left in pockets in the piping system, these will constitute potential sources of contamination, and disinfection or sterilisation will fail as the microbes are protected by the product or CIP liquids.

Sensible installation of instruments in the piping system so as to avoid swirl around the installation area is a prerequisite for the instruments to produce stable measurements. As a minimum, the supplier's instructions must always be observed.

Especially in connection with time-critical control, the reaction time of the instrument should be checked and the sensor be placed correctly to the delay. The valve reaction time should also be known when time-critical control is used.

Make sure there is sufficient distance between elbows and the instrument.

Instruments should be installed in inline casings, alternatively in short T-pieces with the shortest possible dead leg (max. approx. 0.5 x pipe diameter).

When installing in a T-piece, it must be ensured that the CIP flow or CIP time is sufficient in the T-piece to provide efficient cleaning.

Even when the requirements for hygienic installation conditions around the transmitter may be of high priority in a plant, it should also be noted that there must be easy access for maintenance around the individual transmitters.

Where possible, pressure indicators and thermometers must be installed so that they can be read from one and the same spot. This will facilitate monitoring by the operator. Vertical installation of indicating instruments facilitates reading.

Using a plug and socket connection will prove advantageous in connection with troubleshooting, measurement and replacement of electric components. When reconnecting a replaced component, the risk of a wrong connection is minimal. However, in individual cases it should be considered whether the presence of water or high humidity represents particular risk in connection with using plug and socket.



6.1. Flow meters

Generally, flow meters must be installed in a vertical pipe with an upward flow to ensure full flow in the measuring head.

Before the flow meter, the distance to the nearest elbow should be 5 times the pipe diameter and 3 times the pipe diameter after the flow meter.

If a flow meter is installed in a horizontal pipe, any reducers before or after the flow meter must be eccentric (with the straight side down so that air is not trapped and drainage is ensured).

6.2. Inspection glass

Must be installed in a vertical pipe to ensure drainability (see figure 1). Please note that glass is not normally used in the food industry unless it is splinterproof.

Remember to inform the quality control system if an inspection glass is installed so that it can be included in the local glass inspection.

6.3. Thermometers

The sensor must be placed so as to measure at the centre of the flow.

7. Declarations and reports

In addition to the official documentation enclosed in the delivery of instruments, many instruments come with several documents informing on the suitability of the instrument in different applications. Among these, the below are highlighted as they are relevant to the food industry.

7.1. 3-A and EHEDG

Hygienic approvals from 3-A or EHEDG or documents informing on the properties of the instrument, particularly in connection with cleaning. 3-A is an American standard dealing with the roughness of contact surfaces and the suitability of the equipment in the food industry, whereas the EHEDG certificate verifies that the instrument has been subjected to and passed a test devised by the European Hygienic Engineering & Design Group to document the instrument's cleanability.

7.2. FDA

The Food and Drug Administration does not approve instruments and measuring equipment, but establishes guidelines for the materials that can be used in connection with foods and products for medicinal use.

In connection with material certificates, suppliers of components and instruments often present documentation that the materials used (contact parts such as gaskets) are FDA compliant.



8. Overview of other guidelines for flow components

EHEDG Doc. 1, 1992: Microbiologically safe continuous pasteurisation of liquid foods

The guideline deals with the design of pasteurising plants. It contains descriptions of proper configuration of heat exchangers and flow splitting. Furthermore, it provides descriptions of specific elements that must be considered in connection with design. These include temperature meters, holding time, valves, joints and materials.

The guideline can be bought at EHEDG: <http://www.ehedg.org>.

EHEDG Doc. 6, 1993: The microbiologically safe continuous flow thermal sterilisation of liquid foods

The guideline deals with continuous heat treatment of non-particulate foods. It provides descriptions of sterilisations through direct heat treatment (steam) and through indirect heat treatment (heat exchange). It also describes requirements that the heat treatment equipment should meet, and deals with important issues of process control.

The guideline can be bought at EHEDG: <http://www.ehedg.org>.

EHEDG Doc. 8, 2004: Hygienic equipment design criteria, second edition

The guideline provides basic design principles that should be observed to obtain a satisfactory hygienic design. The document contains general guidelines for hygienic design, requirements for materials, function as regards cleaning, decontamination, avoidance of ingress of microorganisms, compatibility with other requirements (e.g. process requirements) and assessment of the hygienic design of equipment.

The guideline can be obtained at EHEDG: <http://www.ehedg.org>.

EHEDG Doc. 10, 1992: Hygienic design of closed equipment for the processing of liquid food

The guideline deals with specific examples of good and poor design of different components and piping systems in closed processing equipment. Some these are: gaskets and couplings, shaft insertions and dead pockets.

The guideline can be bought at EHEDG: <http://www.ehedg.org>.

EHEDG Doc. 12, 1994: The continuous or semi-continuous flow thermal treatment of particulate foods

The guideline deals with the design of continuous and semi-continuous plants for the heat treatment of particulate foods. It provides a thorough presentation of the parts of processes that differ from similar plants for the treatment of non-particulate foods. The guideline furthermore contains a presentation of process control and process validation.

The guideline can be bought at EHEDG: <http://www.ehedg.org>.

EHEDG Doc. 16, 1997: Hygienic pipe couplings

The guideline describes the design details that must be included in the construction of pipe couplings. It provides specific information on problem zones relating to gasket design and the design of the groove in which the gasket is mounted in the coupling.

The guideline can be bought at EHEDG: <http://www.ehedg.org>.



Champden & Chorleywood Technical Manual no. 17 (ISBN nr. 0905942078) 2nd edition, 1997: Hygienic Design of Liquid Handling Equipment for the Food Industry

The guideline is quite comprehensive and contains hygienic design of equipment for the production of liquid products such as milk and other dairy products. It collects advice from the EU directive 89/392/EEC and the Machine Directive, and guidelines from EHEDG publications on equipment for liquids. It touches on subjects such as material selection, including stainless steel, construction, instrumentation of equipment, agitator, piping systems, including taps and pumps, and CIP systems.

The guideline can be bought at <http://www.campden.co.uk/>.

3-A Accepted Practices for the Sanitary Construction, Installation, Testing and Operation of High-Temperature Short-Time and Higher-Heat Shorter-Time Pasteurizer Systems, Revised, Number 603-06, 1992:

The guideline deals with pasteurisation equipment, accessories and control systems that are used as parts of a complete processing plant for milk or dairy products. The pasteurisation equipment is of the HTST or HHST type. The rest of the processing equipment may consist of homogenisation or flavouring systems. The guideline describes hygienic design, construction, material, manufacturing and installation criteria for pasteurisation equipment and the individual parts hereof, and requirements for the remaining part of the processing equipment. The criteria are illustrated. Furthermore, the guideline describes a series of tests that can be performed to check the equipment.

<http://www.techstreet.com/3Agate.html>.

9. Applied methods

Group members' experience and knowledge was collected and structured from 2004 to 2005. Group meetings and visits to companies were held at the authors' companies.

10. Further information

Furthermore, the www.staalcentrum.dk knowledge portal contains a wide range of relevant links to authorities and organisations, etc. The portal also offers a clear picture of the guidelines, standards, legislation, etc. available for specific fields/types of equipment and locations. It is easy to search the material and read a short description of the actual contents. From the relevant links it is possible to order material from the source.

EUR-Lex offers free and direct access to the EU legislation. Go to www.europa.EU.int/eur-lex (choose language code; DA for Danish, EN for English). The system also makes it possible to consult the Official Journal of the European Communities, which includes treaties, legislation, case-law and draft proposals. The system offers comprehensive searching facilities. Any questions in relation to the status of legislation can be directed at tel. 00 800 6789 10 11. The number is toll-free.



The EU has furthermore collected all legal aspects concerning materials relating to materials with food contact. Go to http://europa.eu.int/comm/food/food/chemicalsafety/foodcontact/eu_nat_laws_en.pdf.

11. Concepts/terminology

Please refer to the EHEDG Glossary (<http://www.ehedg.org>).
Go to Guidelines > Library > Glossary.

12. Change protocol

This is the first edition. Future changes will be listed here.